DENMARK'S NATIONAL INVENTORY REPORT 2011

Emission Inventories 1990-2009

– Submitted under the United Nations Framework Convention on Climate Change and the Kyoto Protocol

NERI Technical Report no. 827 2011

NATIONAL ENVIRONMENTAL RESEARCH INSTITUTE
AARHUS UNIVERSITY

DENMARK'S NATIONAL INVENTORY REPORT 2011

Emission Inventories 1990-2009

– Submitted under the United Nations Framework Convention on Climate Change and the Kyoto Protocol

NERI Technical Report no. 827 2011

Ole-Kenneth Nielsen[1]
Mette Hjorth Mikkelsen[1]
Leif Hoffmann[1]
Steen Gyldenkærne[1]
Morten Winther[1]
Malene Nielsen[1]
Patrik Fauser[1]
Marianne Thomsen[1]
Marlene S. Plejdrup[1]
Rikke Albrektsen[1]
Katja Hjelgaard[1]
Henrik G. Bruun[1]
Vivian Kvist Johannsen[2]
Thomas Nord-Larsen[2]
Annemarie Bastrup-Birk[2]
Lars Vesterdal[2]
Inge Stupak Møller[2]
Erik Rasmussen[3]
Karim Arfaoui[3]
Lene Baunbæk[4]
Maria Gunnleivsdóttir Hansen[5]

1) National Environmental Research Institute, Aarhus University
2) Faculty of Life Sciences, University of Copenhagen
3) Danish Energy Agency
4) Statistics Greenland
5) Umhvørvisstovan (The Environment Agency, The Faroe Islands)

NATIONAL ENVIRONMENTAL RESEARCH INSTITUTE
AARHUS UNIVERSITY

Data sheet

Series title and no.: NERI Technical Report No 827

Title: Denmark's National Inventory Report 2011
Subtitle: Emission Inventories 1990-2009 - Submitted under the United Nations Framework Convention on Climate Change and the Kyoto Protocol

Authors: Ole-Kenneth Nielsen[1], Mette Hjorth Mikkelsen[1], Leif Hoffmann[1], Steen Gyldenkærne[1], Morten Winther[1], Malene Nielsen[1], Patrik Fauser[1], Marianne Thomsen[1], Marlene S. Plejdrup[1], Rikke Albrektsen[1], Katja Hjelgaard[1], Henrik G. Bruun[1], Vivian Kvist Johannsen[2], Thomas Nord-Larsen[2], Annemarie Bastrup-Birk[2], Lars Vesterdal[2], Inge Stupak Møller[2], Erik Rasmussen[3], Karim Arfaoui[3], Lene Baunbæk[4], Maria Gunnleivsdóttir Hansen[5]
Departments: [1)]National Environmental Research Institute, Aarhus University
[2)]Faculty of Life Sciences, University of Copenhagen
[3)]Danish Energy Agency
[4)]Statistics Greenland
[5)] Umhvørvisstovan (The Environment Agency, The Faroe Islands)

Publisher: National Environmental Research Institute ©
University of Aarhus - Denmark
URL: http://www.neri.dk

Year of publication: May 2011
Editing completed: April 2011
Referee: Henning Høgh Jensen

Financial support: No external financial support

Please cite as: Nielsen, O.-K., Mikkelsen, M.H., Hoffmann, L., Gyldenkærne, S., Winther, M., Nielsen, M., Fauser, P., Thomsen, M., Plejdrup, M.S., Albrektsen, R., Hjelgaard, K., Bruun, H.G., Johannsen, V.K., Nord-Larsen, T., Bastrup-Birk, A., Vesterdal, L., Møller, I.S., Rasmussen, E., Arfaoui, K., Baunbæk, L. & Hansen, M.G. 2011: Denmark's National Inventory Report 2011 - Emission Inventories 1990-2009 - Submitted under the United Nations Framework Convention on Climate Change and the Kyoto Protocol. National Environmental Research Institute, Aarhus University, Denmark. 1199 pp. http://www.dmu.dk/Pub/FR827.pdf

Abstract: This report is Denmark's National Inventory Report 2011. The report contains information on Denmark's emission inventories for all years' from 1990 to 2009 for CO_2, CH_4, N_2O, HFCs, PFCs and SF_6, NO_x, CO, NMVOC, SO_2.

Keywords: Emission Inventory; UNFCCC; IPCC; CO_2; CH_4; N_2O; HFCs; PFCs; SF_6

Layout: Ann-Katrine Holme Christoffersen
Front page photo: Ann-Katrine Holme Christoffersen (beach landscape from the island of Aeroe)

ISBN: 978-87-7073-234-5
ISSN (electronic): 1600-0048

Number of pages: 1199

Internet version: The report is available in electronic format (pdf) at NERI's website
http://www.dmu.dk/Pub/FR827.pdf

Contents

Acknowledgements

The work of compiling the Danish greenhouse gas inventory requires the input of many individuals, companies and institutions. The authors of this report would like to thank the following for their valuable input in the work process:

- The Danish Energy Agency, in particular Peter Dal, Kaj Stærkind and Dorte Maimann for valuable discussions concerning energy balance data and EU ETS data.
- DTU Transport (Technical University of Denmark), in particular Thomas Jensen for valuable input and discussions on road transport fleet and mileage characterisation.
- Faculty of Agricultural Sciences, Aarhus University, in particular Hanne D. Poulsen for valuable input and discussions on N-excretions and ammonia emission factors for livestock production, Bjørn M. Petersen for valuable contributions in relation to modelling of carbon turnover in agricultural soils, Søren O. Petersen for discussion on emission factors from manure storages, organic soils and wetlands and Mogens H. Greve for valuable contributions to mapping of organic soils.
- Torkild Birkmose, Department of Crop Production, Knowledge Centre for Agriculture, for discussions on actual farming practice and ammonia emissions factors from manure management.
- The Danish Plant Directive for giving us unrestricted access to all agricultural data.
- The European Environment Agency for granting permission for Denmark to use the CRF Aggregator tool for the submissions under the Kyoto Protocol and the UNFCCC.
- Carl Christian Hoffmann, Department of Fresh Water Ecology, NERI, Aarhus University for valuable discussions on organic soils and wetlands.
- The IT department at NERI, in particular Michael Bielefeldt for supporting the emission inventory data system.

Executive summary

ES.1. Background information on greenhouse gas inventories and climate change

Reporting

This report is Denmark's National Inventory Report (NIR) 2011 for submission to the United Nations Framework Convention on Climate change and the Kyoto Protocol, due April 15, 2011. The report contains detailed information about Denmark's inventories for all years from 1990 to 2009. The structure of the report is in accordance with the UNFCCC guidelines on reporting and review. The main difference between Denmark's NIR 2011 report to the European Commission, due March 15, 2011, and this report to UNFCCC is reporting of territories. The NIR 2011 to the EU Commission was for Denmark, while this NIR 2011 to UNFCCC is for Denmark, Greenland and the Faroe Islands. The suggested outline provided by the UNFCCC secretariat has been followed to include the necessary information under the Kyoto Protocol. The report includes detailed and complete information on the inventories for all years from year 1990 to the year 2009, in order to ensure transparency.

The annual emission inventories for the years from 1990 to 2009 are reported in the Common Reporting Format (CRF). Within this submission separate CRF's are available for Denmark (EU), Greenland, the Faroe Islands, for Denmark and Greenland (KP) as well as for Denmark, Greenland and the Faroe Islands (UNFCCC). The CRF spreadsheets contain data on emissions, activity data and implied emission factors for each year. Emission trends are given for each greenhouse gas and for total greenhouse gas emissions in CO_2 equivalents.

The issues addressed in this report are: Trends in greenhouse gas emissions, description of each emission category of the CRF, uncertainty estimates, explanations on recalculations, planned improvements and procedure for quality assurance and control.

This report itself does not contain the full set of CRF tables. Only the trend tables, Tables 10.1-5 of the CRF format for Denmark, are included, refer to Annex 8. The full set of CRF tables is available at the EIONET, Central Data Repository, kept by the European Environmental Agency:
http://cdr.eionet.europa.eu/dk/Air_Emission_Inventories

Please note that figures in Annex 8 are in the Danish notation, which is "," (comma) for decimal sign and "." (full stop) to divide thousands. In the report (except where tables are taken from the CRF as "pictures" as in Annex 8) English notation is used: "." (full stop) for decimal sign and mostly space for division of thousands. The English notation for division of thousand as "," (comma) is mostly not used due to the risk of being misinterpreted by Danish readers.

Institutions responsible

On behalf of the Ministry of the Environment and the Ministry of Climate and Energy the National Environmental Research Institute (NERI), Aarhus University, is responsible for the calculation and reporting of the Danish national emission inventory to EU and the UNFCCC (United Nations Framework Convention on Climate Change) and UNECE CLRTAP (Convention on Long Range Transboundary Air Pollution) conventions. Hence, NERI prepares and publishes the annual submission for Denmark to the EU and UNFCCC of the National Inventory Report and the greenhouse gas (GHG) inventories in the Common Reporting Format, in accordance with the UNFCCC guidelines. Further, NERI is responsible for reporting the national inventory for the Kingdom of Denmark to the UNFCCC. NERI is also the body designated with overall responsibility for the national inventory under the Kyoto Protocol for Greenland and Denmark. Furthermore, NERI participates when reporting issues are discussed in the regime of UNFCCC and EU (Monitoring Mechanism).

The work concerning the annual greenhouse gas emission inventory is carried out in cooperation with Danish ministries, research institutes, organisations and companies. The Government of Greenland is responsible for finalising and transferring the inventory for Greenland to NERI. The Faroe Islands Environmental Agency is responsible for finalising and transferring the inventory for the Faroe Islands to NERI.

Greenhouse gases

The greenhouse gases reported are those under the UN Climate Convention:

- Carbon dioxide CO_2
- Methane CH_4
- Nitrous Oxide N_2O
- Hydrofluorocarbons HFCs
- Perfluorocarbons PFCs
- Sulphur hexafluoride SF_6

The global warming potential (GWP) for various greenhouse gases has been defined as the warming effect over a given time of a given weight of a specific substance relative to the same weight of CO_2. The purpose of this measure is to be able to compare and integrate the effects of the individual greenhouse gases on the global climate. Typical lifetimes in the atmosphere of greenhouse gases are very different, e.g. approximately 12 and 120 years for CH_4 and N_2O, respectively. So the time perspective clearly plays a decisive role. The lifetime chosen is typically 100 years. The effect of the various greenhouse gases can then be converted into the equivalent quantity of CO_2, i.e. the quantity of CO_2 giving the same effect in absorbing solar radiation. According to the IPCC and their Second Assessment Report, which UNFCCC has decided to use as reference, the global warming potentials for a 100-year time horizon are:

- CO_2: 1
- Methane (CH_4): 21
- Nitrous oxide (N_2O): 310

Based on weight and a 100-year period, CH_4 is thus 21 times more powerful a greenhouse gas than CO_2 and N_2O is 310 times more powerful than CO_2. Some of the other greenhouse gases (hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride) have considerably higher global warming potentials. For example, sulphur hexafluoride has a global warming potential of 23 900. The values for global warming potential used in this report are those prescribed by UNFCCC. The indirect greenhouse gases reported are Nitrogenoxide (NO_x), Carbonmonooxide (CO), Non-Methane Volatile Organic Compound (NMVOC) and Sulphurdioxid (SO_2). Since no GWP is assigned these gases they do not contribute to GHG emissions in CO_2-equivalents.

ES.2. Summary of national emission and removal trends

Summary ES.1-4 is the inventory for Denmark only. The inventories for Greenland, Denmark and Greenland and the Faroe islands are described in Chapter 16 and 17 and Annex 9, respectively.

ES.2.1 Greenhouse gas emissions inventory

The greenhouse gas emissions are estimated according to the IPCC guidelines and guidance and are aggregated into seven main sectors. According to decisions made under the UNFCCC and the Kyoto Protocol the greenhouse gas emissions are estimated according to the IPCC 1996 guidelines and the IPCC 2000 good practice guidance. The greenhouse gases include CO_2, CH_4, N_2O, HFCs, PFCs and SF_6. Figure ES.1 shows the estimated total greenhouse gas emissions in CO_2 equivalents from 1990 to 2009. The emissions are not corrected for electricity trade or temperature variations. CO_2 is the most important greenhouse gas contributing in 2009 to the national total emission in CO_2 equiv. excluding LULUCF (Land Use and Land Use Change and Forestry) with 78.8 %, followed by N_2O with 10.1 %, CH_4 with 9.7 % and F-gases (HFCs, PFCs and SF_6) with 1.4 %. Seen over the time span from 1990 to 2009 these contributions (in percentages) have been increasing for CO_2 and F-gases, almost constant for CH_4 and decreasing for N_2O. Stationary combustion plants, transport and agriculture represent the largest emission categories, followed by Industrial processes, Waste and Solvents, see Figure ES.1. The net CO_2 uptake for the LULUCF sector in 2009 is 1.8 % of the total emission in CO_2 equivalents (excluding LULUCF). The national total greenhouse gas emission in CO_2 equivalents excluding LULUCF has decreased by 10.3 % from 1990 to 2009 and decreased 15.9 % including LULUCF. Comments on the overall trends on the individual greenhouse gases etc. seen in Figure ES.1 are given in the sections below.

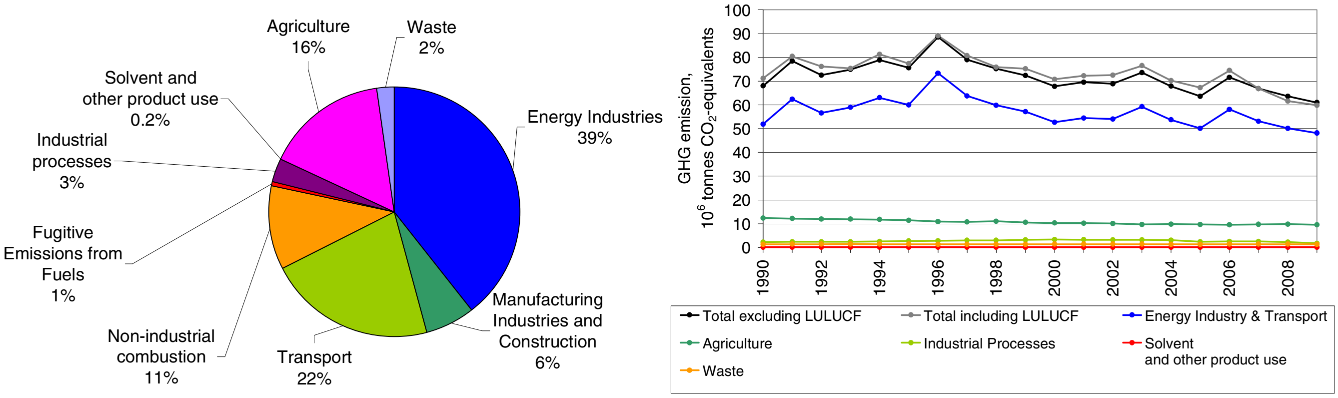


Figure ES.1 Greenhouse gas emissions in CO_2 equivalents distributed on main sectors (excl. LULUCF) for 2009 and time-series for 1990 to 2009, where data for CO_2 excludes LULUCF.

ES.2.2 KP-LULUCF activities

Net removals from Afforestation Reforestation Deforestation (ARD) activities in 2009 were 111.8 Gg CO_2 eqv., hereof 0.4 Gg CO_2 eqv. owe to N_2O emissions from disturbance of soils. Net emissions from FM activity were 2 591.1 Gg CO_2 eqv. (Table ES.1) hereof 12.0 Gg CO_2 eqv. owe to N_2O emissions from drainage of soils.

For Cropland Management (CM) the net emissions in 2009 were 1369.3 Gg CO_2 eqv. compared to a net emission in 1990 of 3 188.6 Gg CO_2 eqv.

For Grassland Management (GM) the net emissions in 2009 were 185.6 Gg CO_2 eqv. compared to a net emission in 1990 of 313.6 Gg CO_2 eqv.

Table ES.1 Emissions and removals in 2008 for activities relating to Article 3.3 and Article 3.4.

	Net CO_2 emissions/ removals	CH_4	N_2O	Net CO_2 equivalent emissions/ removals
			(Gg)	
A. Article 3.3 activities				-111.83
A.1. Afforestation and Reforestation	-145.31	NO	IE,NA,NO	-145.31
Units of land not harvested since the beginning of the commitment period	-145.31	NO	IE,NA,NO	-145.31
Units of land harvested since the beginning of the commitment period	IE,NO	NO	IE,NO	IE,NO
A.2. Deforestation	33.07	NO	0.00	33.48
B. Article 3.4 activities				-1 024.17
B.1. Forest Management	-2 591.13	NO	0.04	-2 579.10
B.2. Cropland Management	1 369.28	NO	IE,NA,NO	1 369.28
B.3. Grazing Land Management	185.64	NO	NO	185.64
B.4. Revegetation	NA	NA	NA	NA

ES.3. Overview of source and sink category emission estimates and trends

ES.3.1 Greenhouse gas emissions inventory

Energy

The largest source of the emission of CO_2 is the energy sector, which includes the combustion of fossil fuels such as oil, coal and natural gas. Energy excluding transport contributes in 2009 with 49 % of the national total CO_2 emissions (excl. LULUCF). The transport sector accounts for approximately 27 %. The CO_2 emission from the energy sector including transport decreased by approximately 9 % from 2008 to 2009. The relatively large fluctuations in the emission time-series from 1990 to 2009 are due to inter-country electricity trade. Thus, high emissions in 1991, 1994, 1996, 2003 and 2006 reflect electricity export and the low emissions in 1990 and 2005 were due to import of electricity in these years. The low emission in 2009 is due to a decrease in the energy demand due to the economic recession. The minor increasing emission of CH_4 is due to increasing use of gas engines in the decentralised cogeneration plants. The deregulation of the electricity market has made production of electricity in gas engines less favourable, therefore the fuel consumption has decreased and hence the CH_4 emission has decreased. The CO_2 emission from the transport sector has increased by 23 % since 1990, mainly due to increasing road traffic.

Industrial processes

The emissions from industrial processes, i.e. emissions from processes other than fuel combustion, amount to 2.9 % of total emissions in CO_2-equivalents (excl. LULUCF) in 2009. The main categories are cement production, refrigeration, foam blowing and calcination of limestone. The CO_2 emission from cement production – which is the largest source contributing in 2009 with 1.3 % of the national total – increased by 13 % from 1990 to 2009. The second largest source has been N_2O from the production of nitric acid. However, the production of nitric acid/fertiliser ceased in 2004 and therefore the emission of N_2O also ceased.

The emission of HFCs, PFCs and SF_6 has increased by 161 % from 1995 until 2009, largely due to the increasing emission of HFCs. The use of HFCs, and especially HFC-134a, has increased several fold and thus HFCs have become the dominant F-gases, contributing 67 % to the F-gas total in 1995, rising to 94 % in 2009. HFC-134a is mainly used as a refrigerant. However, the use of HFC-134a is now stabilising. This is due to Danish legislation, which in 2007, banned new HFC-based refrigerant stationary systems. However, in contrast to this trend is the increasing use of air conditioning systems in mobile systems.

Solvents

The use of solvents in industries and households contribute 0.1 % of the total greenhouse gas emissions in CO_2-equivalents. There is a 48 % decrease in CO_2 emissions from 1990 to 2009. In 2009 N_2O comprises 36 % of the total CO_2-equivalent emissions for solvent use.

Agriculture

The agricultural sector contributes in 2009 with 15.8 % of the total greenhouse gas emission in CO_2-equivalents (excl. LULUCF) and is one of the most important sectors regarding the emissions of N_2O and CH_4. In 2009 the contributions to the total emissions of N_2O and CH_4 were 91 % and 70 %, respectively. The main reason for the decrease of 32 % in the emission of N_2O from 1990 to 2009 is a legislative demand for an improved utilisation of nitrogen in manure. This results in less nitrogen excreted pr livestock unit produced and a considerable reduction in the use of fertilisers. From 1990 to 2009, the emission of CH_4 from enteric fermentation has decreased due to decreasing numbers of cattle. However, the emission from manure management has increased due to changes in stable management systems towards an increase in slurry-based systems. Altogether, the emission of CH_4 for the agricultural sector has decreased by 3 % from 1990 to 2009.

Land Use and Land Use Change and Forestry (LULUCF)

The LULUCF sector alters between being a net sink and a net source of GHG. In 2009 LULUCF was a net sink with 1.8 % of the total GHG emission excluding LULUCF. In 2008 LULUCF was a net sink equivalent to 3.3 % of the total GHG emission (excluding LULUCF). In 2009 Forest Land was a large sink of 2 724 CO_2-eqv., while Cropland, Grassland, Wetlands and Settlements was net sources contributing with 1 347 Gg CO_2-eqv., 199 Gg CO_2-eqv., 5 Gg CO_2-eqv. and 54 Gg CO_2-eqv., respectively. The emission from Croplands is mainly due to emissions from organic soils. Since 1990 there has been a decrease in the total C-stock in soil. Despite the global warming it seems that this decrease has stabilized so that it is possible to maintain the current C-stock level in soil.

Waste

The waste sector contributes in 2009 with 2.2 % of the national total. The trend of emission from 1990 to 2009 is decreasing by 0.4 %. The sector is dominated by CH_4 emission from solid waste disposal contributing with 87.0 % to the sector total in 2009. This emission has decreased by 6.4 % from 1990 to 2009. The decrease is due to the increasing incineration of waste for power and heat production. Since all incinerated waste is used for power and heat production, the emissions are included in the 1A IPCC category.

The CH_4 and N_2O emissions from wastewater handling contribute to the sectoral total with 6.2 and 66 %, respectively. For the wastewater handling the CH_4 emissions has an increasing trend while N_2O are at the same level as in 1990. Waste incineration without energy recovery contributes to the sectoral total of CH_4 and N_2O emissions in 2009 with 7 % and 34 %, respectively; the trends of these emissions are increasing from 1990 to 2009.

ES.3.2 KP-LULUCF activities

In 2009 the activities under Article 3.3 was a net sink of 112 Gg CO_2-eqv. and the activities under Article 3.4 was a net sink of 1 024 Gg CO_2-eqv. A short overview of KP-LULUCF is given in Chapter ES.2.2 and a more detailed description is given in Chapter 11.

ES.4. Other information

ES.4.1 Quality assurance and quality control

A plan for Quality Assurance (QA) and Quality Control (QC) in greenhouse gas emission inventories is included in the report. The plan is in accordance with the guidelines provided by the UNFCCC (Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories and Guidelines for National Systems). ISO 9000 standards are also used as an important input for the plan.

The plan comprises a framework for documenting and reporting emissions in a way that emphasize transparency, consistency, comparability, completeness and accuracy. To fulfil these high criteria, the data structure describes the pathway, from the collection of raw data to data compilation and modelling and finally reporting.

As part of the Quality Assurance (QA) activities, emission inventory sector reports are being prepared and sent for review to national experts, not involved in the inventory development. To date, the reviews have been completed for the stationary combustion plants sector, the fugitive emissions from fuels sector, the transport sector, the solvents and other product use sector and the agricultural sector. In order to evaluate the Danish emission inventories, a project where emission levels and emission factors are compared with those in other countries has been conducted.

ES.4.2. Completeness

The Danish greenhouse gas emission inventories include all sources identified by the revised IPPC guidelines.

Please see Annex 5 for more information.

ES.4.3. Recalculations and improvements

The main improvements of the inventories are:

Energy

Stationary Combustion

For stationary combustion plants, the emission estimates for the years 1990-2008 have been updated according to the latest energy statistics published by the Danish Energy Agency. The update included both end use and transformation sectors as well as a source category update.

The petroleum coke purchased abroad and combusted in Danish residential plants is no longer included in the inventory. The border trade have been increasing since 1990 and was 628 TJ in 2008.

The CO_2 emission factors for coal have been recalculated for 1990-2008. The recalculation has resulted in an improved time-series consistency. Due to the considerable consumption of coal, this recalculation is considerable for the years 1990-2005 before plant specific data (EU ETS) became available. The recalculation resulted in lower estimates for CO_2: -1.9 Gg in 2009 and -245 Gg in 1990.

The CO_2 emission factors for residual oil have also been recalculated based on the EU ETS data and an improved time-series has been implemented.

The CO_2 emission factors for LPG and kerosene have been changed and both emission factors now refer to the IPCC Guidelines (1996).

Emission factors for CH_4 and N_2O that are not country specific have been updated and now all refer to the IPCC Guidelines (1996).

Mobile sources

Road transport

The total mileage per vehicle category from 2005-2008 have been updated based on new data prepared by DTU Transport (Department of Transport, Technical University of Denmark). More accurate fleet and mileage figures are provided by the latter institution, split into the different vehicle layers of the emission model. An important change is the categorisation of fleet data for heavy duty trucks and buses into the numerous weight classes covered by the COPERT IV model.

The minimum and maximum percentage difference and year of numeric maximum differences (min. %, max. %, year of max. %) for the different emission components are: CO_2 (-0.081%, 0.082 %, 1993), CH_4 (-1.3 %, -17.9 %, 2008) and N_2O (-4.6 %, 3.7 %, 1991).

National sea transport

Fuel consumption by vessels sailing between Denmark and Greenland/Faroe Islands, and between Denmark and the North Sea off shore installations has been added to this category. Previously this fuel consumption was reported under international sea transport. The corresponding minimum and maximum percentage difference and year of numeric maximum differences (min. %, max. %, year of max. %) for the different emission components are: CO_2 (9.2 %, 30.8 %, 2008), CH_4 (4.6 %, 10.7 %, 2008) and N_2O (9.6 %, 34.0 %, 2008).

Fisheries

Due to the changes made in national sea transport and the fuel transferral between national sea transport and fisheries made as an integral part of the Danish inventories, significant fuel consumption and emission changes have been made for the fishery sector accordingly, for 2001 onwards. The corresponding minimum and maximum percentage difference and year of numeric maximum differences (min. %, max. %, year of max. %) are (27 %, 39 %, 2006), for all emission components.

Agriculture

The stock of harvesters have been updated for the years 2001-2008, based on discussions with the Danish Knowledge Centre for Agriculture. For gasoline fuelled ATV's the stock has been updated for 2007 and 2008. The changes in fuel consumption and emissions are between 0 and 2 % for CO_2 and N_2O, whereas for CH_4 the emission changes are 12 % and 21 %, in 2007 and 2008, respectively.

Agriculture/forestry/fisheries

The total consequences for agriculture/forestry/fisheries, expressed as minimum and maximum percentage difference and year of numeric maximum differences (min. %, max. %, year of max. %) for the different emission components are: CO_2 (9.6 %, 12.1 %, 2006), CH_4 (4.0 %, 21.7 %, 2008) and N_2O (12.4 %, 15.5 %, 2008).

Military

Emission factors derived from the new road transport simulations have caused some emission changes from 1985-2008. The minimum and maximum emission differences (min. %, max. %) for the different emission components are: CH_4 (-1 %, -16 %) and N_2O (-4 %, 1 %).

Residential

A split in activity codes has been made. In this way the majority of the fuel consumption and emissions previously reported under residential (SNAP code 0809; NFR code 1A4b) are now reported under commercial/institutional (SNAP code 0811; NFR code 1A4a ii).

No changes have been made in the estimated fuel consumption and emissions for Residential and Commercial/institutional as a sum.

Commercial/institutional

A split in activity codes has been made. The majority of the fuel consumption and emissions previously reported under residential (SNAP code 0809; NFR code 1A4b) are now reported under commercial/institutional (SNAP code 0811; NFR code 1A4a ii).

No changes have been made in the estimated fuel consumption and emissions for Residential and Commercial/institutional as a sum.

Industrial non road machinery

The annual working hours for fork lifts in 2008 have been adjusted with a factor of 0.95 due to the decrease in activities caused by the global financial crisis. The total fuel consumption and emission changes in 2008 for industrial non road machinery are approximately -1 %.

Railways

No changes have been made.

Aviation

Very small emission changes between -2 % and 1 % occur for the years 2001-2008, due to inclusion of new aircraft types assigned to the representative aircraft types.

Fugitive emissions

Service stations

The amounts of gasoline sales used for calculation of fugitive emissions from service stations (SNAP 050503) have been updated according to the Energy Statistics for 2009 1990-2008. The NMVOC emission in 2008 has thereby increased by 6 Mg corresponding to 0.5 %.

Extraction of oil and gas

Fugitive emissions from extraction are calculated from the standard formula in the EMEP/EEA Guidebook (EMEP/EEA, 2009) based on the number of platforms. In 2009 the number of platforms has been corrected for 2007 and 2008. In 2008 the NMVOC emission decreased by 20 Mg according to this correction corresponding to 1 %.

Gas distribution

Distribution amounts have been updated for one of three natural gas distribution companies for the years 2006-2008 due to new data availability. The NMVOC emission has thus decreased by 4 Mg in 2008 due to this, corresponding to 10 %. Emissions from venting in gas storage have previously been included in gas transmission, but are now included in the venting and flaring category (1B2c). The emissions have not been changed for the time-series during the IPCC category shift.

Flaring in oil and gas extraction

The NMVOC emission in 2008 from flaring in the gas treatment plant has been updated according to the environmental report leading to an increase of 2 Mg NMVOC. The increase corresponds to 12 % of the NMVOC emission from flaring in oil and gas extraction including off-shore flaring. Emissions from venting in gas storage have previously been included in gas transmission, but are now included in the venting and flaring category (1B2c). The emissions have not been changed for the time-series during the IPCC category shift.

Industry

Emission of NMVOC from 2D2 Food and Drink has been improved by using better emission factors for production of bread and cookies, and breweries.

For F-gases there has been a change in the methodology for mobile air condition. Information on actual amounts of f-gas used for refilling is available from 2009 and has been used as an estimate on f-gas emitted during use of the air condition.

Solvents

Further improvement of the source allocation model, which combines information on Use Categories and NACE Industrial Use Categories from SPIN and use amounts from Statistics DK.

Implementation of correct 2008 import amounts for xylene, which has been verified by Statistics Denmark.

Emissions from use of fireworks have been included under Other Product Use.

Agriculture

Some changes for emissions from the agricultural sector have taken place. These changes reflect decreased emissions in the years 1990-2008 up to 7 % compared to the total CO_2-equivalent emission from the agricultural sector. The decrease is due to an increase in the emissions of CH_4 but a higher decrease in the emission of N_2O.

As recommended by ERT during the in-country review in September 2010, the MCF factor for housing systems with deep litter stored > 1 month is changed from 1 to 10 %. The change in MCF factors influence emissions from cattle, sheep and goats. The total CH_4 emission increased up to 4 % in CO_2-equivalents for the years 1990-2008 with an increasing trend.

The decrease in N_2O emissions is mainly due to a change in the calculation of emission form N-leaching. Because of new data it is now possible to separate the calculation of emissions from leaching in emissions from groundwater and surface drainage, rivers and estuaries.

Two changes have been made which have an increasing effect on the N_2O emission. The implied emission factor for histosols is changed from 2-3 kg N_2O-N per hectare to an IPCC default value at 8 kg N_2O-N per hectare, as recommended by ERT during the in-country review in September 2010. Furthermore, an error for N excreted from sows has been corrected. The total N_2O emissions decreased up to 12 % in CO_2-equivalents for the years 1990-2008.

LULUCF

As a consequence of the Danish election of 3.4 for forest management, cropland management and grassland management is a thoroughly investigation of the LULUCF undertaken. Some results from this investigation are included in this submission, whereas other data will be included in the final 2011 submission. This investigation includes a wall-to-wall mapping of the Danish area through remote sensing (RS) for 1989/90 and 2005, a new soil map for organic soils, Danish emission factors for organic soils, monitoring of hedgerows etc. This submission includes results from the RS, which change several data. The use of RS has made it possible to estimate land use conversion to a much higher degree than previous. The changes in the land area/activity data from the remote sensing affect more or less all subsequent emission estimates.

Forestry

Based on the mapped forest area in 1990 and 2005 a calculation of carbon stored in both the old forests (forest established pre-1990 - under the Kyoto Protocol Article 3.4) and in new forests (afforestation since 1990 - under the Kyoto Protocol Article 3.3) has been performed. The afforestation since 1990 has been mapped to be larger than previously estimated.

The calculation of carbon stock in 1990 and 2000 is based on the age distribution as reported in census 1990 and Forest in 2000 as an expression of the total forest land allocation to species and ages. Based on the actual measurements of carbon storage in different species and age classes, the total standing carbon stock has been recalculated. For each of the years 1990 - 2000 carbon pools are calculated as a moving average, corrected for the deforestation that was detected.

Since the National Forest Inventory (NFI) was initiated in 2002, it is representative from 2005. Calculation of carbon stock in the period 2000-2004 is based on NFI in 2005 and carbon stock as calculated for 2000. For 2005-2009 carbon stock is calculated solely on the basis of the NFI - with additional information about the total forest area from satellite image mapping.

The recalculations have caused Forestry to go from a source of 133 Gg CO_2 in 2008 to be a net sink of -233 Gg CO_2. N_2O is only slightly affected.

Cropland, grassland, wetlands and settlements

For cropland, grassland, wetlands and settlements there has been changes in soil carbon stock from land use changes. There have been minor changes in how the agricultural land area is estimated due to the remote sensing. As new data are arriving from our research programme many new national data has been implemented. The major change comes from our study on the area with organic soils where preliminary data has shown that the area is more likely only 50 000 hectares and not 80 000 hectares as previous reported. This has reduced the overall emission from cropland in 2008 from 2 687 Gg CO_2 to 2 267 Gg CO_2. Final data will be submitted on March 15, 2011. Further more there are changes in grassland, wetlands and settlements but with lesser impact.

Waste

For Solid Waste Disposal no recalculations were made.

For Waste Water handling recalculations was made for 1990 to 2008 for CH_4 and N_2O emissions.

The methane emission Waste Water handling have this year been specified according to contributions from 1) the sewer system, 2) in primary settling tanks 3) during biological N and P removal and 4) from anaerobic treatment processes in closed systems with biogas extraction and combustion for energy production. In this years inventory an estimation of methane emissions from the septic system has been included. Furthermore, a yearly emission factor for the anaerobic processes has been implemented as reported in Chapter 8.3.

Updated quality assured data on the N content in the effluent wastewater for 2005-2009, have resulted in changes of indirect N_2O emission.

Correction of an error in the EF algorithm for direct N_2O emissions has resulted in an increase of 13.7% of the direct N_2O emission.

Emissions from waste incineration have decreased as the calculated emissions from accidental building and vehicle fires have been moved from this section to the waste other section. There are no longer non-biogenic CO_2 emissions from this category.

For the category Waste Other; in addition to the increase in emission due to the moving of accidental fires, are the emissions of methane and nitrous oxide from compost production, which are new in this year's inventory.

The sectoral total increased between 6.1 % (1990) and 12.6 % (2007). For 2008 the increase was 11.3 %.

KP-LULUCF

Almost all sectors in the KP-LULUCF have been recalculated.

This is due to:

- small changes in Land Use Matrix, which affect the land use conversions,
- updated data from the Danish NFI for C-stock changes in above-, belowground, dead wood and litter,
- a new soil map for organic soils,
- a new R:S factor for vegetation in grassland,
- new emission factors for organic soils,

- new data on C-stock in mineral soils from our research (0-100 cm dept compared to 0-50 cm/0-30 cm in the previous submission to be used when land use change takes place ,
- correction of errors in the previous reporting.

The major changes in afforestation/reforestation are corrections of errors in the previous submission and changed methodology for estimation of C accumulation in litter as recommended by the previous ERT.

For deforestation the main reason is a small change in living biomass and updated values on C-stock in mineral soils.

For forest management the major change is due to updated values from the NFI on C-stocks in living biomass.

For cropland management and grazing land management the changes are primarily due to the new soil map for organic soils and the new emission factors for organic soils. The analysis has shown that a large part of the area should be classified as grazing land and not as cropland. Consequently has there been a reduction of 150-200 Gg CO_2-eqvivalents in the emissions from CM and a similar increase in the emission from GM.

For more information on KP-LULUCF recalculations please refer to Chapter 10 and 11.

Sammenfatning

S.1. Baggrund for opgørelse af drivhusgasemissioner og klimaændringer

Rapporteringen

Denne rapport er Danmarks årlige rapport – den såkaldte Nationale Inventory Report (NIR) for 2011. Rapporten beskriver drivhusgasopgørelsen som blev fremsendt til FN's konvention om klimaændringer (UNFCCC) og Kyotoprotokollen den 15. april 2011. Rapporten indeholder detaljerede informationer om Danmarks drivhusgasudslip for alle år fra 1990 til 2009. Rapportens struktur er i overensstemmelse med UNFCCC's retningslinjer for rapportering og review. Hovedforskellen mellem Danmarks NIR 2011 som blev fremsendt til EU-Kommissionen til den 15. marts 2011, og denne rapport til UNFCCC vedrører det territorium rapporteringen omfatter. NIR 2011 til EU-Kommissionen var for Danmark, mens NIR 2011 til UNFCCC er for Danmark, Grønland og Færøerne. For at sikre at opgørelserne er sammenhængende og gennemskuelige indeholder rapporten detaljerede oplysninger om opgørelsesmetoder og baggrundsdata for alle årene fra 1990 og til 2009.

Denne emissionsopgørelse for årene 1990 til 2009, er som tidligere årlige opgørelser, rapporteret i formatet Common Reporting Format (CRF) som Klimakonventionen foreskriver anvendt. Emissionsopgørelsen i CRF foreligger med denne rapportering således at der er separate CRF for Danmark (EU), Grønland, Færøerne, for Danmark og Grønland (KP) samt for Danmark, Grønland og Færøerne (Klimakonventionen). CRF-tabellerne indeholder oplysninger om emissioner, aktivitetsdata og emissionsfaktorer for hvert år, emissionsudvikling for de enkelte drivhusgasser samt den totale drivhusgasemission i CO_2-ækvivalenter.

Følgende emner er beskrevet i rapporten: Udviklingen i drivhusgasemissionerne, metoder mv. som anvendes til opgørelserne i de emissionskategorier som findes i CRF-formatet, usikkerheder, rekalkulationer, planlagte forbedringer og procedure for kvalitetssikring og –kontrol.

Denne rapport indeholder ikke det fulde sæt af CRF-tabeller. Kun trendtabellerne fra CRF for Danmark, som viser udviklingen for de rapporterede direkte drivhusgasser - CO_2, CH_4 og N_2O - for 1990-2009 (tabellerne 10.1-5 fra CRF-formatet) er medtaget, se Annex 8. Det fulde sæt af CRF tabeller er tilgængelige på EIONET, som er det Europæiske Miljøagenturs rapporterings-internetsite:
http://cdr.eionet.europa.eu/dk/Air_Emission_Inventories

Med hensyn til gengivelsen af tal i rapporten og i CRF-formatet, gøres opmærksom på at Annex 8 er med dansk notation: "," (komma) for decimaladskillelse og "." (punktum) til adskillelse af tusinder. I rapporten (undtagen i de få tilfælde hvor tabeller er indsat som "billede" fra CRF, som Annex 9) er den engelske notation brugt: "." (punktum) for decimaltegn og for det meste mellemrum for adskillelse af tusinder. Den engelske notation for adskillelse af tusinder med "," (komma) er for det meste ikke brugt på grund af risikoen for fejltagelser for danske læsere.

Ansvarlige institutioner

Danmarks Miljøundersøgelser (DMU) ved Aarhus Universitet er på vegne af Miljøministeriet samt Klima- og Energiministeriet ansvarlig for udregning og afrapportering af den nationale emissionsopgørelse til EU og til UNFCCC (FN's konvention om klimaændringer) såvel som til UNECE-konventionen om langtransporteret grænseoverskridende luftforurening. Som følge heraf er DMU ansvarlig for udførelse og publisering af opgørelserne af drivhusgasemissioner og den årlige rapportering til EU og UNFCCC for Danmark. DMU er den centrale institution for Danmarks nationale system til drivhusgasopgørelser under Kyotoprotokollen. Ydermere er DMU ansvarlig for rapportering af drivhusgasemissionsopgørelser til Klimakonventionen for Kongeriget Danmark (Færøerne, Grønland og Danmark), samt Danmarks og Grønlands samlede rapportering til Kyotoprotokollen. DMU deltager desuden i arbejdet i regi af Klimakonventionen og Kyotoprotokollen, hvor retningslinjer for rapportering diskuteres og vedtages og i EU's moniteringsmekanisme for opgørelse af drivhusgasser, hvor retningslinjer for rapportering til EU reguleres.

Arbejdet med de årlige opgørelser udføres i samarbejde med andre danske ministerier, forskningsinstitutioner, organisationer og private virksomheder. Grønlands Klima- og Infrastrukturstyrelse er ansvarlig for levering af opgørelser for Grønland til DMU. Færøernes miljømyndighed (Umhvørvisstovan) er ansvarlig for de Færøske opgørelser.

Drivhusgasser

Til Klimakonventionen rapporteres følgende drivhusgasser:

- Kuldioxid CO_2
- Metan CH_4
- Lattergas N_2O
- Hydrofluorcarboner HFC'er
- Perfluorcarboner PFC'er
- Svovlhexafluorid SF_6

Det globale opvarmningspotentiale, på engelsk Global Warming Potential (GWP), udtrykker klimapåvirkningen over en nærmere angivet tid af en vægtenhed af en given drivhusgas relativt til samme vægtenhed af CO_2. Drivhusgasser har forskellige karakteristiske levetider i atmosfæren, således for CH_4 ca. 12 år og for N_2O ca. 120 år. Derfor spiller tidshorisonten en afgørende rolle for størrelsen af GWP. Typisk vælges 100 år. Herefter kan effekten af de forskellige drivhusgasser omregnes til en ækvivalent mængde CO_2, dvs. til den mængde CO_2 der vil give samme klimapåvirkning. Til rapporteringen til Klimakonventionen er vedtaget at anvende GWP-værdier for en 100-årig tidshorisont, som ifølge IPCC's anden vurderingsrapport er:

- Kuldioxid, CO_2: 1
- Metan, CH_4: 21
- Lattergas, N_2O: 310

Regnet efter vægt og over en 100-årig periode er metan således ca. 21 og lattergas ca. 310 gange så effektive drivhusgasser som kuldioxid. For andre drivhusgasser der indgår i rapporteringen, de såkaldte F-gasser (HFC, PFC, SF_6) findes væsentlig højere GWP-værdier. Under Klimakonventionen er der ligeledes vedtaget GWP-værdier for disse baseret på IPCC's anbefalinger. Således har f.eks. SF_6 en GWP-værdi på 23 900. I denne rapport anvendes de GWP-værdier, som UNFCCC har vedtaget.

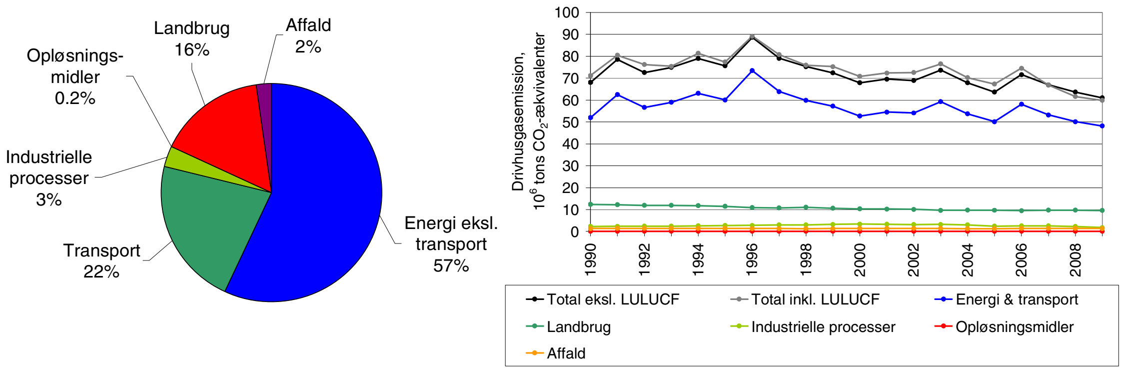
Endvidere rapporteres de indirekte drivhusgasser nitrogenoxid (NO_x), carbonmonooxid (CO), Non-Methane Volatile Organic Compound (NMVOC) og svovldioxid (SO_2). Da der ikke tilskrives disse gasser GWP-værdier, medregnes disse ikke I drivhusgasemissioner i CO_2-ækvivalenter.

S.2. Udviklingen i drivhusgasemissioner og optag

Sammenfatning S.2.-4. omhandler alene opgørelsen for Danmark. Opgørelsen for Grønland, Danmark og Grønland samt for Færøerne beskrives i kapitel 16 o g 17 samt i Annex 9.

S.2.1 Drivhusgas emissionsopgørelse

De danske opgørelser af drivhusgasemissioner følger metoderne som beskrevet i IPCC's retningslinjer. I den forbindelse skal nævnes at det under Klimakonventionen og Kyotoprotokollen er vedtaget at IPCC's 1996 retningslinjer og IPCC's 2000 anvisninger skal anvendes. Opgørelserne er opdelt i seks overordnede sektorer, 1. energi, 2. industrielle processer, 3. opløsningsmidler, 4. landbrug, 5. arealanvendelse for skove og jorder (Land Use Land Use Change and Forestry: LULUCF) og 6. affald. Drivhusgasserne omfatter CO_2, CH_4, N_2O og F-gasserne: HFC'er, PFC'er og SF_6. I Figur S.1 ses de estimerede drivhusgasemissioner for Danmark i CO_2-ækvivalenter for perioden 1990 til 2009. Figuren viser Danmarks totale udledning med og uden LULUCF-sektoren (Land Use and Land Use Change and Forestry). Til venstre i S.1 ses det relative bidrag til Danmarks totale udledning (uden LULUCF) i 2009 for sektorerne 1. – 4. og 6. For sektor 1. energi er vejtrafik vist særskilt. Sektor 5. LULUCF indgår ikke i denne figur da sektoren omfatter kilder der bidrager med både optag og udledninger.



Figur S.1 Danske drivhusgasemissioner. Bidrag til total emission fra hovedsektorer for 2009 og tidsserier i CO_2-ækvivalenter for 1990-2009, hvor data for CO_2 er uden LULUCF.

I overensstemmelse med retningslinjerne for opgørelserne er emissionerne ikke korrigerede for handel med elektricitet med andre lande og temperatursvingninger fra år til år. CO_2 er den vigtigste drivhusgas og bidrager i 2009 med 78,8 % af den nationale totale udledning, efterfulgt af N_2O med 10,1 % og CH_4 med 9,7 %, mens HFC'er, PFC'er og SF_6 kun udgør 1,4 % af de totale emissioner. Set over perioden 1990-2009 så har disse procenter været stigende for CO_2 og F-gasser, nær konstant for CH_4 og faldende for N_2O. Netto-CO_2-optaget fra LULUCF er i 2009 1,8 % af den nationale totale emission eksklusiv LULUCF. Med hensyn til sektorerne (figur S.1) så bidrager energi ekskl. vejtransport (hovedsageligt stationære forbrændingsanlæg), transport og landbrug mest med i 2009 henholdsvis 57 %, 22 % og 16 % af den nationale udledning eksklusiv LULUCF. De nationale totale drivhusgasemissioner i CO_2-ækvivalenter er faldet med 10,3 % fra 1990 til 2009, hvis nettobidraget fra skovenes og jordernes udledninger og optag af CO_2 (LULUCF) ikke indregnes, og faldet med 15,9 % hvis de indregnes.

S.2.2 LULUCF aktiviteter under Kyotoprotokollen

Det samlede optag af drivhusgasser i skov omfattet af Kyotoprotokollens artikel 3.3 udgør 111,8 Gg CO_2-ækv. i 2009, heraf stammer 0,4 Gg CO_2-ækv. fra jorde i forbindelse med skovrydning. Nettooptaget fra skov plantet før 1990 under Kyotoprotokollens artikel 3.4 udgør 2 579,1 Gg CO_2-ækv. i 2009, heraf 12,0 Gg CO_2-ækv. i form af N_2O fra dræning af jorde (tabel S.1). Nettoemissionen fra landbrugsarealer under artikel 3.4 udgør 1 369,3 Gg CO_2-ækv. i 2009. Til sammenligning var nettoemissionen fra samme kilde 3 188,6 Gg CO_2-æqv. i 1990.

Det samlede emission fra permanente græsarealer under artikel 3.4 udgør 185,6 Gg CO_2-ækv. i 2009. I 1990 var den tilsvarende emission på 313,6 Gg CO_2-ækv.

Tabel S.1 Emissioner og optag i 2009 for aktiviteter under Kyotoprotokollens artikel 3.3 og 3.4.

	Netto CO_2 emission/optag	CH_4	N_2O	Netto CO_2 ækvivalent emission/optag
		(Gg)		
A. Aktiviteter under artikel 3.3				-111,83
A.1. Skovrejsning	-145,31	NO	IE,NA,NO	-145,31
A.1.1. Arealer der ikke er afskovet siden starten af 2008	-145,31	NO	IE,NA,NO	-145,31
A.1.2. Arealer der er afskovet siden starten af 2008	IE,NO	NO	IE,NO	IE,NO
A.2. Skovrydning	33,07	NO	0.00	33,48
B. Aktiviteter under artikel 3.4				-1 024,17
B.1. Forvaltning af skov plantet før 1990	-2 591,13	NO	0.04	-2 579,10
B.2. Forvaltning af landbrugsarealer	1 369,28	NO	IE,NA,NO	1 369,28
B.3. Forvaltning af permanente græsarealer	185,64	NO	NO	185,64
B.4. Gentilplantning	NA	NA	NA	NA

NO: Not Occurring, NA: Not applicable, IE: Included Elsewhere

S.3. Oversigt over drivhusgasemissioner og optag fra sektorer

S.3.1 Drivhusgas emissionsopgørelse

1. Energi

Energisektoren inklusiv transport bidrager i 2008 med 79,0 % af den danske totale emission (ekskl. LULUCF). Når transportens bidrag ikke regnes med bidrager energisektoren med 57 % af den nationale udledning eksklusiv LULUCF. Udledningen af CO_2 stammer altovervejende fra forbrænding af kul, olie, benzin og naturgas på kraftværker, i beboelsesejendomme, industri og vejtransport. CO_2-emissionen fra energisektorerne faldt med omkring 9 % fra 2008 til 2009. De relativt store udsving i emissionerne fra år til år skyldes handel med elektricitet med andre lande, herunder særligt de nordiske. De høje emissioner i 1991, 1994, 1996, 2003 og 2006 er et resultat af stor eksport af elektricitet, mens de lave emissioner i 1990 og 2005 skyldes import af elektricitet. Udledningen af CH_4 fra energiproduktion har været stigende på grund af øget anvendelse af gasmotorer, som har en stor CH_4-emission i forhold til andre forbrændingsteknologier. Anvendelsen af gasmotorer er dog blevet mindre siden liberaliseringen af elmarkedet, hvilket har ført til lavere CH_4-emissioner fra energisektoren. Transportsektorens CO_2-emissioner er steget med ca. 23 % siden 1990 hovedsagelig på grund af voksende vejtrafik.

2. Industrielle processer

Emissionen fra industrielle processer – hvilket vil sige andre processer end forbrændingsprocesser – udgør i 2009 2,9 % af de totale danske drivhusgasemissioner. De vigtigste kilder er cementproduktion, kølesystemer, opskumning af plast og kalcinering af kalksten. CO_2-emissionen fra cementproduktion - som er den største kilde - bidrager med 1,3 % af den totale emission i 2009 og stigningen fra 1990 til 2009 er 13 %. Den anden største kilde har tidligere været N_2O fra produktion af salpetersyre. Produktionen af salpetersyre stoppede i midten af 2004, hvilket betyder, at N_2O-emissionen er nul for denne kilde fra 2005.

Emissionen af HFC'er, PFC'er og SF_6 er i perioden fra 1995 og til 2009 steget med 161 %, hovedsageligt på grund af stigende emissioner af HFC'er. Anvendelsen af HFC'er, og specielt HFC-134a, er steget kraftigt, hvilket har betydet, at andelen af HFC'er af den samlede F-gas emission steg fra 67 % i 1995 og til 94 % i 2009. HFC'er anvendes primært inden for køleindustrien. Anvendelsen er dog nu stagnerende, som et resultat af dansk lovgivning, der forbyder anvendelsen af nye HFC-baserede stationære kølesystemer fra 2007. I modsætning til denne udvikling ses et stigende brug af airconditionsystemer i køretøjer.

3. Opløsningsmidler og relaterede produkter

Forbrug af opløsningsmidler i industrier og husholdninger bidrager i 2009 med 0,1 % af totalmængden af emitterede drivhusgasser i CO_2-ækvivalenter. Der er en reduktion på 48 % i total CO_2-emissionerne i perioden 1990 til 2009. Bidraget fra N_2O-forbruget til de totale CO_2-ækvivalent emissioner for solventer er 36 %.

4. Landbrug

Landbrugssektoren bidrager i 2009 med 15,8 % til den totale drivhusgasemission i CO_2-ækvivalenter og er den vigtigste sektor hvad angår emissioner af N_2O og CH_4. I 2009 var landbrugets bidrag til de totale emissioner af N_2O og CH_4 henholdsvis 91 % og 70 %. Fra 1990 til 2009 ses et fald på 32 % i N_2O-emissionen fra landbrug. Dette skyldes mindre brug af kvælstofhandelsgødning og bedre udnyttelse af kvælstof i husdyrgødningen, hvilket resulterer i mindre emissioner pr. produceret dyreenhed. Emissioner af CH_4 fra husdyrenes fordøjelsessystem er faldet fra 1990 til 2009 grundet et faldende antal kvæg. På den anden side har en stigende andel af gyllebaserede staldsystemer bevirket at emissionerne fra husdyrgødning er steget. I alt er CH_4-emissionerne fra landbrugssektoren faldet med 3 % fra 1990 til 2009.

5. Arealanvendelse skove og jorder (LULUCF)

LULUCF-sektoren skifter mellem at udgøre et nettooptag og en nettoudledning. I 2009 udgør LULUCF et nettooptag svarende til 1,8 % af den samlede drivhusgasudledning, eksklusiv LULUCF. I 2008 udgjorde LULUCF et nettooptag svarende til 3,3 % af den samlede drivhusgasudledning inklusiv LULUCF. I 2009 bidrager arealer med skov med et optag på 2 724 Gg CO_2-ækv., mens dyrkede jorder, græsning, vådområder og bebyggelse bidrager med emissioner på hhv. 1 347 Gg CO_2-ækv., 199 Gg CO_2-ækv., 5 Gg CO_2-ækv og 55 Gg CO_2-ækv. Emissionen fra landbrugsjorde stammer hovedsageligt fra organiske jorder. Siden 1990 har der været et fald i den totale mængde kulstof (C) der er lagret i jorder. På trods af den globale opvarmning ser dette fald ud til at aftage så det tilsyneladende er muligt at bevare det nuværende kulstofniveau i jorder.

6. Affald

Affaldssektoren udgør i 2009 2,2 % af den danske total-emission. Lossepladser er den tredjestørste kilde til CH_4-emissioner og dominerer sektor-bidraget med 87 %. Emissionen er faldet med 6,4 % fra 1990 til 2009. Faldet skyldes faldende affaldsmængder til deponering og stigende anvendelse af affald til produktion af elektricitet og varme. Da al affaldsforbrænding bruges til produktion af elektricitet og varme, er emissionerne herfra inkluderet i IPCC-kategorien 1A.

Emissioner af CH_4 og N_2O fra spildevandsanlæg udgør i 2009 henholdsvis 6,2 % og 66 % af sektorens samlede drivhusgasudledning. CH_4 fra spildevandsanlæg er stigende fra 1990 til 2009 på grund af en stigning i mængden af industrielt spildevand, mens N_2O er i samme niveau som i 1990.

CH_4 og N_2O fra afbrænding af affald uden energiudnyttelse udgør i 2009 hhv. 7 % og 34 % af affaldssektorernes bidrag. Tendensen i disse emissioner er en stigning i perioden 1990 – 2009.

S.3.2 KP-LULUCF aktiviteter

I 2009 udgjorde aktiviteterne under Kyotoprotokollens artikel 3.3 et netto optag på 112 Gg CO_2-ækv. mens aktiviteterne under artikel 3.4 udgjorde et netto optag på 1 024 Gg CO_2-ækv. En kort oversigt over KP-LULUCF findes i kapitel S.2.2 mens en mere detaljeret redegørelse findes i kapitel 11.

S.4. Andre informationer

S.4.1 Kvalitetssikring og - kontrol

Rapporten indeholder en plan for kvalitetssikring og -kontrol af emissionsopgørelserne. Kvalitetsplanen bygger på IPCC's retningslinjer og ISO 9000 standarderne. Planen skaber rammer for dokumentation og rapportering af emissionerne, så opgørelserne er gennemskuelige, konsistente, sammenlignelige, komplette og nøjagtige. For at opfylde disse kriterier, understøtter datastrukturen arbejdsgangen fra indsamling af data til sammenstilling, modellering og til sidst rapportering af data.

Som en del af kvalitetssikringen, udarbejdes der for emissionskilderne rapporter, der detaljeret beskriver og dokumenterer anvendte data og beregningsmetoder. Disse rapporter evalueres af personer uden for DMU, der har høj faglig ekspertise indenfor det pågældende område, men som ikke direkte er involveret i arbejdet med opgørelserne. Indtil nu er rapporter for stationære forbrændingsanlæg, transport og landbrug blevet evalueret. Desuden er der gennemført et projekt, hvor de danske opgørelsesmetoder, emissionsfaktorer og usikkerheder sammenlignes med andre landes, for yderligere at verificere rigtigheden af opgørelserne.

S. 4.2. Fuldstændighed i forhold til IPCCs retningslinjer for kilder og gasser

De danske opgørelser af drivhusgasemissioner indeholder alle de kilder, der er beskrevet i IPCC's retningsliner.

I annex 5 er der flere informationer om fuldstændigheden af den danske drivhusgasopgørelse.

S. 4.3. Rekalkulationer og forbedringer

De vigtigste forbedringer af opgørelserne er:

Energi

Stationær forbrænding

Den seneste officielle energistatistik er implementeret i opgørelsen for årene 1990-2008. Opdateringen omfatter både slutforbrug og konverteringssektoren samt opdatering af kilde kategorier.

Petroleumskoks købt i udlandet og brugt i danske husholdninger er fjernet fra opgørelsen i overensstemmelse med retningslinjerne for rapportering. Grænsehandelen med petroleumskoks var 628 TJ i 2009.

CO_2-emissionsfaktoren for kul er genberegnet for årene 1990-2008. Genberegningen har resulteret i en forbedret konsistens for tidsserien. Da forbruget af kul er stort, har denne genberegning stor betydning for årene 1990-2005 inden de anlægsspecifikke data (EU-ETS) var til rådighed. Genberegningen medførte lavere estimater for CO_2: -1,9 Gg i 2009 og -245 Gg i 1990.

CO_2-emissionsfaktoren for fuelolie er også genberegnet, baseret på EU ETS data og en forbedret tidsserie er implementeret.

CO_2 emissionsfaktoren for LPG og petroleum er ændret så begge nu refererer til IPCC Guidelines (1996).

I tilfælde hvor der ikke er nationale emissionsfaktorer for CH_4 og N_2O er disse opdateret så alle nu refererer til IPCC Guidelines (1996).

Mobile kilder

Vejtransport

Data for årskørsler for de forskellige køretøjskategorier er blevet opdateret for 2005 til 2008 baseret på nye data estimeret af DTU. En vigtig forbedring er en mere detaljeret opdeling af bestandsdata for tunge køretøjer (lastbiler og busser) i de mange forskellige vægtklasser inkluderet i COPERT IV-modellen. Minimum og maksimum procentvis difference og år for numerisk maksimum difference (min. %, max. %, year of max. %) for emissionskomponenterne er: CO_2 (-0,081%, 0,082 %, 1993), CH_4 (-1,3 %, -17,9 %, 2008) og N_2O (-4,6 %, 3,7 %, 1991).

National søfart

Brændselsforbrug for skibe sejlende mellem danske havne og Grønland/Færøerne og mellem Danske havne og installationer på Nordsøen er blevet tilføjet denne kategori. Tidligere var en del af brændselsforbruget blevet rapporteret under international transport i energistatistikken. De tilsvarende minimum og maksimum procentvis differencer og år for numerisk maksimum difference (min. %, max. %, year of max. %) for emissionskomponenterne er: CO_2 (9,2 %, 30,8 %, 2008), CH_4 (4,6 %, 10,7 %, 2008) and N_2O (9,6 %, 34,0 %, 2008).

Fiskeri

På grund af ændringerne for national søfart og den brændselsudveksling der foregår mellem disse kategorier er der foretaget betydelige ændringer for både brændselsforbrug og emissioner for fiskeri fra 2001 og fremefter. De tilsvarende minimum og maksimum procentvis differencer og år for nummerisk maksimum difference (min. %, max. %, year of max. %) er (27 %, 39 %, 2006) for alle emissionskomponenter.

Landbrug

Antallet af mejetærskere er blevet opdateret for 2001-2008 baseret på oplysninger fra Videncenter for Landbrug. For benzindrevne ATV'er er bestandsdata opdateret for 2007 og 2008. Ændringen i brændselsforbruget og emissionerne er mellem 0 % og 2 % for CO_2 og N_2O, mens ændringerne for CH_4 er 12 % og 21 % i hhv.2007 og 2008.

Landbrug/skovbrug/fiskeri

Den samlede betydning for landbrug/skovbrug/fiskeri, udtrykt ved minimum og maksimum procentvis difference og år for numerisk maksimum difference (min. %, max. %, year of max. %) for emissionskomponenterne er: CO_2 (9,6 %, 12,1 %, 2006), CH_4 (4,0 %, 21,7 %, 2008) og N_2O (12,4 %, 15,5 %, 2008).

Militær

Emissionsfaktorer afledt fra de nye modelsimulationer for vejtransport har medført små ændringer i emissionerne i perioden 1985-2008. Minimum og maksimum emissionsdifference er: CH_4 (-1 %, -16 %) og N_2O (-4 %, 1 %).

Husholdninger
Et split i aktivitetskoder er blevet foretaget. Det har medført at hovedparten af det brændselsforbrug og de emissioner, der tidligere er blevet rapporteret under husholdninger (SNAP kode 0809; NFR kode 1A4b) nu bliver rapporteret under handel & service (SNAP kode 0811; NFR kode 1A4a).

Der er ikke foretaget ændringer i det samlede brændselsforbrug eller emissioner, der er udelukkende tale om en ny allokering.

Handel & service
Et split i aktivitetskoder er blevet foretaget. Det har medført at hovedparten af det brændselsforbrug og de emissioner, der tidligere er blevet rapporteret under husholdninger (SNAP kode 0809; NFR kode 1A4b) nu bliver rapporteret under handel & service (SNAP kode 0811; NFR kode 1A4a).

Der er ikke foretaget ændringer i det samlede brændselsforbrug eller emissioner, der er udelukkende tale om en ny allokering.

Maskiner og redskaber i industrien
De årlige drifttimer for gaffeltrucks i 2008 er blevet justeret med en faktor på 0,95 pga. det faldende aktivitetsniveau forårsaget af den finansielle krise. Den totale ændring i brændselsforbrug og emissioner i 2008 er ca. -1 %.

Luftfart
For årene 2001-2008 er der små ændringer på mellem -2 % og 1 %. Dette skyldes inkluderingen af nye flytyper knyttet til repræsentative flytyper i emissionsberegningen.

Flygtige emissioner

Tankstationer
Mængden af benzin anvendt til beregning af flygtige emissioner fra tankstationer (SNAP 050503) er blevet opdateret for årene 1990-2008 i henhold til energistatistikken 2009. Emissionen af NMVOC fra benzinsalg i 2008 er som konsekvens øget med 6 ton svarende til 0,5 %.

Udvinding af olie og gas
Flygtige emissioner fra udvinding er beregnet på baggrund af formlen i EMEP/EEA Guidebook baseret på antallet af platforme. I 2009 er antallet af platforme blevet korrigeret for 2007 og 2008. Emissionen af NMVOC er som konsekvens faldet med 20 ton svarende til ca. 1 %.

Gas distribution
De distribuerede mængder er blevet opdateret for et af de tre naturgas distributionsselskaber for årene 2006-2008 pga. nye data. Emissionen af NMVOC er som konsekvens faldet med 4 ton i 2008 svarende til 10 %. Emissioner fra venting på gaslagre var tidligere inkluderet i transmission, men er nu inkluderet under venting & flaring (1B2c). Emissionerne er ikke ændret men kun re-allokeret.

Flaring I forbindelse med lagring og behandling af naturgas
Emissionen af NMVOC i 2008 fra flaring i forbindelse med gasbehandling er blevet opdateret på baggrund af virksomhedens grønne regnskab.

Dette har medført en stigning i NMVOC-emissionen på 2 ton svarende til en stigning for denne kategori på 12 %.

Industri

Emissionen af NMVOC fra produktion af fødevarer og drikkevarer er forbedret via brug af nye emissionsfaktorer for produktion af brød og småkager, samt bryggerier.

Metoden til bestemmelse af F-gasser fra mobile air condition-anlæg er ændret. Data for aktuelle mængder af F-gas anvendt til genfyldning er tilgængelige fra 2009 og er anvendt som et estimat for emissionen ved brug af air condition-anlæggene.

Opløsningsmidler

Forbedringer og genberegninger finder løbende sted pga. den store udbredelse og kompleksitet af anvendelsen af opløsningsmidler i husholdninger og industrien. De største forbedringer i forbindelse med 2011 rapporteringen er:

- Fortsatte forbedringer i kilde allokeringsmodellen, som kombinerer informationer om anvendelseskategorier og NACE-kategorier fra SPIN-databasen og anvendte mængde fra Danmarks Statistik.
- Opdatering af værdien for import af xylen i 2008, der var fejlbehæftet. Ændringen er verificeret af Danmarks Statistik.
- Emissioner fra fyrværkeri er inkluderet for første gang.

Landbrug

Genberegninger for landbrugssektoren har medført fald i emissionerne for årene 1990-2008 på op til 7 % af den totale emission i CO_2-ækvivalenter fra landbrugssektoren. I perioden er CH_4-emissionen steget, men denne stigning overskygges af et større fald i N_2O-emissionen.

Som anbefalet af ERT under in-country review i september 2010 er MCF-faktoren for staldsystemer med dybstrøelse > 1 måned ændret fra 1 til 10 %. Ændringen af MCF-faktorer påvirker emissionerne fra kalve, får og geder. Den total CH_4-emission i CO_2-ækvivalenter steg op til 4 % for årene 1990-2008 med en stigende tendens.

Faldet i N_2O-emissionen skyldes hovedsageligt ændring i beregningen af emissionen fra N-udvaskning. Nye data har gjort det muligt at opsplitte beregningen af emissioner fra udvaskning mellem grundvand og overflade afløb, vandløb og hav.

To ændringer, der medfører stigning af N_2O-emissionen, er gennemført. Emissionsfaktoren (implied emission factor) for histosoler er ændret fra 2-3 kg N_2O-N per ha. til IPCC-standardfaktoren på 8 kg N_2O-N per ha., som anbefalet af ERT under in-country review i september 2010. Desuden er en fejl for N fra sojabønner blevet rettet. Den totale N_2O-emission i CO_2-ækvivalenter er faldet op til 12 % for årene 1990-2008.

Arealanvendelse (LULUCF)

Som følge af Danmarks tilvalg af artikel 3.4 for forvaltning af skovarealer, landbrugsarealer og græsningsarealer er der foretaget en grundig undersøgelse af LULUCF. Nogle resultater af denne undersøgelse er inkluderet i denne rapportering, mens andre data vil blive inkluderet i den endelige 2011 rapportering. Undersøgelsen er en wall-to-wall kortlægning af det danske areal via remote sensing (RS) for 1989/1990 og 2005, et nyt kort over organiske jorde, Danske emissionsfaktorer for organiske jorde, kortlægning af hegn mm. I denne rapportering er der inkluderet resultater fra RS der medfører ændringer i flere data. Anvendelse af RS har i høj grad forbedret muligheden for ar estimere ændring i arealanvendelse i forhold til tidligere. Ændringerne i areal/aktivitets data som følge af RS påvirker stort set alle tidligere beregnede emissioner.

Skov

Kortlægningen af skovarealet i 1990 og 2005 er anvendt som basis for beregning af den lagrede kulstofmængde i både gammel skov (skov plantet før 1990 – under Kyotoprotokollens artikel 3.4) og ny skov (skovrydning siden 1990 - under Kyotoprotokollens artikel 3.3). Skovrydning siden 1990 er kortlagt til at være større end tidligere antaget.

Beregningen af den lagrede mængde kulstof i 1990 og 2000 er baseret på aldersfordelingen som angivet i den nationale skovtælling og skov i 2000 som et udtryk for det totale skovareal fordelt på arter og alder. På baggrund af målinger af kulstofindholdet i forskellige arter og aldersklasser er kulstofindholdet i den samlede stående skov genberegnet. For hver af årene 1990-2000 er kulstofpuljerne beregnet som et løbende gennemsnit korrigeret for den dokumenterede skovrydning.

Da NFI'en blev iværksat i 2002, er den repræsentativ fra 2005. Beregning af kulstoflagring i årene 2000-2004 er baseret på NFI 2005 og kulstofmængden beregnet for år 2000. For 2005-2009 er kulstofmængden beregnet alene på baggrund af NFI – med yderligere information om det totale skovareal baseret på satellitfotos.

Genberegningen har medført af Skov er gået fra en kilde på 133 Gg CO_2 i 2008 til et netto optag på -233 Gg CO_2 i 2009. N_2O-emissionen er kun ændret i begrænset omfang.

Landbrugsarealer, græsningsarealer, vådområder og bebyggelse

For landbrugsarealer, græsningsarealer, vådområder og bebyggelse har der været ændringer i lagrede kulstofmængder som følge af ændringer i arealanvendelse. Der har været en lille ændring i hvordan landbrugsarealet er estimeret via RS. I takt med at nye data bliver leveret fra vores forskningsprogram bliver der implementeret mange nationale data. De største ændringer kommer fra vores studie af organiske jorde hvor midlertidige data har vist at arealet nærmere er 50 000 ha end de tidligere rapporterede 80 000 ha. Denne ændring har medført en reduktion af emissionen fra landbrugsarealer fra 2 687 Gg CO_2 til 2 267 Gg CO_2. Endelige data blev rapporteret d. 15. marts 2011. Desuden er der mindre ændringer for græsningsarealer, vådområder og bebyggelse.

Affald

For spildevandsbehandling er der sket genberegning for årene 1990-2008 for CH_4 og N_2O.

CH_4-emissionen fra spildevandsbehandling er blevet opdelt i bidrag fra 1) kloak systemet, 2) i primære bundfældningstanke, 3) under biologisk rensning for N og P og 4) fra den anaerobe behandlingsproces i lukkede systemer med biogasudvinding og forbrænding med energiproduktion.

Desuden er der i år inkluderet estimater for CH_4-emissioner fra septiktanke.

Desuden er der implementeret en årlig emissionsfaktor for den anaerobe proces, jf. beskrivelsen i kapitel 8.3.

Opdaterede og kvalitetssikrede data for N-indholdet i kloak spildevand for årene 2005-2009 har medført en ændring af den indirekte N_2O-emission.

Rettelse af en fejl i emissionsfaktor algoritmen for den direkte N_2O-emission har medført en stigning på 13,7 % af den direkte N_2O-emission.

Emissioner fra affaldsforbrænding er faldet da beregningen af emissioner fra brande i bygninger og køretøjer er re-allokeret fra denne sektor til "Other waste". Der er ikke længere ikke-biogen CO_2-emission fra denne kategori.

I kategorien "Other waste" er der, ud over stigningen som følge af re-allokeringen af emissioner fra brande, inkluderet CH_4- og N_2O-emissioner fra kompostering i dette års rapportering.

Den totale emission fra affaldssektoren er steget med mellem 6,1 % (1990) og 12,6 % (2007). For 2008 er stigningen 11,3 %.

KP-LULUCF

Stort set alle sektorer under KP-LULUCF er blevet genberegnet.

Genberegningerne skyldes:

- mindre ændringer i matricen for arealanvendelse,
- små ændringer i matricen for arealanvendelse der påvirker ændringer i arealanvendelse,
- opdaterede data fra den danske NFI for kulstoflagring i vedmasse over jorden, vedmasse under jorden, dødt ved og vedmasse/blade på skovbunden,
- et nyt kort over organiske jorde,
- en ny R:S faktor for vegetation på græsningsarealer,
- ny emissionsfaktor for organiske jorde,
- nye data for kulstofindhold i mineral jorder fra vores forskningsprogram (0-100 cm dybde sammenlignet med 0-50 cm / 0-30 cm i sidste rapportering) til anvendelse hvor der er sket skift i arealanvendelse,
- rettelse af fejl i den tidligere rapportering.

Den største ændring vedrørende skovrejsning er korrektioner af fejl i den forrige rapportering samt ændring i metoden til estimering af kulstof akkumulering i blade og andet vedmasse i skovbunden som anbefalet af ERT ved in-country review i september 2010.

For skovrydning afspejler genberegningen hovedsageligt en mindre ændring af levende biomasse og opdaterede værdier for kulstoflagring i mineraljorde.

Forvaltning af skov er genberegnet hovedsageligt pga. opdaterede data fra NFI for kulstoflagring i levende biomasse.

Genberegninger for forvaltning af landbrugsarealer og permanente græsningsarealer skyldes hovedsageligt anvendelse af det nye kort over organiske jorde samt nye emissionsfaktorer for organiske jorde. Analyses har vist at en stor del af arealer skal klassificeres som permanent græsningsareal og ikke landbrugsareal. Konsekvensen er en reduktion emissionen fra landbrugsarealer på 150-200 Gg CO_2-ækvivalenter og en tilsvarende stigning for permanente græsningsarealer.

For yderligere beskrivelse af KP-LULUCF henvises til kapitel 10 og 11.

1 Introduction

1.1 Background information on greenhouse gas inventories and climate change

1.1.1 Annual report

This report is Denmark's National Inventory Report (NIR) 2011 for submission to the United Nations Framework Convention on Climate change and the Kyoto Protocol (KP), due April 15, 2011. The report contains detailed information about Denmark's inventories for all years from 1990 to 2009. The structure of the report is in accordance with the UNFCCC guidelines on reporting and review. The main difference between Denmark's NIR 2011 report to the European Commission, due March 15, 2011, and this report to UNFCCC is reporting of territories. The NIR 2011 to the EU Commission was for Denmark, while this NIR 2011 to UNFCCC is for Denmark, Greenland and the Faroe Islands. The suggested outline provided by the UNFCCC secretariat has been followed to include the necessary information under the Kyoto Protocol. The report includes detailed and complete information on the inventories for all years from year 1990 to the year 2009, in order to ensure transparency.

The issues addressed in this report are trends in greenhouse gas emissions, a description of each IPCC category, uncertainty estimates, recalculations, planned improvements and procedures for quality assurance and control.

The annual emission inventories for the years from 1990 to 2009, are reported in the Common Reporting Format (CRF) as requested in the reporting guidelines. The CRF-spreadsheets contain data on emissions, activity data and implied emission factors for each year. Emission trends are given for each greenhouse gas and for the total greenhouse gas emissions in CO_2 equivalents.

According to the instrument of ratification, the Danish government has ratified the UNFCCC on behalf of Denmark, Greenland and the Faroe Islands. The Danish government has ratified the Kyoto Protocol on behalf of Denmark and Greenland. The information in the sectoral chapters in this report relates to Denmark only, while information for Greenland is included in Chapter 16 and for the Faroe Islands in Annex 9.

This report itself does not contain the full set of CRF Tables. Only the trend tables, Tables 10.1-5 of the CRF format, are included, refer Annex 8. The full set of CRF tables is available at the EIONET, Central Data Repository, kept by the European Environmental Agency:
http://cdr.eionet.europa.eu/dk/Air_Emission_Inventories/Submission_UNFCCC

1.1.2 Greenhouse gases

The greenhouse gases reported under the Climate Convention are:

- Carbon dioxide CO_2
- Methane CH_4
- Nitrous Oxide N_2O
- Hydrofluorocarbons HFCs
- Perfluorocarbons PFCs
- Sulphur hexafluoride SF_6

The main greenhouse gas responsible for the anthropogenic influence on the heat balance is CO_2. The atmospheric concentration of CO_2 has increased from a pre-industrial value of about 280 ppm to 379 ppm in 2005 (an increase of about 35 %), and exceeds now the natural range of 180-300 ppm over the last 650 000 years as determined by ice cores (IPCC, Fourth Assessment Report, 2007). The main cause for the increase in CO_2 is the use of fossil fuels, but changing land use, including forest clearance, has also been a significant factor. The greenhouse gases CH_4 and N_2O are very much linked to agricultural production; CH_4 has increased from a pre-industrial atmospheric concentration of about 715 ppb to 1774 ppb in 2005 (an increase of about 140 %) and N_2O has increased from a pre-industrial atmospheric concentration of about 270 ppb to 319 ppb in 2005 (an increase of about 18 %) (IPCC, Fourth Assessment Report, 2007). Changes in the concentrations of greenhouse gases are not related in simple terms to the effect on the heat balance, however. The various gases absorb radiation at different wavelengths and with different efficiency. This must be considered in assessing the effects of changes in the concentrations of various gases. Furthermore, the lifetime of the gases in the atmosphere needs to be taken into account – the longer they remain in the atmosphere, the greater the overall effect. The global warming potential (GWP) for various gases has been defined as the warming effect over a given time of a given weight of a specific substance relative to the same weight of CO_2. The purpose of this measure is to be able to compare and integrate the effects of individual substances on the global climate. Typical lifetimes in the atmosphere of substances are very different, e.g. 12 and 120 years approximately for CH_4 and N_2O, respectively. So the time perspective clearly plays a decisive role. The lifetime chosen is typically 100 years. The effect of the various greenhouse gases can, then, be converted into the equivalent quantity of CO_2, i.e. the quantity of CO_2 giving the same effect in absorbing solar radiation. According to the IPCC and their Second Assessment Report, which UNFCCC has decided to use as reference for reporting for inventory years throughout the commitment period 2008-2012, the global warming potentials for a 100-year time horizon are:

- CO_2: 1
- Methane (CH_4): 21
- Nitrous oxide (N_2O): 310

Based on weight and a 100-year period, methane is thus 21 times more powerful a greenhouse gas than CO_2, and N_2O is 310 times more powerful. Some of the other greenhouse gases (hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride) have considerably higher global warming potential values. For example, sulphur hexafluoride has a global warming potential of 23 900.

The indirect greenhouse gases reported are nitrogenoxide (NO_x), carbonmonooxide (CO), Non-Methane Volatile Organic Compounds

(NMVOC) and sulphurdioxid (SO_2). Since no GWP is assigned these gases they do not contribute to GHG emissions in CO_2-equivalents.

1.1.3 The Climate Convention and the Kyoto Protocol

At the United Nations Conference on Environment and Development in Rio de Janeiro in June 1992, more than 150 countries signed the UNFCCC (the Climate Convention). On the 21st of December 1993, the Climate Convention was ratified by a sufficient number of countries, including Denmark, for it to enter into force on the 21st of March 1994. One of the provisions of the treaty was to stabilise the greenhouse gas emissions from the industrialised nations by the end of 2000. At the first conference under the UN Climate Convention in March 1995, it was decided that the stabilisation goal was inadequate. At the third conference in December 1997 in Kyoto in Japan, a legally binding agreement was reached committing the industrialised countries to reduce the six greenhouse gases by 5.2 % by 2008-2012 compared with the base year and 1990 levels. For the 1990 levels and the base year and the F-gases, the nations can choose freely between 1990 and 1995 as the base year. On May 16, 2002, the Danish parliament voted for the Danish ratification of the Kyoto Protocol. Denmark (including Greenland and excluding the Faroe Islands) is, thus, under a legal commitment to meet the requirements of the Kyoto Protocol, when it came into force on the 16th of February 2005. Denmark (including Greenland) is committed to reduce greenhouse gases with 8 %. The European Union is under the KP committed to reduce emissions of greenhouse gases by 8 %. However, within the EU member states have made a political agreement – the Burden Sharing Agreement – on the contributions to be made by each state to the overall EU reduction level of 8 %.

Under the Burden Sharing Agreement, Denmark (excluding Greenland and the Faroe Islands) must reduce emissions by an average of 21 % in the period 2008-2012 compared with the base year emission level.

In accordance with the Kyoto Protocol, Denmark's base year emissions include the emissions of CO_2, CH_4 and N_2O in 1990 in CO_2-equivalents and Denmark has chosen the emissions of HFCs, PFCs and SF_6 in 1995 in CO_2-equivalents for the base year.

1.1.4 The role of the European Union

The European Union (EU) is a party to the UNFCCC and the Kyoto Protocol. Therefore, the EU has to submit similar datasets and reports for the collective 15 EU Member States under the burden sharing. The EU imposes some additional guidelines and obligations to these EU Member States through Decision No. 280/2004/EC concerning a mechanism for monitoring community greenhouse gas emissions and for implementing the Kyoto Protocol (EU monitoring mechanism).

1.1.5 Background information on supplementary information required under KP article 7.1

For the LULUCF activities under Article 3, paragraphs 3 and 4, of the Kyoto Protocol Denmark has chosen annual accounting. Article 3.3 covers direct, human induced afforestation (A), reforestation (R) and deforestation (D) activities, and accounting of these activities is mandatory. Under Article 3.4 Denmark has elected the activities Forest Management (FM), Cropland Management (CM) and Grazing Land Management (GM) for optional accounting of the first Commitment Period (CP). Net removals from FM activity can be used to compensate net emissions from activities under Article 3.3., and through the issuance of removal units (RMUs) up to a cap value. Denmark's cap value for the CP is 916 667 tonnes CO_2 equivalents.

1.2 A description of the institutional arrangement for inventory preparation

On behalf of the Ministry of the Environment and the Ministry of Climate and Energy NERI is responsible for the calculation and reporting of the Danish national emission inventory to EU and the UNFCCC (United Nations Framework Convention on Climate Change) and UNECE CLRTAP (Convention on Long Range Transboundary Air Pollution) conventions. Hence, the National Environmental Research Institute (NERI), University of Aarhus, prepares and publishes the annual submission for Denmark to the EU and UNFCCC of the National Inventory Report and the GHG inventories in the Common Reporting Format, in accordance with the UNFCCC guidelines. Furthermore, NERI is responsible for reporting the national inventory for the Kingdom of Denmark to the UNFCCC. NERI is also the body designated with overall responsibility for the national inventory under the Kyoto Protocol for Greenland and Denmark.

The work concerning the annual greenhouse gas emission inventory is carried out in cooperation with Danish ministries, research institutes, organisations and companies. The Government of Greenland is responsible for finalising and transferring the inventory for Greenland to NERI. The Faroe Islands Environmental Agency is responsible for finalising and transferring the inventory for the Faroe Islands to NERI.

There are now data agreements in place with both Greenland and the Faroe Islands ensuring the data delivery.

NERI has been and is engaged in work in connection to the meetings of the Conference of Parties (COP) to the UNFCCC and the meetings of the parties (COP/MOP) to the Kyoto protocol and its subsidiary bodies, where the reporting rules are negotiated and settled. Furthermore, NERI participates in the EU Monitoring Mechanism, Working Group 1 (WG1), where the guidelines, methodologies etc. on inventories to be prepared by the EU Member States are regulated.

The main experts responsible for the sectoral inventories and the corresponding chapters and annexes in this report are:

Project leader		**Ole-Kenneth Nielsen (okn@dmu.dk)**
Sector	Sub-sector	Expert name
Energy	Stationary combustion:	Malene Nielsen, Ole-Kenneth Nielsen
	Transport and other mobile sources	Morten Winther
	Fugitive emissions:	Marlene Plejdrup, Ole-Kenneth Nielsen
Industrial processes		Leif Hoffmann
Solvent and other product use		Patrik Fauser, Katja Hjelgaard
Agriculture		Mette Hjorth Mikkelsen, Rikke Albrektsen & Steen Gyldenkærne
LULUCF		Vivian Kvist Johannsen, Lars Vesterdal & Steen Gyldenkærne
Waste	Solid waste disposal on land	Marianne Thomsen, Katja Hjelgaard
	Wastewater handling	Marianne Thomsen
	Waste incineration	Katja Hjelgaard
Greenland		Lene Baunbæk
Faroe Islands		Maria Gunnleivsdóttir Hansen

The work concerning the annual greenhouse emission inventory is carried out in cooperation with other Danish ministries, research institutes, organisations and companies:

Danish Energy Agency, the Ministry of Climate and Energy: Annual energy statistics in a format suitable for the emission inventory work and fuel-use data for the large combustion plants. Company reports submitted under EU ETS.

Danish Environmental Protection Agency, The Ministry of the Environment: Database on waste and emissions of the F-gases.

Danish Nature Agency, The Ministry of the Environment: Database on Danish waste water quality parameters.

Statistics Denmark, The Ministry of Economic and Business Affairs: Statistical yearbook, sales statistics for manufacturing industries and agricultural statistics.

Faculty of Agricultural Sciences, Aarhus University: Data on use of mineral fertiliser, feeding stuff consumption and nitrogen turnover in animals.

The Road Directorate, the Ministry of Transport and Energy: Number of vehicles grouped in categories corresponding to the EU classification, mileage (urban, rural, highway), trip speed (urban, rural, highway).

Danish Centre for Forest, Landscape and Planning, University of Copenhagen: Background data for Forestry and CO_2 uptake by forest. Responsible for preparing estimates of emissions/removals for reporting under KP article 3.3 and for reporting FM under article 3.4.

Civil Aviation Agency of Denmark, the Ministry of Transport and Energy: City-pair flight data (aircraft type and origin and destination airports) for all flights leaving major Danish airports.

Danish Railways, the Ministry of Transport and Energy: Fuel-related emission factors for diesel locomotives.

Danish companies: Audited green accounts and direct information gathered from producers and agency enterprises.

Formerly, the provision of data was on a voluntary basis, but more formal agreements are now prepared.

Additionally NERI receives data from Greenland and the Faroe Islands in order to report for the Kingdom of Denmark:

Statistics Greenland: Complete CRF tables for Greenland and documentation for the inventory process.

The Faroe Islands Environmental Agency: Complete CRF tables for the Faroe Islands and documentation for the inventory process.

The complete emission inventories for the three different submissions (EU, Kyoto Protocol and UNFCCC) by Denmark are compiled by NERI and along with the documentation report (NIR) sent for official approval. In recent years the responsibility for official approval has changed. Previously it was the Danish Environmental Protection Agency (Ministry of the Environment) now it is the Danish Energy Agency (Ministry of Climate and Energy). This means that the emission inventory is finalised no later than March 15, whereupon the official approval is done prior to the reporting deadlines under the UNFCCC and the Kyoto Protocol.

1.3 Brief description of the process of inventory preparation. Data collection and processing, data storage and archiving

The background data (activity data and emission factors) for estimation of the Danish emission inventories is collected and stored in central databases located at NERI. The databases are in Access format and handled with software developed by the European Environmental Agency and NERI. As input to the databases, various sub-models are used to estimate and aggregate the background data in order to fit the format and level in the central databases. The methodologies and data sources used for the different sectors are described in Chapter 1.4 and Chapters 3 to 9. As part of the QA/QC plan (Chapter 1.6), the data structure for data processing support the pathway from collection of raw data to data compilation, modelling and final reporting.

For each submission, databases and additional tools and submodels are frozen together with the resulting CRF-reporting format. This material is placed on central institutional servers, which are subject to routine backup services. Material which has been backed up is archived safely. A further documentation and archiving system is the official journal for NERI. In this journal system, correspondence, both in-going and out-going, is registered, which in this case involves the registration of submissions and communication on inventories with the UNFCCC Secretariat, the European Commission, review teams, etc.

Figure 1.1 shows a schematic overview of the process of inventory preparation. The figure illustrates the process of inventory preparation from the first step of collecting external data to the last step, where the reporting schemes are generated for the UNFCCC and EU (in the CRF format (Common Reporting Format)) and to the United Nations Economic Commission for Europe/Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (UNECE/EMEP) (in the NFR format (Nomenclature For Reporting)). For data handling, the software tool is CollectER (Pulles et al., 1999) and for reporting the software tool is the CRF reporter tool developed by the UNFCCC Secretariat together with additional tools developed by NERI. Data files and programme files used in the inventory preparation process are listed in Table 1.1.

Table 1.1 List of current data structure; data files and programme files in use.

QA/QC Level	Name	Application type	Path	Type	Input sources
4 store	CFR Submissions (UNFCCC and EU)	External report	I:\ROSPROJ\LUFT_EMI\Inventory\AllYears\8_AllSectors\Level_4a_Storage\	MS Excel, xml	CRF Reporter
4 store	NFR Report	External report	I:\ROSPROJ\LUFT_EMI\Inventory\AllYears\8_AllSectors\Level_4a_Storage\	xls	NRF Report N8 Process
3 process	CRF Reporter	Management tool	Working path: local machine Archive path: I:\ROSPROJ\LUFT_EMI\Inventory\AllYears\8_AllSectors\Level_3b_Processes	(exe + mdb)	National Compliler and Importer2CRF(xml) and IDAtoCRF(xml)
3 process	NRF Report N8 Process	Helptool	I:\ROSPROJ\LUFT_EMI\Inventory\AllYears\8_AllSectors\Level_3b_Processes\NFR	Excel	NERIRep and Report Template (xls)
3 process	Importer2CRF	Help tool	I:\ROSPROJ\LUFT_EMI\Inventory\AllYears\8_AllSectors\Level_3b_Processes	MS Access	CRF Reporter, CollectEr2CRF, and excel files
3 process	CollectER2CRF	Help tool	I:\ROSPROJ\LUFT_EMI\Inventory\AllYears\8_AllSectors\Level_3b_Processes	MS Access	NERIRep
3 proces	IDA2CRF	Help tool	I:\ROSPROJ\LUFT_EMI\Inventory\AllYears\8_AllSectors\Level_3b_Processes	MS Access	IDA_backend
2 process 3 store	NERIRep	Help tool	Working path: I:\ROSPROJ\LUFT_EMI\DMURep	MS Access	CollectER databases; dk1972.mdb..dkxxxx.mdb and IDA_backend
2 process	CollectER	Management tool	Working path: local machine Archive path: I:\ROSPROJ\LUFT_EMI\Inventory\AllYears\8_AllSectors\Level_2b_Processes	(exe +mdb)	Sector Expert
2 store	dk1972.mdb.dkxxxx.mdb	Datastore	I:\ROSPROJ\LUFT_EMI\Inventory\AllYears\8_AllSectors\Level_2a_Storage	MS Access	CollectER
1 process	IDA	Management	I:\ROSPROJ\LUFT_EMI\Agriculture\InventoryAgricultureData	MS Access	Sector Expert
1 store	IDA_Backend	Datastore	I:\ROSPROJ\LUFT_EMI\Agriculture\InventoryAgricultureData	MS Access	IDA

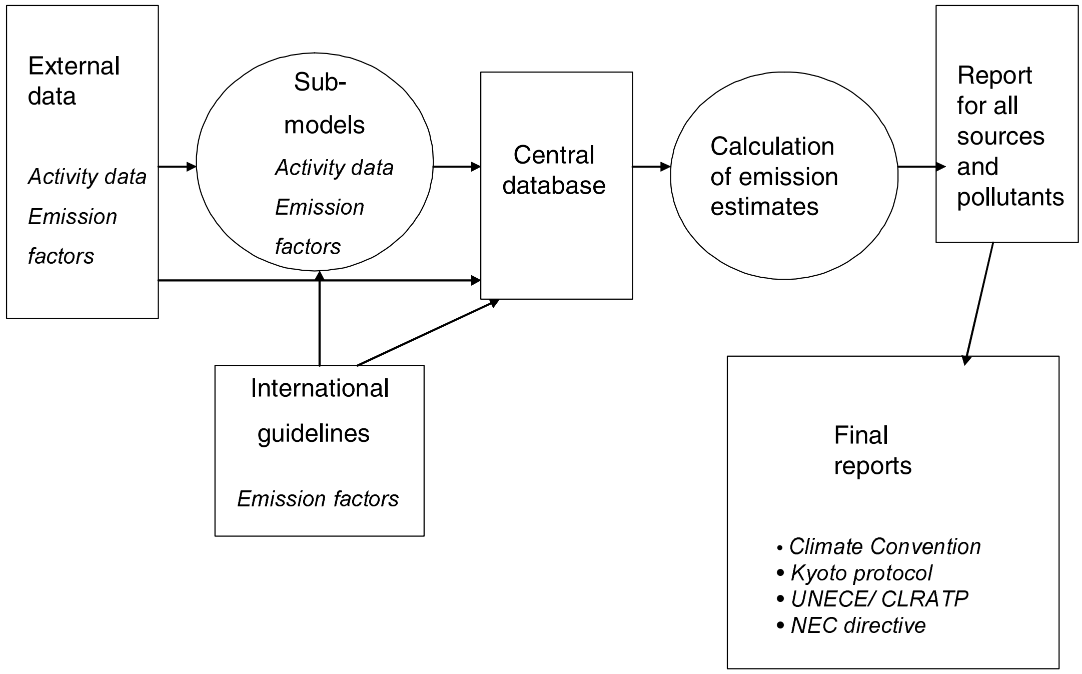


Figure 1.1 Schematic diagram of the process of inventory preparation.

Denmark has different geographical definitions for different submissions. Under the European Union only mainland Denmark is included. For the reporting under the Kyoto Protocol the submission includes Denmark and Greenland, while the reporting under the UNFCCC includes Denmark, Greenland and the Faroe Islands.

Due to the different geographical scopes of the Danish inventory submissions it is necessary to operate three independent installations of the CRF Reporter software on different virtual computers.

For the preparation of the Danish submission under the Kyoto Protocol the full Danish CRF is aggregated with the Greenlandic CRF and for the UNFCCC reporting this is also aggregated with the CRF of the Faroe Islands. The process of aggregation requires additional software tools and two additional installations of CRF Reporter. The process of aggregating the KP inventory is described in Chapter 17.

1.4 Brief general description of methodologies and data sources used

Denmark's air emission inventories are based on the Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (IPCC, 1997), the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC, 2000), the Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC, 2003) and the CORINAIR methodology. CORINAIR (COoRdination of INformation on AIR emissions) is a European air emission inventory programme for national sector-wise emission estimations, harmonised with the IPCC guidelines. To ensure estimates are as timely, consistent, transparent, accurate and comparable as possible, the inventory programme has developed calculation methodologies for most subsectors and software for storage and further data processing (EMEP-/CORINAIR, 2007).

A thorough description of the CORINAIR inventory programme used for Danish emission estimations is given in Illerup et al. (2000). The CORINAIR calculation principle is to calculate the emissions as activities multiplied by emission factors. Activities are numbers referring to a specific process generating emissions, while an emission factor is the mass of emissions pr unit activity. Information on activities to carry out the CORINAIR inventory is largely based on official statistics. The most consistent emission factors have been used, either as national values or default factors proposed by international guidelines.

A list of all subsectors at the most detailed level is given in Illerup et al. (2000) together with a translation between CORINAIR and IPCC codes for sector classifications.

1.4.1 Stationary Combustion Plants

Stationary combustion plants are part of the CRF emission sources *1A1 Energy Industries*, *1A2 Manufacturing Industries* and *1A4 Other sectors*.

The Danish emission inventory for stationary combustion plants is based on the CORINAIR system described in Illerup et al. (2000). The inventory is based on activity rates from the Danish energy statistics and on emission factors for different fuels, plants and sectors.

The Danish Energy Agency aggregates fuel consumption rates in the official Danish energy statistics to SNAP categories.

For each of the fuel and SNAP categories (sector and e.g. type of plant), a set of general emission factors has been determined. Some emission factors refer to the IPCC Guidelines or the EMEP/EEA Guidebook and some are country-specific and refer to Danish legislation, Danish research reports or calculations based on emission data from a considerable number of plants.

Some of the large plants, such as e.g. power plants and municipal waste incineration plants are registered individually as large point sources and emission data from the actual plants are used. This enables use of plant specific emission factors that refer to emission measurements stated in annual environmental reports, etc. At present, the emission factors for CH_4 and N_2O are, however, not plant-specific, whereas emission factors for SO_2 and NO_X often are. For CO_2 it was for the first time possible to use data reported under the EU-ETS in the emission inventory for 2006. Therefore it was possible to derive some plant specific CO_2 emission factors for coal and oil fired power plants.

The CO_2 from incineration of the plastic part of municipal waste is included in the Danish inventory.

In addition to the detailed emission calculation in the national approach, CO_2 emission from fuel combustion is aggregated using the reference approach. In 2009, the CO_2 emission inventory based on the reference approach and the national approach, respectively, differ by -1.28 %.

Please refer to Chapter 3.2 and Annex 3A for further information on the emission inventory for stationary combustion plants.

1.4.2 Transport

The emissions from transport, referring to SNAP category 07 (road transport) and the sub-categories in 08 (other mobile sources), are made up in the IPCC categories: 1A2f (Industry-other), 1A3a (Civil aviation), 1A3b (road transport), 1A3c (Railways), 1A3d (Navigation), 1A4a (Commercial and Institutional), 1A4b (Residential), 1A4c (Agriculture/forestry/fisheries) and 1A5 (Other).

An internal NERI model with a structure similar to the European COPERT IV emission model (EMEP/EEA, 2009) is used to calculate the Danish annual emissions for road traffic. The emissions are calculated for operationally hot engines, during cold start and fuel evaporation. The model also includes the emission effect of catalyst wear. Input data for vehicle stock and mileage is obtained from the DTU Transport, and is grouped according to average fuel consumption and emission behaviour. For each group the emissions are estimated by combining vehicle and annual mileage numbers with hot emission factors, cold:hot ratios and evaporation factors (Tier 2 approach).

For air traffic, the 2001-2009 estimates are made on a city-pair level, using flight data from the Danish Civil Aviation Agency (CAA-DK) and LTO and distance-related emission factors from the CORINAIR guidelines (Tier 2 approach). For previous years the background data consists of LTO/aircraft type statistics from Copenhagen Airport and total LTO numbers from CAA-DK. With appropriate assumptions, consistent time-series of emissions are produced back to 1990, which also include the findings from a Danish city-pair emission inventory in 1998.

Off-road working machines and equipment are grouped in the following sectors: inland waterways, agriculture, forestry, industry, and household and gardening. In general, the emissions are calculated by combining information on the number of different machine types and their respective load factors, engine sizes, annual working hours and emission factors (Tier 2 approach).

For the most important ferry routes in Denmark (a sub-part of Navigation (1A3d)) detailed calculations are made by combining annual number of return trips, sailing time, engine size, load factor and emission factors (Tier 2 approach).

Please refer to Chapter 3.3 and Annex 3B for further information on emissions from transport.

1.4.3 Fugitive Emissions from Fuels

Emissions from offshore activities are estimated using the methodology described in the Emission Inventory Guidebook (EMEP/EEA, 2009). The sources include emissions from the extraction of oil and gas, on-shore oil tanks, flaring and onshore and offshore loading of ships. The emission factors are based on the figures given in the guidebook, except for the onshore oil tanks where national values are used.

The VOC emissions from petroleum refinery processes cover non-combustion emissions from feedstock handling/storage, petroleum products processing, product storage/handling and flaring. SO_2 is also emitted from the non-combustion processes and includes emissions from processing the products and from sulphur recovery plants. The emission calculations are based on information from the Danish refineries and the energy statistics.

Inventories of the VOC emission from gas transmission and distribution is based on annual environmental reports from the Danish gas transmission company, Energinet.dk, and annual data from the distribution companies.

Please refer to Chapter 3.5 for further information on fugitive emissions from fuels.

1.4.4 Industrial Processes

Energy consumption associated with industrial processes and the emissions thereof are included in the Energy sector of the inventory. This is due to the overall use of energy balance statistics for the inventory.

There is only one producer of cement in Denmark, Aalborg Portland Ltd. The activity data for the production of cement clinker is obtained from the company and the CO_2 emission is from the company report to EU-ETS. The methodology is approved by the Danish Energy Agency and the yearly emission estimate is in accordance with the methodology.

The reference for the activity data for production of lime, hydrated lime, expanded clay products and bricks are the production statistics from the manufacturing industries, published by Statistics Denmark.

Limestone is used for the refining of sugar as well as for wet flue gas cleaning at power plants and waste incineration plants. The reference for the activity data is Statistics Denmark for sugar, Energinet.dk for gypsum from power plants combined with specific information on consumption of $CaCO_3$ at specific power plants and National Waste Statistics for gypsum from waste incineration. The emission factors are based on stoichiometric relations between consumption of $CaCO_3$ and gypsum generation as well as consumption of lime for sugar refining and precipitation with CO_2. This information is supplemented with company reports to EU-ETS.

The reference for the activity data for asphalt roofing is Statistics Denmark for consumption of roofing materials, combined with technical specifications for roofing materials produced in Denmark. The emission factors are default factors.

For road paving with asphalt the reference for the activity data is Statistics Denmark for consumption of asphalt and cut-back asphalt. The emission factors are default factors for consumption of asphalt and an estimated emission factor for cut-back asphalt based on the statistics on the emission of NMVOC compiled by the industrial organisations in question.

The reference for activity data for the production of glass and glass wool are obtained from the producers published in their environmental reports. Emission factors are based on stoichiometric relations between raw materials and CO_2 emissions. This information is supplemented with company reports to EU-ETS.

The production of lime and yellow bricks gives rise to CO_2 emissions. The emission factors are based on stoichiometric relations, assumption on $CaCO_3$ content in clay as well as a default emission factor for expanded clay products. This information is supplemented with company reports to EU-ETS.

There has been one producer of nitric acid in Denmark. To date, the data in the inventory relies on information from the producer. The producer reports emissions of NO_x and NH_3 as measured emissions and emissions of N_2O for 2003 as estimated emissions. The emission of N_2O in 2005 and forward is not occurring as the nitric acid production was closed down in the middle of 2004.

There is one producer of catalysts in Denmark. The data in the inventory relies on information published by the producer in environmental reports.

There is one steelwork in Denmark. The activity data as well as data on consumption of raw materials (coke) has been published by the producer in environmental reports. Emission factors are based on stoichiometric relations between raw materials and CO_2 emission. The electro steelwork was closed in 2005.

The inventory on the F-gases (HFCs, PFCs and SF_6) is based on work carried out by the Danish Consultant Company "Planmiljø". Their yearly report (DEPA, 2011) documents the inventory data up to the year 2009. The methodology is implemented for the whole time-series 1990-2009, but full information on activities only exists since 1995.

Please refer to Chapter 4 for further information on industrial processes.

1.4.5 Solvents

The approach for calculating the emissions of Non-Methane Volatile Organic Carbon (NMVOC) from industrial and household use in Denmark focuses on single chemicals rather than activities. This leads to a clearer picture of the influence from each specific chemical, which enables a more detailed differentiation on products and the influence of product use on emissions. The procedure is to quantify the use of the chemicals and estimate the fraction of the chemicals that is emitted as a consequence of use.

The detailed approach in EMEP/CORINAIR (2004) is used. Here all relevant consumption data on all relevant solvents must be inventoried or at least those together representing more than 90 % of the total NMVOC emission. Simple mass balances for calculating the use and emissions of chemicals are set up 1) use = production + import – export, 2) emission = use * emission factor. Production, import and export figures are extracted from Statistics Denmark, from which a list of 427 single chemicals, a few groups and products is generated. For each of these, a "use" amount in tonnes pr yr (from 1995 to 2009) is calculated. It is found that approximately 40 different NMVOCs comprise over 95 % of the total use and it is these approximately 40 chemicals that are investigated further. The "use" amounts are distributed across industrial activities according to the Nordic SPIN (Substances in Preparations in Nordic Countries) database, where information on industrial use categories and products is available in a NACE coding system. The chemicals are also related to specific products. Emission factors are obtained from regulators or the industry.

Outputs from the inventory are: a list where the approximately 40 most predominant NMVOCs are ranked according to emissions to air; specification of emissions from industrial sectors and from households - contribution from each chemical to emissions from industrial sectors and households; tidal (annual) trend in NMVOC emissions, expressed as total NMVOC and single chemical, and specified in industrial sectors and households.

This emission inventory includes N_2O emissions from the use of anaesthesia for 2005-2009. Five companies sell N_2O in Denmark and only one company produces N_2O. Due to confidentiality no data on produced amount are available and thus the emissions related to N_2O production are unknown. An emission factor of one is assumed for all use, which equals the sold amount to the emitted amount.

This year emissions from fireworks are included under other product use. Data on consumption of fireworks are obtained from Statistics Denmark. The emission factors used refer to international literature.

Please refer to Chapter 5 and Annex 3D for further information on the emission inventory for solvent and other product use.

1.4.6 Agriculture

The emissions are provided in CRF: Table 4 Sectoral Report for Agriculture and Table 4.A, 4.B(a), 4.B(b), 4.D and 4.F Sectoral Background Data for Agriculture. The calculation of emissions from the agricultural sector is based on methods described in the IPCC Guidelines (IPCC, 1996) and the Good Practice Guidance (IPCC, 2000). Activity data for livestock is on a one-year average basis from the agriculture statistics published by Statistics Denmark (2010). Data concerning the land use and crop yield is also from the agricultural statistics. Data concerning the feed consumption and nitrogen excretion is based on information from the Faculty of Agricultural Science, University of Aarhus. The CH_4 Implied Emission Factors for Enteric Fermentation and Manure Management are based on a Tier 2/CS approach for all animal categories except for poultry which are based on a Tier 1 approach. All livestock categories in the Danish emission inventory are based on an average of certain subgroups separated by differences in animal breed, age and weight class. The emissions from enteric fermentation for fur farming are estimated to be not applicable.

Emission of N_2O is closely related to the nitrogen balance. Thus, quite a lot of the activity data is related to the Danish calculations for ammonia emission (Mikkelsen et al., 2011). National standards are used to estimate the amount of ammonia emission. When estimating the N_2O emission the IPCC standard value is used for all emission sources. The emission of CO_2 from Agricultural Soils is included in the LULUCF sector.

A model-based system is applied for the calculation of the emissions in Denmark. This model (IDA – Integrated Database model for Agricultural emissions) is used to estimate emission from both greenhouse gases and ammonia. A more detailed description is published in Mikkelsen et al. (2011). The emission from the agricultural sector is mainly related to livestock production. IDA works on a detailed level and includes around 38 livestock categories, and each category is subdivided according to housing type and manure type. The emission is calculated from each subcategory and the emission is aggregated in accordance with the livestock category given in the CRF.

To ensure data quality, both data used as activity data and background data used to estimate the emission factor are collected, and discussed in cooperation with specialists and researchers in different institutes and research sections. Thus, the emission inventory will be evaluated continuously according to the latest knowledge. Furthermore, time-series both of emission factors and emissions in relation to the CRF categories are prepared. Any considerable variations in the time-series are explained.

The uncertainties for assessment of emissions from enteric fermentation, manure management, agricultural soils and field burning of agricultural residue have been estimated based on a Tier 1 and Tier 2 approach. The most significant uncertainties are related to the emissions of N_2O from agricultural soils.

A more detailed description of the methodology for the agricultural sector is given in Chapter 6 and Annex 3E.

1.4.7 Forestry, Land Use and Land Use Change

A complete Land Use Change matrix based on satellite imaging of the whole Danish land area has been performed into the six major area classes. This has improved the coverage and the quality of the inventory substantially.

In the forest inventory some changes has been made since the 2010 submission on how the standing C-stock are estimated. All applicable pools are reported. This type of forest inventory is very similar to inventories used in other countries, e.g. Sweden or Norway. Please see Chapter 7 for further details.

CO_2 emissions from Cropland and Grassland are based on census data from Statistics Denmark as regards size of area and crop yield combined with GIS-analysis on land use from the EU agricultural subsidiary system. This gives a very high accuracy on land use. All applicable pools are reported for Cropland and Grassland. The emission from mineral soils for cropland is estimated with a three-pooled dynamical soil C model (C-TOOL). C-TOOL was initialised in 1980. The model is run for each county in Denmark. Emissions from organic soils in Cropland are based on new national developed emission factors. For Grassland IPCC Tier 1b values are used. The area with a complete new map of the organic soils combined with field-specific crop data. National models have been developed for wooden perennial crops in Cropland based on area statistics from Statistic Denmark. These are of minor importance. Sinks in hedgerows are based on a national developed model. The area with hedgerows is based on hedgerows established with financial support from the Danish Government and aerial photos. Emissions from liming are based on annual sales data collected by the Danish Agricultural Advisory Centre, combined with the acid neutralisation capacity for each lot produced.

For Wetlands emissions are reported from peat extraction areas. Natural wetlands are not reported. A comprehensive programme for restoration of wetlands is taking place in Denmark. "Land" converted to Wetlands is therefore reported.

For the purpose of having estimates for the KP accounting "Land" converted to Settlements is reported but not Settlements remaining Settlements.

No estimates are made for Other Land remaining Other Land and no conversion of land to Other Land is made. For the purpose of having estimates for the KP accounting estimates for living biomass are provided for land converted from Other Land to Other Land Use.

1.4.8 Waste

For 6.A Solid Waste Disposal on Land, only managed waste disposal sites are of importance and registered; i.e. unmanaged and illegal disposal of waste is considered to play a negligible role in the context of this category. The CH_4 emission at the Danish SWDSs is based on a First Order Decay (FOD) model according to an IPCC tier 2 approach (IPCC 1997, 2000 and 2006). Data on waste types and amounts deposited at solid waste disposal sites is according to the official registration performed by the Danish Environmental Protection Agency (DEPA). The model calculations are performed using landfill site characteristics and statistics on the amounts of waste fractions deposited each year. Improved documentation of the methodology, input parameter data including uncertainty analysis are described in Chapter 8.2.

For 6.B Waste Water Handling, country-specific methodologies for calculating the emissions of CH_4 and N_2O at wastewater treatment plants (WWTPs). The review team have requested better documentation of derived EF and national activity data, and improvements has been performed with respect to dividing the contributions to the net methane emission into specific treatment processes. Fugitive methane releases from the municipal and private WWTPs have been divided into contributions from 1) the sewer system, primary settling tank and biological N and P removal processes, 2) from anaerobic treatment processes in closed systems with biogas extraction and combustion for energy production and 3) septic tanks. N_2O formation and releases during the treatment processes at the WWTPs and from discharged effluent waste water are included. Documentation of the improved methodology, emission factors and activity data are described in Chapter 8.3.

Regarding 6.C Waste Incineration all municipal, industrial, hazardous and medical waste incinerated is used for energy and heat production. This production is included in the energy statistics, hence emissions are included in the CRF under fuel combustion activities (CRF sector 1A), and more specifically waste incineration takes place in CRF sectors 1A1a, 1A2f and 1A4a. For the 2011 submission reporting in this category covers incineration of corpses and carcasses. The activity data are obtained from the National Association of Danish Crematoria, the three facilities incinerating carcasses and the Danish Emergency Management Agency.

In CRF category 6.D Other small emissions due to gasification of waste are included for the years 1994-2005. In 2006 onwards these emissions do not occur. In the 2011 submission emissions from accidental fires have been reallocated from category 6C to category 6D

Please refer to Chapter 8 and Annex 3F for further information on emission inventories for waste.

1.4.9 KP-LULUCF

Regarding the possibility of including in the first commitment period emissions and removals associated with land use, land-use change and forestry activities under Article 3.4 of the Kyoto Protocol, Denmark has decided to include emissions and removals from Forest Management (FM), Cropland Management (CM) and Grazing land Management (GM).

The national system has identified land areas associated with the activities under Article 3.4 of the Kyoto Protocol in accordance with definitions, modalities, rules and guidelines relating to land use, land-use change and forestry activities under the protocol by satellite monitoring, use of EU Land Parcel Information System (LPIS), detailed crop information data on field level, soil mapping and sample plots from the national forest inventory (NFI). All land converted from other activities into Cropland and Grassland is accounted for. No land has been allowed to leave elected areas under art. 3.4.

The forest definition adopted in the NFI is identical to the FAO definition (TBFRA, 2000). It includes "wooded areas larger than 0.5 ha, that are able to form a forest with a height of at least 5 m and crown cover of at least 10 %". The minimum width is 20 m. For afforestation the carbon stock change in the period 1990 - 2009 is based both on the area of afforestation, the information on species composition from the Forest Census 2000 and from the NFI. In the afforestation a steady increase in carbon stock is found. The estimates for the carbon pools in the afforestation are similar to previous estimates, with a slight increase due to the new knowledge on species composition, average carbon stock in those areas based on the NFI data and new data on the carbon stock in soils. Carbon stock change caused by deforestation is estimated based on the deforested area and the mean values of carbon stock in the total forest area. This is due to the fact that no specific knowledge is available on the carbon pools of the deforested areas. For Forest Management are used census and NFI data.

For Cropland and Grassland the same methodology is used in the Convention reporting as used in the KP reporting.

Please see Chapter 11 for further details.

1.4.10 Use of EU Emission Trading Scheme data

In 2004 the first guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to the EU Emission Trading Scheme (ETS) Directive (2003/87/EC) were implemented (EU Commission, 2004). These were updated in 2007 and are available from the EU Commission website (EU Commission, 2007).

The Danish emission inventory only includes data from plants using higher tier methods as defined in the EU decision establishing guidelines for monitoring and reporting (EU Commission, 2007). In the Guidelines the specific methods for determining carbon contents, oxidation factor and calorific value are specified.

In the Danish inventory plant or activity based CO_2 emission factors have been derived for power plants combusting coal and oil, refinery gas and flare gas in refineries, fuel gas and flare gas at off-shore installations, cement production, production of brick and tiles and lime production. For all these sources the EU ETS reports are only used in the Danish inventory for plants using high tier methods. The EU ETS data have been applied for the years 2006 - 2009.

The EU ETS reporting guidelines emphasizes the need for a high quality reporting through ensuring completeness, consistency, accuracy, transparency and faithfulness. The quality criteria as defined under the EU ETS reporting guidelines are in complete agreement with the principles in the IPCC good practice guidance. For all activities covered by the EU ETS installations are divided in to three categories (A, B and C) depending on the annual CO_2 emission. A category A installation has an annual emission of less than 50 Gg CO_2, a category B installation has an annual emission of between 50 and 500 Gg CO_2 and a category C installation has an annual emission of more than 500 Gg CO_2. For each activity table 1 of the EU ETS guidelines (EU Commission, 2007) specifies the minimum tier level for the different calculation parameters. An example for combustion installations is shown in Table 1.2, the full list for all activities is available in the EU ETS guidelines (EU Commission, 2007).

Table 1.2 Example of minimum requirements in EU ETS guidelines (EU Commission, 2007).

	Activity data						Emission factor			Oxidation factor		
	Fuel flow			Net calorific value								
Activity	A	B	C	A	B	C	A	B	C	A	B	C
Commercial standard fuels	2	3	4	2a/2b	2a/2b	2a/2b	2a/2b	2a/2b	2a/2b	1	1	1
Other gaseous and liquid fuels	2	3	4	2a/2b	2a/2b	3	2a/2b	2a/2b	3	1	1	1
Solid fuels	1	2	3	2a/2b	3	3	2a/2b	3	3	1	1	1

The determination of the variables needed for the emission calculation has to be done in accordance with international standards. It is not possible to list all the relevant standards here, but an overview is available in annex 1, chapter 13 of the EU ETS guidelines. There are also demands concerning sampling methods and frequency of analysis.

As an example the tier 3 regarding fuel flow for fuel combustion, corresponds to a determination of the fuel consumption with an maximum uncertainty of 2.5 % taking into account possible effects of stock change. Tier 4 is a maximum uncertainty of 1.5 %. These uncertainties are very low and are in line with what could be expected from a well functioning energy statistics system. More information regarding the use of EU ETS data in the specific subsectors of the inventory is included in Chapter 3.2.5 (Power plants), Chapter 3.5.2 (Refineries and off-shore installations) and Chapter 4.2.2 (Cement production and other mineral products).

The operators shall establish, document, implement and maintain effective data acquisition and handling activities. This means assigning responsibilities for the quality process, as well as quality assurance, reviews and validation of data. Furthermore an independent verification ensuring that emissions have been monitored in accordance with the EU ETS guidelines and that reliable and correct emission data are reported. There are also demands that records and documentation of the control activities must be stored for at least 10 years. The demands for the QA/QC system in the EU ETS guidelines are fully comparable to the requirements in the IPCC good practice guidance. Even so NERI also performs QC checks of the data received as part of company reporting under EU ETS. This includes comparing the reported parameters with previous years, identifying outliers etc. In case NERI detects what is considered to be abnormal values NERI contacts the Danish Energy Agency, which is the regulating authority for the EU ETS system in Denmark.

1.5 Brief description of key categories

The key category analysis described in this section covers only Denmark. The aggregation used for the analysis is not directly suited for emissions from Greenland. If Greenlandic emissions were included in the analysis, they would not affect the overall results of the key category analysis. For a key category analysis covering Greenland refer to Chapter 16 and for Denmark and Greenland refer to Chapter 17.

All KCA have been carried out in accordance with Good Practice Guidance (GPG) and IPCC Guidelines (2006).

The KCA for Denmark includes a total of 12 different analyses:

- base year, reporting year and trend
- including and excluding LULUCF
- Tier 1 and tier 2 approach

The KCA is based on 143 emission source categories including 20 LULUCF source categories.

The 12 different KCA for Denmark point out 26-36 key source categories each and a total of 63 different key source categories. The number of key categories in each of the main sectors is: energy 31, industrial processes

5, solvents and other product use 0, agriculture 12, LULUCF 11 and waste 4.

The tier 1 approach point out mainly the large emission sources as key categories and thus CO_2 emission from stationary and mobile combustion are important key categories. The tier 2 approach point out some of the sources with larger uncertainty rates.

The categorisation and results of all KCA are included in Annex 1.

1.5.1 Tier 1 key category analysis

The KCA for **1990** excluding LULUCF points out 26 key categories (32 key categories for the KCA including LULUCF). Stationary combustion of coal is the main source category accounting for 35 % of the emission[1]. Road transport, stationary combustion of gas oil and stationary combustion of natural gas account for 14 %, 7 % and 6 % respectively.

The KCA for **2009** excluding LULUCF points out 26 key categories (32 key categories for the KCA including LULUCF). Stationary combustion of coal is the main source category accounting for 26 % of the emission[1]. Road transport, and stationary combustion of natural gas account for 20 % and 15 % respectively.

The KCA for **trend (1990-2009)** excluding LULUCF points out 26 key categories (36 key categories for the KCA including LULUCF). Stationary combustion of coal is the main source category accounting for 21 % of the emission[1]. Stationary combustion of natural gas, road transport and stationary combustion of gas oil account for 21 %, 15 % and 9 % respectively.

1.5.2 Tier 2 key category analysis

The KCA for **1990** excluding LULUCF points out 26 key categories (31 key categories for the KCA including LULUCF). N_2O from leaching is the main source category accounting for 16 % of the aggregation value[2]. N_2O from synthetic fertilizer, CH_4 from solid waste disposal on land and N_2O from animal waste applied to soils account for 16 %, 9 % and 7 % respectively.

The KCA for **2009** excluding LULUCF points out 29 key categories (33 key categories for the KCA including LULUCF). N_2O from leaching is the main source category accounting for 11 % of the aggregation value[2]. N_2O from synthetic fertilizer, CH_4 from solid waste disposal on land, N_2O from animal waste applied to soils and N_2O from biomass combustion in stationary combustion plants account for 9 %, 9 %, 9 % and 6 % respectively.

The KCA for **trend (1990-2009)** excluding LULUCF points out 28 key categories (35 key categories for the KCA including LULUCF). N_2O from synthetic fertilizer is the main source category accounting for 18 % of the aggregation value[2]. N_2O from leaching, N_2O from biomass com-

[1] Data for the KCA excluding LULUCF.
[2] According to IPCC Guidelines (2006).

bustion in stationary combustion plants and consumption of HFC account for 15 %, 9 % and 6 % respectively.

1.5.3 KP-LULUCF

See Chapter 11.9.1 for discussion on the key category analysis of KP-LULUCF.

1.6 Information on QA/QC plan including verification and treatment of confidential issues where relevant

1.6.1 Introduction

This section outlines the Quality Control (QC) and Quality Assurance (QA) plan for greenhouse gas emission inventories performed by the Danish National Environmental Research Institute (Sørensen et al., 2005). The plan is in accordance with the guidelines provided by the IPCC (IPCC, 1997), and the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC, 2000). The ISO 9000 standards are also used as important input for the plan.

The QA/QC plan also covers Greenland. NERI receives the data corresponding to data processing level 3 and data storage level 4 and the data undergoes the same QA/QC procedure as the Danish data, some further QC checks are described in Chapter 17. The QA/QC specific to the Greenlandic emission inventory is described in Chapter 16.

1.6.2 Concepts of quality work

The quality planning is based on the following definitions as outlined by the ISO 9000 standards as well as the Good Practice Guidance (IPCC, 2000):

- Quality management (*QM*) Coordinates activity to direct and control with regard to quality.
- Quality Planning (*QP*) Defines quality objectives including specification of necessary operational processes and resources to fulfil the quality objectives.
- Quality Control (*QC*) Fulfils quality requirements.
- Quality Assurance (*QA*) Provides confidence that quality requirements will be fulfilled.
- Quality Improvement (*QI*) Increases the ability to fulfil quality requirements.

The activities are considered inter-related in this report as shown in Figure 1.2.

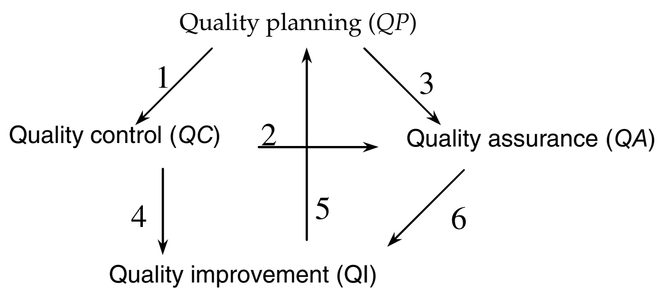


Figure 1.2 Interrelation between the activities with regard to quality. The arrows are explained in the text below this figure.

1: The *QP* sets up the objectives and, from these, measurable properties valid for the *QC*.

2: The *QC* investigates the measurable properties that are communicated to *QA* for assessment in order to ensure sufficient quality.

3. The *QP* identifies and defines measurable indicators for the fulfilment of the quality objectives. This yields the basis for the *QA* and has to be supported by the input coming from the *QC*.

4: The result from *QC* highlights the degree of fulfilment for every quality objective. It is thus a good basis for suggestions for improvements to the inventory to meet the quality objectives.

5: Suggested improvements in the quality may induce changes in the quality objectives and their measurability.

6: The evaluation carried out by external authorities is important input when improvements in quality are being considered.

1.6.3 Definition of quality

A solid definition of quality is essential. Without such a solid definition, the fulfilment of the objectives will never be clear and the process of quality control and assurance can easily turn out to be a fuzzy and unpleasant experience for the people involved. On the contrary, in case of a solid definition and thus a clear goal, it will be possible the make a valid statement of "good quality" and thus form constructive conditions and motivate the inventory work positively. A clear definition of quality has not been given in the UNFCCCC guidelines. In the Good Practice Guidance, Chapter 8.2, however, it is mentioned that:

"Quality control requirements, improved accuracy and reduced uncertainty need to be balanced against requirements for timeliness and cost effectiveness." The statement of balancing requirements and costs is not a solid basis for QC as long as this balancing is not well defined.

The resulting standard of the inventory is defined as being composed of accuracy and regulatory usefulness. The goal is to maximise the standard of the inventory and the following statement defines the quality objective:

The quality objective is only inadequately fulfilled if it is possible to make an inventory of higher standard without exceeding the frame of resources.

1.6.4 Definition of Critical Control Points (*CCP*)

A Critical Control Point (*CCP*) is defined in this submission as an element or an action which needs to be taken into account in order to fulfil the quality objectives. Every *CCP* has to be necessary for the objectives and the *CCP* list needs to be extended if other factors, not defined by the *CCP* list, are needed in order to reach at least one of the quality objectives.

The objectives for the *QM*, as formulated by IPCC (2000), are to improve elements of transparency, consistency, comparability, completeness and confidence. In the IPCC guidelines (IPCC, 1997), the element "confidence" is replaced by "accuracy" and in this plan "accuracy" is used.

The objectives for the *QM* are used as *CCP*s, including the elements mentioned above. The following explanation is given by IPCC guidelines (IPCC, 1997) for each *CCP*:

Transparency means that the assumptions and methodologies used for an inventory should be clearly explained to facilitate replication and assessment of the inventory by users of the reported information. The transparency of the inventories is fundamental to the success of the process for communication and consideration.

Consistency means that an inventory should be internally consistent in all its elements with inventories of other years. An inventory is consistent if the same methodologies are used for the base and for all subsequent years and if consistent datasets are used to estimate emissions or removals from source or sinks. Under certain circumstances, an inventory using different methodologies for different years can be considered to be consistent if it has been recalculated in a transparent manner in accordance with the Intergovernmental Panel on Climate Change (IPCC) guidelines and good practice guidance.

Comparability means that estimates of emission and removals reported by Annex I Parties in inventories should be comparable among Annex I parties. For this purpose, Annex I Parties should use the methodologies and formats agreed upon by the COP for estimating and reporting inventories. The allocation of different source/sink categories should follow the split of *Revised 1996 IPCC Guidelines for national Greenhouse Gas Inventories* (IPCC, 1997) at the level of its summary and sectoral tables.

Completeness means that an inventory covers all sources and sinks, as well as all gases, included in the IPCC guidelines as well as other existing relevant source/sink categories, which are specific to individual Annex I Parties and, therefore, may not be included in the IPCC guidelines. Completeness also means full geographic coverage of sources and sinks of an Annex I Party.

Accuracy is a relative measure of the exactness of an emission or removal estimate. Estimates should be accurate and should systematically neither over nor underestimate emissions or removals. Uncertainties on estimates should be reduced if possible. Appropriate methodologies should be used in accordance with the *IPCC good practice guidance*, to promote data accuracy in inventories.

The robustness against unexpected disturbance of the inventory work has to be high in order to secure high quality, which is not covered by the *CCP*s above. The correctness of the inventory is formulated as an independent objective. This is so because the correctness of the inventory is a condition for all other objectives to be effective. A large part of the Tier 1 procedure given by the Good Practice Guidance (IPCC, 2000) is actually checks for miscalculations and, thus, supports the objective of correctness. Correctness, as defined here, is not similar to accuracy, because the correctness takes into account miscalculations, while accuracy relates to minimizing the always present data-value uncertainty.

Robustness implies arrangement of inventory work as regards e.g. inventory experts and data sources in order to minimize the consequences of any unexpected disturbance due to external and internal conditions. A change in an external condition could be interruption of access to an external data source and an internal change could be a sudden reduction in qualified staff, where a skilled person suddenly leaves the inventory work.

Correctness has to be secured in order to avoid uncontrollable occurrence of uncertainty directly due to errors in the calculations.

The different *CCP*s are not independent and represent different degrees of generality. E.g. deviation from *comparability* may be accepted if a high degree of *transparency* is applied. Furthermore, there may even be a conflict between the different *CCP*s. E.g. new knowledge may suggest improvements in calculation methods for better *completeness*, but the same improvements may to some degree violate the *consistency* and *comparability* criteria with regard to earlier years' inventories and the reporting from other nations. It is, therefore, a multi-criteria problem of optimisation to apply the set of *CCP*s in the aim for good quality.

1.6.5 Process-oriented QC

The strategy is based on a process-oriented principle (ISO 9000 series) and the first step is, thus, to set up a system for the process of the inventory work. The product specification for the inventory is a dataset of emission figures and the process, thereby, equates with the data flow in the preparation of the inventory.

The data flow needs to support the QC/QA in order to facilitate a cost-effective procedure. The flow of data has to take place in a transparent way by making the transformation of data detectable. It should be easy to find the original background data for any calculation and to trace the sequence of calculations from the raw data to the final emission result. Computer programming for automated calculations and checking will enhance the accuracy and minimize the number of miscalculations and flaws in input value settings. Especially manual typing of numbers needs to be minimized. This assumes, however, that the quality of the programming has been verified to ensure the correctness of the automated calculations. Automated value control is also one of the important means to secure accuracy. Realistic uncertainty estimates are necessary for securing accuracy, but they can be difficult to produce due to the uncertainty related to the uncertainty estimates themselves. It is, therefore, important to include the uncertainty calculation procedures into the data structure as far as possible. The QC/QA needs to be supported as far as possible by the data structure; otherwise the procedures can easily become troublesome and subject to frustration.

Both data processing and data storage form the data structure. The data processing is carried out using mathematical operations or models. The models may be complicated where they concern human activity or be simple summations of lower aggregated data. The data storage includes databases and file systems of data that are either calculated using the data processing at the lower level, using input to new processing steps or even using both output and input in the data structure. The measure for quality is basically different for processing and storage, so these need to be kept separate in a well-designed quality manual. A graphical display of the data flow is seen in Figure 1.3 and explained in the following.

The data storage takes place for the following types of data:

External Data**:** a single numerical value of a parameter coming from an external source. These data govern the calculation of *Emission calculation input.*

Emission calculation input**:** Data for input to the final emission calculation in terms of data for release source strength and activity. The data is directly applicable for use in the standardized forms for calculation. These data are calculated using external data or represent a direct use of *External Data* when they are directly applicable for *Emission Calculations*.

Emission Data**:** Estimated emissions based on the *emission calculation input.*

Emission Reporting**:** Reporting of emission data in requested formats and aggregation level.

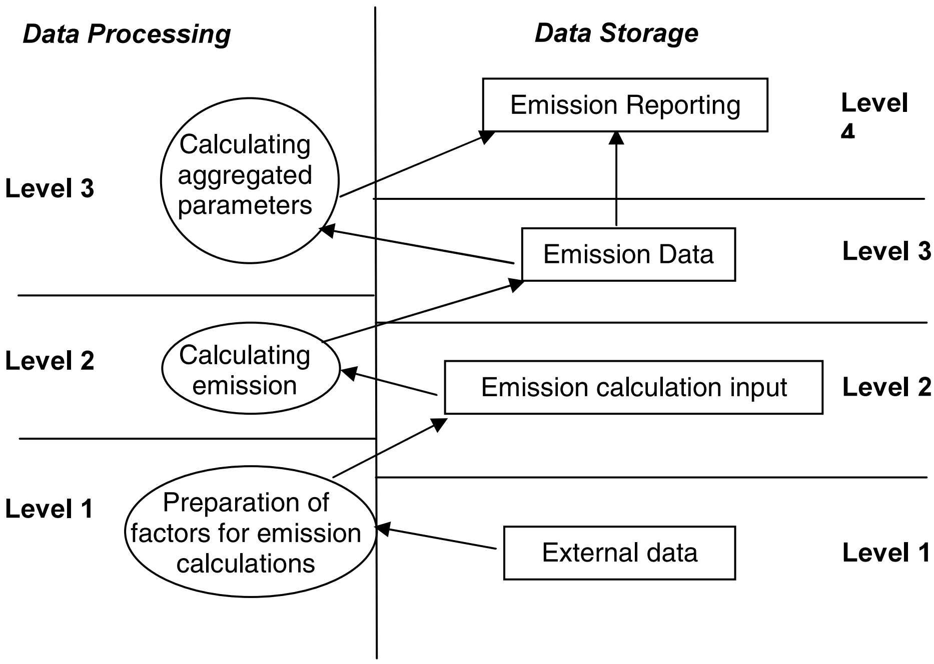


Figure 1.3 The general data structure for the emission inventory.

Key levels are defined in the data structure as:

Data storage Level 1*, *External data

Collection of external data for calculation of emission factors and activity data. The activity data are collected from different sectors and statistical surveys, typically reported on a yearly basis. The data consist of raw data, having an identical format to the data received and gathered from external sources. Level 1 data acts as a base-set, on which all subsequent calculations are based. If alterations in calculation procedures are made, they are based on the same dataset. When new data are introduced they can be implemented in accordance with the QA/QC structure of the inventory.

***Data storage Level 2*,** Data directly usable for the inventory

This level represents data that have been prepared and compiled in a form that is directly applicable for calculation of emissions. The compiled data are structured in a database for internal use as a link between more or less raw data and data that are ready for reporting. The data are compiled in a way that elucidates the different approaches in emission assessment: (1) directly on measured emission rates, especially for larger point sources, (2) based on activities and emission factors, where the value setting of these factors are stored at this level.

Data storage Level 3, Emission data

The emission calculations are reported by the most detailed figures and divided in sectors. The unit at this level is typically mass pr yr for the country. For sources included in the SNAP system, the SNAP level 3 is relevant. Internal reporting is performed at this level to feed the external communication of results.

***Data storage Level 4*,** Final reports for all subcategories

The complete emission inventory is reported to UNFCCC at this level by summing up the results from every subcategory.

Data processing Level 1 Compilation of external data

Preparation of input data for the emission inventory based on the external data sources. Some external data may be used directly as input to the data processing at level 2, while other data needs to be interpreted using more or less complicated models, which takes place at this level. The interpretation of activity data is to be seen in connection with availability of emission factors and vice versa. These models are compiled and processed as an integrated part of the inventory preparation.

Data processing Level 2 Calculation of inventory figures

The emission for every subcategory is calculated, including the uncertainty for all sectors and activities. The summation of all contributions from sub-sources makes up the inventory.

Data processing Level 3 Calculation aggregated parameters

Some aggregated parameters need to be reported as part of the final reporting. This does not involve complicated calculations but important figures, e.g. implied emission factors at a higher aggregated level to be compared in time-series and with other countries.

1.6.6 Definition of Point of Measurements (*PM*)

The *CCP*s have to be based on clear measurable factors, otherwise the *QP* will end up being just a loose declaration of intent. Thus, in the following, a series of *Points for Measuring* (*PM*) is identified as building blocks for a solid *QC*. Table 8.1 in Good Practice Guidance is a listing of such *PM*s. However, the listing in Table 1.1 below is an extended and modified listing, in comparison to Table 8.1. in the Good Practice Guidance supporting all the *CCP*s. The *PM*s will be routinely checked in the QC reporting and, when external reviews take place, the reviewers will be asked to assess the fulfilment of the *PM*s using a checklist system. The list of *PM*s is continually evaluated and modified to offer the best possible support for the *CCP*s. The actual list used is seen in Table 1.2.

Table 1.2 The list of *PM*s as used.

Level	CCP	Id	Description
Data Storage level 1	1. Accuracy	DS.1.1.1	General level of uncertainty for every dataset including the reasoning for the specific values
		DS.1.1.2	Quantification of the uncertainty level of every single data value, including the reasoning for the specific values.
	2. Comparability	DS1.2.1	Comparability of the data values with similar data from other countries, which are comparable with Denmark, and evaluation of the discrepancy.
	3.Completeness	DS.1.3.1	Documentation showing that all possible national data sources are included, by setting down the reasoning behind the selection of datasets.
	4.Consistency	DS.1.4.1	The origin of external data has to be preserved whenever possible without explicit arguments (referring to other PMs)
	6.Robustness	DS.1.6.1	Explicit agreements between the external institution holding the data and NERI about the conditions of delivery
		DS.1.6.2	At least two employees must have a detailed insight into the gathering of every external dataset.
	7.Transparency	DS.1.7.1	Summary of each dataset including the reasoning behind the selection of the specific dataset
		DS.1.7.2	The archiving of datasets needs to be easily accessible for any person in the emission inventory
		DS.1.7.3	References for citation for any external dataset have to be available for any single number in any dataset.
		DS.1.7.4	Listing of external contacts for every dataset
Data Processing level 1	1. Accuracy	DP.1.1.1	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to type of variability. (Distribution as: normal, log normal or other type of variability)
		DP.1.1.2	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to scale of variability (size of variation intervals)
		DP.1.1.3	Evaluation of the methodological approach using international guidelines
		DP.1.1.4	Verification of calculation results using guideline values
	2.Comparability	DP.1.2.1	The inventory calculation has to follow the international guidelines suggested by UNFCCC and IPCC.
	3.Completeness	DP.1.3.1	Assessment of the most important quantitative knowledge which is lacking.
		DP.1.3.2	Assessment of the most important cases where access is lacking with regard to critical data sources that could improve quantitative knowledge.
	4.Consistency	DP.1.4.1	In order to keep consistency at a high level, an explicit description of the activities needs to accompany any change in the calculation procedure
		DP.1.4.2	Identification of parameters (e.g. activity data, constants) that are common to multiple source categories and confirmation that there is consistency in the values used for these parameters in the emission calculations
	5.Correctness	DP.1.5.1	Shows at least once, by independent calculation, the correctness of every data manipulation
		DP.1.5.2	Verification of calculation results using time-series
		DP.1.5.3	Verification of calculation results using other measures
		DP.1.5.4	Show one-to-one correctness between external data sources and the databases at Data Storage level 2

Continued			
Level	CCP	Id	Description
	6.Robustness	DP.1.6.1	Any calculation must be anchored to two responsible persons who can replace each other in the technical issue of performing the calculations.
	7.Transparency	DP.1.7.1	The calculation principle and equations used must be described
		DP.1.7.2	The theoretical reasoning for all methods must be described
		DP.1.7.3	Explicit listing of assumptions behind all methods
		DP.1.7.4	Clear reference to dataset at Data Storage level 1
		DP.1.7.5	A manual log to collect information about recalculations
Data Storage level 2	2.Comparability	DS.2.2.1	Comparison with other countries that are closely related to Denmark and explanation of the largest discrepancies
	5.Correctness	DS.2.5.1	Documentation of a correct connection between all data types at level 2 to data at level 1
		DS.2.5.2	Check if a correct data import to level 2 has been made
	6.Robustness	DS.2.6.1	All persons in the inventory work must be able to handle and understand all data at level 2.
	7.Transparency	DS.2.7.1	The time trend for every single parameter must be graphically available and easy to map
		DS.2.7.2	A clear Id must be given in the dataset having reference to level 1.
Data Processing level 2	1. Accuracy	DP.2.1.1	Documentation of the methodological approach for the uncertainty analysis
		DP.2.1.2	Quantification of uncertainty
	2.Comparability	DP.2.2.1	The inventory calculation has to follow the international guidelines suggested by UNFCCC and IPCC
	6.Robustness	DP.2.6.1	Any calculation at level 4 must be anchored to two responsible persons who can replace each other in the technical issue of performing the calculations.
	7.Transparency	DP.2.7.1	Reporting of the calculation principle and equations used
		DP.2.7.2	Reporting of the theoretical reasoning for all methods
		DP.2.7.3	Reporting of assumptions behind all methods
		DP.2.7.4	The reasoning for the choice of methodology for uncertainty analysis needs to be written explicitly.
Data Storage level 3	1. Accuracy	DS.3.1.1	Quantification of uncertainty
	5.Correctness	DS.3.5.1	Comparison with inventories of the previous years on the level of the categories of the CRF as well as on SNAP source categories. Any major changes are checked, verified, etc.
		DS.3.5.2	Total emissions, when aggregated to CRF source categories, are compared with totals based on SNAP source categories (control of data transfer).
		DS.3.5.3	Checking of time-series of the CRF and SNAP source categories as they are found in the Corinair databases. Considerable trends and changes are checked and explained.
	7.Transparency	DS.3.7.1	Documentation of a correct connection between all data types at DS3 to data at level DS2

Continued			
Level	CCP	Id	Description
Data Processing level 3	7.Transparency	DP.3.7.1	In the calculation sheets, there must be clear Id to Data Storage level 3 data
Data Storage level 4	1. Accuracy	DS.4.1.1	Questionnaire to external experts: The performance of the PMs that relate to accuracy.
	2.Comparability	DS.4.2.1	Description of similarities and differences in relation to other countries' inventories for the methodological approach.
	3.Completeness	DS.4.3.1	Questionnaire to external experts: The performance of the PMs that relate to completeness.
		DS.4.3.2	National and international verification including explanation of the discrepancies.
		DS.4.3.3	Check that the no sources where a methodology exists in the IPCC guidelines are reported as NE by Greenland.
	4.Consistency	DS.4.4.1	The inventory reporting must follow the international guidelines suggested by UNFCCC and IPCC.
		DS.4.4.2	Check time-series consistency of the reporting by Greenland and the Faroe Islands prior to aggregating the final submissions.
	5.Correctness	DS.4.5.1	Check that the aggregated submissions for Denmark under the Kyoto Protocol and the UNFCCC match the sum of the individual submissions.
	7.Transparency	DS.4.7.1	External review for evaluation of the communication performance.
		DS.4.7.2	Perform QA on the documentation report provided by the Government of Greenland.

1.6.7 Plan for the quality work

The IPCC uses the concept of a tiered approach, i.e. a stepwise approach, where complexity, advancement and comprehensiveness increase. Generally, more detailed and advanced methods are recommended in order to give guidance to countries which have more detailed datasets and more capacity, as well as to countries with less available data and manpower. The tiered approach helps to focus attention on the areas of the inventories that are relatively weak, rather than investing effort in irrelevant areas. Furthermore, the IPCC guidelines recommend using higher tier methods for key categories in particular. Therefore, the identification of key categories is crucial for planning quality work. However, there exist several issues regarding the listing of priority categories: (1) The contribution to the total emission figure (key source listing); (2) The contribution to the total uncertainty; (3) Most critical categories in relation to implementation of new methodologies and thus highest risk for miscalculations. All the points listed are necessary for different aspects of producing high quality work. These listings will be used to secure implementation of the full quality scheme for the most relevant categories. Verification in relation to other countries has been undertaken for priority categories.

1.6.8 Implementation of the QA/QC plan

The PMs listed in Table 1.2 are described for each sector in the QA/QC sections of Chapters 3-8, where a status with regard to implementation is also given. Some of the PMs are the same for all sectors and a common description for these PMs is given in Section 1.6.10, below. The focus has been on level 1 for both data storage and data processing as this is the most labour-intensive part. The quality system will be evaluated and adjusted continuously.

1.6.9 Archiving of data and documentations

The QA/QC work is supported by an inventory file system, where all data, models and QA/QC procedures and checks are stored as files in folders (Figure 1.4).

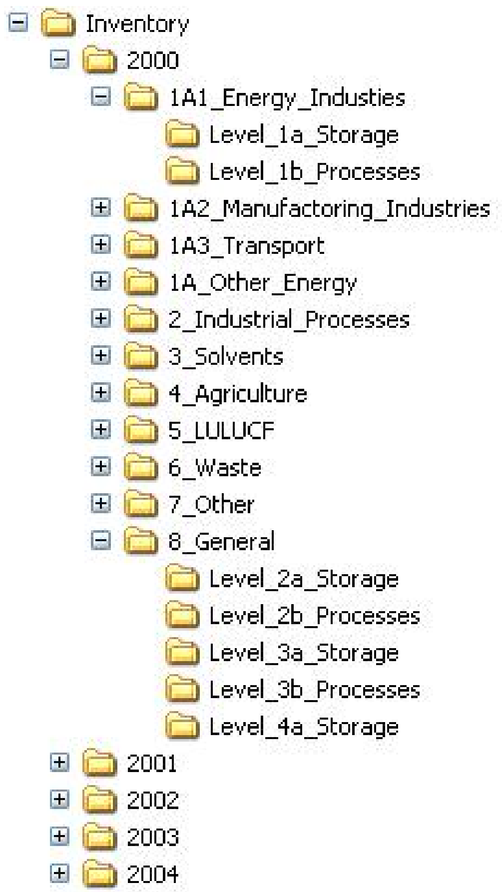


Figure 1.4 Schematic diagram of the folder structure in the inventory file system.

The inventory file system consists of the following levels: year, sector and the level for the process of the inventory work, as illustrated in Figure 1.4. The first level in the file system is year, which here means the inventory year and not the calendar year. The sector level contains the PMs relevant for the individual sectors i.e. the first levels (DS1 and DP1) (except the PMs described in Section 1.6.10), while the rest of the PMs (DS2-4 and DP2-3), are common for all sectors.

All data, models and other QA/QC related files are stored in the inventory file system and are accessible for all staff involved in the inventory work.

1.6.10 Common QA/QC PMs

The following PMs are common for all the sectors:

Data storage Level 1

Data Storage level 1	6. Robustness	DS.1.6.2	At least two employees must have a detailed insight into the gathering of every external dataset.

For all sectors: energy, industrial processes, solvent and other product use, agriculture, LULUCF and waste, two persons have detailed insight in data gathering and processing. A strong effort is continuously made to ensure the robustness of the inventory process.

Data Storage level 1	7. Transparency	DS.1.7.2	The archiving of datasets needs to be easy accessible for any person involved in the emission inventory.

All data, models and other QA/QC related files are stored in the inventory file system and are accessible for all inventory staff members. Refer to Section 1.6.9.

Data processing Level 1

Data Processing level 1	4. Consistency	DP.1.4.2	Identification of parameters (e.g. activity data, constants) that are common to multiple source categories and confirmation that there is consistency in the values used for these parameters in the emission calculations.

This PM is supported by the inventory file system where it is possible to compare and harmonise parameters that are common to multiple source categories.

Data Processing level 1	6.Robustness	DP.1.6.1	Any calculation must be anchored to two responsible persons who can replace each other in the technical issue of performing the calculations.

All data, models and other QA/QC related files are stored in the inventory file system and are accessible for all inventory staff members. Refer to Section 1.6.9.

Data storage Level 2

Data Storage level 2	2.Comparability	DS.2.2.1	Comparison with other countries that are closely related to Denmark and explanation of the largest discrepancies.

Systematic inter-country comparison has only been made on data storage level 4. Refer to DS 4.3.2.

Data Storage level 2	6.Robustness	DS.2.6.1	All persons in the inventory work must be able to handle and understand all data at level 2.

This PM is fulfilled for all sectors. The PM is supported by the inventory file system. Refer to Section 1.6.9.

Data Storage level 2	7.Transparency	DS.2.7.1	The time trend for every single parameter must be graphically available and easy to map.

Programs exist to make time-series for all parameters. A tool for graphically showing time-series has not yet been developed.

Data Storage level 2	7.Transparency	DS.2.7.2	A clear Id must be given in the dataset having reference to level 1.

An overview of all external data is given in DS 1.4.1 including ID numbers for all external datasets. Many references already exist in the databases (level 2) which point to the original source of data, but ID numbers have to be implemented and extended to all data in the databases.

Data Processing Level 2

Data Processing level 2	1. Accuracy	DP.2.1.1	Documentation of the methodological approach for the uncertainty analysis

Refer to chapter 1.7.

Data Processing level 2	1. Accuracy	DP.2.1.2	Quantification of uncertainty

Refer to chapter 1.7 and the QA/QC sections in the sectoral chapters (Chapter 3-8).

Data Processing level 2	2.Comparability	DP.2.2.1	The inventory calculation has to follow the international guidelines suggested by UNFCCC and IPCC.

The emission calculations follow the international guidelines.

Data Processing level 2	6.Robustness	DS.2.6.1	All persons in the inventory work must be able to handle and understand all data at level 2.

At present the emission calculations are carried out using applications developed at NERI. The software development and programme runs are anchored to two inventory staff members.

Data Processing level 2	7.Transparency	DP.2.7.1	Reporting of the calculation principle and equations used.

Due to the uniform treatment of input data in the calculation routines used by the NERI software programmes, a central documentation of calculation principles, equations, theoretical reasoning and assumptions must be given, treating all national emission sources. This documentation still remains to be made, but is planned to be carried out in the future.

Data Processing level 2	7.Transparency	DP.2.7.2	Reporting of the theoretical reasoning for all methods

Due to the uniform treatment of input data in the calculation routines used by the NERI software programmes, a central documentation of calculation principles, equations, theoretical reasoning and assumptions must be given, treating all national emission sources. This documentation still remains to be made, but is planned to be carried out in the future.

Data Processing level 2	7.Transparency	DP.2.7.3	Reporting of assumptions behind all methods

Due to the uniform treatment of input data in the calculation routines used by the NERI software programmes, a central documentation of calculation principles, equations, theoretical reasoning and assumptions must be given, treating all national emission sources. This documentation still remains to be made, but is planned to be carried out in the future.

Data Processing level 2	7.Transparency	DP.2.7.4	The reasoning for the choice of methodology for uncertainty analysis needs to written explicitly.

Refer to chapter 1.7 and the QA/QC sections in the sectoral chapters.

Data storage Level 3

Data Storage level 3	1. Accuracy	DS.3.1.1	Quantification of uncertainty

Refer to chapter 1.7 and the QA/QC sections in the sector chapters.

Data Storage level 3	5.Correctness	DS.3.5.1	Comparison with inventories of the previous years on the level of the categories of the CRF as well as on SNAP source categories. Any major changes are checked, verified, etc.

Time-series is prepared and checked, any major change is closely examined with the purpose of verifying and explaining changes from earlier inventories.

Data Storage level 3	5.Correctness	DS.3.5.2	Total emissions when aggregated to CRF source categories are compared with totals based on SNAP source categories (control of data transfer).

Total emission, when aggregated to IPCC and LRTAP reporting tables, is compared with totals based on SNAP source categories (control of data transfer).

Data Storage level 3	5.Correctness	DS.3.5.3	Checking of time-series of the CRF and SNAP source categories as they are found in the Corinair databases. Considerable trends and changes are checked and explained.

Time-series are prepared and checked, any major change is closely examined with the purpose of verifying and explaining fluctuations.

Data Storage level 3	7.Transparency	DS.3.7.1	Documentation of a correct connection between all data types at DS3 to data at level DS2

A central documentation will be provided, treating all national emission sources.

Data Processing Level 3

Data Processing level 3	7.Transparency	DP.3.7.1	In the calculation sheets, there must be clear Id to Data Storage level 3 data.

A central documentation will be provided, treating all national emission sources.

Data Storage Level 4

Data Storage level 4	1. Accuracy	DS.4.1.1	Questionnaire to external experts: The performance of the PMs that relates to accuracy

This PM is checked when the sectoral reports are reviewed by external experts.

Data Storage level 4	2.Comparability	DS.4.2.1	Description of similarities and differences in relation to other countries' inventories for the methodological approach

For each key source category, a comparison has been made between Denmark and the EU-15 countries. This is performed by comparing emission density indicators, defined as emission intensity value divided by a chosen indicator. The indicators are identical to the ones identified in the Norwegian verification inventory (Holtskog et al., 2000). The correlation between emissions and an independent indicator does not necessarily imply cause and effect, but in cases where the indicator is directly associated with the emission intensity value, such as for the energy sector, the emission density indicator is a measure of the implied emission factor and a direct comparison can be made. A qualitative verification of implied emission factors can, furthermore, be made when a measured or theoretical value of the CO_2 content in the respective fuel type (or other relevant parameter) is available. For the energy sector, all countries are, in principle, comparable and inter-country deviations arise from variations in fuel purities and fuel combustion efficiencies. A comparison of national emission density indicators, analogous to the implied emission factors, will give valuable information on the quality and efficiency of the national energy sectors.

Furthermore, the inter-country comparison of emission density indicators and comparison of theoretical values gives a methodological verification of the derivation of emission intensity values, and of the correlation between emission intensity values and activity values.

When emissions are compared with non-dependent parameters, similarities with regard to geography, climate, industry structure and level of economic development may be necessary for obtaining comparable emission density indicators (Fauser et al., 2007).

Data Storage level 4	3.Completeness	DS.4.3.1	Questionnaire to external experts: The performance of the PMs that relate to completeness

This PM is checked when the sectoral reports are reviewed by external experts. Please see the sectoral chapters for information on the review of sectoral reports.

Data Storage level 4	3.Completeness	DS.4.3.2	National and international validation including explanation of the discrepancies.

Refer to DS 4.2.1

Data Storage level 4	3.Completeness	DS.4.3.3	Check that no sources where a methodology exists in the IPCC guidelines or good practice guidance are reported as NE by Greenland

A check is made to filter any NE's from the CRF tables. If any greenhouse gas emissions are reported as NE, it is checked whether methodologies exist in the IPCC guidelines or the IPCC good practice guidance. If methodologies do exist efforts are made to quickly estimate and report emissions.

Data Storage level 4	4.Consistency	DS.4.4.1	The inventory reporting must follow the international guidelines suggested by UNFCCC and IPCC.

The inventory reporting is in accordance with the UNFCCC guidelines on reporting and review (UNFCCC, 2007). The present report includes detailed and complete information on the inventories for all years from the base year to the year of the current annual inventory submission, in order to ensure the transparency of the inventory. The annual emission inventory for Denmark is reported in the Common Reporting Format (CRF) as requested in the reporting guidelines. The CRF-spreadsheets contain data on emissions, activity data and implied emission factors for each year. Emission trends are given for each greenhouse gas and for total greenhouse gas emissions in CO_2 equivalents. The complete sets of CRF-files are available on the NERI homepage (www.dmu.dk).

Data Storage level 4	4.Consistency	DS.4.4.2	Check time-series consistency of the reporting of Greenland and the Faroe Islands prior to aggregating the final submissions

The time-series for all pollutants in the submissions from Greenland and the Faroe Islands are checked at the CRF 3 level for large variations in the time-series. Any large variations are explained or corrected in cooperation with the authorities in Greenland and the Faroe Islands.

Data Storage level 4	5.Correctness	DS.4.5.1	Check that the aggregated submissions for Denmark under the Kyoto Protocol and the UNFCCC matches the sum of the individual submissions

To ensure that the submission for Denmark under the Kyoto Protocol matches the sum of the submissions of Denmark and Greenland a spreadsheet check has been implemented to ensure complete correctness of the submitted inventory. The same procedure is followed for the submission under the UNFCCC, where it is ensured that the submitted emissions equate to the sum of Denmark, Greenland and the Faroe Islands. Special attention is paid to the additional information provided in the CRF, e.g. for the agricultural sector. Certain parameters can not simply be added, e.g. animal weights. In these cases a weighted average is reported in the CRF tables.

Data Storage level 4	7.Transparency	DS.4.7.1	External review for evaluation of the communication performance

The transparency of the CRF reporting is reviewed by experts when UNFCCC performs annual review of the Danish GHG inventory.

Data Storage level 4	7.Transparency	DS.4.7.2	Perform QA on the documentation report provided by the Government of Greenland

The documentation report is received by NERI from the Government of Greenland in the early spring every year. The documentation report is included in the NIR as Chapter 16. NERI experts read and provide comments on the report to the Government of Greenland, so that any questions are resolved prior to the UNFCCC reporting deadline of April 15.

1.7 General uncertainty evaluation, including data on the overall uncertainty for the inventory totals

1.7.1 Tier 1 uncertainties

The uncertainty estimates are based on the Tier 1 methodology in the IPCC Good Practice Guidance (GPG) (IPCC, 2000). Uncertainty estimates for the following sectors are included in the current year: stationary combustion plants, mobile combustion, fugitive emissions from fuels, industry, solid waste and wastewater treatment, CO_2 from solvents, agriculture and LULUCF. The sources included in the uncertainty estimate cover 100 % of the total net Danish greenhouse gas emissions and removals.

The uncertainties for the activity rates and emission factors are shown in Table 1.3.

Table 1.3 Summary of base year and 2009 emissions in Gg CO_2-eq and activity data and emission factor uncertainties. Calculated Tier 1 and Tier 2 uncertainties for each emission source are given as % of the total 2009 emission. The base year for F-gases is 1995 and for all other sources the base year is 1990. Tier 2 uncertainty is not calculated for LULUCF.

IPCC Source category	Gas	Base year emission Gg CO_2 eq	Year t emission Gg CO_2 eq	Activity data uncertainty %	Emission factor uncertainty %	Tier 1 Combined uncertainty % of total emissions	Tier 2 uncertainty % of total emissions
Stationary Combustion, Coal	CO_2	23 834	15 726	0.9	1.1	0.373	0.357
Stationary Combustion, BKB	CO_2	11	1	3	5	0.000108	0.000104
Stationary Combustion, Coke	CO_2	138	81	2.0	5	0.00730	0.00710
Stationary Combustion, Fossil waste	CO_2	394	1266	4.8	25	0.538	0.570
Stationary Combustion, Petroleum coke	CO_2	410	550	2.0	5	0.0494	0.0477
Stationary Combustion, Residual oil	CO_2	2440	1077	0.88	2	0.0393	0.0379
Stationary Combustion, Gas oil	CO_2	4547	1792	2.5	4	0.141	0.136
Stationary Combustion, Kerosene	CO_2	366	8	2.6	5	0.000742	0.000727
Stationary Combustion, LPG	CO_2	164	88	2.2	5	0.00801	0.00771
Stationary Combustion, Refinery gas	CO_2	816	876	1	2	0.0327	0.0736
Stationary Combustion, Natural gas	CO_2	4335	9380	1.0	0.4	0.170	0.163
Stationary Combustion, SOLID	CH_4	13	4	0.97	100	0.00711	0.0102
Stationary Combustion, LIQUID	CH_4	3	1	1.1	100	0.00217	0.00325
Stationary Combustion, GAS	CH_4	3	6	1	100	0.00994	0.0153
Natural gas fuelled engines, GAS	CH_4	1	192	1	2	0.00716	0.00695
Stationary Combustion, WASTE	CH_4	1	1	5	100	0.00233	0.00337
Stationary Combustion, BIOMASS	CH_4	105	148	20	100	0.252	0.358
Biogas fuelled engines, BIOMASS	CH_4	0	28	3.7	10	0.00499	0.00498
Stationary Combustion, SOLID	N_2O	68	43	0.97	400	0.286	0.406
Stationary Combustion, LIQUID	N_2O	40	16	1.1	1000	0.263	0.339
Stationary Combustion, GAS	N_2O	16	41	1	750	0.510	0.689
Stationary Combustion, WASTE	N_2O	7	16	5	400	0.106	0.151
Stationary Combustion, BIOMASS	N_2O	38	81	2.2	1000	1.35	0.750
Transport, Road transport	CO_2	9282	12125	2	5	1.09	1.07
Transport, Military	CO_2	119	160	2	5	0.0144	0.0140
Transport, Railways	CO_2	297	230	2	5	0.0207	0.0201
Transport, Navigation (small boats)	CO_2	48	100	41	5	0.0689	0.0812
Transport, Navigation (large vessels)	CO_2	748	498	11	5	0.100	0.143
Transport, Fisheries	CO_2	591	557	2	5	0.0501	0.0486
Transport, Agriculture	CO_2	1272	1268	24	5	0.519	0.575
Transport, Forestry	CO_2	36	17	30	5	0.00868	0.00970
Transport, Industry (mobile)	CO_2	842	823	41	5	0.568	0.651
Transport, Residential	CO_2	39	63	35	5	0.0372	0.0422
Transport, Commercial/institutional	CO_2	74	174	35	5	0.103	0.115
Transport, Civil aviation	CO_2	243	156	10	5	0.0290	0.0287
Transport, Road transport	CH_4	53	15	2	40	0.00100	0.0115
Transport, Military	CH_4	0	0	2	100	0.000185	0.000277
Transport, Railways	CH_4	0	0	2	100	0.000234	0.000351
Transport, Navigation (small boats)	CH_4	0	1	41	100	0.000923	0.00146
Transport, Navigation (large vessels)	CH_4	0	0	11	100	0.000386	0.000441
Transport, Fisheries	CH_4	0	0	2	100	0.000475	0.000704
Transport, Agriculture	CH_4	2	2	24	100	0.00350	0.00511
Transport, Forestry	CH_4	0	0	30	100	0.000136	0.000207
Transport, Industry (mobile)	CH_4	1	1	41	100	0.00114	0.00171
Transport, Residential	CH_4	1	1	35	100	0.00244	0.00380
Transport, Commercial/institutional	CH_4	2	4	35	100	0.00622	0.00948
Transport, Civil aviation	CH_4	0	0	10	100	0.000343	0.000497
Transport, Road transport	N_2O	93	119	2	50	0.0996	0.122
Transport, Military	N_2O	1	2	2	1000	0.0285	0.0452
Transport, Railways	N_2O	3	2	2	1000	0.0329	0.0474

Continued							
Transport, Navigation (small boats)	N_2O	0	1	41	1000	0.0180	0.0265
Transport, Navigation (large vessels)	N_2O	15	10	11	1000	0.163	0.194
Transport, Fisheries	N_2O	11	11	2	1000	0.182	0.240
Transport, Agriculture	N_2O	15	17	24	1000	0.278	0.406
Transport, Forestry	N_2O	0	0	30	1000	0.00281	0.00414
Transport, Industry (mobile)	N_2O	11	11	41	1000	0.181	0.251
Transport, Residential	N_2O	0	0	35	1000	0.00558	0.00845
Transport, Commercial/institutional	N_2O	0	1	35	1000	0.0138	0.0182
Transport, Civil aviation	N_2O	3	3	10	1000	0.0419	0.0608
1.B.2. Flaring in refinery	CO_2	24	17	11	5	0.00341	0.00314
1.B.2. Flaring off-shore	CO_2	276	241	7.5	5	0.0363	0.0313
1.B.2. Flaring in refinery	CH_4	1	0	11	15	3.52E-05	3.69E-05
1.B.2. Flaring off-shore	CH_4	0	1	7.5	5	0.000171	0.00384
1.B.2. Refinery processes	CH_4	1	45	1	125	0.0937	0.148
1.B.2. Land based activities	CH_4	17	29	2	40	0.0195	0.0224
1.B.2. Off-shore activities	CH_4	15	37	2	30	0.0187	0.0209
1.B.2. Transmission of natural gas	CH_4	4	0	15	5	5.1E-05	4.93E-05
1.B.2. Distribution of natural gas	CH_4	5	3	25	10	0.00127	0.00727
1.B.2 Venting in gas storage	CH_4	0	1	15	5	0.000294	0.000284
1.B.2. Flaring in refinery	N_2O	0	0	11	500	0.000363	0.000975
1.B.2. Flaring off-shore	N_2O	1	1	7.5	500	0.0047	0.0121
2A1 Cement production	CO_2	882	764	1	2	0.0286	0.0277
2A2 Lime production	CO_2	116	43	5	5	0.00511	0.00508
2A3 Limestone and dolomite use	CO_2	14	38	5	5	0.00448	0.00432
2A5 Asphalt roofing	CO_2	0	0	5	25	6.61E-06	6.92E-06
2A6 Road paving with asphalt	CO_2	2	2	5	25	0.0007	0.000759
2A7 Glass and Glass wool	CO_2	55	34	5	2	0.00303	0.000945
2B5 Catalysts/Fertilizers, Pesticides and Sulphuric acid	CO_2	1	2	5	5	0.000251	0.000247
2C1 Iron and steel production	CO_2	28	0	5	5	0	0
2D2 Food and Drink	CO_2	4	2	5	5	0.000227	0.000214
2G Lubricants	CO_2	50	31	2	5	0.00281	0.00273
2B2 Nitric acid production	N_2O	1043	0	2	25	0	0
2F Consumption of HFC	HFC	218	799	10	50	0.680	0.810
2F Consumption of PFC	PFC	1	14	10	50	0.0121	0.0144
2F Consumption of SF6	SF_6	107	37	10	50	0.0312	0.0375
3A Paint application	CO_2	26	9	10	15	0.00260	0.00270
3B Degreasing and dry cleaning	CO_2	0	0	10	15	2.1E-09	2.21E-09
3C Chemical products, manufacturing and processing	CO_2	23	12	10	15	0.00368	0.00380
3D5 Other	CO_2	86	44	10	20	0.0163	0.0170
3D5 Consumption of fireworks	CO2	0	0	8	300	0.00117	0.00113
3D5 Consumption of fireworks	CH_4	0	0	8	300	0	0.000444
3D1 Other - Use of N2O for Anaesthesia	N_2O	0	34	5	5	0.00399	0.00385
3D5 Consumption of fireworks	N_2O	1	3	8	300	0.0162	0.0151
4A Enteric Fermentation	CH_4	3249	2859	2	20	0.960	0.995
4B Manure Management	CH_4	976	1228	5	20	0.423	0.457
4F Field burning af agricultural residues	CH_4	2	3	25	50	0.00268	0.000154
4.B Manure Management	N_2O	604	426	22	50	0.390	0.483
4.D1.1 Syntehetic Fertilizer	N_2O	2395	1196	25	100	2.06	3.15
4.D1.2 Animal waste applied to soils	N_2O	1097	1163	30	100	2.03	3.10
4.D1.3 N-fixing crops	N_2O	269	248	20	100	0.422	0.614
4.D1.4 Crop Residue	N_2O	361	312	20	100	0.531	0.812
4.D1.5 Cultivation of histosols	N_2O	171	164	20	100	0.279	0.418
4.D.2 Grassing animals	N_2O	311	213	25	100	0.367	0.554
4.D3 Atmospheric deposition	N_2O	465	296	19	100	0.503	0.754

Continued							
4.D3 Leaching	N_2O	2455	1416	20	100	2.41	3.60
4.D1.6 Sewage sludge and Industrial waste used as fertiliser	N_2O	28	81	20	100	0.138	0.202
4.F Field Burning of Agricultural Residues	N_2O	1	1	25	50	0.00103	0.00125
5.A.1 Broadleaves	CO_2	-659	-1012	15	50	-0.882	
5.A.1 Conifers	CO_2	-66	-1579	15	50	-1.38	
5.A.2 Broadleaves	CO_2	3	-78	15	50	-0.0684	
5.A.2 Conifers	CO_2	7	-67	15	50	-0.0584	
5IID Forest Land.	N_2O	16	12	30	75	0.0162	
5.B Cropland, Living biomass	CO_2	174	76	10	50	0.0645	
5.B Cropland, Dead organic matter	CO_2	6	1	10	50	0.00111	
5.B Cropland, Mineral soils	CO_2	1054	-198	10	75	-0.250	
5.B Cropland, Organic soils	CO_2	1343	1282	10	90	1.94	
5.B Disturbance, Land converted to cropland	N_2O	3	0	50	75	0.000619	
5.C Grassland, Living biomass	CO_2	304	35	10	50	0.0297	
5.C Grassland, Dead organic matter	CO_2	32	3	10	50	0.00222	
5.C Grassland, Mineral soils	CO_2	1	24	10	75	0.0308	
5.C Grassland, Organic soils	CO_2	137	137	10	90	0.208	
5.D Wetlands, Living biomass	CO_2	0	-11	10	50	-0.00965	
5.D Wetlands, Dead organic matter	CO_2	0	0	10	100	0.000182	
5.D Wetlands, Soils	CO_2	86	16	10	100	0.0272	
5IID Wetlands. Peatland	N_2O	0	0	10	100	0.000227	
5.E Settlements, Living biomass	CO_2	90	55	10	50	0.0466	
5IV Cropland Limestone	CO_2	623	186	0	0	0	
6 A. Solid Waste Disposal on Land	CH_4	1111	1039	10	118	2.05	1.89
6 B. Wastewater Handling	CH_4	66	75	44	78	0.112	0.0772
5 B. Wastewater Handling - Direct	N_2O	27	47	37	98	0.0829	0.0173
6 B. Wastewater Handling - Indirect	N_2O	82	34	59	39	0.0396	0.0151
6.D Accidental fires, buildings	CO_2	15	18	10	500	0.147	0.134
6.D Accidental fires, vehicles	CO_2	7	10	10	500	0.0839	0.0760
6.C Incineration of corpses	CH_4	0	0	1	150	2.62E-05	2.45E-05
6.C Incineration of carcasses	CH_4	0	0	40	150	1.32E-05	1.30E-05
6.D Compost production	CH_4	27	78	40	100	0.140	0.144
6.D Accidental fires, buildings	CH_4	2	3	10	700	0.0332	0.0295
6.D Accidental fires, vehicles	CH_4	0	0	10	700	0.00514	0.00508
6.C Incineration of corpses	N_2O	0	0	1	150	0.000484	0.000455
6.C Incineration of carcasses	N_2O	0	0	40	150	0.000243	0.000245
6.D Compost production	N_2O	11	40	40	100	0.0728	0.0730
6.D Accidental fires, buildings	N_2O	0	0	0	0	0	0
6.D Accidental fires, vehicles	N_2O	0	0	0	0	0	0

1.7.2 Results of the tier 1 uncertainty estimation

The estimated uncertainties for total GHG and for CO_2, CH_4, N_2O and F-gases are shown in Table 1.4. The base year for F-gases is 1995 and for all other sources the base year is 1990. The total Danish net GHG emission is estimated with an uncertainty of ±5.7 % and the trend in net GHG emission since 1990 has been estimated to be -16.2 % ± 3.0 %-age points. The GHG uncertainty estimates do not take into account the uncertainty of the GWP factors.

The uncertainty on CH_4 emission from solid waste disposal, N_2O emission from leaching and run-off and N_2O emission from synthetic fertiliser are the largest sources of uncertainty for the Danish GHG inventory.

The uncertainty of the GHG emission from combustion (sector 1A) is 2.7 % and the trend uncertainty is -7.5 % ±2.0 %-age points.

Table 1.4 Uncertainties 1990-2009.

	Uncertainty [%]	Trend [%]	Uncertainty in trend [%-age points]
GHG	5.7	-16.2	± 3.0
CO_2	3.8	-15.5	± 2.7
CH_4	24	2.5	± 4.8
N_2O	42	-37	± 12
F-gases	48	+161	± 62

1.7.3 Tier 2 uncertainties

On the recommendation of recent ERTs Denmark has undertaken a tier 2 uncertainty analysis. Please see the sectoral chapters for the sectoral results of the tier 2 uncertainty analysis. Below is a description on the theoretical basis for the tier 2 uncertainty calculations. For the overall result please refer to Chapter 1.7.4.

When to use Tier 2

When the activity data and emission factors cannot fulfil the criteria for using the error propagation equations in Tier 1 an alternative stochastic simulation, i.e. Monte Carlo method, can be employed. The Monte Carlo method constitutes Tier 2 and Approach 2 in IPCC (2000 and 2006) and is suitable for estimating uncertainty in emission rates, from uncertainties in activity data and emission factors, when:

- Uncertainties are large.
- Their distribution are non-normal.
- The algorithms are complex function and not only simple multiplication of activity data with emission factors.
- Correlations occur between some of the activi.ty data sets, emission factors, or both.

Uncertainties found in inventory source categories can vary widely from a few percent to orders of magnitude. When using a normal distribution for a parameter with large uncertainty there is a risk of having a certain probability for negative values, which is not possible in reality. Furthermore large uncertainty gives a certain probability of having extremely large values, i.e. values orders of magnitude larger than the mean value. Extreme values are an often occurring quality for the distribution of realistic activity data and emission factors. However, in some cases the extreme values are unrealistic and here the method allows for upper and lower truncation of input parameters. This implies applying a lower and/or upper boundary for the distribution function of input parameters. A logarithmic plot of data with large uncertainties will transform a skewed distribution probability function (a) into a bell-shaped log-normal distribution function (b), cf. Figure 1.5. The latter can be defined by a mean value, α, and standard deviation, σ, respectively. The log-normal distribution is selected as standard in the first version of the Tier 2 and Approach 2 uncertainty assessment for year 2009. A further feature of applying truncation boundaries is that a probability distribution will converge towards a box distribution when narrowing the truncation interval.

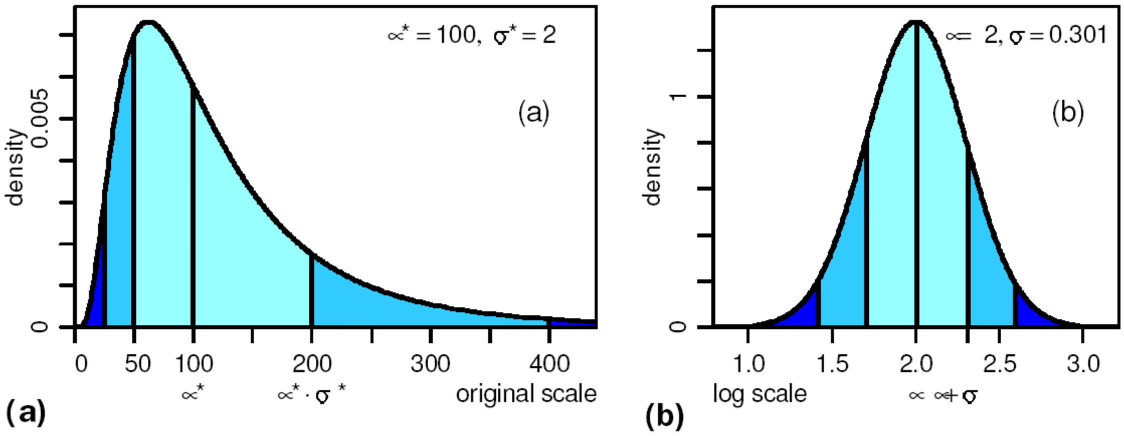


Figure 1.5 Log-normal distribution ($\log_{10}$), both on original (a) and log scale (b). The median (α^*) is 100 and the multiple standard deviation (σ^*) is 2. The resulting median (equal mean) and the standard deviation in the $\log_{10}$ distribution is respectively $\alpha = \log_{10}(100) = 2$ and $\sigma = \log_{10}(2) = 0.301$ (Limbert et al., 2001).

In case the uncertainty is much smaller than the mean value then the normal and log-normal distributions will not differ much, cf. Figure 1.6, where the relationship between normal and log-normal distributions are illustrated (Limbert et al., 2001).

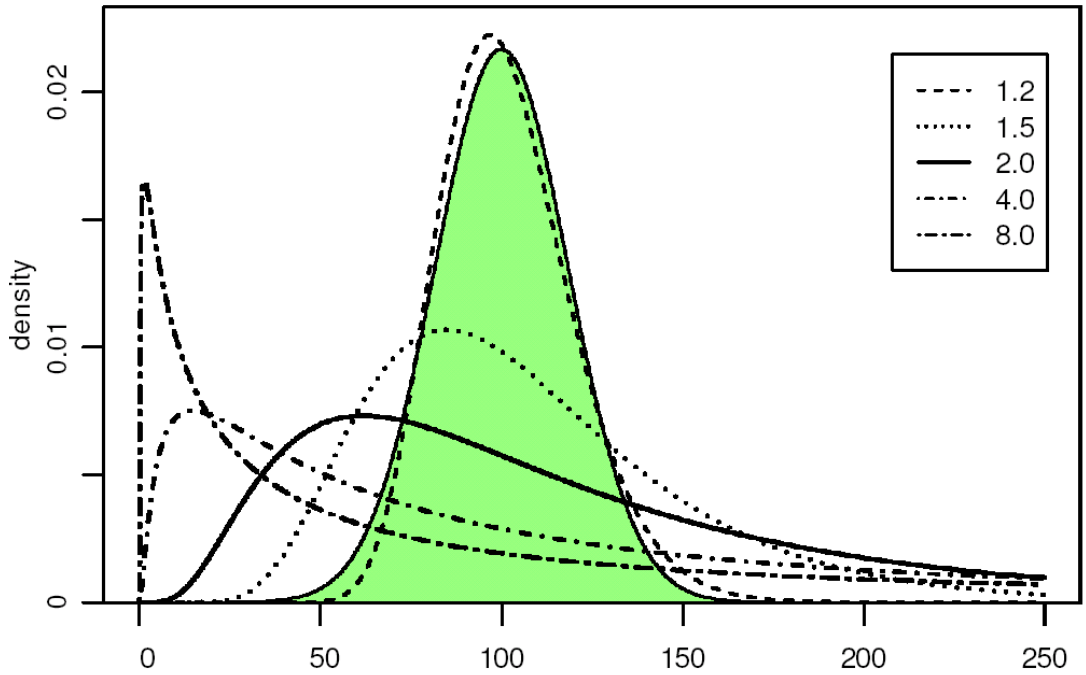


Figure 1.6 Comparison between the normal distribution (green area, median 100, standard deviation 20) the different degrees of variability (described by σ^*) for log-normal distributions that all have the same median value, i.e. α^* on original scale, of 100 (Limbert et al., 2001).

The difference in shape between a normal and log-normal distribution is seen in Figure 1.6 for different values of σ^*. The standard deviation for the normal distribution is 20 and thus equal to 20 % of the mean value and the log-normal distribution having a σ^* value of 1.2 reflects the same level of "deviation" as in the normal distribution. So, the discrepancy between the green area and the curve for σ^*=1.2 illustrates the difference in interpretation of a 20 % deviation as measured by respectively the normal and log-normal distribution. This discrepancy is so limited that it is overruled by the vagueness related to empirical quantification of the uncertainty level based on expert knowledge and data and the fact that any assumed distribution function is an approximation. Therefore, by using log-normal distributions as standard description of all uncertainty input it will in reality include normal distributions when the magnitude of uncertainty is limited to a minor fraction of the mean value.

A way of calculating the intervals of confidence, expressed by the median (α^*) and standard deviation (σ^*), for a log-normal distribution on original scale, cf. Figure 1a, is presented in Limbert et al. (2001). For normally distributed data, the interval [median ± standard deviation] covers a probability of 68.3 %, while [median ± 2*standard deviation] covers 95.5 %. Correspondingly for log normal data on original scale, cf. Figure 1a, the interval [α^* / σ^*, $\alpha^* * \sigma^*$] covers 68.3 % and the interval [$\alpha^* / (\sigma^*)^2$, $\alpha^* * (\sigma^*)^2$] covers 95.5 %.

Often the default uncertainty values in IPCC (2000) e.g. for emission factors, are expressed as a percentage, e.g. 30 %. When this represents a standard deviation (68.3 %) on original scale we will proceed using σ^* = 1.3 in the uncertainty analysis. When it represents a 95 % interval of confidence, we will use σ^* = (1.3)^0.5 = 1.14 in the uncertainty analysis. When the 95 % interval of confidence on original scale is below approximately 300 % the standard deviation for a log-normal distribution on original scale, can be approximated by dividing with a factor of 2, i.e. 0.3/2 = 0.15, and thus σ^* = 1.15.

Procedure of Tier 2 (Monte Carlo method)

The procedure of the Tier 2 (MC) analysis consists of four steps where only Step 1 requires effort from the user:

- Step 1: Estimation of activity data and emission factors, their associated mean values, uncertainties such as standard deviation, probability density functions and any correlations.
- Step 2: Selection of random values of activity data and emission factors.
- Step 3: Calculate emissions from selected random values.
- Step 4: The calculated result in step 3 is stored and the process is repeated from step 2.

Repetition of steps 2 and 3 are continued until the calculated mean value and error intervals are sufficiently determined (typically 10,000 times). Each single repetition is denoted a "single sample" in the following and one execution of steps 2 and 3 is denoted a "MC sample".

The software is developed in excel VBA programming by a scientist associated with the sector experts, which enables a transparent and accurate transfer and interpretation of emission factors and activity data (input) and calculated emissions with uncertainties (output).

Different criteria and guidelines for estimation of value uncertainty for activity data and emission factors are outlined in the next section. Whether they are based on information from models, empirical data or expert judgement, they form lines of evidence towards the most appropriate estimate. The basic paradigm for a MC analysis is outlined in Figure 1.7.

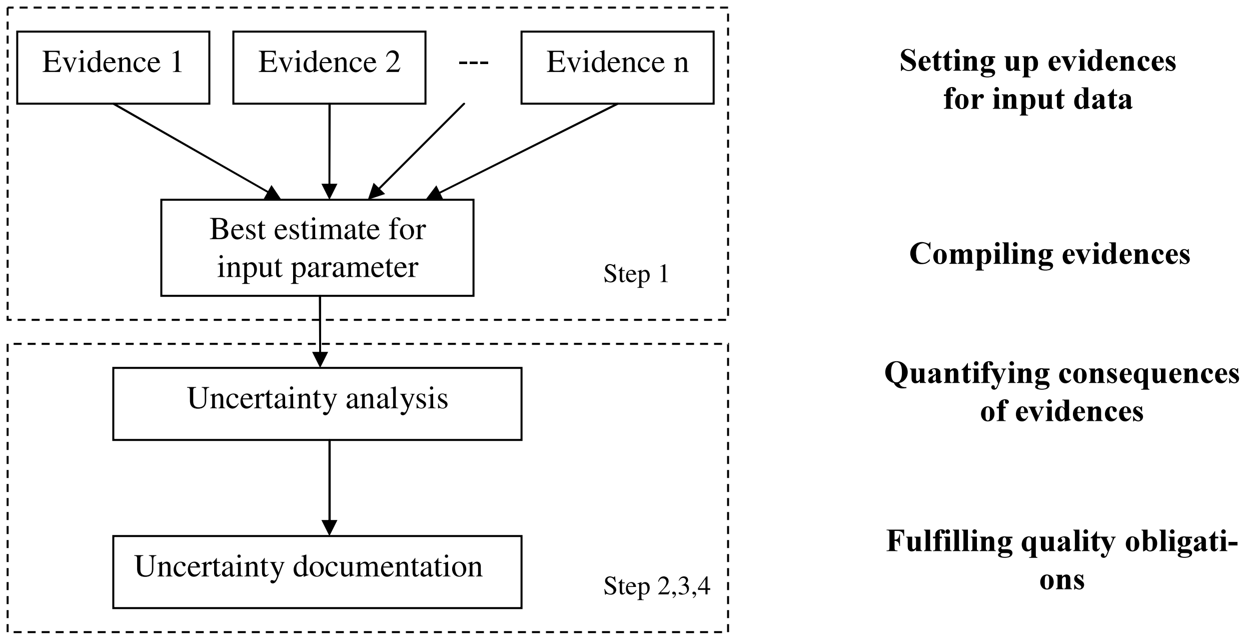


Figure 1.7 Methodological principle in compiling and quantifying input data for input parameters, e.g. emission factors, which are to be used in Tier 2 (MC) uncertainty analysis. Each evidence is formed from assessment of information from models, empirical data or expert judgement. The upper dotted box represents step 1 in the MC analysis, which is performed for each input parameter. The lower dotted box represents steps 2 to 4, and is performed in the emission modelling with all input parameters.

The principle of the MC method is to generate many "possible" calculations and thus map the resulting "possible" results. The possible calculations are made based on the "realistic" variability (uncertainty) related to the input parameter values. This variability needs to be described as a distribution function. The MC method is considered in two parts: (1) A distribution estimation part, where the variabilities of the input parameters are parameterised; (2) A technical part that makes the simulation based on the estimated distributions. The first part is highly critical and requires high attention. The second part is a question of programming and therefore mostly a technical issue. The MC method is a model for how uncertainty of input parameters influences the calculation results, so the MC also involves uncertainty in the prediction of uncertainty. It is therefore important to predict the variability of the input parameters as correctly as possible. The MC method does not include the validity of the calculations as estimators of reality but only the uncertainty of the input parameter values. Consequently, there are many fundamental types of uncertainty that are not included in the MC method.

The method is based on single samples, where the mean is unity and where the variability is determined by the uncertainty of the parameter as discussed above, see Figure 1.8. This sampled value is subsequently multiplied with the best estimate of the parameter value to yield a sampled value for this parameter. The reason for this two stage sampling is that it makes it possible directly to include correlation in uncertainty between years as explained below.

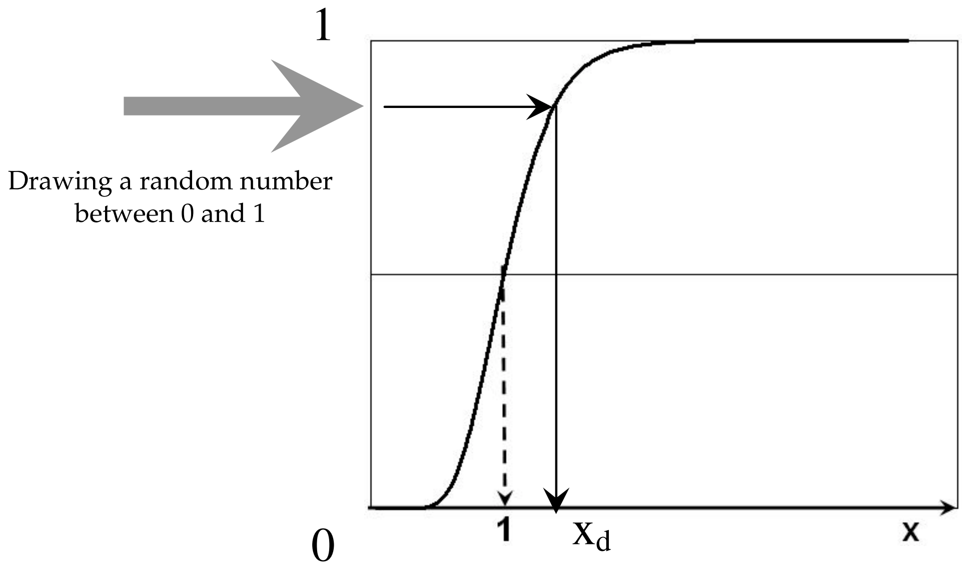


Figure 1.8 The principle in a single MC draw of the value x_d, where the median (α^*) is unity and where the standard deviation (σ^*) determines the variation around 1.

Correlation in the uncertainty may occur between years, e.g. when the same sources are responsible for uncertainties in several years. This takes place because many sources of uncertainty are dependent between years, so if a parameter is over-estimated for one year then this parameter may also tend to be overestimated other years. This implies that when the uncertainty is high one year the uncertainty will also be high the other year(s). The principle of performing a MC analysis with an emission factor and activity data that have uncertainties that are correlated between one or more years is illustrated in Figure 1.9.

The principle in Figure 1.9 is to sample a value (*x*) as shown in Figure 4, where the median value is unity and subsequently multiply the sampled value with the estimated median value (e.g. $AD_{s1}=AD_1 \cdot x$). This two-step approach makes is possible to include correlating uncertainty between different years. If two years are correlated then a deviation from the estimated mean value is assumed to be the same in relative terms for the two years. By sampling, using the median of unity once, and subsequently use this value to estimate the value for the two years, using the two medians for each year, this will yield the correlation between the two years as a simple consequence and thereby be directly simulated in the MC sampling.

The MC sampling is illustrated in Figure 1.9 for a single source, where *s* is the sampling number index, counting up to e.g. 10,000. In Figure 5 there will be a strong correlation between year 2 and 3, because both the uncertainty of *EF* and *AD* is correlated, for year 1 there will be a partial correlation with respectively year 2 and 3 because the uncertainty of the *EF* value is correlated, but the uncertainty is independent for *AD*. Year 4 is completely independent of the other years. The figure is only illustrating a single source and typically the emission estimates includes several sources each having some more or less correlated uncertainty. The final emission estimates are thus more or less correlated between years in a highly complex way.

Performing MC analysis for correlated parameters corresponds to the calculation scheme for MC analysis of emissions and the trend of a category as shown in Appendix A (IPCC, 2006) (Figure 3.7 pp. 3.36). The scheme shows calculations for correlated and non-correlated parameters.

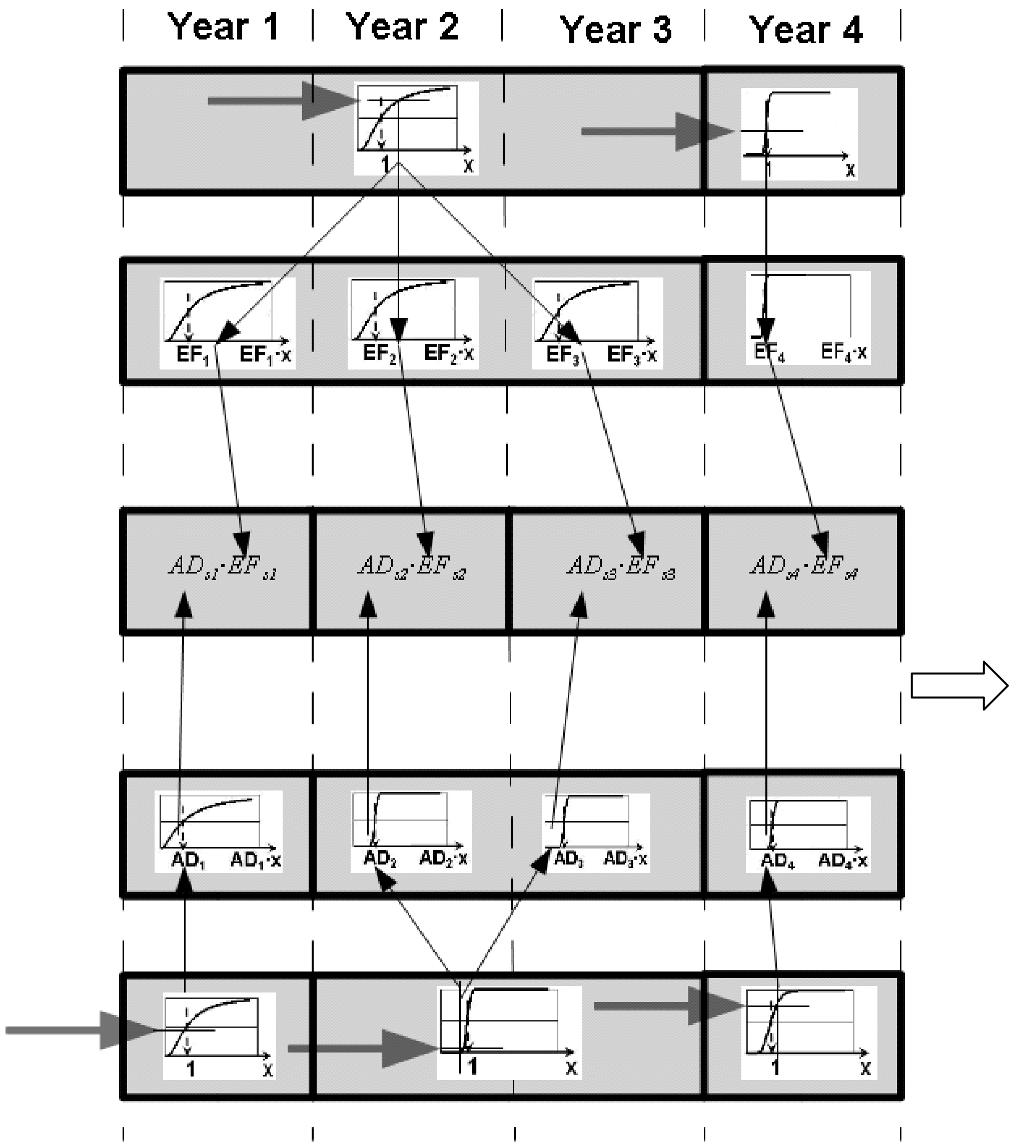


Figure 1.9 The principle of a MC sample for draws of random numbers and generation of any emission factor and activity data for a four year period. The upper half illustrates the sampling of any emission factor for year 1 to year 4. The uncertainty associated to the emission factor is correlated for year 1, 2 and 3 and therefore the same random number is used for generating EF1, EF2 and EF3. The lower half illustrates the sampling of activity data. The uncertainty associated to the activity data is correlated for year 2 and 3 and therefore the same random number is used for generating AC2 and AC3. In the middle row the emission factor and activity data are multiplied for each year.

In some cases there exist additional a priori information about categories of activity data, where the total sum is know with high certainty, but where the sub categories are more uncertain. In this case the single samples within one year are adjusted so all sub sources together adds up to the correct total number and the single sampling in this case will describe the uncertainty between the single categories.

MC analyses for emissions

When a 95% confidence interval has been entered as percentages of median values of the input parameters, i.e. emission factors and activity data, for source categories and sub-categories, the above MC procedure is executed 10,000 times. The output of the MC analysis is reported as in Table 1.5 where the median emissions are shown together with the 95% confidence interval (2.5% - 97.5%).

Two basic questions are important to answer: (1) What is the uncertainty for a time trend estimate; (2) What is the uncertainty within the same year of the single sub-categories, source categories and the total estimate. The first question takes correlation of uncertainty between years into account and the second question considers one year at a time and correlation between years is not relevant.

In the ideal case it will be possible to answer the two questions based on the same MC samples, where every single sample is stored for every source and for every year. However, this is not possible in the VBA programming due to limitations in variable table on a normal pc. Thus two MC samplings take place: (1) The total emission is calculated for every year and every MC sample, so for 10,000 MC samples and 20 years, this needs storage of 200,000 numbers; (2) Every year is analysed separately where only results for one year is stored at a time, so for 10,000 MC samples and 50 sources this yields 500,000 numbers to be stored. Using this two-stage approach it is easily possible to run the MC analysis in Excel. Consequently, the exact value for the median analysed for a specific year (question 2 above) is not similar with the medians in the time trend analysis (question 1 above) due to a finite number of MC samples, but this is not a real problem. If this discrepancy is considered as critical then it simply tells that the number of MC samples should be increased and that the analysis thus has to be redone.

Table 1.5 Example of output scheme for tier 2 MC uncertainty analysis. Median emissions and 95 % confidence intervals are calculated for total emission, emissions for source categories and emissions for sub-categories. Calculated 95% confidence intervals are furthermore calculated for activity data and emission factors.

Source category	Sub-categories	Activity			EF			Emissions			
		< 2.5%	>97.5%	Interval	< 2.5%	> 97.5%	Interval	Median	< 2.5%	> 97.5%	Interval
all	all	-	-	-	-	-	-				
A	all	-	-	-	-	-	-				
B	all	-	-	-	-	-	-				
C	all	-	-	-	-	-	-				
A	1										
A	2										
A	3										
B	1										
B	2										
C	1										
C	2										
C	3										
C	4										

Results for each row can also be reported as:

Median emission [- (median - <2.5%)/median/100%, + (>97.5% - median)/median/100%]

MC trend analysis

The trend analysis is performed by comparing emissions two years at a time. The probability for Year 1 to be above Year 2 is calculated using the equation:

$$P_{Year1>Year2} = \frac{N_{year1>year2} - N_{year2>year1}}{N_{year1>year2} + N_{year2>year1}},$$

where $N_{year1>year\,2}$ is the number of MC samples where year 1 is estimated to have higher emission than year 2, while $N_{year2>year2}$ is the reverse, where year 2 is estimated to have higher emission compared to year 1. In case of $P_{year1>year2} \approx 1$ it is strongly significant to conclude that year 1 has higher emission than year 2, and reverse (significant that year 2 > year 1) for $P_{year1>year2} \approx -1$. This is a comparison between years in pairs that can be filled in to a matrix, where all years are compared with all other years.

Table 1.6 Comparison of emissions between years in trend analysis.

	year 1	year 2	year 3	year 4
year 1	0			
year 2		0		
year 3			0	
year 4				0

Results for trend analysis of emissions between two years, year 1 and year 2, can be reported as median difference, <2.5% and >97.5%, or as:

Median difference [- (median difference - <2.5%)/median difference/100%, + (>97.5% - median difference)/median difference/100%]

Quantifying uncertainties in Tier 2

In order to perform the four steps of a Tier 2 (MC) uncertainty analysis as described in the previous paragraph the user has to gather the information stated in step 1. It is essential to establish the best possible estimate, and the following guide sets up a procedure for assessing, quantifying and compiling uncertainties for the parameters that are entered in the emission models. The guide is based on IPCC guidelines (IPCC, 2000 & 2006) and NUSAP and expert elicitation in van der Sluijs et al. (2004).

The uncertainty of a parameter, e.g. activity data and emission factor, is considered to be proportional to the associated parameter. This means that the uncertainty is expressed as a percentage of the parameter value. The median value is used and the uncertainties represent the parameter standard deviation, σ^*. We assume log-normal distributions, which equals normal distributions at low uncertainty values. Although van der Sluijs et al. (2004) suggest different probability distribution functions depending on the level of knowledge on input parameters we will use log-normal distributions for all parameters, as argued in the previous sectio.

The methodology offers a possibility for correlating the uncertainties of two or more parameters. When uncertainties of two or more parameters are assumed to be correlated they will be attributed the same random number in any MC sample, as explained in the previous paragraph.

Uncertainties will be reported according to the IPCC General Reporting Table for Uncertainty. Uncertainties will be reported for:

- Total uncertainty of the entire sector
- Key source categories
- Aggregated CRF levels
- Most differentiated CRF category levels that are entered by the user

IPCC guideline - Sources of data

Quantifying uncertainties is dependent on the source of data, and in general there are three broad sources of data and information (IPCC, 2000 & 2006):

Information contained in models

A model is a representation of the real world and does therefore not exactly mimic real-world systems. The structure of a model is often thought of in terms of the equations used. The key considerations in model uncertainty are; has the correct, most relevant real-world system been identified and are the model equations accurate representations of the chosen system. Typically the model equations are the product of activity data and emission factors, cf. Eq 1, but there may also be more complex model equations for emissions and also for derivation of activity data and emission factors.

In some cases, model uncertainty can be significant. It is typically poorly characterised and may not be characterised at all. The inventory expert must consider the parameters that are used and assess if there are model assumptions that are imprecise or inaccurate. For the most critical models an effort can be made to evaluate and quantify the size of the potential error that occurs from using the model. There are at least three approaches for estimating the model uncertainty: 1) comparison of a model result with independent data, 2) comparison of a model result with the result of alternative models, and 3) expert judgement regarding the magnitude of the model uncertainty. These approaches can be used in combination.

Empirical data for sources and sinks and activity

This implies empirical data associated with measurements of emissions, emission factors and activity data from surveys and censuses. When estimating uncertainty from measured emissions data, considerations include; Representativeness of the data and potential for bias, precision and accuracy of the measurements, sample size and inter-individual variability in measurements and their implications for uncertainty in mean annual emissions, inter-annual variability in emissions and whether estimates are based on an average of several years or on the basis of a particular year.

Quantification of uncertainties and defining the probability distribution function (PDF) for empirical data can be summarised as follows: 1) Compilation of activity data, emission factors and other parameters. These data typically represent variability, 2) Visualisation of data by plotting empirical distribution functions for each parameter; horizontally according to numerical value or interval and vertically by frequency, 3) Fitting, evaluation and selection of PDFs for representing variability of data, 4) Characterisation of mean value and of uncertainty in the mean of the distributions for variability. If the standard error of the mean is small, a normality assumption can be made regardless of the sample size or skewness of data. If the standard error of the mean is large, then typically a log-normality assumption can be made, 5) Once mean values, uncertainties and standard errors have been specified, these can be used as input to Tier 2 MC analysis for estimating uncertainties in total emissions, 6) Sensitivity analysis can be used to determine which parameters induce highest uncertainties in the total uncertainty, and prioritise efforts to develop good estimates of these key uncertainties.

Expert judgement as a source of information

In many situations, relevant empirical data are not available for activity data, emission factors etc. to an inventory. In such situations, a practical solution is to obtain well informed judgements from domain experts regarding best estimates and uncertainties of input data.

Commonly used methods for converting an expert's judgement regarding uncertainty into a quantitative PDF are: 1) Fixed value; Estimate the probability of being higher (or lower) than an arbitrary value and repeat, three or five times. For example, what is the probability that an emission factor would be less than 100? 2) Fixed probability; Estimate the value associated with a specified probability of being higher (or lower). For example, what is the emission factor such that there is only a 2.5% probability that the emission factor could be lower (or higher) than that value, 3) Interval methods; For example, choose a value of the emission factor such that it is equally likely that the true emission factor would be higher or lower than that value. This yields the median. Then divide the lower range into two bins such that there is assumed to be equally likely (25% probability) that the emission factor could be in either bin. Repeat this for the other end of the distribution. Finally, either fixed probability or fixed value methods could be used to get judgements for extreme values, 4) Graphing; the expert draws a distribution. This should be used cautiously because some experts are overconfident about their knowledge of PDFs.

Sometimes the only available expert judgement consists of a range, maybe quoted together with a most likely value. Under these circumstances the following rules are considered good practice: Where experts only provide an upper and a lower value, assume that the PDF is uniform and that the range corresponds to the 95 percent confidence interval. Where experts also provide a most likely value (point estimate), assume a triangular PDF using the most likely values as the mode and assume that the upper and lower values each exclude 2.5% of the population. The distribution needs not to be symmetrical. Normal or log-normal distributions can be used given appropriate justifications.

Concluding remarks and planned improvements

Tier 2 uncertainties are found to be greater than Tier 1 uncertainties. When large input uncertainties, e.g. > 10%, are used, the deviation becomes pronounced. For smaller input uncertainties, e.g. < 1%, tier1 approximates Tier 2 calculations.

The Log-normal distribution was selected due the likely conditions for the distribution as being close to a normal distribution for smaller uncertainties on one hand and close to the understanding of larger uncertainties on the other hand. However, in case of larger uncertainty the outcome of the MC analysis includes rather extreme values that in some cases are unrealistic. The method therefore allows for truncation of input uncertainties, either a lower boundary, upper boundary or both, depending of which truncation is most realistic.

1.7.4 Results of the tier 2 uncertainty estimation

Tier 2 uncertainty results for sectors and categories are shown in Table 1.3. The input uncertainties for activity data and emission factors stated in Table 1.3 are used both in Tier 1 and Tier 2 uncertainty calculations. The total Danish net GHG emission for 2009 is estimated with an uncertainty of +5.4 % and -4.2 and the trend in net GHG emission since 1990 is estimated to be -10.4 % (+9.4 and -8.3 %-age points).

Tier 2 uncertainties are typically larger than tier 1 uncertainties when input uncertainties are larger than approximately 25%, which corresponds to the model domain of Tier 1 method. This implies that the Tier 2 method is more reliable for large input uncertainties.

1.8 General assessment of the completeness

The present Danish greenhouse gas emission inventory includes all major sources identified by the Revised IPPC Guidelines. Please see Annex 5 for detailed discussion on minor sources that are not included.

References

DEPA, 2011: The greenhouse gases HFCs, PFCs and SF_6. Danish consumption and emissions 2009. Tomas Sander Poulsen and Mads Werge, PlanMiljø. In press.

DEPA, 2011: Waste Statistics 2009. Affaldsstatistik 2009. Danish Environmental Protection Agency. In press.

EMEP/CORINAIR, 2007: EMEP/CORINAIR Atmospheric Emission Inventory Guidebook – 2007, prepared by the UNECE/EMEP Task Force on Emissions Inventories and Projections. Technical Report No 16/2007. Available at:
http://www.eea.europa.eu/publications/EMEPCORINAIR5 (10-02-2011).

EMEP/EEA, 2009: EMEP/EEA air pollutant emission inventory guidebook 2009. Technical guidance to prepare national emission inventories. EEA Technical Report 9/2009. Available at:
http://www.eea.europa.eu/publications/emep-eea-emission-inventory-guidebook-2009 (10-02-2011).

EU Commission, 2004: COMMISSION DECISION of 29 January 2004 establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council. Available in English at: http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:059:0001:0074:EN:PDF. (10-02-2011).

EU Commission, 2007: COMMISSION DECISION of 18 July 2007 establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council. Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:229:0001:0085:EN:PDF (10-02-2011).

Fauser, P., Thomsen, M., Nielsen, O-K., Winther, M., Gyldenkærne, S., Hoffmann, L., Lyck, E. & Illerup, J.B. 2007: Verification of the Danish emission inventory data by national and international data comparisons. National Environmental Research Institute, University of Aarhus, Denmark. 53 pp. – NERI Technical Report no. 627. Available at: http://www.dmu.dk/Pub/FR627.pdf (08-02-2011).

Illerup, J.B., Lyck, E., Winther, M. & Rasmussen, E. 2000: Denmark's National Inventory Report – Submitted under the United Nations Framework Convention on Climate Change. Emission Inventories. Research Notes from National Environmental Research Institute, Denmark no. 127, 326 pp. Available at: http://www.dmu.dk/1_viden/2_Publikationer/3_arbrapporter/rapporter/ar127.pdf (08-02-2011).

IPCC, 1997: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. Available at: http://www.ipcc-nggip.iges.or.jp/public/gl/invs6.htm (08-02-2011).

IPCC, 2000: Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. Available at: http://www.ipcc-nggip.iges.or.jp/public/gp/english/ (08-02-2011).

IPCC, 2003: Good Practice Guidance for Land Use, Land-Use Change and Forestry Available at: http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html (08-02-2011).

IPCC, 2006: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan.

IPCC, 2007: Climate Change 2007. The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z.Chen. M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA 996 pp.

Limpert, E., Stahel, W.A., Abbt, M., (2001), Log-normal distributions across the Sciences: Keys abd Clues, BioScience, Vol. 51, No. 5.

Mikkelsen, M.H. Albrektsen, R. & Gyldenkærne, S. 2011: Danish emission inventories for agriculture. Inventories 1985 - 2009. National Environmental Research Institute, Aarhus University. 136 pp. – NERI Technical Report No. 810. Available at: http://www2.dmu.dk/Pub/FR810.pdf (15.02.2011).

Pulles, T., Mareckova, K., Svetlik, J., Linek, M., & Skakala, J. 1999: CollectER -Installation and User Guide, EEA Technical Report No 31.

Ntziachristos, L. & Samaras, Z. 2000: COPERT III Computer Programme to Calculate Emissions from Road Transport - Methodology and Emission Factors (Version 2.1). Technical report No 49. European Environment Agency, November 2000, Copenhagen. Available at: http://reports.eea.eu.int/Technical_report_No_49/en (08-02-2011).

Holtskog, S., Haakonsen, G., Kvingedal, E., Rypdal, K. & Tornsjø, B., 2000: Verification of the Norwegian emission inventory – Comparing emission intensity values with similar countries. The Norwegian Pollution Control Authority in cooperation with Statistics Norway. SFT report 1736/2000.

Statistics Denmark, 2010: Agriculture Statistics 2009. Copenhagen, Denmark. Available at: http://www.statistikbanken.dk/statbank5a/default.asp?w=1280 (25-02-2011).

Sørensen, P.B., Illerup, J.B., Nielsen, M., Lyck, E., Bruun, H.G., Winther, M., Mikkelsen, M.H. & Gyldenkærne, S. 2005: Quality manual for the green house gas inventory. Version 1. National Environmental Research Institute. - Research Notes from NERI 224: 25 pp. (electronic). Available at: http://www2.dmu.dk/1_viden/2_Publikationer/3_arbrapporter/rapporter/AR224.pdf

UNFCCC, 2007: Updated UNFCCC reporting guidelines on annual inventories following incorporation of the provisions of decision 14/CP.11 Available at: http://unfccc.int/resource/docs/2006/sbsta/eng/09.pdf (10-02-2011).

Van der Sluijs, J.P., Janssen, P.H.M., Petersen, A.C., Kloprogge, P., Risbey, J.S., Tuinstra, W., Ravetz, J.R., 2004. RIVM/MNP Guidance for Uncertainty Assessment and Communication: Tool Catalogue for Uncertainty assessment. Netherlands Environmental Assessment Agency, RIVM. Report no. NMS-E-2004-37.

2 Trends in Greenhouse Gas Emissions

The trends presented in this Chapter cover the emissions from Denmark. Due to the small emissions originating from Greenland the trends are very similar in fact close to identical. A trend discussion of the aggregated greenhouse gas emissions from Denmark and Greenland is included in Chapter 17.1.

2.1 Description and interpretation of emission trends for aggregated greenhouse gas emissions

Greenhouse Gas Emissions

The greenhouse gas emissions are estimated according to the IPCC guidelines and are aggregated into seven main sectors. The greenhouse gases include CO_2, CH_4, N_2O, HFCs, PFCs and SF_6. Figure 2.1 shows the estimated total greenhouse gas emissions in CO_2 equivalents from 1990 to 2009. The emissions are not corrected for electricity trade or temperature variations. CO_2 is the most important greenhouse gas contributing in 2009 to National total in CO_2 equivalents excluding LULUCF (Land Use and Land Use Change and Forestry) with 78.8 % followed by N_2O with 10.1 %, CH_4 9.7 % and F-gases (HFCs, PFCs and SF_6) with 1.4 %. Seen over the time-series from 1990 to 2009 these percentages have been increasing for F-gases, almost constant for CO_2 and CH_4 and falling for N_2O. Stationary combustion plants, transport and agriculture represent the largest categories, followed by Industrial processes, Waste and Solvents, see Figure 2.1. The net CO_2 uptake by LULUCF in 2009 is 1.8 % of the total emission in CO_2 equivalents excl. LULUCF. The national total greenhouse gas emission in CO_2 equivalents excluding LULUCF has decreased by 10.3 % from 1990 to 2009 and decreased 15.9 % including LULUCF. Comments on the overall trends etc seen in Figure 2.1 are given in the sections below on the individual greenhouse gases.

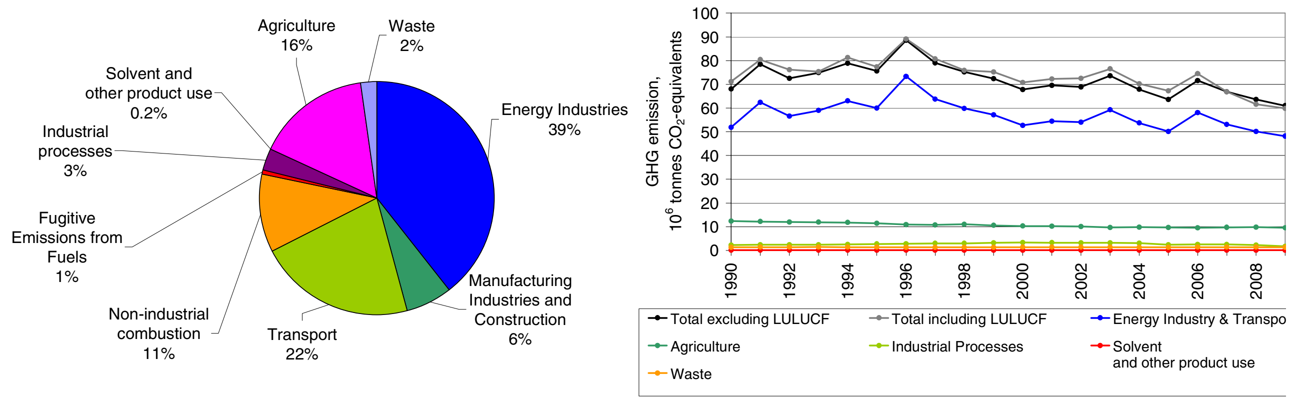


Figure 2.1 Greenhouse gas emissions in CO_2 equivalents distributed on main sectors for 2009 (excluding LULUCF) and time-series for 1990 to 2009 (including LULUCF).

2.2 Description and interpretation of emission trends by gas

2.2.1 Carbon dioxide

The largest source to the emission of CO_2 is the energy sector, which includes combustion of fossil fuels like oil, coal and natural gas (Figure 2.2). Energy Industries contribute with 49 % of the emissions (excl. LULUCF). About 27 % come from the transport sector. The CO_2 emission (excl. LULUCF) decreased by 4.6 % from 2008 to 2009. The main reason for this decrease was the financial crises causing reduction in especially manufacturing industries and cement production. In 2009, the actual CO_2 emission (incl. LULUCF) was 15.5 % less than the emission in 1990.

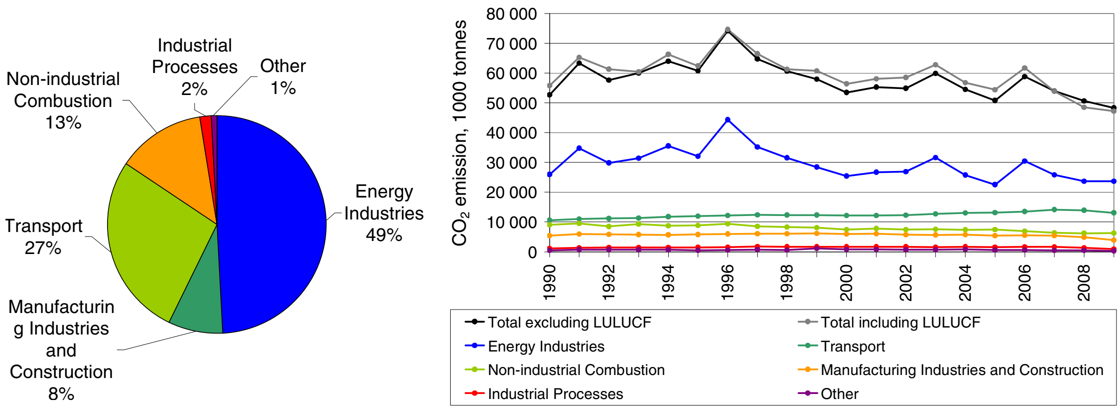


Figure 2.2 CO_2 emissions. Distribution according to the main sectors (2009) and time-series for 1990 to 2009.

2.2.2 Nitrous oxide

Agriculture is the most important N_2O emission source in 2009 contributing 91.2 % (Figure 2.3) of which N_2O from agricultural soils accounts for 92.3 %. N_2O is emitted as a result of microbial processes in the soil. Substantial emissions also come from drainage water and coastal waters where nitrogen is converted to N_2O through bacterial processes. However, the nitrogen converted in these processes originates mainly from the agricultural use of manure and nitrogen fertilisers. The main reason for the drop in the emissions of N_2O in the agricultural sector of 32.4 % from 1990 to 2009 is legislation to improve the utilisation of nitrogen in manure. The legislation has resulted in less nitrogen excreted pr unit of livestock produced and a considerable reduction in the use of nitrogen fertilisers. The basis for the N_2O emission is then reduced. Combustion of fossil fuels in the energy sector, both stationary and mobile sources, contributes 6.2 %. The N_2O emission from transport contributes by 2.2 % in 2009. This emission has increased during the nineties because of the increase in the use of catalyst cars. Production of nitric acid stopped in 2004 and the emissions from industrial processes is therefore not occurring from 2005 onwards. The sector Solvent and Other Product Use covers N_2O from e.g. anaesthesia.

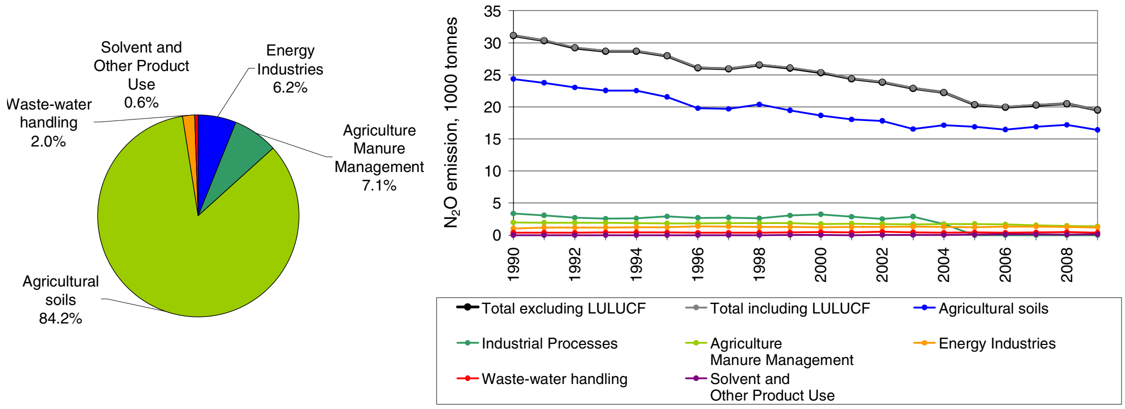


Figure 2.3 N_2O emissions. Distribution according to the main sectors (2009) and time-series for 1990 to 2009.

2.2.3 Methane

The largest sources of anthropogenic CH_4 emissions are agricultural activities contributing in 2009 with 70.4 %, waste (20.6 %), public power and district heating plants (3.2 %), see Figure 2.4. The emission from agriculture derives from enteric fermentation and management of animal manure contributing with 49.2 % and 21.2 % of the national CH_4 emission excl LULUCF in 2009. The CH_4 emission from public power and district heating plants increased in the nineties, mainly 1992-1996, due to the increasing use of gas engines in the decentralised cogeneration plant sector. Up to 3 % of the natural gas in the gas engines is not combusted. The deregulation of the electricity market has made production of electricity in gas engines less favourable, therefore the fuel consumption has decreased and hence the CH_4 emission has decreased. Over the time-series from 1990 to 2009, the emission of CH_4 from enteric fermentation has decreased 12.0 % due to the decrease in the number of cattle. However, the emission from manure management has in the same period increased 25.8 % due to a change in traditional stable systems towards an increase in slurry-based stable systems. Altogether, the emission of CH_4 from the agriculture sector has decreased by 3.3 % from 1990 to 2009. The emission of CH_4 from solid waste disposal has decreased 6.4 % since 1990 due to an increase in the incineration of waste.

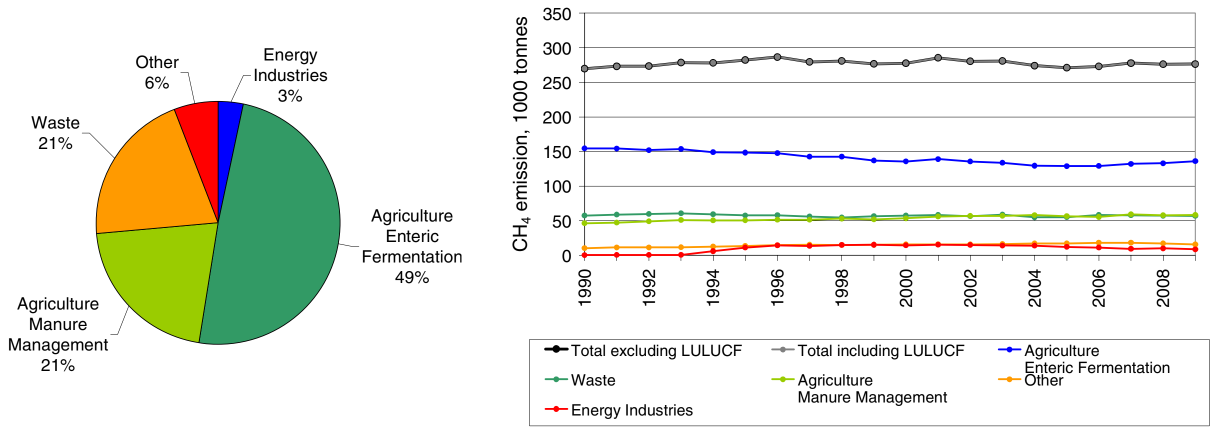


Figure 2.4 CH_4 emissions. Distribution according to the main sectors (2009) and time-series for 1990 to 2009.

2.2.4 HFCs, PFCs and SF_6

This part of the Danish inventory only comprises a full data set for all substances from 1995. From 1995 to 2000, there has been a continuous and substantial increase in the contribution from the range of F-gases as a whole, calculated as the sum of emissions in CO_2 equivalents, see Figure 2.5. This increase is simultaneous with the increase in the emission of HFCs. For the time-series 2000-2009, the increase is lower than for the years 1995 to 2000. The increase from 1995 to 2009 for the total F-gas emission is 161 %. SF_6 contributed considerably to the F-gas sum in earlier years, with 33 % in 1995. Environmental awareness and regulation of this gas under Danish law has reduced its use in industry, see Figure 2.5. A further result is that the contribution of SF_6 to F-gases in 2009 was only 4.3 %. The use of HFCs has increased several folds. HFCs have, therefore, become the even more dominant F-gases, comprising 66.9 % in 1995, but 94.0 % in 2009. HFCs are mainly used as a refrigerant. Danish legislation regulates the use of F-gases, e.g. since January 1, 2007 new HFC-based refrigerant stationary systems are forbidden. Refill of old systems are still allowed. The use of air conditioning in mobile systems and the amount of HFC for this purpose increases.

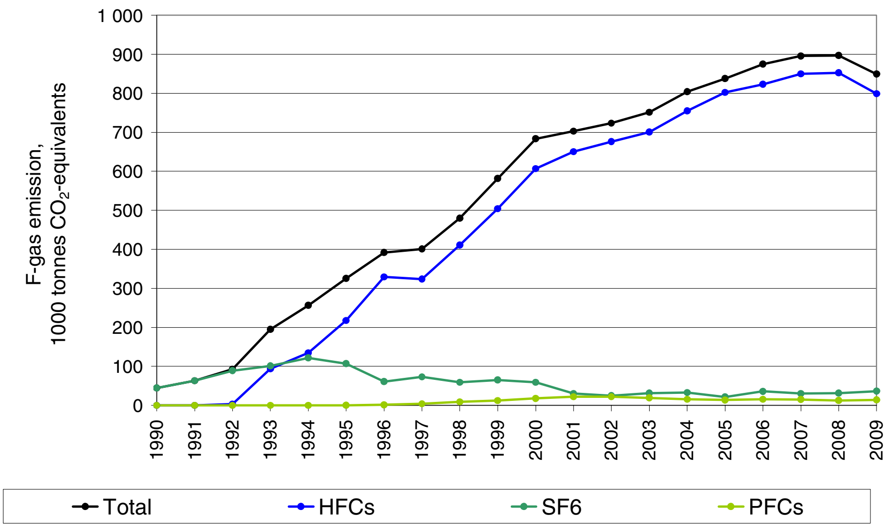


Figure 2.5 F-gas emissions. Time-series for 1990 to 2009.

2.3 Description and interpretation of emission trends by source

2.3.1 Energy

The emission of CO_2 from Energy Industries has decreased by 8.7 % from 1990 to 2009. The relatively large fluctuation in the emission is due to inter-country electricity trade. Thus, the high emissions in 1991, 1996, 2003 and 2006 reflect a large electricity export and the low emissions in 1990 and 2005 are due to a large import of electricity. The increasing emission of CH_4 during the nineties is due to the increasing use of gas engines in decentralised cogeneration plants. The CH_4 emissions from this sector has been decreasing since 2001 due to the liberalisation of the electricity market. The CO_2 emission from the transport sector increased by 23.5 % from 1990 to 2009, mainly due to increasing road traffic.

2.3.2 Industrial processes

The emissions from industrial process, i.e. emissions from processes other than fuel combustion, amount in 2009 to 2.9 % of the total emission in CO_2 equivalents (excl. LULUCF). The main sources are cement production, refrigeration, foam blowing and calcination of limestone. The CO_2 emission from cement production – which is the largest source contributing in 2009 with 1.3 % of the National total – increased by 13.4 % from 1990 to 2009. The second largest source has previously been N_2O from the production of nitric acid. However, the production of nitric acid/fertiliser ceased in 2004 and therefore the emission of N_2O also ceased.

2.3.3 Agriculture

The agricultural sector contributes in 2009 with 15.8 % of the total greenhouse gas emission in CO_2 equivalents (excl. LULUCF) and is the most important sector regarding the emissions of N_2O and CH_4. In 2009, the contribution of N_2O and CH_4 to the total emission of these gases was 91.2 % and 70.4 %, respectively. The N_2O emission from agriculture decreased by 32.4 % and the CH_4 emission including field burning and reduction of biogas decreased by 3.3 % from 1990 to 2009.

2.3.4 Forestry

The carbon stock change for forests has been estimated based on best available data. Based on mapped forest area in 1990 and in 2005 a calculation of carbon stored in both forest remaining forest and in afforestation since 1990 have been performed. The forest areas in 1990 as well as in 2005 have been mapped to be larger than previously estimated for the times. The calculation of carbon stock in 1990 and in 2000 used age distribution as reported in census 1990 and in 2000 as an expression of the total forest land allocation to species and ages. Based on the actual measurements of carbon storage in different species and age classes with the current National Forest Inventory, the total standing carbon stock was calculated. For each of the years 1990 - 2000 calculated a standing carbon stock as a moving average, corrected for the deforestation which was detected. Windthrows and the effects of these are included in the overall estimation of changes in carbon stock. As carbon stock is based on moving average the annual effect is not dramatically.

Since the NFI was initiated in 2002, it is representative from 2005. Calculation of carbon stock in the period 2000-2004 is based on NFI in 2005 and carbon stock as calculated for 2000. For 2005-2009 carbon stock is calculated solely on the basis of the NFI - with additional information about the total forest area from satellite image mapping. The data for 2009 estimates the Danish forests to be a large sink of 2 736 Gg CO_2.

The forecast for the period 2010 - 2020 show a decreasing trend of forest carbon stock. This is due to the current high proportion of old trees, which face rejuvenation. Hereby large old trees felled and replaced by new small trees. The net result is that the total carbon stock decreases. If the forests had a completely even distribution of ages, carbon stock would be virtually constant - assuming unchanged harvesting and growth. Changes in forest management, may affect the development of forests. Thus, a postponement of cutting of old trees - will postpone the decline in carbon storage. Conversely, increased logging (e.g. due to increased demand, increased price or similar) may lead to a sharper decline in carbon stock.

For the afforestated areas a steady increase in carbon stocks is expected also in the future years. The rate of increase of area will depend on both availability of land and on possible subsidies for afforestation. Deforestation occurs mainly in relation to other specific projects e.g. for nature restoration or test areas for wind mills.

2.3.5 Cropland, Grassland and Wetlands

The emission estimates for mineral cropland soils is estimated with a dynamic Tier 3 model which take into account actual biomass input to the soil and actual temperatures. The harvest yield in 2009 was the highest ever recorded in Denmark and combined with moderate temperatures the mineral soils turned to be a small sink compared to 2008. 2008 were very warm which resulted in a net loss of carbon from the cropland soils. A new map of organic soils and new national EF for organic soils has been implemented in the current inventory. This has, among other things, altered the distribution of the emission from organic soils between cropland soils and grassland soils. The emission from organic cropland soils has been estimated to 1 282 Gg CO_2 and the total emission from Cropland to 1 347 Gg CO_2. Since 1990 there has been a decrease in the total C-stock in mineral soils which partly can be allocated to the global warming. A continuous increase in raised number of shelterbelts increases the C sequestration here.

Grassland is showing a stable annual emission around 125 Gg CO_2 per year which mainly comes from the utilisation of organic soils.

Emissions from managed wetlands with peat extraction are unaltered at a low level.

2.3.6 Waste

The waste sector contributes in 2008 with 2.2 % to the National total of greenhouse gas emissions (excl. LULUCF), 20.6 % of the total CH_4 emission and 2.0 % of the total N_2O emission. The GHG emission from the sector has decreased by 0.4 % from 1990 to 2009. This decrease is a result of (1) a decrease in the CH_4 emission from solid waste disposal sites (SWDS) by 4.4 % due to the increasing use of waste for power and heat production, and (2) a decrease in emission of N_2O from wastewater (WW) handling systems of 26.1 % due to upgrading of WW treatment plants. These decreases are counteracted by an increase in CH_4 from WW of 12.7 % due to increasing industrial load to WW systems. In 2009 the contribution of CH_4 from SWDS was 17.9 % of the total CH_4 emission. The CH_4 emission from WW amounts in 2009 to 1.3 % of the total CH_4 emissions. The emission of N_2O from WW in 2008 is 1.3 % of national total of N_2O. Since all incinerated waste is used for power and heat production, the emissions are included in the 1A IPCC category.

2.4 Description and interpretation of emission trends for indirect greenhouse gases and SO_2

2.4.1 NO_x

The largest sources of emissions of NO_x are road transport followed by other mobile sources and combustion in energy industries (mainly public power and district heating plants). The transport sector is the sector contributing the most to the emission of NO_X and, in 2009, 45.3 % of the Danish emissions of NO_X stems from road transport, national navigation, railways and civil aviation. Also emissions from national fishing and off-road vehicles contribute significantly to the NO_X emission. For non-industrial combustion plants, the main sources are combustion of wood, gas oil and natural gas in residential plants. The emissions from energy industries have decreased by 70 % from 1990 to 2009. In the same period, the total emission decreased by 53 %. The reduction is due to the increasing use of catalyst cars and installation of low-NO_X burners and denitrifying units in power and district heating plants.

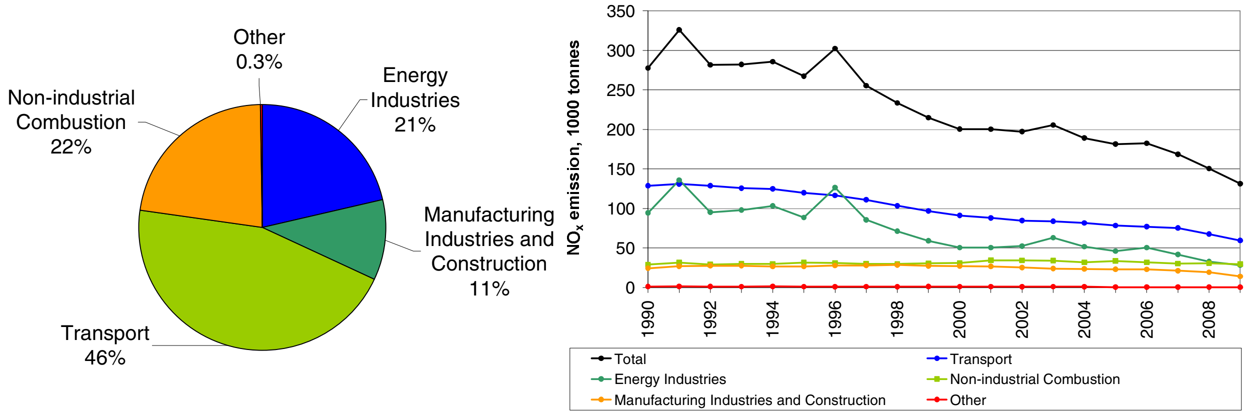


Figure 2.6 NO_X emissions. Distribution according to the main sectors (2009) and time-series for 1990 to 2009.

2.4.2 CO

Non-industrial combustion plants and transport is by far the major contributors to the total emission of this pollutant with 62.4 and 30.0 % of the total CO emission. The total CO emission decreased by 45 % from 1990 to 2009, largely because of decreasing emissions from road transportation due to the introduction of private catalyst cars in 1990 and the introduction of even more emission-efficient private cars in the following years.

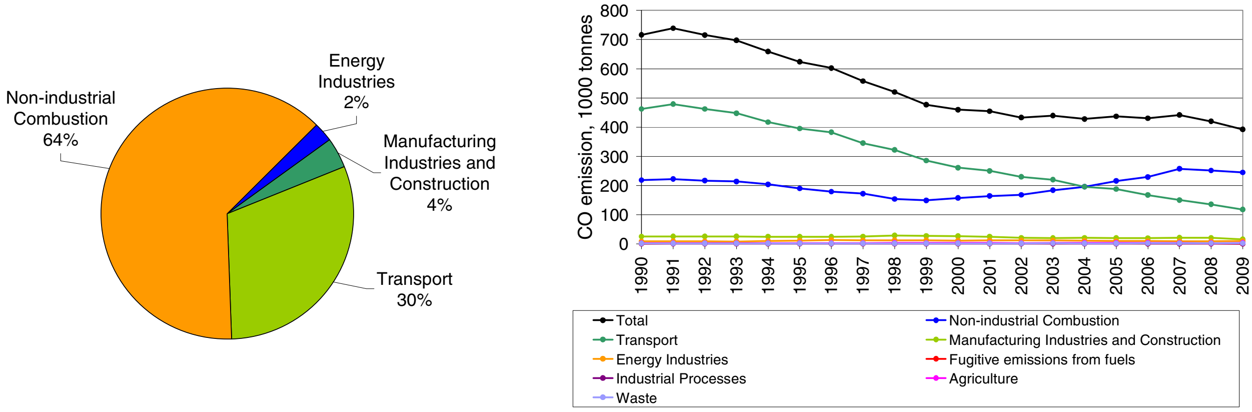


Figure 2.7 CO emissions. Distribution according to the main sectors (2009) and time-series for 1990 to 2009.

2.4.3 NMVOC

The emissions of NMVOC originate from many different sources and can be divided into two main groups: incomplete combustion and evaporation. Road vehicles and other mobile sources such as national navigation vessels and off-road machinery are the main sources of NMVOC emissions from incomplete combustion processes. Road transportation vehicles are still the main contributors even though the emissions have declined since the introduction of catalyst cars in 1990. The evaporative emissions mainly originate from the use of solvents and the extraction, handling and storage of oil and natural gas. The emissions from the energy industries have increased during the nineties due to the increasing use of stationary gas engines, which have much higher emissions of NMVOC than conventional boilers. The total anthropogenic emissions have decreased by 49.7 % from 1990 to 2009, largely due to the increased use of catalysts in cars and reduced emissions from use of solvents.

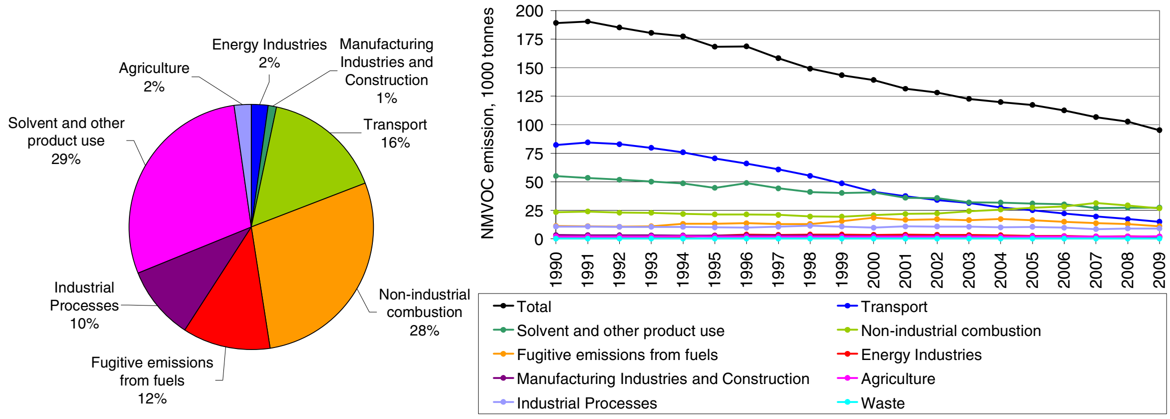


Figure 2.8 NMVOC emissions. Distribution according to the main sectors (2009) and time-series for 1990 to 2009.

2.4.4 SO_2

The main part of the SO_2 emission originates from combustion of fossil fuels, i.e. mainly coal and oil, in public power and district heating plants. From 1980 to 2009, the total emission decreased by 96.7 %. The large reduction is mainly due to installation of desulphurisation plant and use of fuels with lower content of sulphur in public power and district heating plants. Despite the large reduction of the SO_2 emissions, these plants make up 33.5 % of the total emission in 2009. Also emissions from industrial combustion plants, non-industrial combustion plants and other mobile sources are important. National sea traffic (navigation and fishing) contributes with about 13.2 % of the total SO_2 emission. This is due to the use of residual oil with high sulphur content.

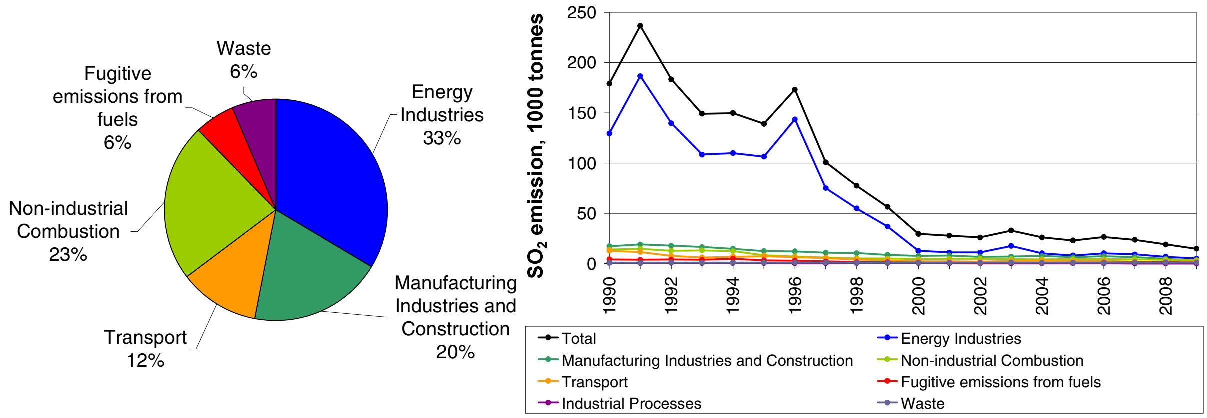


Figure 2.9 SO_2 emissions. Distribution according to the main sectors (2009) and time-series for 1990 to 2009.

2.5 Description and interpretation of emission trends for KP-LULUCF inventory in aggregate, by activity and by gas

Coverage relating to reporting of activities under Article 3.3 and elected activities under Article 3.4 are listed in Table 2.10 for reporting concerning change in carbon pool and for greenhouse gas sources. All pools are reported. Carbon stock change in below-ground biomass for Cropland Management and Grazing Land Management under Article 3.4 are included under Above-ground biomass for the same area categories. Fertilisation of forests and other land is negligible and all fertiliser consumption is therefore reported in the agricultural sector. All liming is reported under Cropland because only very limited amounts are used in forestry and on permanent grassland. Field burning of wooden biomass is prohibited in Denmark and therefore reported as not occurring. Wildfires are very seldom and if occurring very small in Denmark and hence reported as NO.

CO_2 is by far the most important greenhouse gas relating to activities under Article 3.3 and Article 3.4. There is however a minor contribution of N_2O due to Deforestation (1.2 % of GHG from Deforestation in 2009) and Forest Management (0.5 % of GHG from Forest Management in 2009).

Table 2.10 Coverage of reporting of change of carbon pools relating to activities under Article 3.3 and elected activities under Article 3.4.

		Change in carbon pool reported					Greenhouse gas sources reported						
		Above-ground bio-mass	Below-ground bio-mass	Litter	Dead wood	Soil	Fertili-zation	Drainage of soils under forest manage-ment	Disturbance associated with land-use conversion to croplands	Liming	Biomass burning		
							N_2O	N_2O	N_2O	CO_2	CO_2	CH_4	N_2O
Article 3.3	Afforestation and Reforestation	R	R	R	R	R	IE			IE	NO	NO	NO
	Deforestation	R	R	R	R	R			R	IE	NO	NO	NO
Article 3.4	Forest Management	R	R	R	R	R	IE	R		IE	NO	NO	NO
	Cropland Management	R	IE	NO	NO	R			R	R	NO	NO	NO
	Grazing Land Management	R	IE	NO	NO	R				IE	NO	NO	NO
	Revegetation	NA	NA	NA	NA	NA				NA	NA	NA	NA

R: reported, NR: not reported, IE: included elsewhere, NO: not occurring, NA: not applicable.

2.5.1 Forest

The trends in forest in the first commitment period are dependent on both the current structure of the forests and the management actions in the coming years. If similar management is applied as in the previous 15 years a decline in the total carbon stock in the forest remaining forest is expected. However, for 2008 and 2009 a sink in forest remaining forest is reported.

For the afforestated areas a steady increase in carbon stocks is expected also in the future years. The rate of increase of area will depend on both availability of land and on possible subsidies for afforestation. Deforestation occurs mainly in relation to other specific projects e.g. for nature restoration or test areas for wind mills.

2.5.2 Cropland, Grassland and Wetlands

The trend for the Cropland and Grassland under KP-LULUCF seems to be that there has been a stabilisation of the loss of C from agricultural soils compared to previous due to an increased input of organic matter in the soil. However, the loss depends much of the climatic conditions. As a consequence of the global warming, where 18 years out of the last 20 years has been above the average for 1961-1990, it is difficult to avoid substantial losses of C from the agricultural soils in future. The changes in Cropland management since 1990 have undoubtedly prevented further losses of soil carbon. A further increase in the actual temperature will have consequences for the ability to maintain or even to prevent further losses of soil carbon.

The reestablishment of wetlands on agricultural land is especially targeted towards organic soils which lead to a decreased emission from these soils. Further reestablishments are expected to take place in the future.

3 Energy (CRF sector 1)

3.1 Overview of the sector

The energy sector has been reported in four main chapters:

3.2 Stationary combustion plants (CRF sector 1A1, 1A2 and 1A4)
3.3 Transport (CRF sector 1A2, 1A3, 1A4 and 1A5)
3.4 Additional information on fuel combustion (CRF sector 1A)
3.5 Fugitive emissions (CRF sector 1B)

Though industrial combustion is part of stationary combustion, detailed documentation for some of the specific industries is discussed in the industry chapters. Table 3.1.1 shows detailed source categories for the energy sector and plant category in which the sector is discussed in this report.

Table 3.1.1 CRF energy sectors and relevant NIR chapters.

IPCC id	IPCC sector name	NERI documentation
1	Energy	Stationary combustion, Transport, Fugitive, Industry
1A	Fuel Combustion Activities	Stationary combustion, Transport, Industry
1A1	Energy Industries	Stationary combustion
1A1a	Electricity and Heat Production	Stationary combustion
1A1b	Petroleum Refining	Stationary combustion, Fugitive
1A1c	Solid Fuel Transf./Other Energy Industries	Stationary combustion
1A2	Fuel Combustion Activities/Industry (ISIC)	Stationary combustion, Transport, Industry
1A2a	Iron and Steel	Stationary combustion, Industry
1A2b	Non-Ferrous Metals	Stationary combustion, Industry
1A2c	Chemicals	Stationary combustion, Industry
1A2d	Pulp, Paper and Print	Stationary combustion, Industry
1A2e	Food Processing, Beverages and Tobacco	Stationary combustion, Industry
1A2f	Other (please specify)	Stationary combustion, Transport, Industry
1A3	Transport	Transport
1A3a	Civil Aviation	Transport
1A3b	Road Transportation	Transport
1A3c	Railways	Transport
1A3d	Navigation	Transport
1A3e	Other (please specify)	Transport
1A4	Other Sectors	Stationary combustion, Transport
1A4a	Commercial/Institutional	Stationary combustion
1A4b	Residential	Stationary combustion, Transport
1A4c	Agriculture/Forestry/Fishing	Stationary combustion, Transport
1A5	Other (please specify)	Stationary combustion, Transport
1A5a	Stationary	Stationary combustion
1A5b	Mobile	Transport
1B	Fugitive Emissions from Fuels	Fugitive
1B1	Solid Fuels	Fugitive
1B1a	Coal Mining	Fugitive
1B1a1	Underground Mines	Fugitive
1B1a2	Surface Mines	Fugitive
1B1b	Solid Fuel Transformation	Fugitive
1B1c	Other (please specify)	Fugitive
1B2	Oil and Natural Gas	Fugitive
1B2a	Oil	Fugitive
1B2a2	Production	Fugitive
1B2a3	Transport	Fugitive
1B2a4	Refining/Storage	Fugitive
1B2a5	Distribution of oil products	Fugitive
1B2a6	Other	Fugitive
1B2b	Natural Gas	Fugitive
1B2b1	Production/processing	Fugitive
1B2b2	Transmission/distribution	Fugitive
1B2c	Venting and Flaring	Fugitive
1B2c1	Venting and Flaring Oil	Fugitive
1B2c2	Venting and Flaring Gas	Fugitive
1B2d	Other	Fugitive

Summary tables for the energy sector are shown below.

Table 3.1.2 CO_2 emission from the energy sector.

Greenhouse gas source categories	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
						(Gg)				
1. Energy	51,343	61,815	56,005	58,342	62,284	59,112	72,344	62,818	58,770	56,129
A. Fuel Combustion (Sectoral Approach)	51,043	61,223	55,393	57,808	61,759	58,697	71,888	62,178	58,295	55,120
1. Energy Industries	25,952	34,775	29,835	31,387	35,521	32,046	44,316	35,194	31,541	28,443
2. Manufacturing Industries and Construction	5,412	5,965	5,874	5,767	5,723	5,829	6,007	6,059	6,079	6,167
3. Transport	10,617	11,001	11,200	11,319	11,802	11,940	12,188	12,381	12,353	12,373
4. Other Sectors	8,943	9,195	8,344	9,096	8,460	8,631	9,201	8,373	8,120	7,954
5. Other	119	287	141	237	252	252	176	171	204	182
B. Fugitive Emissions from Fuels	300	593	611	534	526	415	456	641	475	1,010
1. Solid Fuels	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
2. Oil and Natural Gas	300	593	611	534	526	415	456	641	475	1,010
Continued	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
						(Gg)				
1. Energy	51,655	53,457	53,045	58,184	52,658	49,098	57,013	52,176	49,155	47,274
A. Fuel Combustion (Sectoral Approach)	50,992	52,749	52,449	57,568	51,974	48,600	56,534	51,758	48,779	47,017
1. Energy Industries	25,414	26,715	26,918	31,584	25,766	22,566	30,463	25,827	23,705	23,698
2. Manufacturing Industries and Construction	5,953	6,035	5,748	5,673	5,736	5,438	5,563	5,389	4,905	3,915
3. Transport	12,173	12,184	12,282	12,738	13,047	13,166	13,544	14,161	13,929	13,109
4. Other Sectors	7,341	7,718	7,412	7,481	7,186	7,159	6,838	6,206	6,133	6,135
5. Other	111	97	89	92	239	271	126	175	108	160
B. Fugitive Emissions from Fuels	662	708	596	616	684	499	478	418	376	258
1. Solid Fuels	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
2. Oil and Natural Gas	662	708	596	616	684	499	478	418	376	258

Table 3.1.3 CH_4 emission from the energy sector.

Greenhouse gas source categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
						(Gg)				
1. Energy	10.99	12.31	12.25	12.71	18.94	25.17	29.29	29.22	30.44	30.78
A. Fuel Combustion (Sectoral Approach)	8.92	9.74	9.79	10.03	16.02	21.84	26.03	25.75	27.03	26.93
1. Energy Industries	0.50	0.64	0.72	0.87	6.11	11.39	14.47	13.87	15.25	15.36
2. Manufacturing Industries and Construction	0.40	0.45	0.47	0.51	0.37	0.47	0.89	0.89	0.98	0.97
3. Transport	2.55	2.64	2.63	2.58	2.53	2.40	2.29	2.19	2.08	1.96
4. Other Sectors	5.46	5.99	5.96	6.06	7.01	7.57	8.37	8.80	8.70	8.64
5. Other	0.01	0.02	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01
B. Fugitive Emissions from Fuels	2.07	2.57	2.46	2.68	2.91	3.33	3.26	3.47	3.41	3.86
1. Solid Fuels	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
2. Oil and Natural Gas	2.07	2.57	2.46	2.68	2.91	3.33	3.26	3.47	3.41	3.86
Continued	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
						(Gg)				
1. Energy	30.51	31.52	30.95	30.71	31.36	29.81	29.89	28.04	27.55	24.80
A. Fuel Combustion (Sectoral Approach)	26.54	27.36	26.77	26.42	26.25	24.70	23.48	21.95	21.50	19.25
1. Energy Industries	14.64	15.54	15.12	14.40	14.08	12.40	11.49	9.57	10.17	8.87
2. Manufacturing Industries and Construction	1.19	1.23	1.15	1.12	1.14	1.06	0.92	0.70	0.74	0.69
3. Transport	1.82	1.69	1.58	1.50	1.39	1.27	1.18	1.07	0.91	0.76
4. Other Sectors	8.89	8.88	8.91	9.40	9.63	9.96	9.89	10.61	9.68	8.93
5. Other	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.01
B. Fugitive Emissions from Fuels	3.97	4.15	4.18	4.29	5.11	5.11	6.41	6.08	6.05	5.55
1. Solid Fuels	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
2. Oil and Natural Gas	3.97	4.15	4.18	4.29	5.11	5.11	6.41	6.08	6.05	5.55

Table 3.1.4 N_2O emission from the energy sector.

Greenhouse gas source categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
						(Gg)				
1. Energy	1.05	1.18	1.15	1.18	1.21	1.22	1.38	1.31	1.26	1.26
A. Fuel Combustion (Sectoral Approach)	1.04	1.18	1.15	1.17	1.21	1.21	1.38	1.31	1.25	1.25
1. Energy Industries	0.27	0.35	0.32	0.33	0.38	0.36	0.49	0.42	0.38	0.38
2. Manufacturing Industries and Construction	0.17	0.19	0.19	0.17	0.15	0.14	0.14	0.14	0.14	0.14
3. Transport	0.37	0.39	0.41	0.42	0.45	0.48	0.50	0.52	0.51	0.51
4. Other Sectors	0.23	0.24	0.23	0.24	0.23	0.23	0.23	0.22	0.21	0.21
5. Other	0.00	0.01	0.00	0.01	0.01	0.01	0.01	0.00	0.01	0.01
B. Fugitive Emissions from Fuels	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.01
1. Solid Fuels	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
2. Oil and Natural Gas	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.01
Continued	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
						(Gg)				
1. Energy	1.22	1.25	1.26	1.32	1.27	1.24	1.33	1.30	1.26	1.20
A. Fuel Combustion (Sectoral Approach)	1.22	1.25	1.26	1.31	1.26	1.24	1.32	1.29	1.26	1.20
1. Energy Industries	0.36	0.38	0.39	0.43	0.38	0.35	0.42	0.37	0.36	0.36
2. Manufacturing Industries and Construction	0.14	0.14	0.14	0.13	0.13	0.12	0.14	0.13	0.12	0.10
3. Transport	0.50	0.49	0.48	0.49	0.49	0.47	0.47	0.48	0.47	0.43
4. Other Sectors	0.22	0.24	0.24	0.26	0.25	0.28	0.29	0.30	0.30	0.30
5. Other	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.00	0.01
B. Fugitive Emissions from Fuels	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00
1. Solid Fuels	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
2. Oil and Natural Gas	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00

3.2 Stationary combustion (CRF sector 1A1, 1A2 and 1A4)

3.2.1 Source category description

In the Danish emission database all activity rates and emissions are defined in SNAP sector categories (Selected Nomenclature for Air Pollution) according the CORINAIR system. The emission inventories are prepared from a complete emission database based on the SNAP source categories. Aggregation to the IPCC source category codes is based on a correspondence list enclosed in Annex 3A-1. Stationary combustion is defined as combustion activities in the SNAP sectors 01 – 03.

Stationary combustion plants are included in the emission source subcategories to *Energy, Fuel combustion*:

- 1A1 Energy Industries.
- 1A2 Manufacturing Industries and Construction.
- 1A4 Other Sectors.

However, the emission sources *1A2* and *1A4* also include emission from transport subcategories. The emission source *1A2* includes emissions from some off-road machinery in the industry. The emission source *1A4* includes off-road machinery in agriculture, forestry and household/gardening. Further emissions from national fishing are included in subcategory *1A4*.

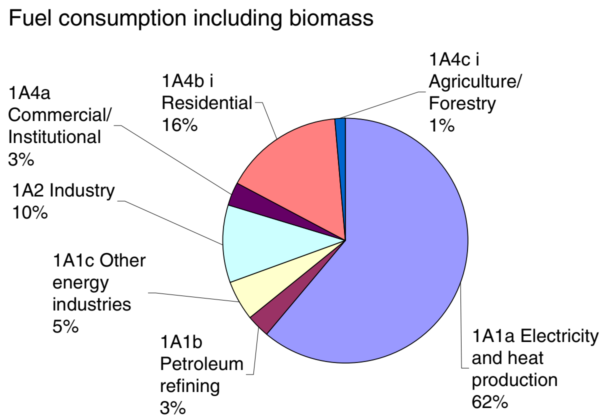
The emission and fuel consumption data included in tables and figures in Chapter 3.2 only include emissions originating from stationary combustion plants of a given IPCC source category. The IPCC source category codes have been applied unchanged, but some source category names have been changed to reflect the stationary combustion element of the source.

The CO_2 emission from calcinations is not part of the source category *Energy*. This emission is included in the source category *Industrial Processes*.

3.2.2 Fuel consumption data

In 2009 the total fuel consumption for stationary combustion plants was 521 PJ of which 411 PJ was fossil fuels and 110 PJ was biomass.

Fuel consumption distributed according to the stationary combustion subcategories is shown in Figure 3.2.1 and Figure 3.2.2. The majority - 61 % - of all fuels is combusted in the source category, *Public electricity and heat production*. Other source categories with high fuel consumption are *Residential* and *Industry*.



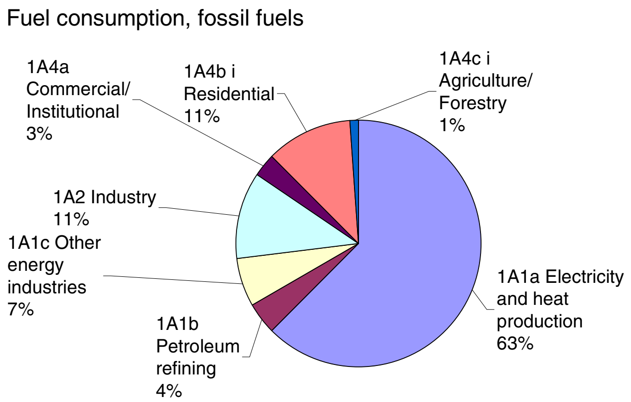


Figure 3.2.1 Fuel consumption of stationary combustion source categories, 2009. Based on DEA (2010a).

Coal and natural gas are the most utilised fuels for stationary combustion plants. Coal is mainly used in power plants and natural gas is used in power plants and decentralised combined heating and power (CHP) plants, as well as in industry, district heating, residential plants and off-shore gas turbines (see Figure 3.2.2).

Detailed fuel consumption rates are shown in Annex 3A-2.

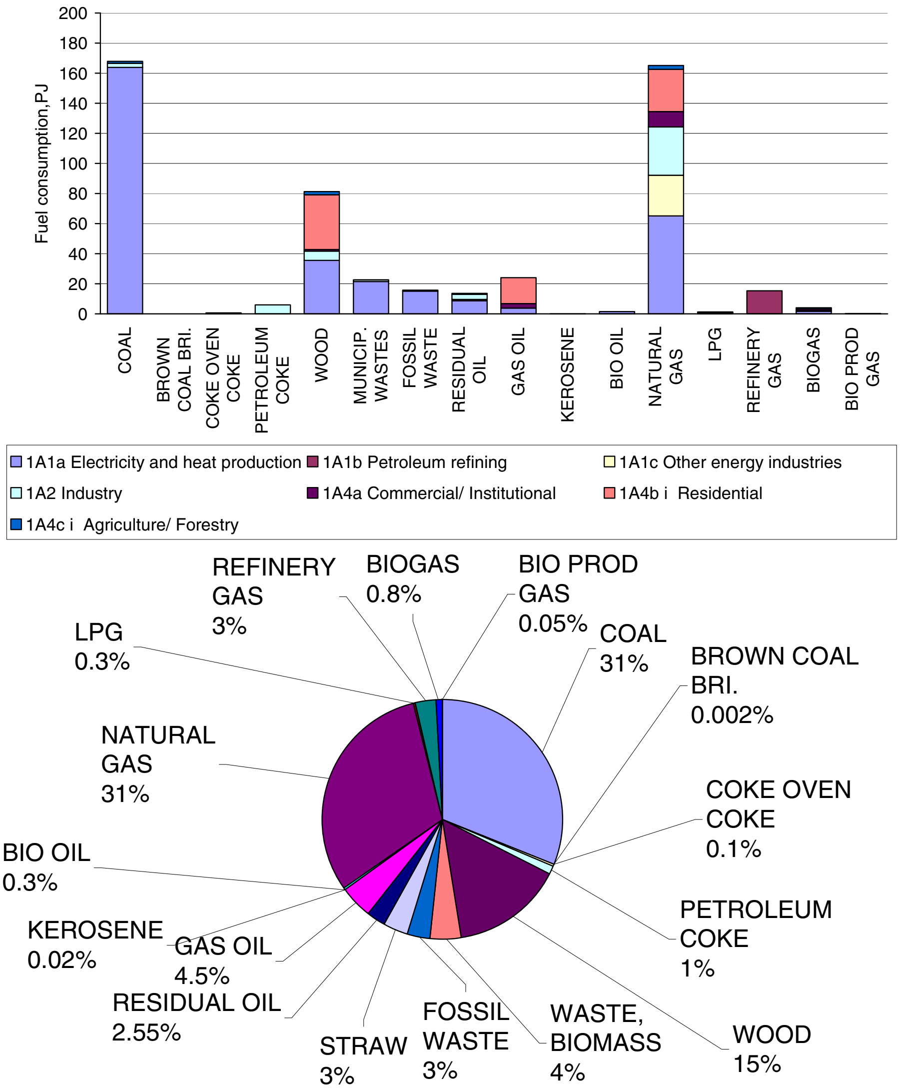
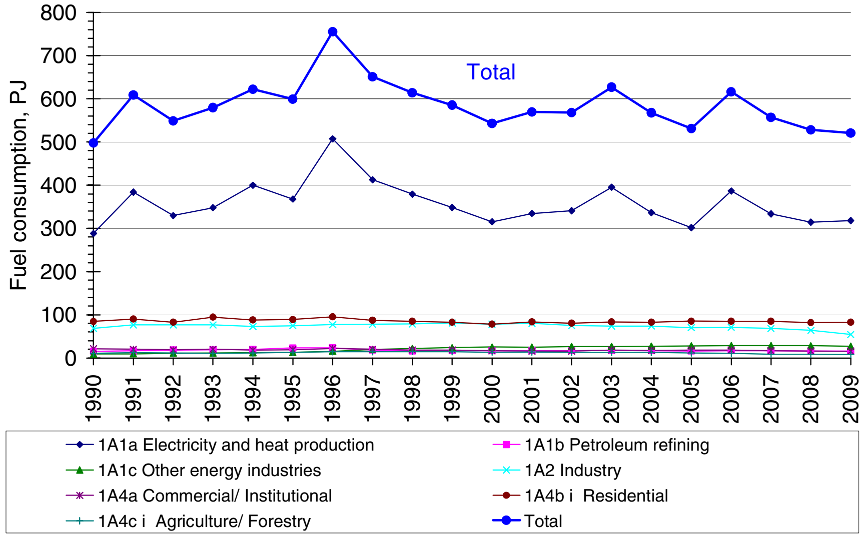


Figure 3.2.2 Fuel consumption of stationary combustion 2009, disaggregated to fuel type. Based on DEA (2010a).

Fuel consumption time-series for stationary combustion plants are presented in Figure 3.2.3. The fuel consumption for stationary combustion was 5 % higher in 2009 than in 1990, while the fossil fuel consumption was 10 % lower and the biomass fuel consumption 158 % higher than in 1990.

The consumption of natural gas and biomass has increased since 1990 whereas coal consumption has decreased.



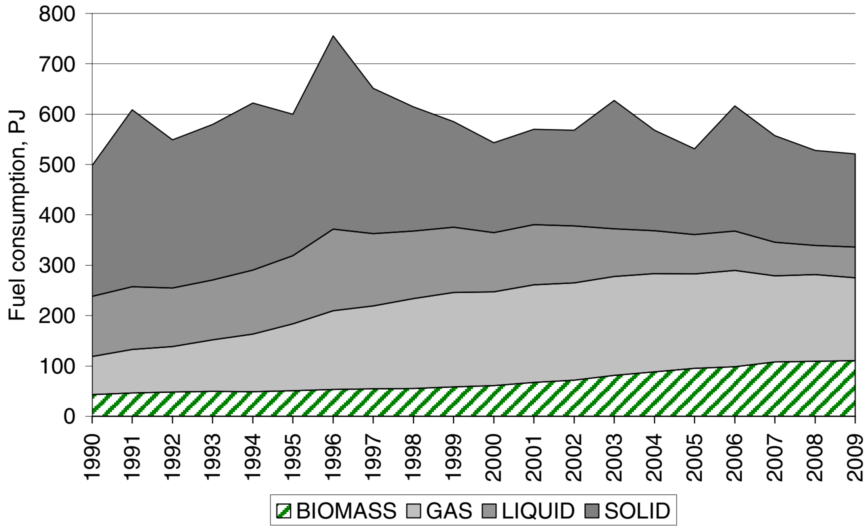


Figure 3.2.3 Fuel consumption time-series, stationary combustion. Based on DEA (2010a).

The fluctuations in the time-series for fuel consumption are mainly a result of electricity import/export, but also of outdoor temperature variations from year to year. This, in turn, leads to fluctuations in emission levels. The fluctuations in electricity trade, fuel consumption, CO_2 and NO_x emission are illustrated and compared in Figure 3.2.4. In 1990 the Danish electricity import was large causing relatively low fuel consumption, whereas the fuel consumption was high in 1996 due to a large electricity export. In 2009 the net electricity import was 1.2 PJ, whereas there was a 5.2 PJ electricity import in 2008. The large electricity export that occurs some years is a result of low rainfall in Norway and Sweden causing insufficient hydropower production in both countries.

To be able to follow the national energy consumption as well as for statistical and reporting purposes, the Danish Energy Agency produces a correction of the actual fuel consumption and CO_2 emission without random variations in electricity imports/exports and in ambient temperature. This fuel consumption trend is also illustrated in Figure 3.2.4. The corrections are included here to explain the fluctuations in the time-series for fuel rate and emission.

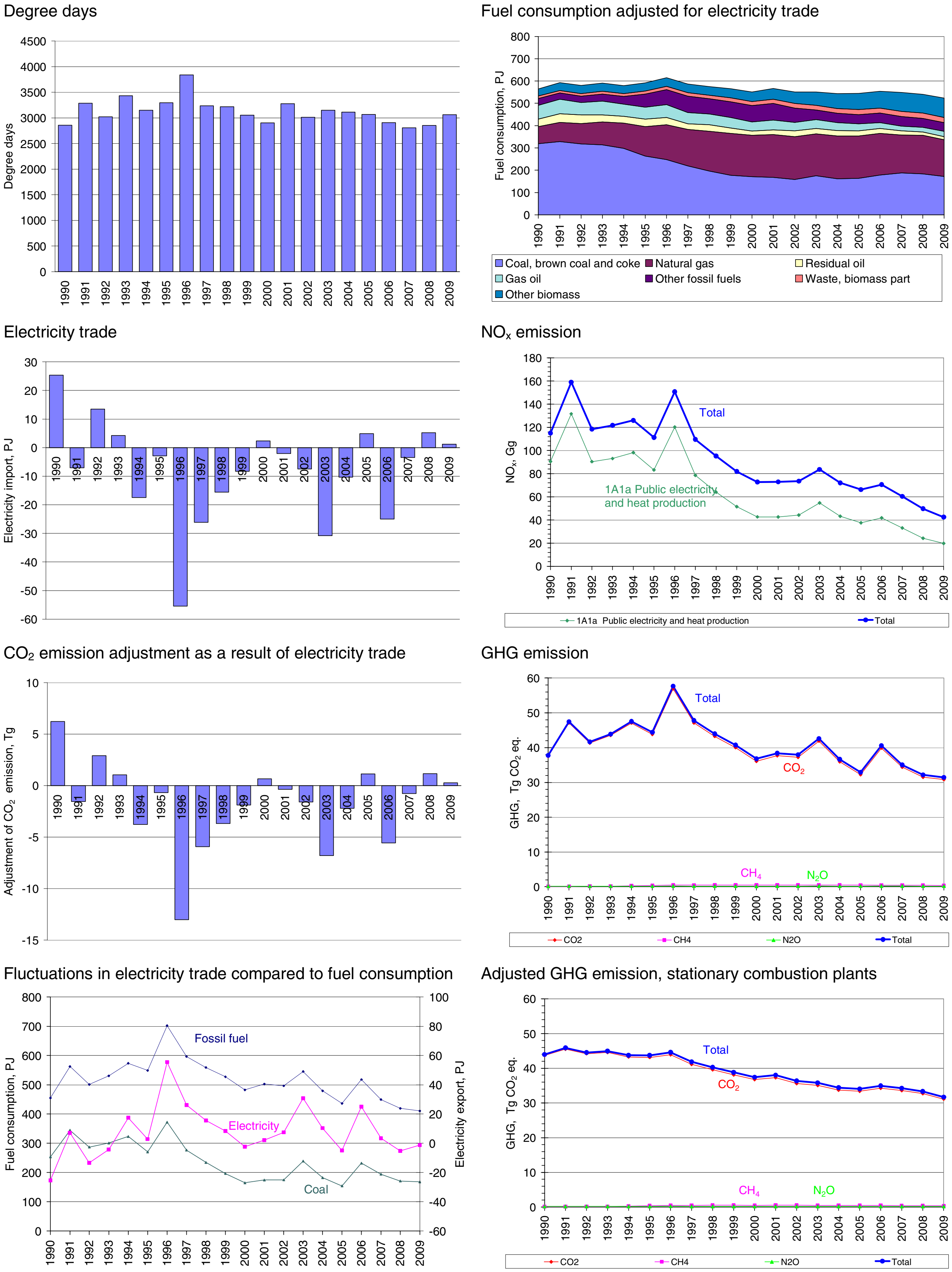


Figure 3.2.4 Comparison of time-series fluctuations for electricity trade, fuel consumption and NO_x emission. Based on DEA (2010b).

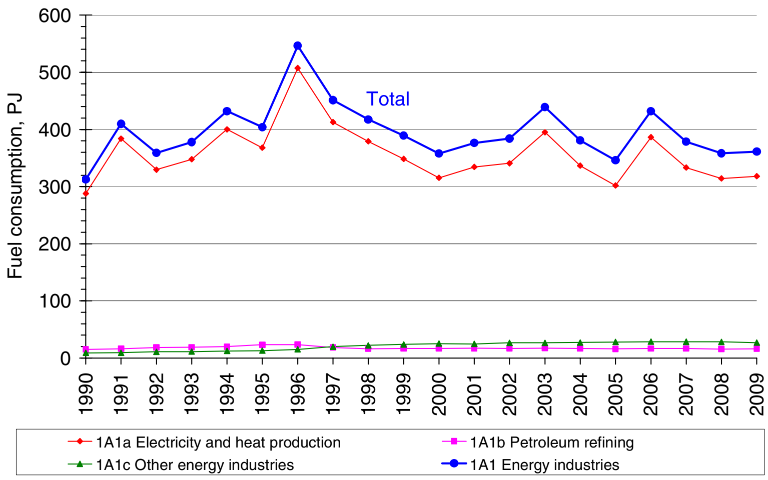
Fuel consumption time-series for the subcategories to stationary combustion are shown in Figure 3.2.5, 3.2.6 and 3.2.7.

Fuel consumption for *Energy Industries* fluctuates due to electricity trade as discussed above. The fuel consumption in 2009 was 16 % higher than in 1990. The fluctuation in electricity production is based on fossil fuel consumption in the subcategory *Electricity and Heat Production*. The energy consumption in *Other energy industries* is mainly natural gas used in gas turbines in the off-shore industry. The biomass fuel consumption in *Energy Industries* 2009 added up to 61 PJ, which is 3.5 times the level in 1990.

The fuel consumption in *Industry* was 21 % lower in 2009 than in 1990 (Figure 3.2.6). The fuel consuption industrial plants has decreased considerably as a result of the financial crisis. The biomass fuel consumption in *Industry* in 2009 added up to 8 PJ which is a 10 % increase since 1990.

The fuel consumption in *Other Sectors* decreased 10 % since 1990 (Figure 3.2.7). The biomass part of the fuel consumption has increased from 16 % in 1990 to 39 % in 2009. Wood consumption in residential plants in 2009 was 2.3 times the consumption in year 2000.

Time-series for subcategories are shown in Chapter 3.2.4.



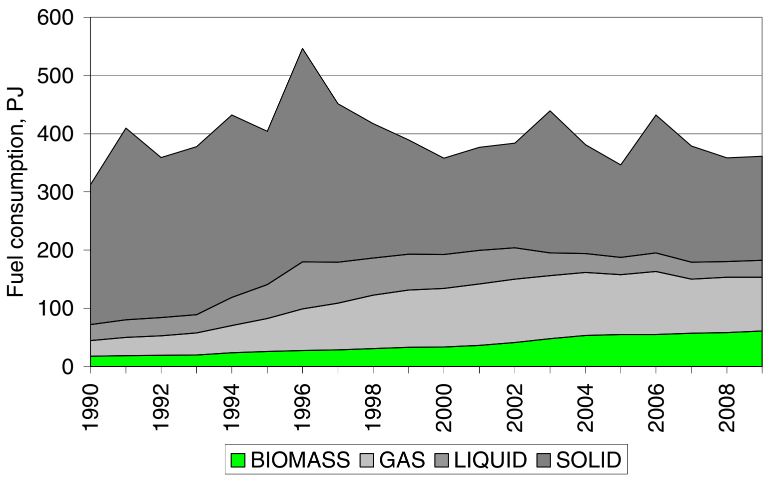


Figure 3.2.5 Fuel consumption time-series for subcategories - 1A1 Energy Industries.

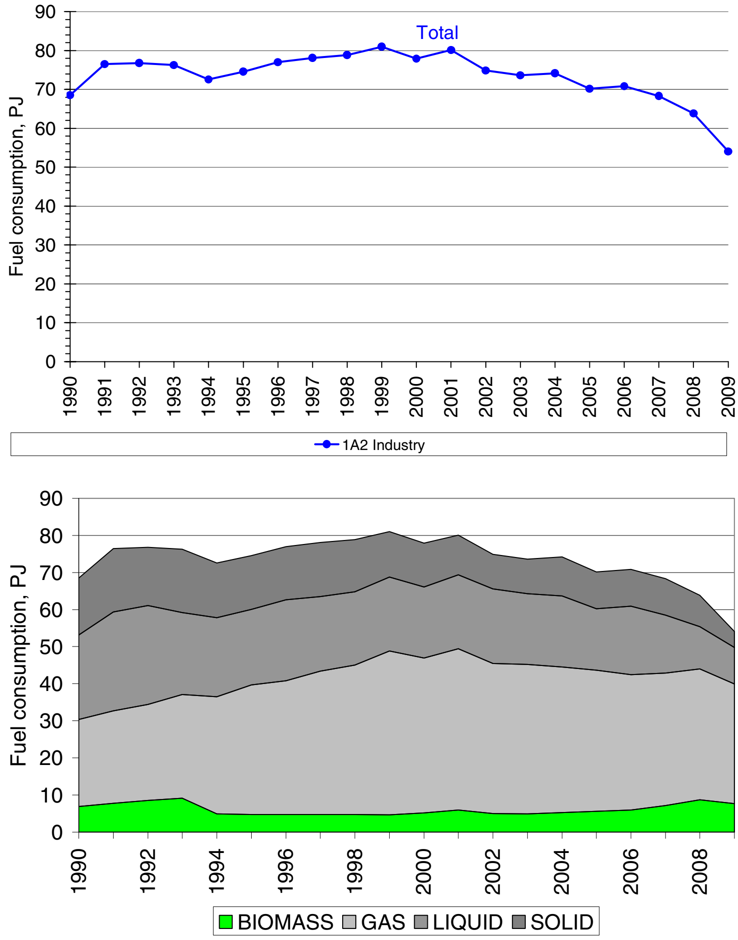
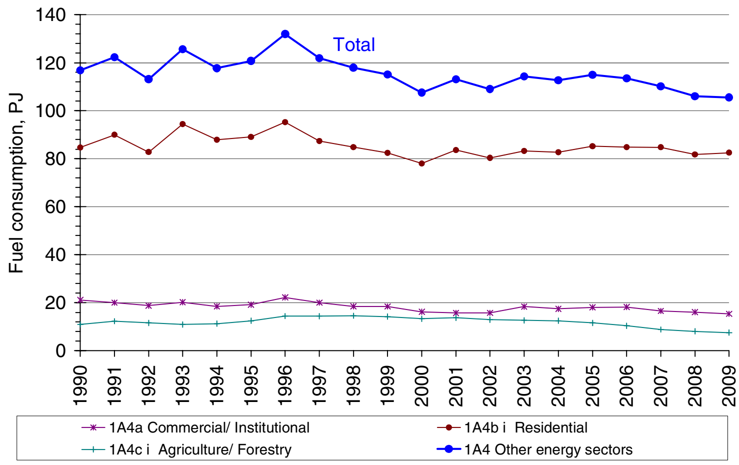


Figure 3.2.6 Fuel consumption time-series for subcategories - **1A2 Industry.**



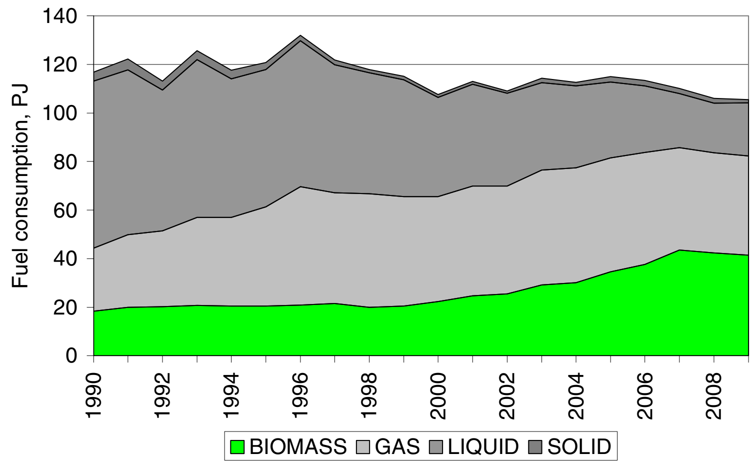


Figure 3.2.7 Fuel consumption time-series for subcategories **- 1A4 Other Sectors.**

3.2.3 Emissions

Greenhouse gas emission

The GHG emissions from stationary combustion are listed in Table 3.2.1. The emission from stationary combustion accounted for 47 % of the national GHG emission (excluding LULUCF) in 2009.

The CO_2 emission from stationary combustion plants accounts for 61 % of the national CO_2 emission (not including LULUCF). The CH_4 emission accounts for 7 % of the national CH_4 emission and the N_2O emission for 3 % of the national N_2O emission.

Table 3.2.1 Greenhouse gas emission, 2009 [1)].

	CO_2	CH_4	N_2O
	Gg CO_2 equivalent		
1A1 Fuel Combustion, Energy industries	23698	186	113
1A2 1A2 Fuel Combustion, Manufacturing Industries and Construction[1)]	3092	14	20
1A4 Fuel Combustion, Other sectors [1)]	4055	180	63
Emission from stationary combustion plants	30845	380	196
Emission share for stationary combustion	61%	7%	3%

[1)] Only stationary combustion sources of the category is included.

CO_2 is the most important GHG pollutant accounting for 98.2 % of the GHG emission (CO_2 eq.) from stationary combustion. CH_4 accounts for

1.2 % and N_2O for 0.6 % of the GHG emission (CO_2 eq.) from stationary combustion (Figure 3.2.8).

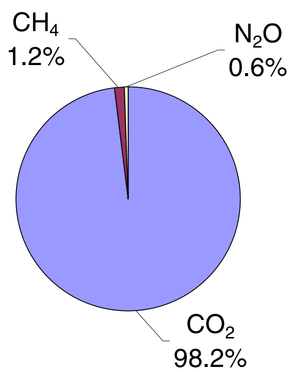


Figure 3.2.8 Stationary combustion - GHG emission (CO_2 equivalent), contribution from each pollutant.

Figure 3.2.9 depicts the time-series of GHG emission (CO_2 eq.) from stationary combustion and it can be seen that the GHG emission development follows the CO_2 emission development very closely. Both the CO_2 and the total GHG emission are lower in 2009 than in 1990, CO_2 by 18 % and GHG by 17 %. However, fluctuations in the GHG emission level are large.

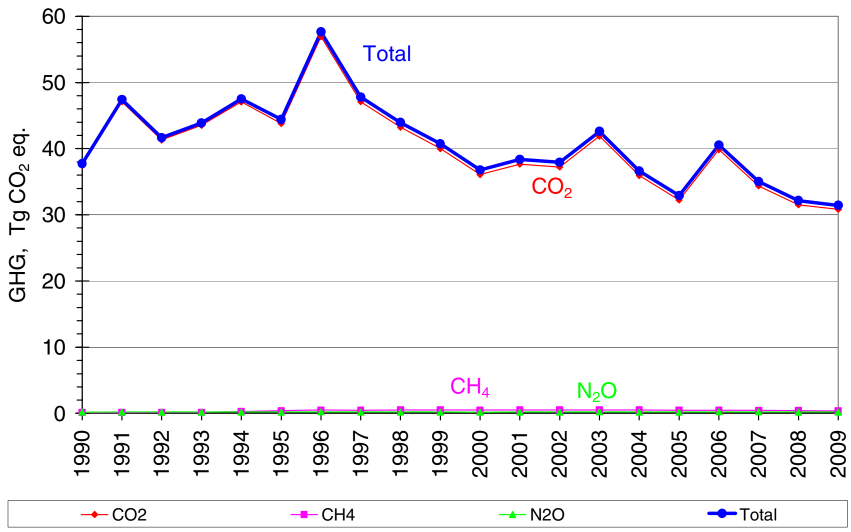


Figure 3.2.9 GHG emission time-series for stationary combustion.

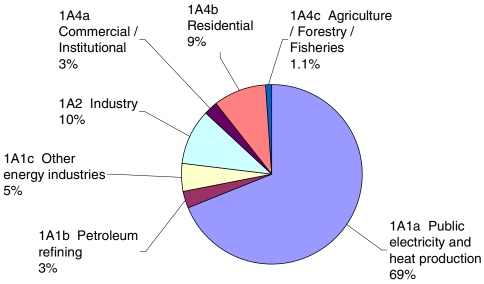
The fluctuations in the time-series are largely a result of electricity import/export, but also of outdoor temperature variations from year to year. The fluctuations follow the fluctuations in fuel consumption discussed in Chapter 3.2.2. As mentioned in Chapter 3.2.2, the Danish Energy Agency estimates a correction of the actual CO_2 emission without random variations in electricity imports/exports and in ambient temperature. The GHG emission corrected for electricity import/export and ambient temperature has decreased by 28 % since 1990, and the CO_2 emission by 29 %. These data are included here to explain the fluctuations in the emission time-series.

CO_2

The carbon dioxide (CO_2) emission from stationary combustion plants is one of the most important GHG emission sources. Thus the CO_2 emission from stationary combustion plants accounts for 61 % of the national CO_2 emission. Table 3.2.2 lists the CO_2 emission inventory for stationary combustion plants for 2009. *Electricity and heat production* accounts for 69 % of the CO_2 emission from stationary combustion. This share is somewhat higher than the fossil fuel consumption share for this category, which is 61 % (Figure 3.2.1). This is due to a large share of coal in this category. Other large CO_2 emission sources are *Industry* and *Residential* plants. These are the source categories, which also account for a considerable share of fuel consumption.

Table 3.2.2 CO_2 emission from stationary combustion plants, 2009[1].

		CO_2 Gg
1A1a	Public electricity and heat production	21224
1A1b	Petroleum refining	933
1A1c	Other energy industries	1542
1A2	Industry	3092
1A4a	Commercial/Institutional	806
1A4b	Residential	2925
1A4c	Agriculture/Forestry/Fisheries	324
Total		30845

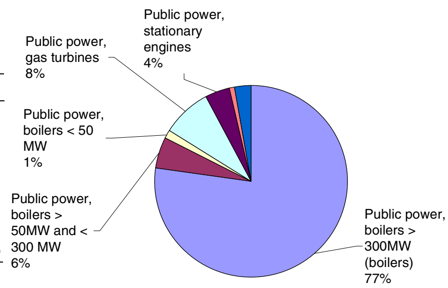


[1] Only emission from stationary combustion plants in the categories is included.

In the Danish inventory the source category *Electricity and heat production* is further disaggregated. The CO_2 emission from each of the subcategories is shown in Table 3.2.3. The largest subcategory is power plant boilers >300MW.

Table 3.2.3 CO_2 emission from subcategories to 1A1a Electricity and heat production.

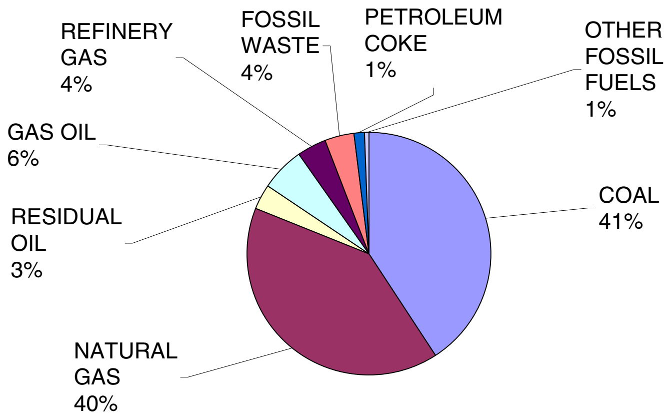
Sub-category ID (SNAP)	Subcategory name	CO_2, Gg
0101	**Public power**	
010101	Combustion plants ≥ 300MW (boilers)	16365
010102	Combustion plants ≥ 50MW and < 300 MW (boilers)	1172
010103	Combustion plants <50 MW (boilers)	296
010104	Gas turbines	1732
010105	Stationary engines	883
0102	**District heating plants**	
010202	Combustion plants ≥ 50MW and < 300 MW (boilers)	158
010203	Combustion plants <50 MW (boilers)	619



CO_2 emission from combustion of biomass fuels is not included in the total CO_2 emission data, because biomass fuels are considered CO_2 neutral. The CO_2 emission from biomass combustion is reported as a memo item in the Climate Convention reporting. In 2009 the CO_2 emission from biomass combustion was 11 861 Gg.

In Figure 3.2.10 the fuel consumption share (fossil fuels) is compared to the CO_2 emission share disaggregated to fuel origin. Due to the higher CO_2 emission factor for coal than oil and gas, the CO_2 emission share from coal combustion is higher than the fuel consumption share. Coal accounts for 41 % of the fossil fuel consumption and for 51 % of the CO_2 emission. Natural gas accounts for 40 % of the fossil fuel consumption but only 30 % of the CO_2 emission.

Fossil fuel consumption share.



CO_2 emission, fuel origin.

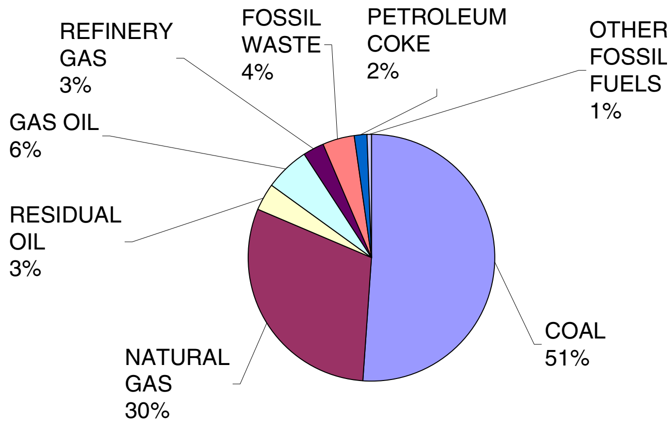


Figure 3.2.10 CO_2 emission, fuel origin.

Time-series for CO_2 emission are provided in Figure 3.2.11. Despite an increase in fuel consumption of 5 % since 1990 CO_2 emission from stationary combustion has decreased by 18 % because of the change of fuel type used.

The fluctuations in total CO_2 emission follow the fluctuations in CO_2 emission from *Electricity and heat production* (Figure 3.2.11) and in coal consumption (Figure 3.2.4). The fluctuations are a result of electricity import/export as discussed in Chapter 3.2.2.

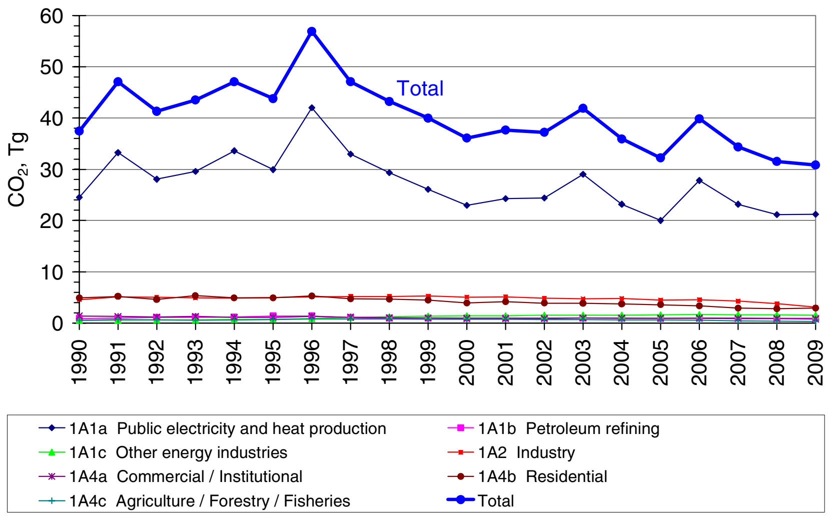


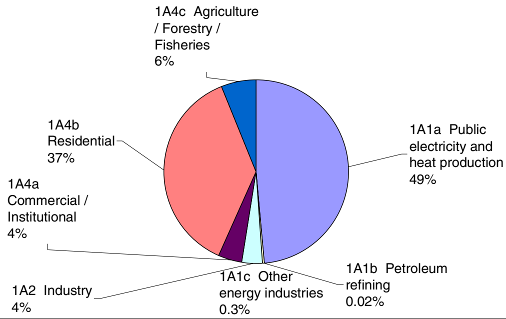
Figure 3.2.11 CO_2 emission time-series for stationary combustion plants.

CH_4

The methane (CH_4) emission from stationary combustion plants accounts for 7 % of the national CH_4 emission. Table 3.2.4 lists the CH_4 emission inventory for stationary combustion plants in 2009. *Electricity and heat production* accounts for 49 % of the CH_4 emission from stationary combustion, which is somewhat less than the fuel consumption share. The emission from residential plants adds up to 37 % of the emission.

Table 3.2.4 CH_4 emission from stationary combustion plants, 2009[1)].

	CH_4 Mg
1A1a Public electricity and heat production	8817
1A1b Petroleum refining	4
1A1c Other energy industries	46
1A2 Industry	656
1A4a Commercial/Institutional	729
1A4b Residential	6722
1A4c Agriculture/Forestry/Fisheries	1130
Total	18103



[1)] Only emission from stationary combustion plants in the source categories is included.

The CH_4 emission factor for reciprocating gas engines is much higher than for other combustion plants due to the continuous ignition/burn-out of the gas. Lean-burn gas engines have an especially high emission factor. A considerable number of lean-burn gas engines are in operation in Denmark and in 2009 these plants accounted for 58 % of the CH_4 emission from stationary combustion plants (Figure 3.2.12). Most engines are installed in CHP plants and the fuel used is either natural gas or biogas. Residential wood combustion is also a large emission source.

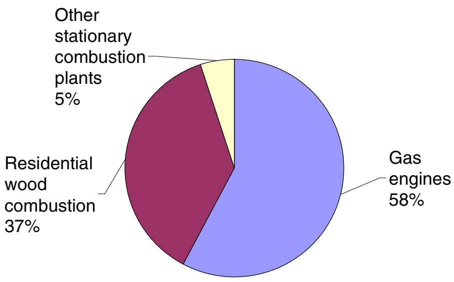


Figure 3.2.12 CH_4 emission share for gas engines and residential wood combustion, 2009.

Figure 3.2.13 shows the time-series for CH_4 emission. The CH_4 emission from stationary combustion has increased by a factor of 3.0 since 1990. This results from the considerable number of lean-burn gas engines installed in CHP plants in Denmark during the 1990s. Figure 3.2.14 provides time-series for the fuel consumption rate in gas engines and the corresponding increase of CH_4 emission. The decline in later years is due to structural changes in the Danish electricity market, which means that the fuel consumption in gas engines has been decreasing.

The emission from residential plants has increased since 1990 due to increased combustion of biomass in residential plants until 2007. The consumption has however decreased since 2007. Combustion of wood accounted for 76 % of the emission from residential plants in 2009.

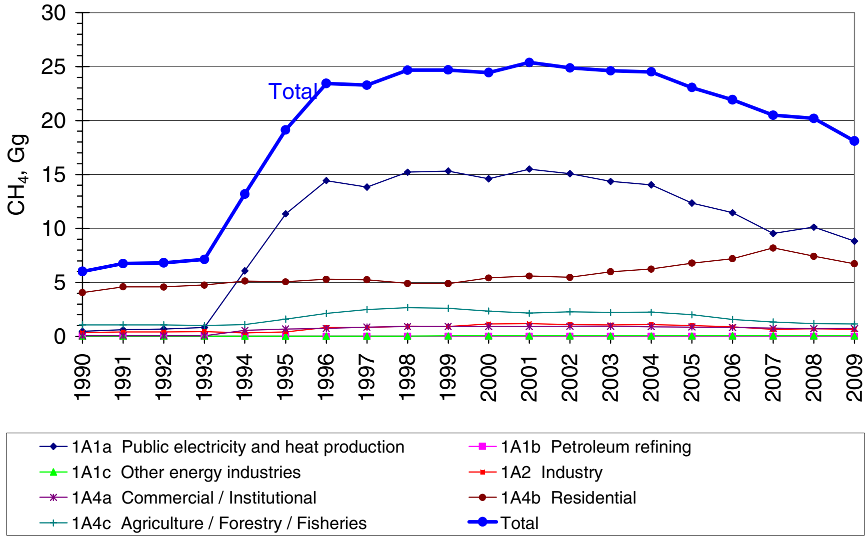


Figure 3.2.13 CH_4 emission time-series for stationary combustion plants.

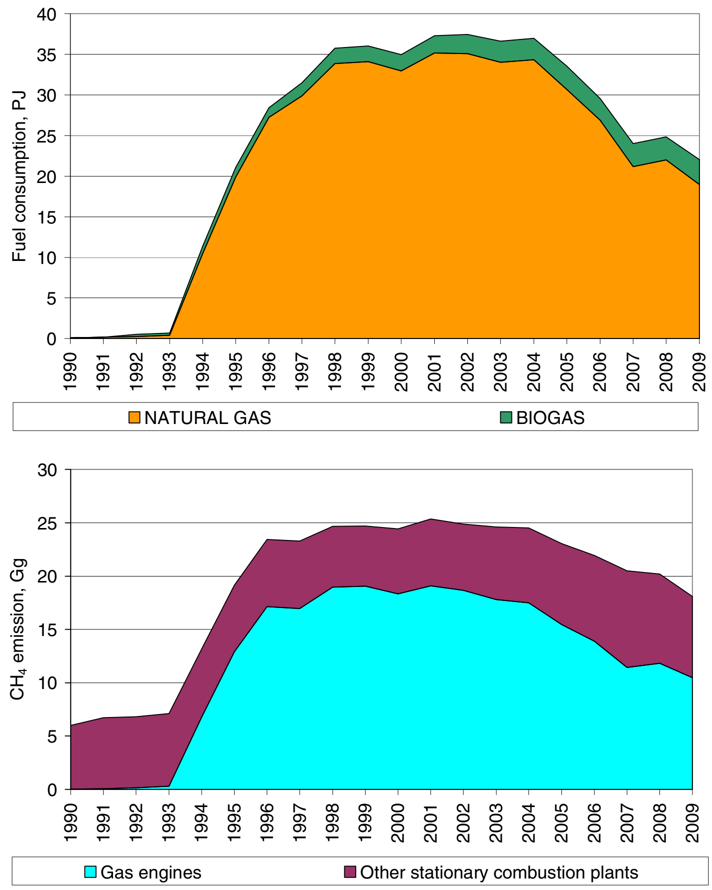


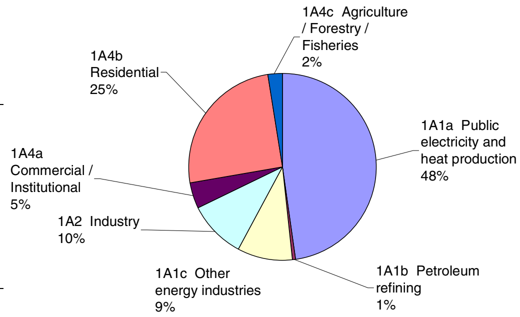
Figure 3.2.14 Fuel consumption and CH_4 emission from gas engines, time-series.

N_2O

The nitrous oxide (N_2O) emission from stationary combustion plants accounts for 3 % of the national N_2O emission. Table 3.2.5 lists the N_2O emission inventory for stationary combustion plants in the year 2009. *Electricity and heat production* accounts for 48 % of the N_2O emission from stationary combustion.

Table 3.2.5 N_2O emission from stationary combustion plants, 2009[1)].

	N_2O Mg
1A1a Public electricity and heat production	301
1A1b Petroleum refining	4
1A1c Other energy industries	59
1A2 Industry	64
1A4a Commercial/Institutional	29
1A4b Residential	159
1A4c Agriculture/Forestry/Fisheries	16
Total	632



[1)] Only emission from stationary combustion plants in the source categories is included.

Figure 3.2.15 shows time-series for N_2O emission. The N_2O emission from stationary combustion has increased by 15 % from 1990 to 2009, but again fluctuations in emission level due to electricity import/export are considerable.

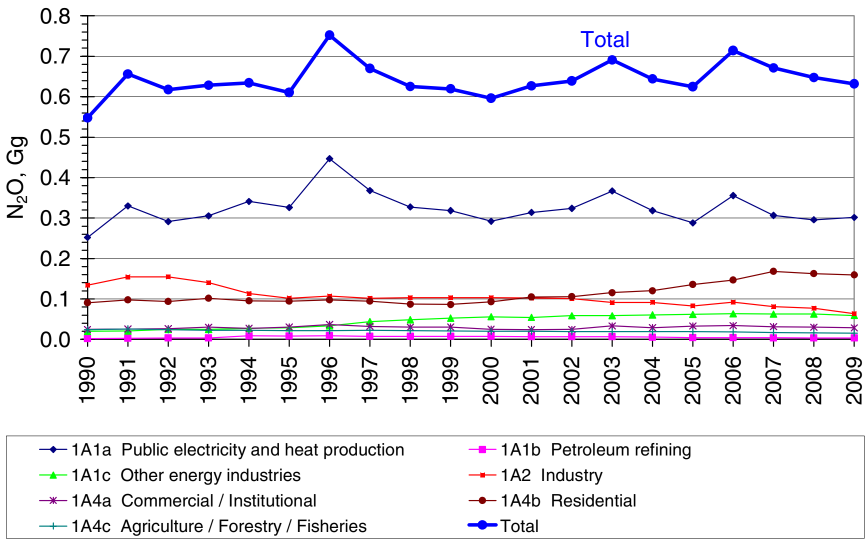


Figure 3.2.15 N_2O emission time-series for stationary combustion plants.

SO_2, NO_x, NMVOC and CO

The emissions of sulphur dioxide (SO_2), nitrogen oxides (NO_x), non volatile organic compounds (NMVOC) and carbon monoxide (CO) from Danish stationary combustion plants 2009 are presented in Table 3.2.6.

SO_2 from stationary combustion plants accounts for 73 % of the national emission. NO_x, CO and NMVOC account for 32 %, 37 % and 20 % of national emissions, respectively.

Table 3.2.6 SO_2, NO_x, NMVOC and CO emission, 2009[1)].

Pollutant	NO_x Gg	CO Gg	NMVOC Gg	SO_2 Gg
1A1 Fuel consumption, Energy industries	28.1	9.4	2.0	4.9
1A2 Fuel consumption, Manufacturing Industries and Construction[1)]	6.8	10.3	0.3	2.8
1A4 Fuel consumption, Other sectors[1)]	7.7	127.0	17.0	3.0
Emission from stationary combustion plants	42.6	146.7	19.2	10.8
Emission share for stationary combustion, %	32	37	20	73

1) Only emissions from stationary combustion plants in the source categories are included.

SO_2

Stationary combustion is the most important emission source for SO_2 accounting for 73 % of the national emission. Table 3.2.7 presents the SO_2 emission inventory for the stationary combustion subcategories.

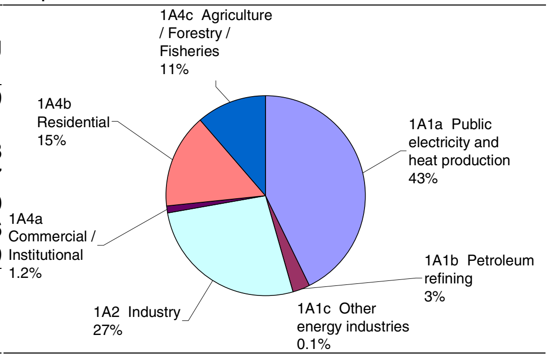
Electricity and heat production is the largest emission source accounting for 43 % of the emission. However, the SO_2 emission share is lower than the fuel consumption share for this source category, which is 61 %. This is a result of effective flue gas desulphurisation equipment installed in power plants combusting coal. In the Danish inventory the source category *Electricity and heat production* is further disaggregated. Figure 3.2.16 shows the SO_2 emission from *Electricity and heat production* on a disaggregated level. Power plants >300MW$_{th}$ are the main emission source, accounting for 52 % of the emission.

The SO_2 emission from industrial plants is 26 %, a remarkably high emission share compared with fuel consumption. The main emission sources in the industrial category are combustion of coal and residual oil, but emissions from the cement industry is also a considerable emission source. Ten years ago SO_2 emission from the industrial category only accounted for a small part of the emission from stationary combustion, but as a result of reduced emissions from power plants the share has now increased.

Time-series for SO_2 emission from stationary combustion are shown in Figure 3.2.17. The SO_2 emission from stationary combustion plants has decreased by 93 % since 1990. The large emission decrease is mainly a result of the reduced emission from *Electricity and heat production*, made possible due to installation of desulphurisation plants and due to the use of fuels with lower sulphur content. Despite the considerable reduction in emission from electricity and heat production plants, these still account for 43 % of the emission from stationary combustion, as mentioned above. The emission from other source categories also decreased considerably since 1990. Time-series for subcategories are shown in Chapter 3.2.4.

Table 3.2.7 SO_2 emission from stationary combustion plants, 2009[1)].

	SO_2 Mg
1A1a Public electricity and heat production	4589
1A1b Petroleum refining	341
1A1c Other energy industries	8
1A2 Industry	2847
1A4a Commercial/Institutional	130
1A4b Residential	1636
1A4c Agriculture/Forestry/Fisheries	1219
Total	10771



1) Only emission from stationary combustion plants in the source categories is included.

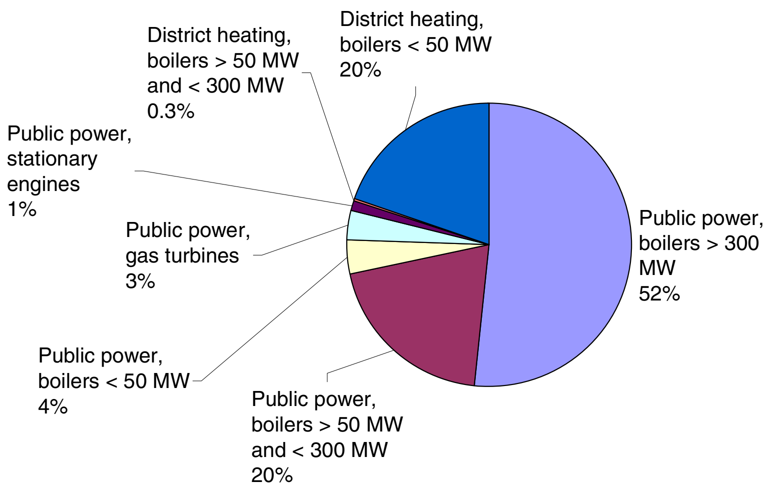


Figure 3.2.16 Disaggregated SO_2 emissions from 1A1a Energy and heat production.

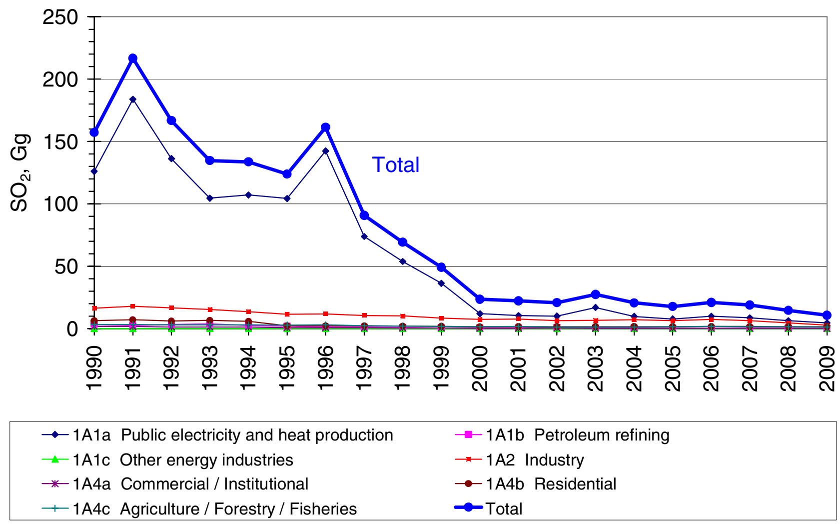


Figure 3.2.17 SO_2 emission time-series for stationary combustion.

NO_x

Stationary combustion accounts for 32 % of the national NO_x emission. Table 3.2.8 shows the NO_x emission inventory for stationary combustion subcategories.

Electricity and heat production is the largest emission source accounting for 47 % of the emission from stationary combustion plants. The emission from public power boilers > 300 MW_{th} accounts for 39 % of the emission in this subcategory.

Industrial combustion plants are also an important emission source accounting for 16 % of the emission. The main industrial emission source is cement production, which accounts for 57 % of the emission.

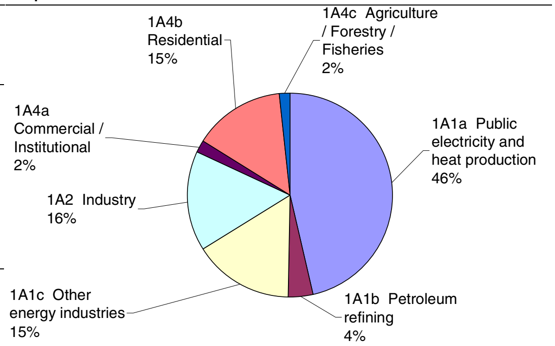
Residential plants account for 15 % of the NO_x emission. The fuel origin of this emission is mainly wood accounting for 65 % of the residential plant emission.

Other energy industries which is mainly off-shore gas turbines accounts for 16 % of the NO_x emission.

Time-series for NO_x emission from stationary combustion are shown in Figure 3.2.18. NO_x emission from stationary combustion plants has decreased by 63 % since 1990. The reduced emission is largely a result of the reduced emission from electricity and heat production due to installation of low NO_x burners, selective catalytic reduction (SCR) units and selective non-catalytic reduction (SNCR) units. The fluctuations in the time-series follow the fluctuations in electricity and heat production, which, in turn, result from electricity trade fluctuations.

Table 3.2.8 NO_x emission from stationary combustion plants, 2009[1)].

	NO_x Mg
1A1a Public electricity and heat production	19796
1A1b Petroleum refining	1610
1A1c Other energy industries	6686
1A2 Industry	6764
1A4a Commercial/Institutional	812
1A4b Residential	6192
1A4c Agriculture/Forestry/Fisheries	702
Total	42563



1) Only emission from stationary combustion plants in the source categories is included.

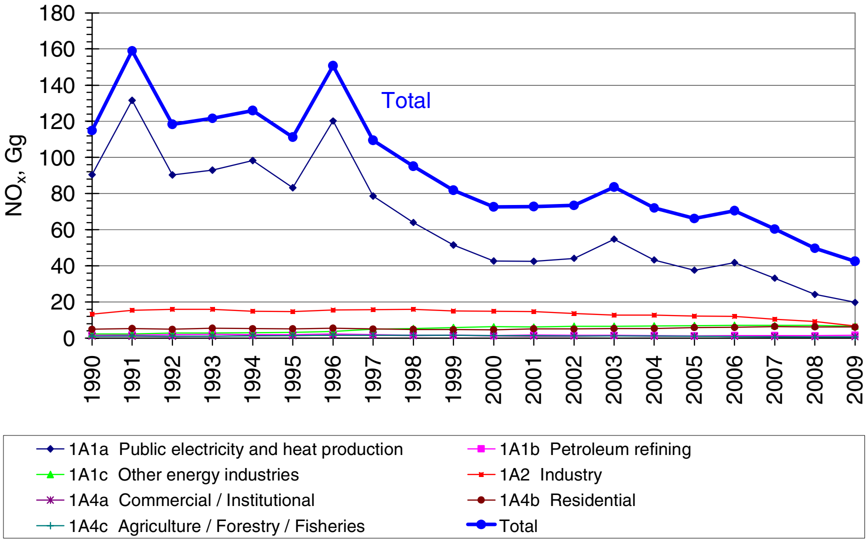


Figure 3.2.18 NO_x emission time-series for stationary combustion.

NMVOC

Stationary combustion plants account for 20 % of the national NMVOC emission. Table 3.2.9 presents the NMVOC emission inventory for the stationary combustion subcategories.

Residential plants are the largest emission source accounting for 84 % of the emission from stationary combustion plants. For residential plants NMVOC is mainly emitted from wood and straw combustion, see Figure 3.2.19.

Electricity and heat production is also a considerable emission source, accounting for 10 % of the emission. Lean-burn gas engines have a relatively high NMVOC emission factor and are the most important emission source in this subcategory (see Figure 3.2.19). The gas engines are either natural gas or biogas fuelled.

Time-series for NMVOC emission from stationary combustion are shown in Figure 3.2.20. The emission has increased by 31 % from 1990. The increased emission is mainly a result of the increasing wood consumption in residential plants and of the increased use of lean-burn gas engines in CHP plants.

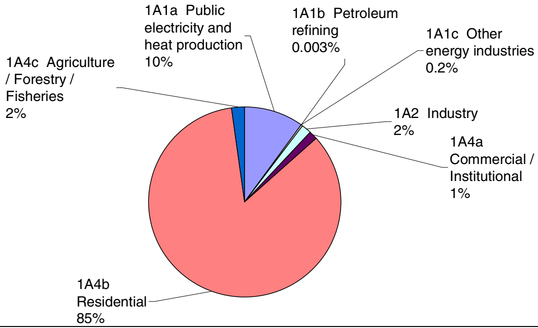
The emission from residential plants increased 34 % since 1990. The NMVOC emission from wood combustion in 2009 was 2.5 times the 1990 level due to increased wood consumption. However, the emission factor has decreased since 1990 due to installation of modern stoves and boilers with improved combustion technology. Further the emission from straw combustion in farmhouse boilers has decreased (75 %) over this period due to both a decreasing emission factor and decrease in straw consumption in this source category.

The use of wood in residential boilers and stoves was relatively low in 1998-99 resulting in a lower emission level.

The decrease of the NMVOC emission since 2007 is a result of both a decline of the consumption of wood in residential plants and a decreasing emission factor for firewood combustion in residential plants.

Table 3.2.9 NMVOC emission from stationary combustion plants, 2009[1)].

		NMVOC Mg
1A1a	Public electricity and heat production	1938
1A1b	Petroleum refining	1
1A1c	Other energy industries	38
1A2	Industry	295
1A4a	Commercial/Institutional	275
1A4b	Residential	16245
1A4c	Agriculture/Forestry/Fisheries	444
Total		19236



1) Only emission from stationary combustion plants in the categories is included.

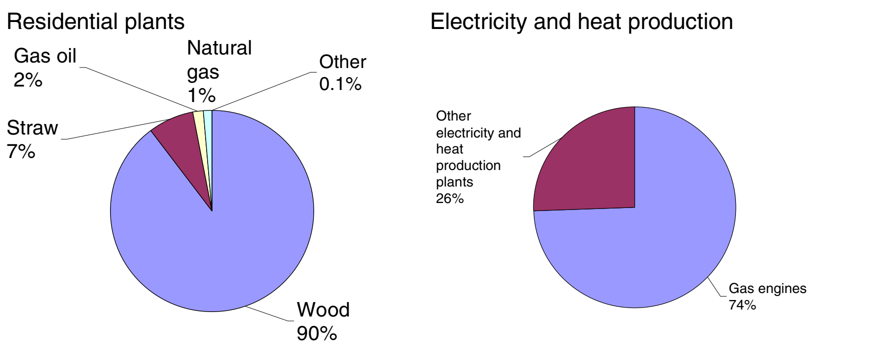


Figure 3.2.19 NMVOC emission from Residential plants and from Electricity and heat production, 2009.

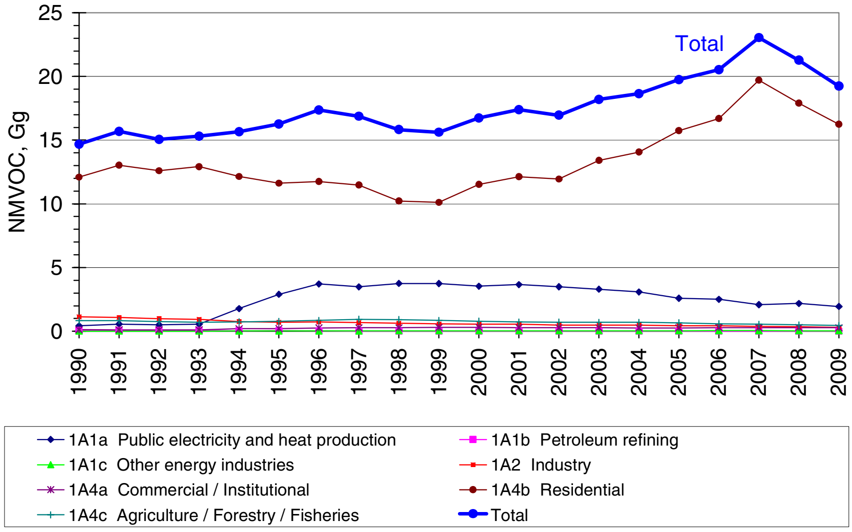


Figure 3.2.20 NMVOC emission time-series for stationary combustion.

CO

Stationary combustion accounts for 37 % of the national CO emission. Table 3.2.10 presents the CO emission inventory for stationary combustion subcategories.

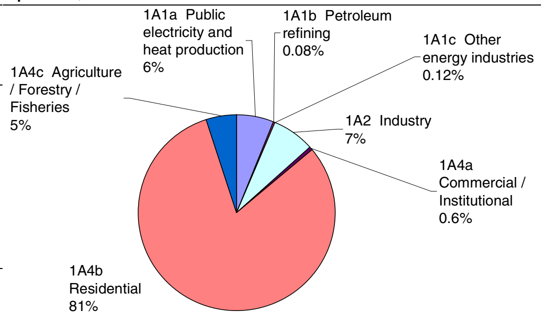
Residential plants are the largest emission source, accounting for 81 % of the emission. Wood combustion accounts for 89 % of the emission from residential plants, see Figure 3.2.21. This is in spite of the fact that the fuel consumption share is only 40 %. Combustion of straw is also a considerable emission source whereas the emission from other fuels used in residential plants is almost negligible.

Time-series for CO emission from stationary combustion are shown in Figure 3.2.22. The emission has increased by 3 % from 1990. The time-series for CO from stationary combustion plants follows the time-series for CO emission from residential plants. The decreased wood consumption in residential plants since 2007 has resulted in a decrease of CO emission from stationary combustion since 2007.

The consumption of wood in residential plants in 2009 was 3.7 times the 1990 level. However, the CO emission factor for wood has decreased since 1990 causing the CO emission from wood combustion in residential plants in 2009 to be only 2.8 times the 1990 level. Both straw consumption and CO emission factor for residential plants have decreased since 1990.

Table 3.2.10 CO emission from stationary combustion plants, 2009[1)].

	CO Mg
1A1a Public electricity and heat production	9079
1A1b Petroleum refining	118
1A1c Other energy industries	176
1A2 Industry	10330
1A4a Commercial/Institutional	865
1A4b Residential	118706
1A4c Agriculture/Forestry/Fisheries	7441
Total	146714



1) Only emission from stationary combustion plants in the source categories is included.

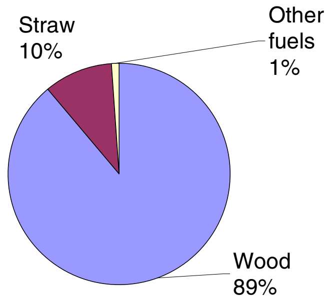


Figure 3.2.21 CO emission sources, residential plants, 2009.

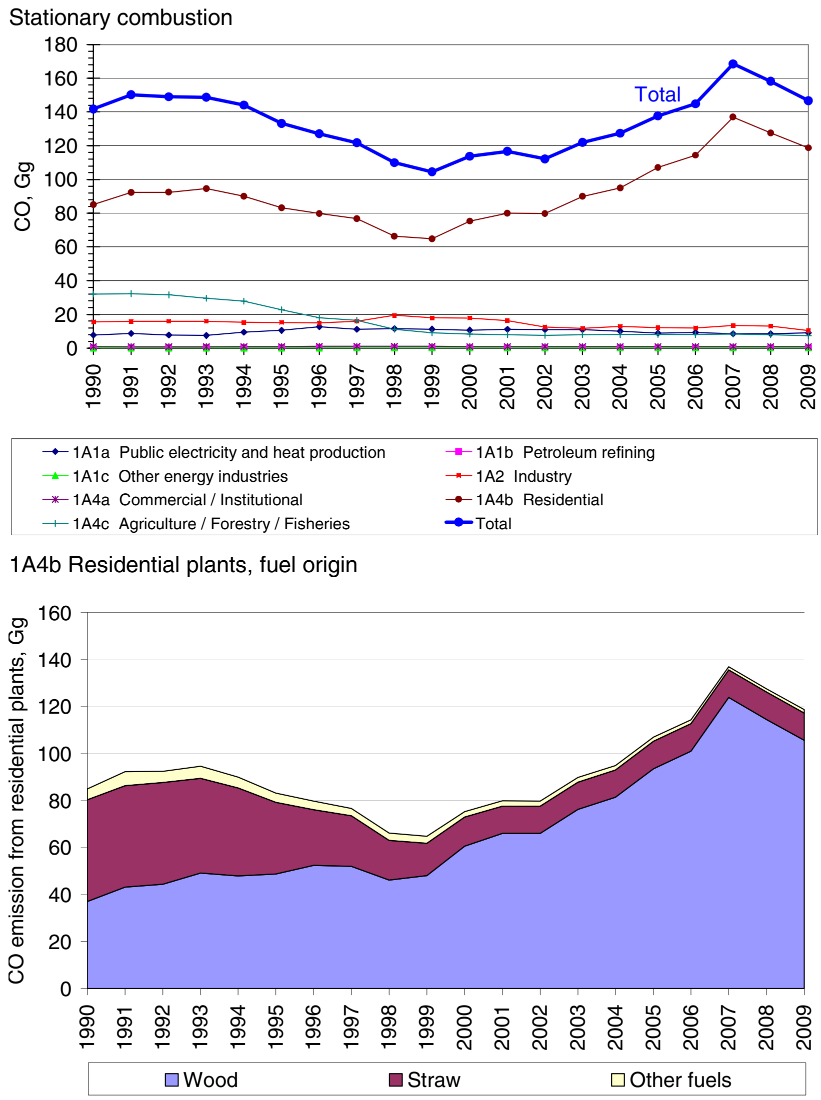


Figure 3.2.22 CO emission time-series for stationary combustion.

3.2.4 Sectoral trend

In addition to the data for stationary combustion this chapter presents and discusses data for each of the subcategories in which stationary combustion is included. Time-series are presented for fuel consumption and emissions.

1A1 Energy industries

The emission source category *1A1 Energy Industries* consists of the subcategories:

- 1A1a Electricity and heat production.
- 1A1b Petroleum refining.
- 1A1c Other energy industries.

Figure 3.2.23 – 3.2.25 present time-series for the *Energy Industries*. *Electricity and heat production* is the largest subcategory accounting for the main part of all emissions. Time-series are discussed below for each subcategory.

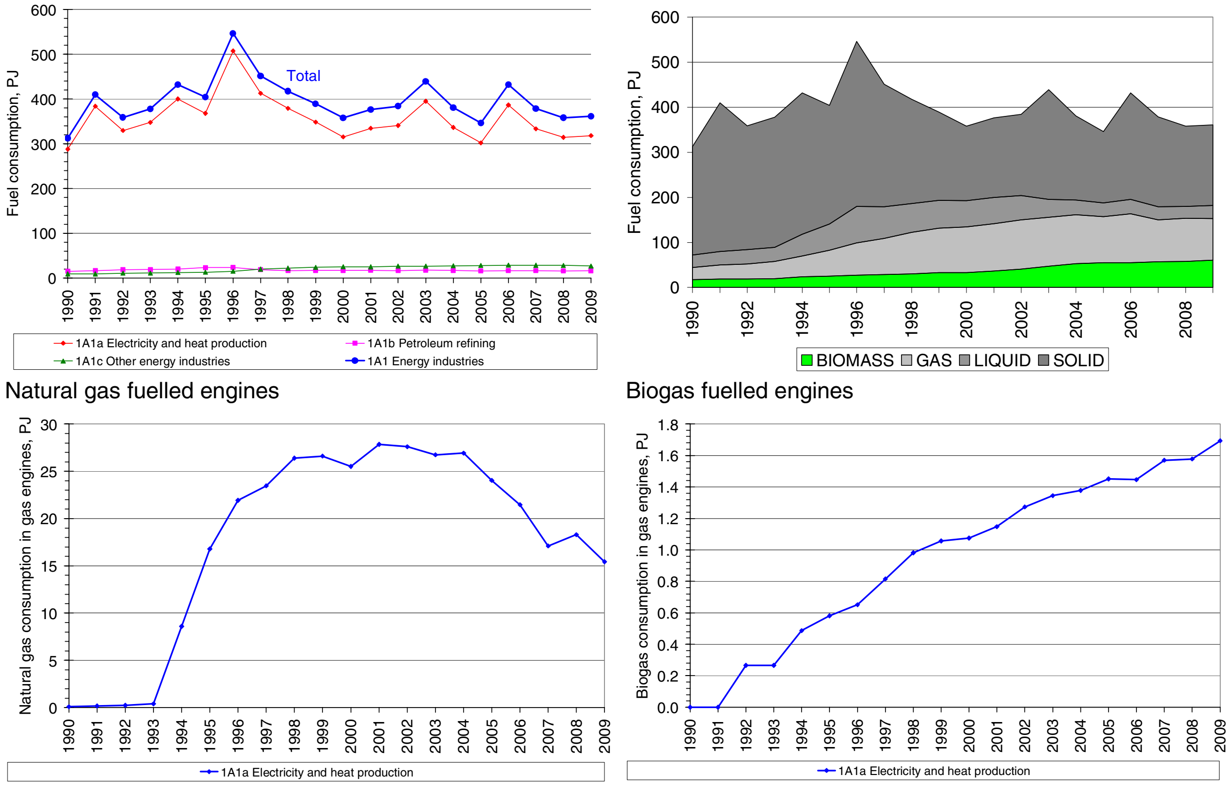


Figure 3.2.23 Time-series for fuel consumption, 1A1 Energy industries.

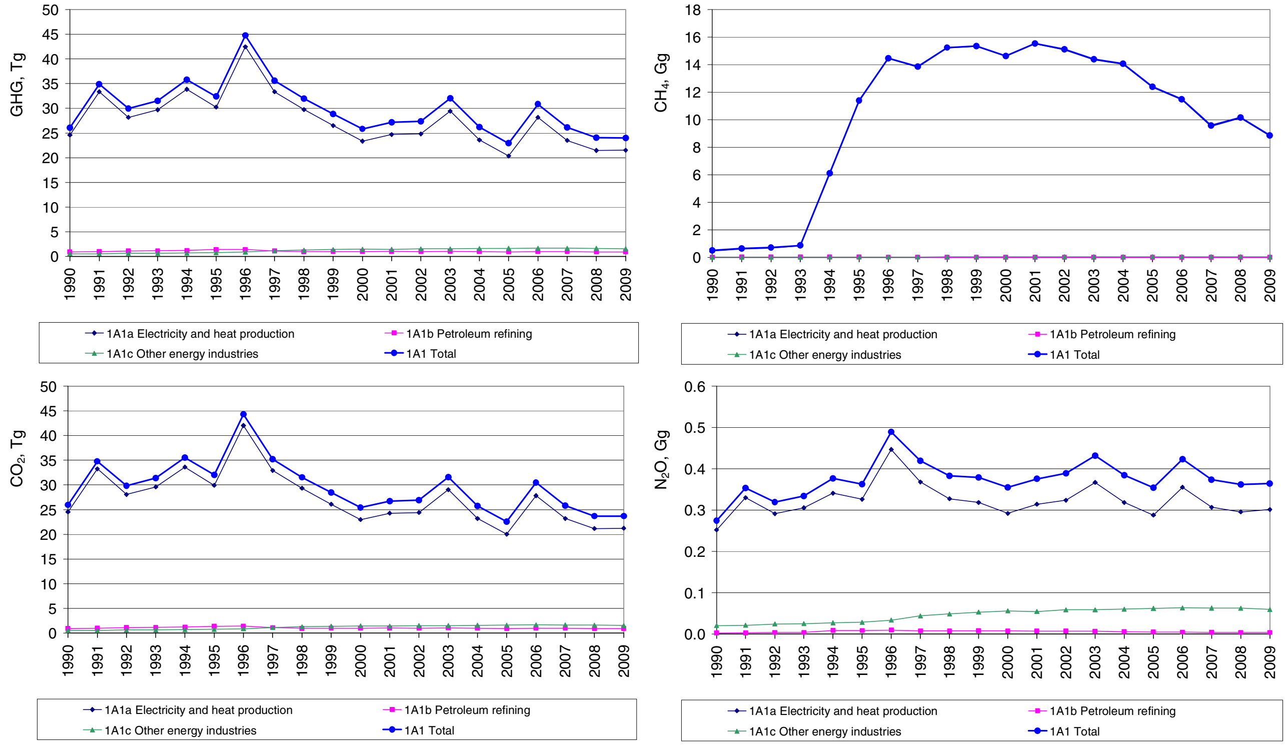


Figure 3.2.24 Time-series for greenhouse gas emission, 1A1 Energy industries.

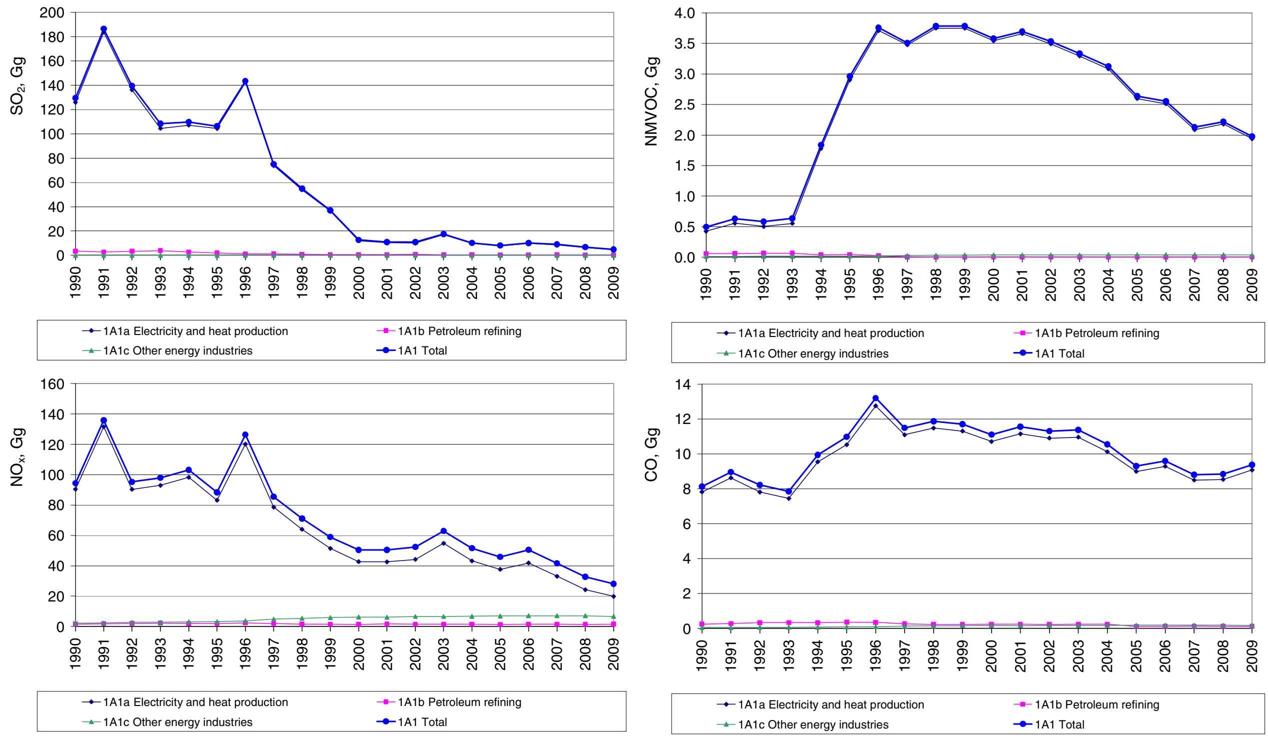


Figure 3.2.25 Time-series for SO_2, NO_x, NMVOC and CO emission, 1A1 Energy industries.

1A1a Electricity and heat production

Public electricity and heat production is the largest source category regarding both fuel consumption and greenhouse gas emissions for stationary combustion. Figure 3.2.26 shows the time-series for fuel consumption and emissions.

The fuel consumption in electricity and heat production was 10 % higher in 2009 than in 1990. As discussed in Chapter 3.2.2 the fuel consumption fluctuates mainly as a consequence of electricity trade. Coal is the fuel that is affected the most by the fluctuating electricity trade. Coal is the main fuel in the source category even in years with electricity import. The coal consumption in 2009 was 31 % lower than in 1990. Natural gas is also an important fuel and the consumption of natural gas has increased since 1990, but decreased since 2003. A considerable part of the natural gas is combusted in gas engines (Figure 3.2.23). The consumption of municipal waste and biomass has increased.

The CO_2 emission was 13 % lower in 2009 than in 1990. This decrease – in spite of higher fuel consumption - is a result of the change of fuel discussed above.

For CH_4 the emission increase until the mid-nineties is a result of the considerable number of lean-burn gas engines installed in CHP plants in Denmark in this period. The decline in later years is due to structural changes in the Danish electricity market, which means that the fuel consumption in gas engines has been decreasing (Figure 3.2.23). The emission in 2009 was 19 times the 1990 emission level.

The N_2O emission in 2009 was 19 % above the 1990 emission level. The emission fluctuates similar to the fuel consumption.

The SO_2 emission has decreased 96 % since 1990. This decrease is a result of both lower sulphur content in fuels and installation and improved performance of desulphurisation plants.

The NO_x emission has decreased 78 % due to installation of low NO_x burners, selective catalytic reduction (SCR) units and selective non-catalytic reduction (SNCR) units. The fluctuations in time-series follow the fluctuations in fuel consumption and electricity trade.

The emission of NMVOC in 2009 was 4.6 times the 1990 emission level. This is a result of the large number of gas engines that has been installed in Danish CHP plants as mentioned above.

The CO emission was 16 % higher in 2009 than in 1990. The fluctuations follow the fluctuations of the fuel consumption. In addition the emission from gas engines is considerable.

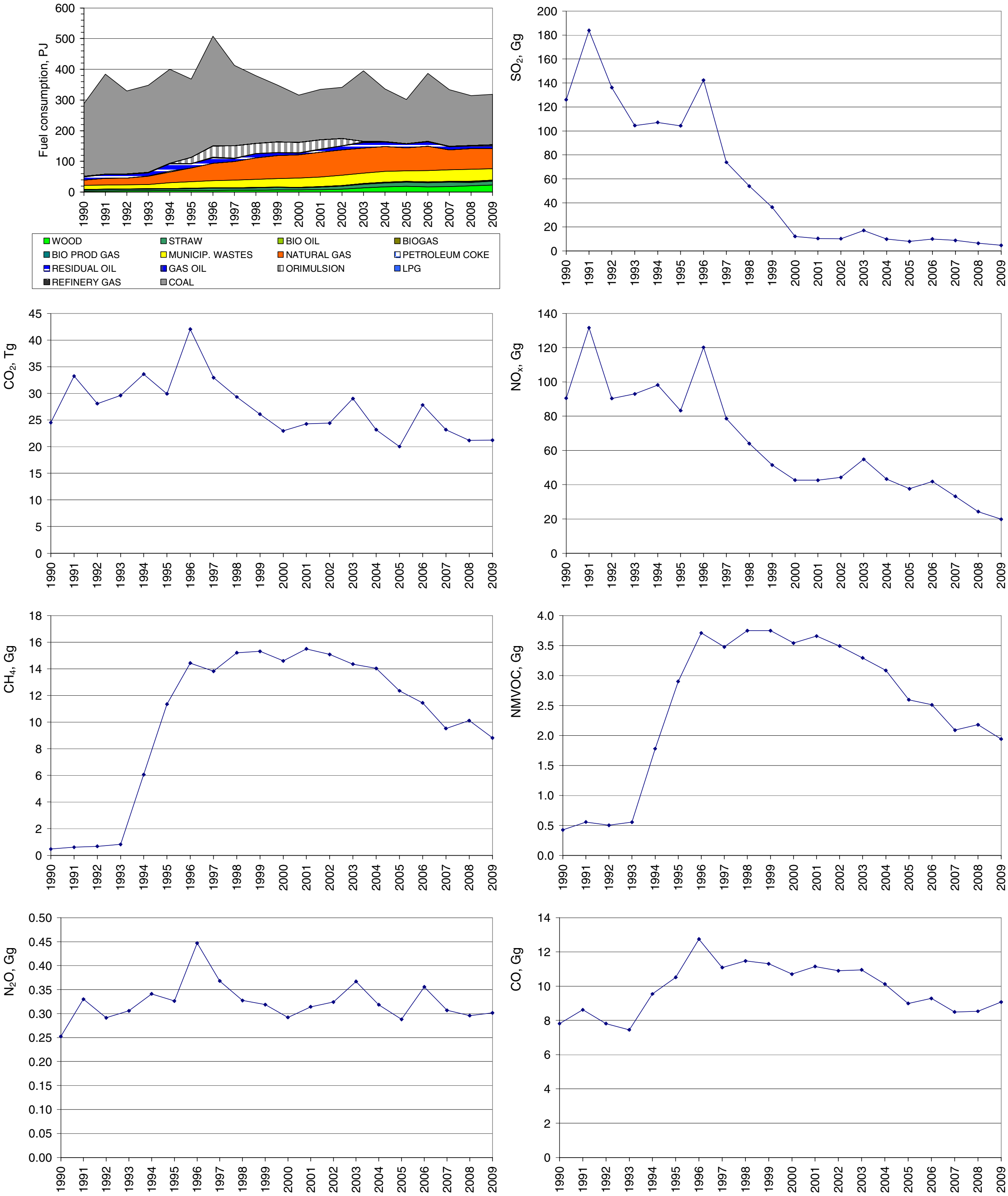


Figure 3.2.26 Time-series for 1A1a Electricity and heat production.

1A1b Petroleum refining

Petroleum refining is a small source category regarding both fuel consumption and greenhouse gas emissions for stationary combustion. There are presently only two refineries operating in Denmark. Figure 3.2.27 shows the time-series for fuel consumption and emissions.

The significant decrease in both fuel consumption and emissions in 1996 is a result of the closure of a third refinery.

The fuel consumption has increased 6 % since 1990 and the CO_2 emission has increased 3 %.

The reduction in CH_4 emission from 1995 to 1996 is caused by the closure of a refinery. The reduction 1997 - 1999 is a result of inconsistency of methodology that will be corrected in the next inventory[3].

The N_2O emission was 71 % higher in 2009 than in 1990. The emission increased in 1990 – 1994 as a result of the installation of a gas turbine in one of the refineries. The gas turbine was installed in 1993 (DEA 2010c) but plant specific fuel consumption data (technology specific data) are only available from 1994 onwards. Thus, the N_2O emission in 1993 is likely to be underestimated because the emission factor for gas turbines is higher than for other plants in the sector.

The N_2O emission factor for the refinery gas fuelled gas turbine has been assumed equal to the emission factor for natural gas fuelled turbines and thus the emission factor have been decreasing since 1994. This cause the decreasing time-series since 1994. However, since only one gas turbine is included in the sector the same emission factor will be applied for all years in future inventories.

The emission of SO_2 has shown a pronounced decrease (90 %) since 1990, mainly because of technical improvements at the refineries. The NO_x emission in 2009 was the same as in 1990. In recent years, data for both SO_2 and NO_x are plant specific data stated by the refineries.

The time-series for NMVOC will be recalculated in the next inventory due to an inconsistency of methodology similar to the one mentioned above concerning CH_4. Further, the emission factor time-series are inconsistent.

Inconsistent time-series for CO emission factors (2004 - 2005) will also be corrected in the next inventory.

Emissions from refineries are further discussed in Chapter 3.5.

[3] The emission of CH_4 and NMVOC have for some years been assumed (NERI assumption) included annual plant specific emission data reported in emission source 1B2.

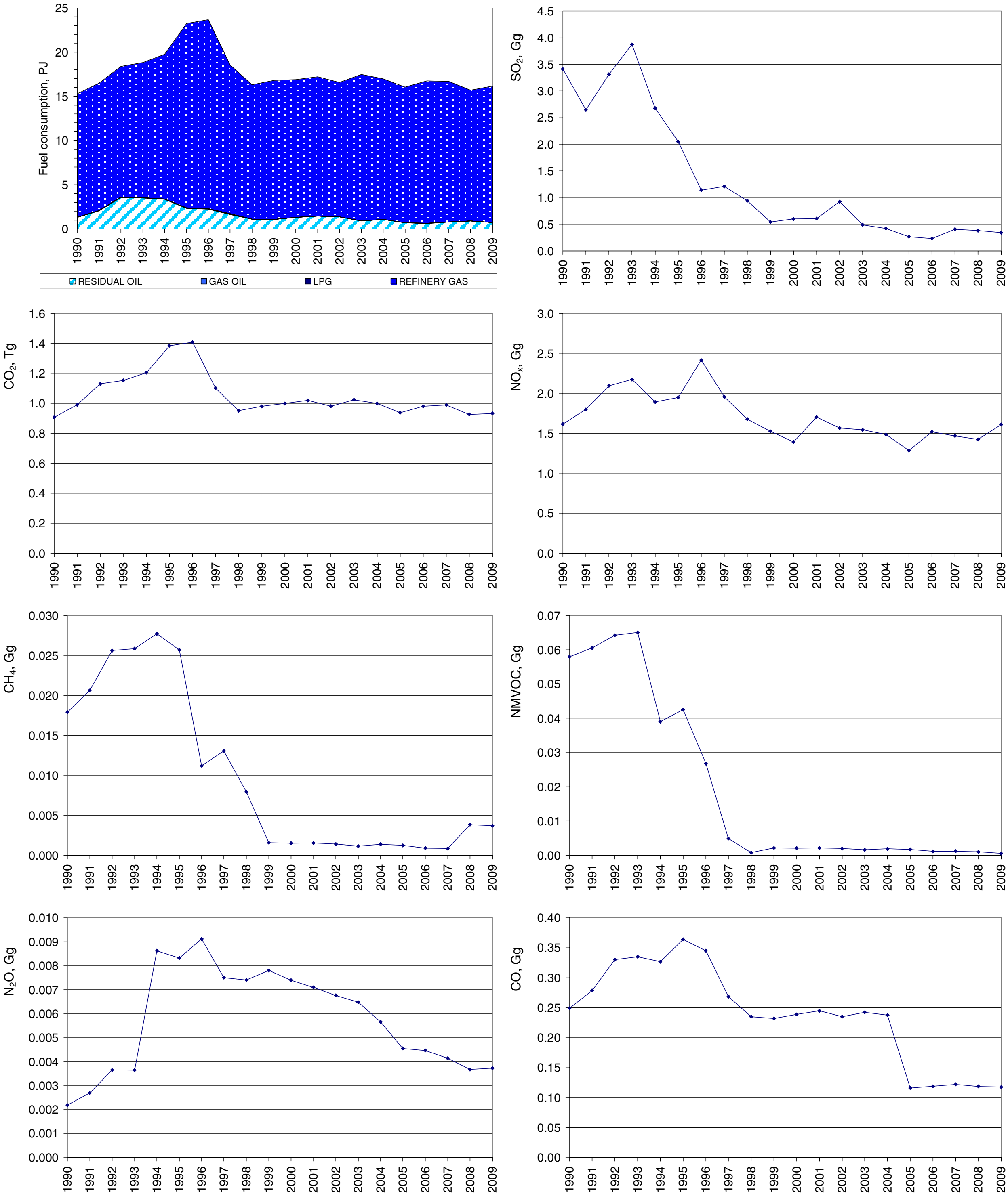


Figure 3.2.27 Time-series for 1A1b Petroleum refining.

1A1c Other energy industries

The source category *Other energy industries* comprises natural gas consumption in the off-shore industry. Gas turbines are the main plant type. Figure 3.2.28 shows the time-series for fuel consumption and emissions.

The fuel consumption in 2009 was 2.9 times the consumption in 1990. The CO_2 emission follows the fuel consumption and the emission in 2009 was also 2.9 times the emission in 1990.

The emissions from all pollutants follow the increase of fuel consumption.

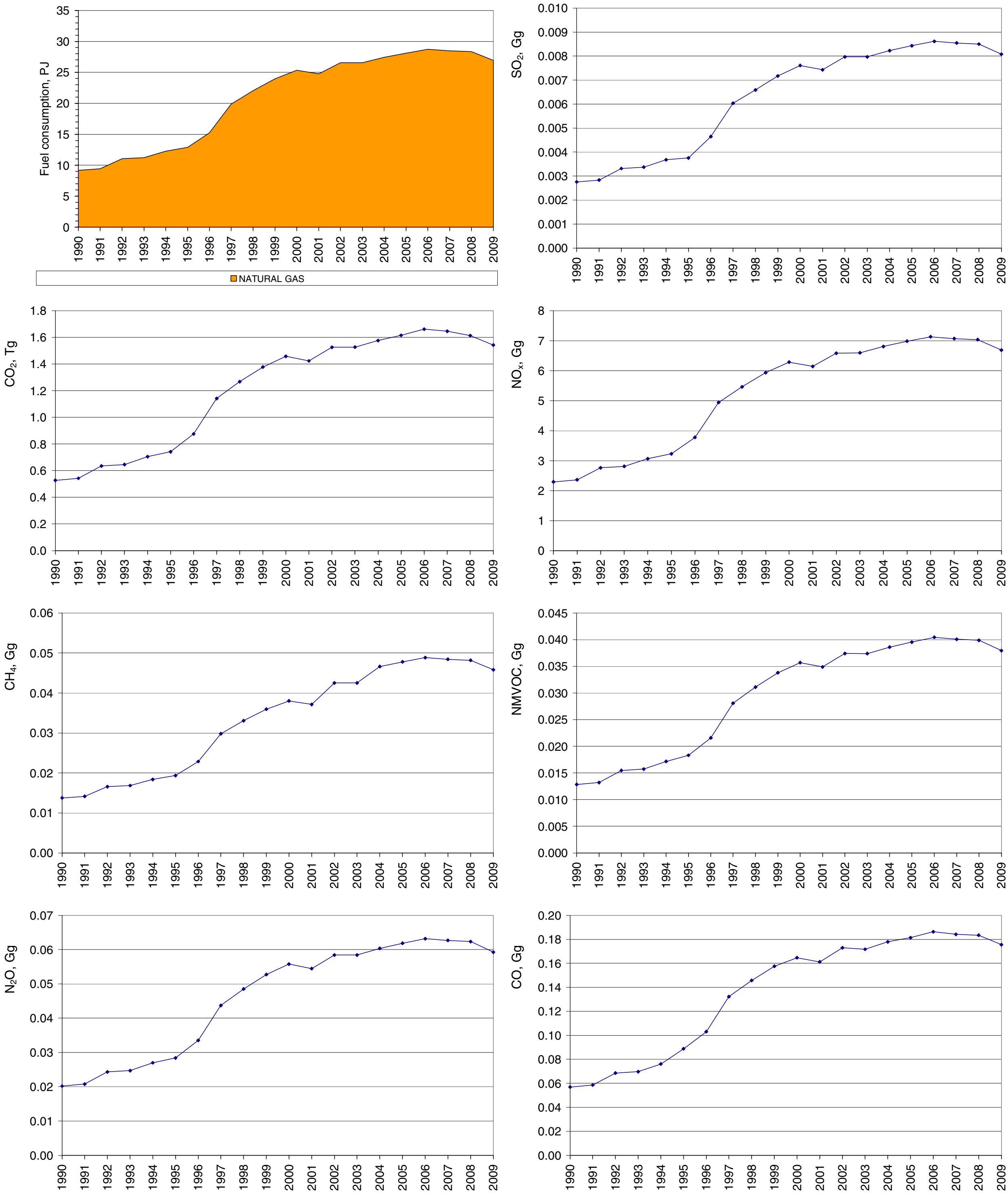


Figure 3.2.28 Time-series for 1A1c Other energy industries.

1A2 Industry

Manufacturing industries and construction (Industry) consists of both stationary and mobile sources. In this chapter only stationary sources are included.

Figure 3.2.29 – 3.2.31 show the time-series for fuel consumption and emissions. The data have not been disaggregated to industrial subcate-

gories due to the fact that the Danish inventory is based on data for the industrial plants as a whole. Disaggregation to subcategories for the reporting to the Climate Convention is discussed in the methodology chapter (page 166).

The total fuel consumption in industrial combustion was 21 % lower in 2009 than in 1990. The fuel consumption has decreased considerably (24 %) since 2006 and the financial crisis has resulted in a remarkable decrease in 2009. The consumption of gas has increased since 1990 whereas the consumption of coal has decreased. The consumption of residual oil has decreased, but the consumption of petroleum coke increased. The biomass part of fuel has not changed considerably since 1990.

The GHG emission and the CO_2 emission are both rather stable following the small fluctuations in fuel consumption and the decrease since 2006. Due to change of applied fuels the GHG and CO_2 emissions have decreased more than the fuel consumption since 1990; both emissions have decreased 32 %.

The CH_4 emission has increased from 1994-2000 and decreased again from 2004 - 2007. In 2009 the emission was 95 % higher than in 1990. The CH_4 emission follows the consumption of natural gas in gas engines. Most industrial CHP plants based on gas engines came in operation during 1995 to 1999. The decrease in later years is a result of the liberalisation of the electricity market.

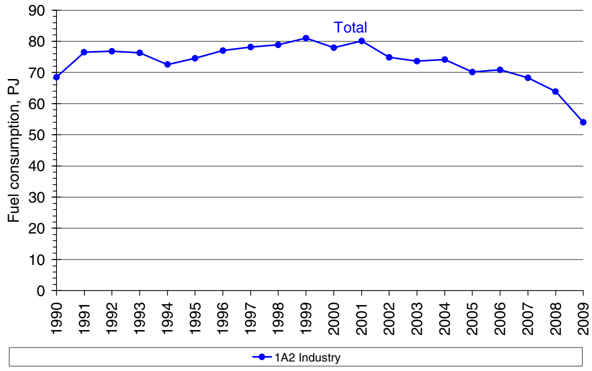
The N_2O has decreased 32 % since 1990, mainly due to the decreased residual oil consumption. In resent years combustion of wood is a considerable emission source.

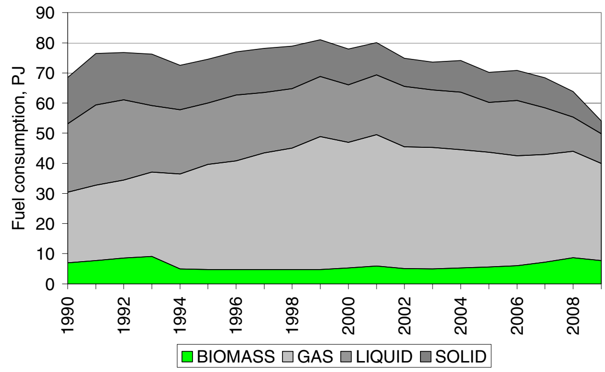
The SO_2 emission has decreased 83 % since 1990. This is mainly a result of lower consumption of residual oil in the industrial sector. Further the sulphur content of residual oil and several other fuels has decreased since 1990 due to legislation and tax laws.

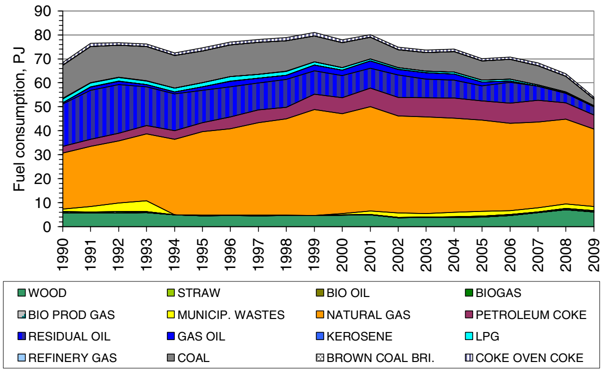
The NO_x emission fluctuations follow the fuel consumption in the cement production. However, the NO_x emission has decreased 49 % since 1990 due to the reduced emission from industrial boilers in general.

The NMVOC emission has decreased 74 % since 1990. The decrease is a mainly result of decreased emission factor for combustion of wood in industrial boilers. The emission from gas engines has however increased considerably after 1995 due to the increased fuel consumption that is a result of the installation of a large number of industrial CHP plants. The NMVOC emission factor for gas engines is much higher than for boilers regardless of the fuel.

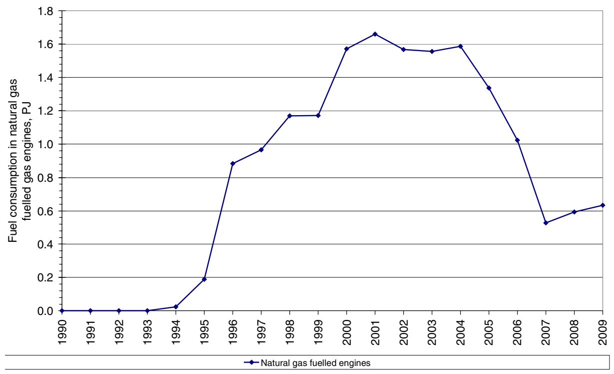
The CO emission in 2009 was 34 % lower than in 1990. The main source of emission is combustion in mineral wool production. This emission follows the fuel consumption in the mineral wool production plants.







Fuel consumption in natural gas fuelled engines



Fuel consumption, residual oil

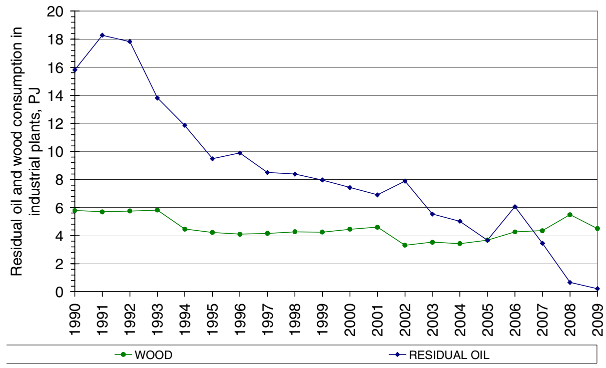


Figure 3.2.29 Time-series for fuel consumption, 1A2 Industry.

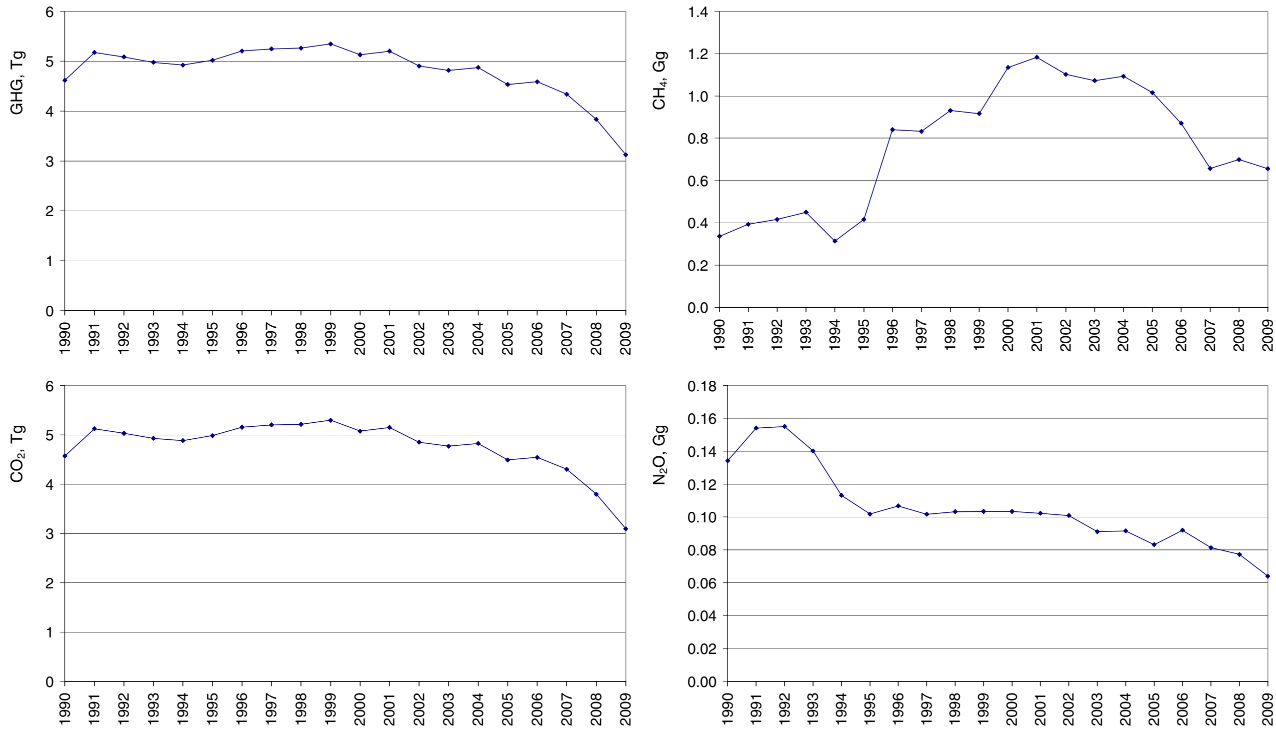


Figure 3.2.30 Time-series for greenhouse gas emission, 1A2 Industry.

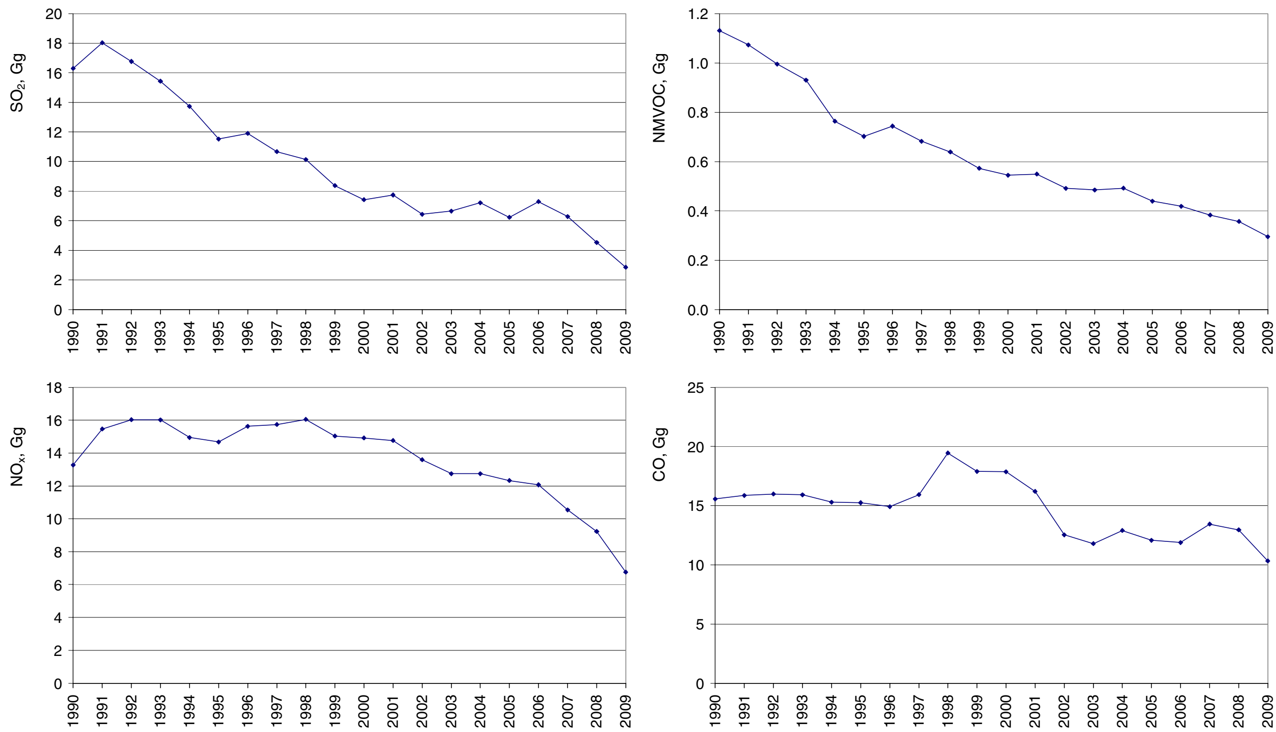


Figure 3.2.31 Time-series for SO_2, NO_x, NMVOC and CO emission, 1A2 Industry.

1A4 Other Sectors

The emission source category *1A4 Other Sectors* consists of the subcategories:

- 1A4a Commercial/Institutional plants.
- 1A4b Residential plants.
- 1A1c Agriculture/Forestry.

Figure 3.2.32-34 present time-series for this emission source category. Residential plants is the largest subcategory accounting for the largest part of all emissions. Time-series are discussed below for each subcategory.

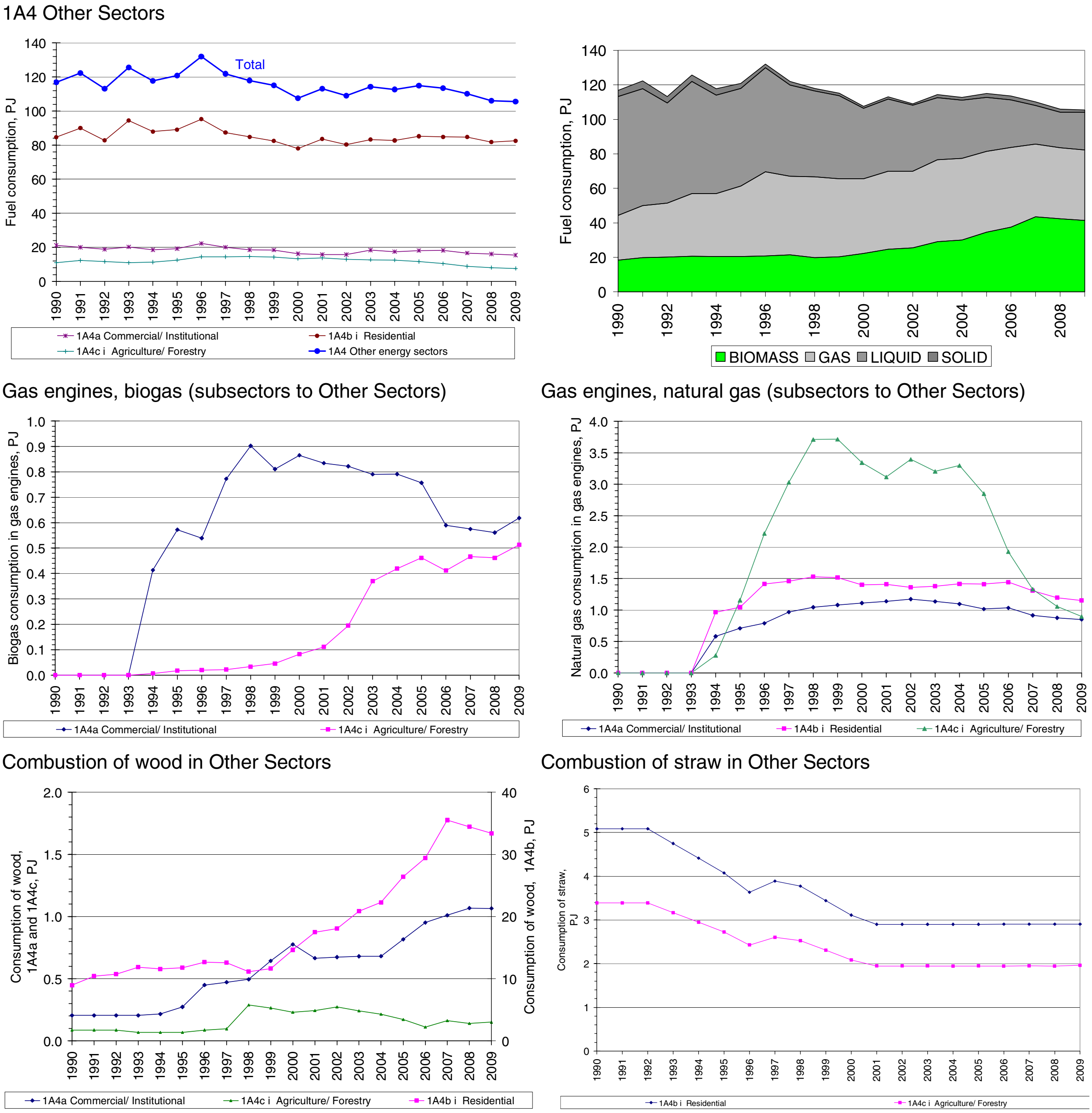


Figure 3.2.32 Time-series for fuel consumption, 1A4 Other Sectors.

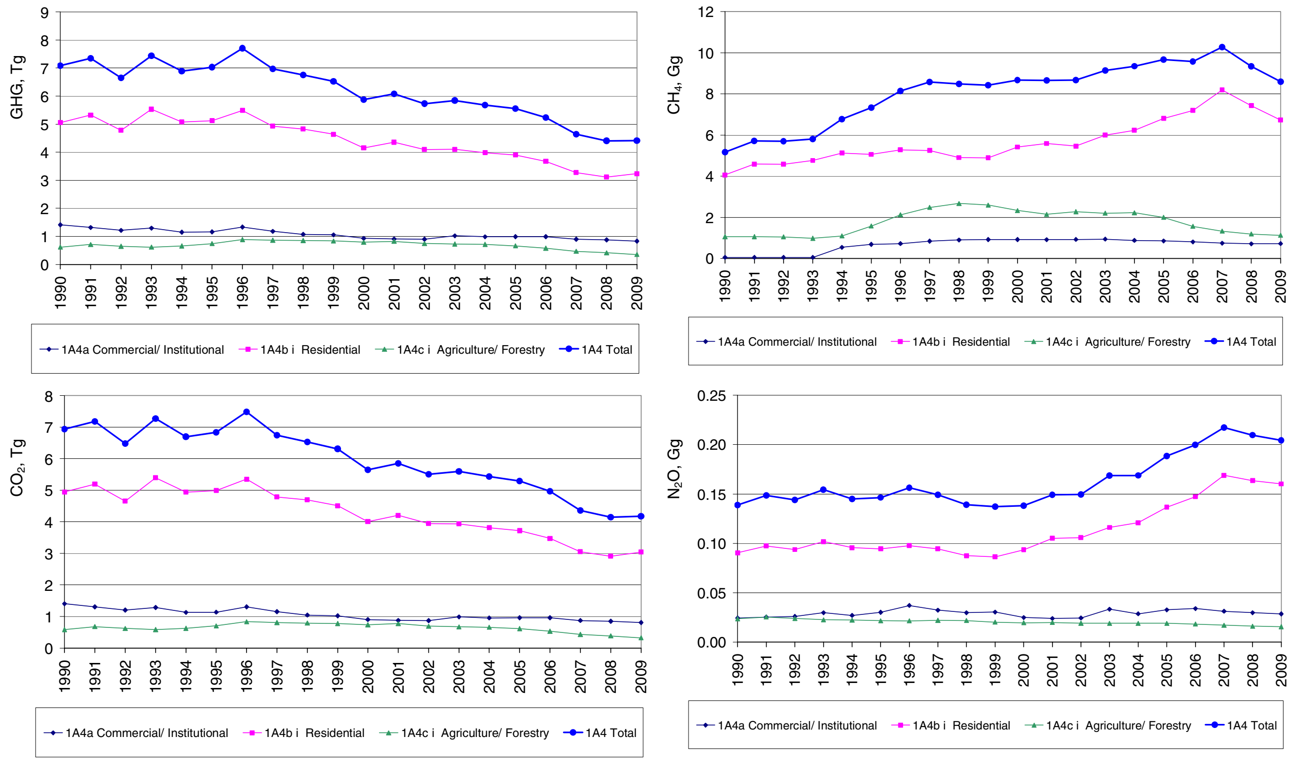


Figure 3.2.33 Time-series for greenhouse gas emission, 1A4 Other Sectors.

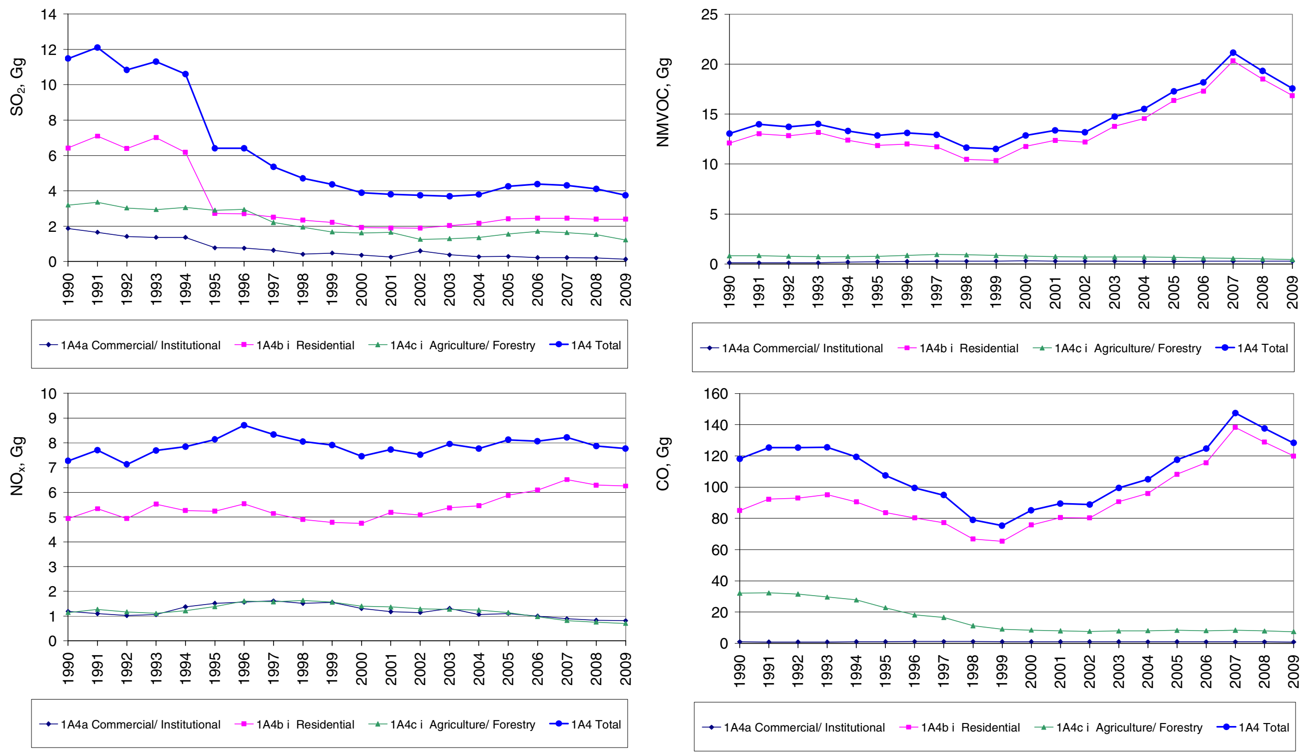


Figure 3.2.34 Time-series for SO_2, NO_x, NMVOC and CO emission, 1A4 Other Sectors.

1A4a Commercial and institutional plants

The subcategory *Commercial and institutional plants* has low fuel consumption and emissions compared to the other stationary combustion emission source categories. Figure 3.2.35 shows the time-series for fuel consumption and emissions.

The fuel consumption in commercial/institutional plants has decreased 27 % since 1990 and there has been a change of fuel type. The fuel consumption consists mainly of gas oil and natural gas. The consumption of gas oil has decreased and the consumption of natural gas has increased since 1990. The consumption of wood and biogas has also increased. The wood consumption in 2009 was five times the consumption in 1990.

The CO_2 emission has decreased 43 % since 1990. Both the decrease of fuel consumption and the change of fuels – from gas oil to natural gas - contribute to the decreased CO_2 emission.

The CH_4 emission in 2009 was 14 times the 1990 level. The increase is mainly a result of the increased emission from natural gas fuelled engines. The emissions from biogas fuelled engines and from combustion of wood also contribute to the increase. The time-series for consumption of natural gas and biogas are shown in Figure 3.2.32.

The N_2O emission in 2009 was 16 % higher than in 1990. This increase is a result of the change of fuel from gas oil to natural gas[4]. The emission from wood combustion have also been increasing. The fluctuations of the N_2O emission follow the fuel consumption.

The SO_2 emission has decreased 93 % since 1990. The decrease is a result of both the change of fuel from gas oil to natural gas and of the lower sulphur content in gas oil and in residual oil. The lower sulphur content (0.05 % for gas oil since 1995 and 0.7 % for residual oil since 1997) is a result of Danish tax laws (MST 1998).

The NO_x emission was 32 % lower in 2009 than in 1990. The decrease is mainly a result of the lower fuel consumption but also the change from gas oil to natural gas has contributed to the decrease. The emission from gas engines and wood combustion has increased.

The NMVOC emission in 2009 was 2.2 times the 1990 emission level. The large increase is a result of the increased combustion of wood that is the main source of emission. The increased consumption of natural gas in gas engines also contribute to the increased NMVOC emission.

The CO emission has decreased 3 % since 1990. The emission from wood and from natural gas fuelled engines and boilers has increased whereas the emission from gas oil has decreased. This is a result of the change of fuels applied in the sector.

[4] Boilers

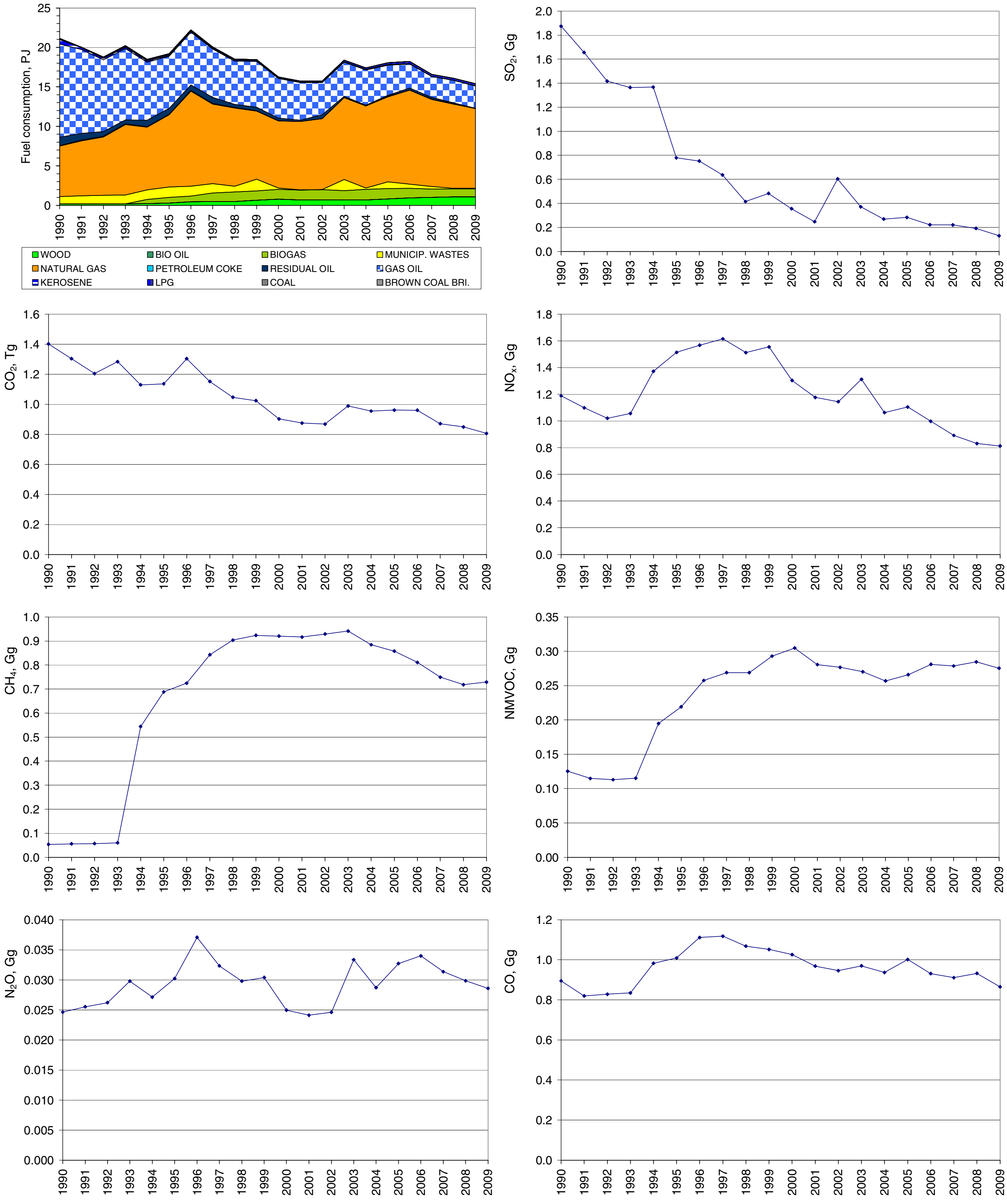


Figure 3.2.35 Time-series for 1A4a Commercial /institutional.

1A4b Residential plants

The emission source category *Residential plants* consists of both stationary and mobile sources. In this chapter only stationary sources are included. Figure 3.2.36 shows the time-series for fuel consumption and emissions.

For residential plants the total fuel consumption has been rather stable, and in 2009 the consumption was 2 % lower than in 1990. However, the consumption of gas oil has decreased since 1990 whereas the consumption of wood has increased considerably (four times the 1990 level). The consumption of natural gas has also increased since 1990.

The CO_2 emission has decreased by 39 % since 1990. This decrease is mainly a result of the considerable change of applied fuel from gas oil to wood and natural gas.

The CH_4 emission from residential plants has increased 66 % since 1990 due to the increased combustion of wood in residential plants, which is the main source of emission. The increased emission from gas engines also contributes to the increased emission.

The change of fuel from gas oil to wood has resulted in a 77 % increase of N_2O emission since 1990 due to a higher emission factor for wood than for gas oil.

The large decrease (63 %) of SO_2 emission from residential plants is mainly a result of a change of sulphur content in gas oil since 1995. The lower sulphur content (0.05 %) is a result of Danish tax laws (MST 1998). In addition, the consumption of gas oil has decreased and the consumption of natural gas that results in very low SO_2 emissions has increased.

The NO_x emission has increased by 27 % since 1990 due to the increased emission from wood combustion. The emission factor for wood is higher than for gas oil.

The emission of NMVOC has increased 39 % since 1990 as a result of the increased combustion of wood. The emission factor for wood has decreased since 1990, but not as much as the increase in consumption of wood. The emission factor for wood and straw is higher than for liquid or gaseous fuels.

The CO emission has increased 41 % due to the increased use of wood that is the main source of emission. The emission from combustion of straw has decreased since 1990.

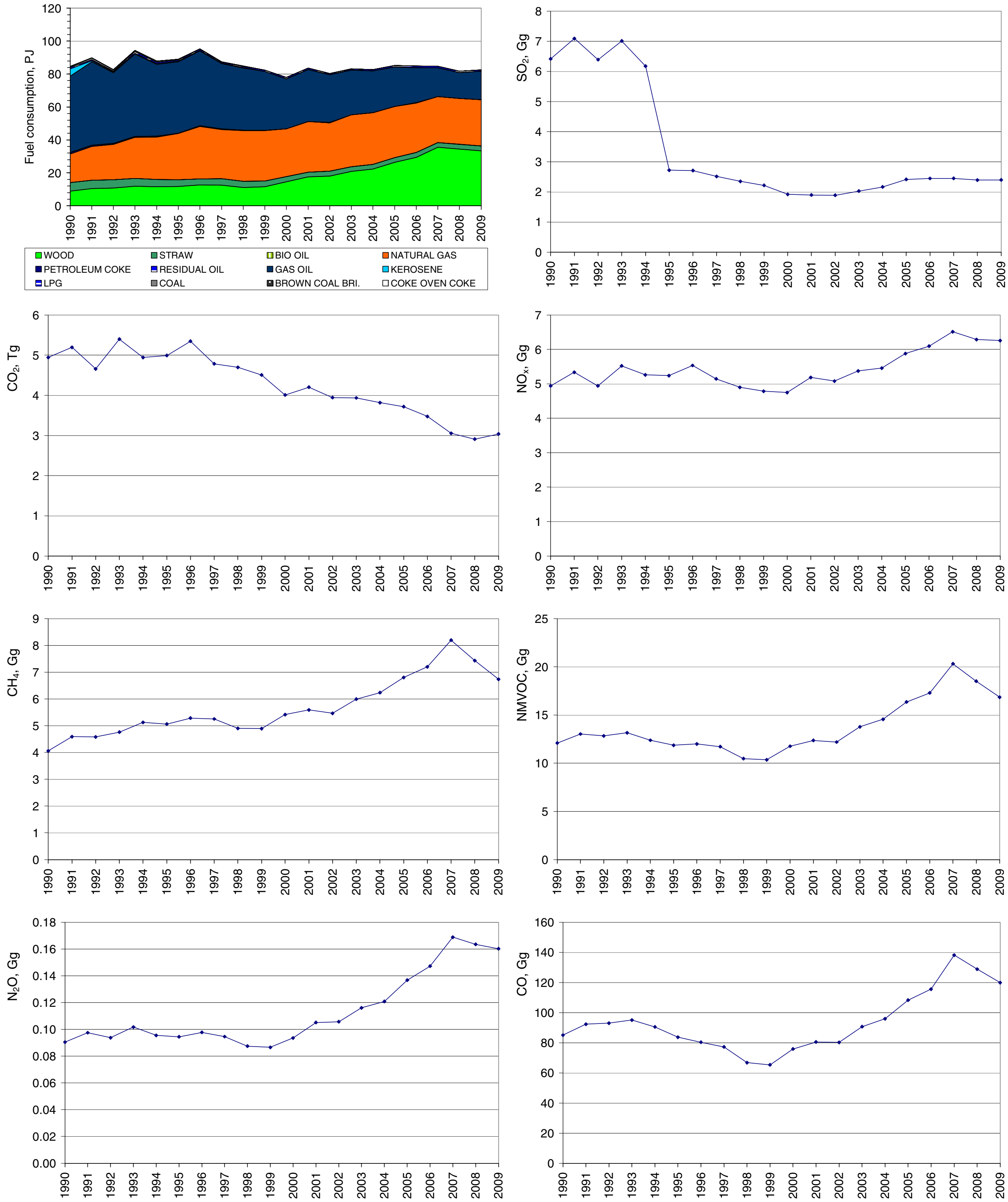


Figure 3.2.36 Time-series for 1A4b Residential plants.

1A4c Agriculture/forestry

The emission source category *Agriculture/forestry* consists of both stationary and mobile sources. In this chapter only stationary sources are included. Figure 3.2.37 shows the time-series for fuel consumption and emissions.

For plants in agriculture/forestry the fuel consumption has decreased 31 % since 1990. A remarkable decrease of fuel consumption has taken place since year 2000.

The type of fuel that has been applied has changed since 1990. In the years 1994-2004 the consumption of natural gas was high, but in recent years the consumption decreased again. A large part of the natural gas consumption has been applied in gas engines (Figure 3.2.32). Most CHP plants in agriculture/forestry based on gas engines came in operation in 1995-1999. The decrease in later years is a result of the liberalisation of the electricity market.

The consumption of straw has decreased since 1990. The consumption of both residual oil and gas oil has increased after 1990 but has decreased again in recent years.

The CO_2 emission in 2009 was 45 % lower than in 1990. The CO_2 emission increased from 1990 to 1996 due to increased fuel consumption. Since 1996 the CO_2 emission has decreased in line with the decrease in fuel consumption.

The CH_4 emission in 2009 was 4 % higher than the emission in 1990. The emission follows the time-series for natural gas combusted in gas engines (Figure 3.2.32). The emission from combustion of straw has decreased as a result of the decreasing consumption of straw in the sector.

The emission of N_2O has decreased by 34 % since 1990. The decrease is a result of the lower fuel consumption as well as the change of fuel. The decreasing consumption of straw contributes considerably to the decrease of emission.

The SO_2 emission was 62 % lower in 2009 than in 1990. The emission decreased mainly in the years 1996-2002. The main emission sources are coal, residual oil and straw.

The emission of NO_x was 39 % lower in 2009 than in 1990. This is in line with the decrease of fuel consumption.

The emission of NMVOC has decreased 46 % since 1990. The major emission source is combustion of straw. The consumption of straw has decreased since 1990. The emission from gas engines has increased mainly due to increased fuel consumption.

The CO emission has decreased 77 % since 1990. The major emission source is combustion of straw. In addition to the decrease of straw consumption the emission factor for straw has also decreased since 1990.

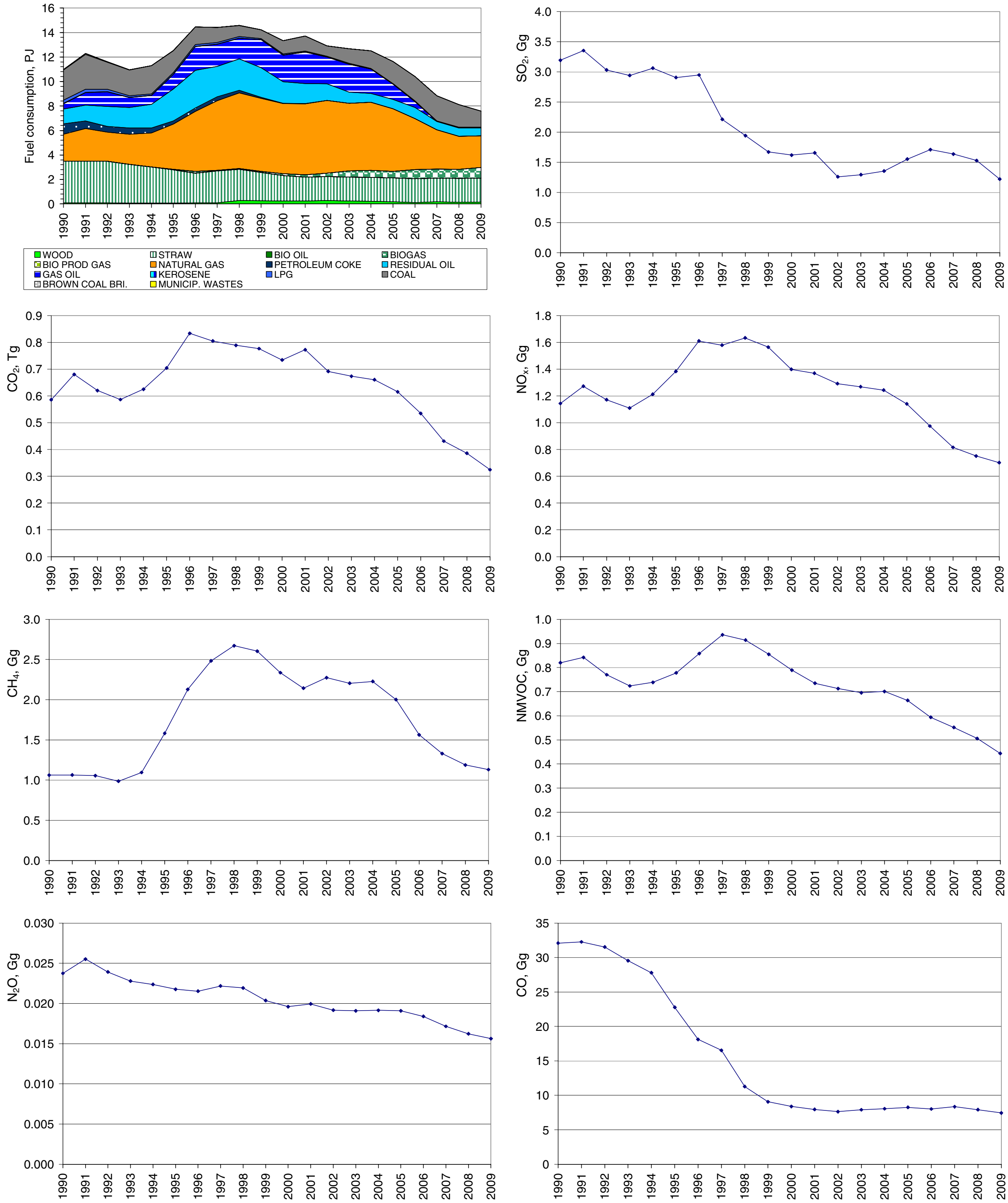


Figure 3.2.37 Time-series for 1A4c Agriculture/Forestry.

3.2.5 Methodological issues

The Danish emission inventory is based on the CORINAIR (CORe INventory on AIR emissions) system, which is a European program for air emission inventories. CORINAIR includes methodology structure and software for inventories. The methodology is described in the EMEP/CORINAIR Emission Inventory Guidebook 2007 update, prepared by the UNECE/EMEP Task Force on Emissions Inventories and Projections (EEA 2007). Emission data are stored in an Access database, from which data are transferred to the reporting formats.

In the Danish emission database all activity rates and emissions are defined in SNAP sector categories (Selected Nomenclature for Air Pollution) according the CORINAIR system. The emission inventories are prepared from a complete emission database based on the SNAP source categories. Aggregation to the source category codes used in CRF is based on a correspondence list enclosed in Annex 3A-1.

The emission inventory for stationary combustion is based on activity rates from the Danish energy statistics. General emission factors for various fuels, plants and sectors have been determined. Some large plants, such as power plants, are registered individually as large point sources and plant-specific emission data are used.

Tiers

The emission inventory is based on the methodology referred to as Tier 2 and Tier 3 in the IPCC Guidelines (IPCC 1996).

Large point sources

Large emission sources such as power plants, industrial plants and refineries are included as large point sources in the Danish emission database. Each point source may consist of more than one part, e.g. a power plant with several units. By registering the plants as point sources in the database it is possible to use plant-specific emission factors.

In the inventory for the year 2009, 71 stationary combustion plants are specified as large point sources. These point sources include:

- Power plants and decentralised CHP plants (combined heat and power plants).
- Municipal waste incineration plants.
- Large industrial combustion plants.
- Petroleum refining plants.

The criteria for selection of point sources consist of the following:

- All centralized power plants, including smaller units.
- All units with a capacity of above 25 MW_e.
- All district heating plants with an installed effect of 50 MW_{th} or above and significant fuel consumption.
- All waste incineration plants obliged to report environmental data annualy according to Danish law (MST 2010).
- Industrial plants,
  - with an installed effect of 50 MW_{th} or above and significant fuel consumption.
  - with a significant process related emission.

The fuel consumption of stationary combustion plants registered as large point sources in the 2009 inventory was 310 PJ. This corresponds to 60 % of the overall fuel consumption for stationary combustion.

A list of the large point sources for 2009 and the fuel consumption rates is provided in Annex 3A-5. The number of large point sources registered in the databases increased from 1990 to 2009.

The emissions from a point source are based either on plant specific emission data or, if plant specific data are not available, on fuel consumption data and the general Danish emission factors. Annex 3A-5 shows which of the emission data for large point sources are plant-specific and the corresponding share of the emission from stationary combustion.

CO_2 emission factors are plant specific for the major power plants and for cement production. SO_2 and NO_x emissions from large point sources are often plant-specific based on emission measurements. Emissions of CO and NMVOC are also plant-specific for some plants. Plant-specific emission data are obtained from:

- CO_2 data reported under the EU Emission Trading Scheme.
- Annual environmental reports / environmental reporting available on the Danish EPA home page[5]
- Annual plant-specific reporting of SO_2 and NO_x from power plants >25MW_e prepared for the Danish Energy Agency.
- Emission data reported by DONG Energy and Vattenfall, the two major electricity suppliers.
- Emission data reported from industrial plants.

The EU ETS data are discussed in the chapter Emission factors (page 144).

Annual environmental reports for the plants include a considerable number of emission data sets. Emission data from annual environmental reports are, in general, based on emission measurements, but some emissions have potentially been calculated from general emission factors.

If plant-specific emission factors are not available, general area source emission factors are used.

Emissions of the greenhouse gases CH_4 and N_2O from the large point sources are all based on the area source emission factors.

Area sources

Fuels not combusted in large point sources are included as source category specific area sources in the emission database. Plants such as residential boilers, small district heating plants, small CHP plants and some industrial boilers are defined as area sources. Emissions from area sources are based on fuel consumption data and emission factors. Further information on emission factors is provided below in the chapter Emission factors (page 144).

Activity rates, fuel consumption

The fuel consumption rates are based on the official Danish energy statistics prepared by the Danish Energy Agency (DEA). NERI aggregates fuel consumption rates to SNAP categories. Some fuel types in the official Danish energy statistics are added to obtain a less detailed fuel aggregation level cf. Annex 3A-3. The calorific values on which the energy statistics are based are also enclosed in Annex 3A-3. The correspondence list

[5] http://www3.mst.dk/Miljoeoplysninger/PrtrPublicering/Index

between the energy statistics and SNAP categories is enclosed in Annex 3A-9.

The fuel consumption of the IPCC category *Manufacturing industries and construction* (corresponding to SNAP category *03 Combustion in manufacturing industries)* is not disaggregated into specific industries in the NERI emission database. Disaggregations into specific industries have been estimated for the reporting to the Climate Convention. The disaggregation of fuel consumption and emissions from the industrial category is discussed below on page 166.

Both traded and non-traded fuels are included in the Danish energy statistics. Thus, for example, estimation of the annual consumption of non-traded wood is included.

Petroleum coke purchased abroad and combusted in Danish residential plants (border trade of 628 TJ in 2009) is not included in the Danish inventory. This is in agreement with the IPCC Guidelines (1996).

The fuel consumption data for large point sources refer to the EU Emission Trading Scheme (EU ETS) data for plants for which the CO_2 emission also refer to EU ETS, see page 144.

For all other large point sources the fuel consumption refers to a DEA database (DEA 2010c). The DEA compiles a database for the fuel consumption of each district heating and power-producing plant, based on data reported by plant operators.

The fuel consumption of area sources is calculated as total fuel consumption minus fuel consumption of large point sources.

The Danish national energy statistics includes three fuels used for non-energy purposes; bitumen, white spirit and lubricants. The total consumption for non-energy purposes is relatively low, e.g. 10.6 PJ in 2009. The use of white spirit is included in the inventory in *Solvent and other product use*. The emissions associated with the use of bitumen and lubricants are included in *Industrial Processes.* The non-energy use of fuels is included in the reference approach for Climate Convention reporting.

In Denmark all municipal waste incineration are utilised for heat and power production. Thus, incineration of waste is included as stationary combustion in the source category *Energy* (subcategories *1A1*, *1A2* and *1A4)*.

Fuel consumption data are presented in Chapter 3.2.2.

Town gas

Town gas has been included in the fuel category natural gas. The consumption of town gas in Denmark is very low, e.g. 0.5 PJ in 2009. In 1990 the town gas consumption was 1.6 PJ and the consumption has been steadily decreasing through out the time-series.

In Denmark town gas is produced based on natural gas. The use of coal for town gas production ceased in the early 1980s.

An indicative composition of town gas according to the largest supplier of town gas in Denmark is shown in Table 3.2.11 (KE 2009).

Table 3.2.11 Composition of town gas currently used (KE 2009).

Component	Town gas, % (mol.)
Methane	43.9
Ethane	2.9
Propane	1.1
Butane	0.5
Carbon dioxide	0.4
Nitrogen	40.5
Oxygen	10.7

The lower heating value of the town gas currently used is 19.3 MJ per Nm^3 and the CO_2 emission factor 56.4 kg per GJ. This is very close to the emission factor used for natural gas of 56.69 kg per GJ. According to the supplier both the composition and heating value will change during the year. It has not been possible to obtain a yearly average.

In earlier years the composition of town gas was somewhat different. Table 3.2.12 is constructed with the input from Københavns Energi (KE) (Copenhagen Energy) and Danish Gas Technology Centre (DGC), (Jeppesen, 2008; Kristensen, 2007). The data refer to three measurements performed several years apart; the first in 2000 and the latest in 2005.

Table 3.2.12 Composition of town gas, information from the period 2000-2005.

Component	Town gas, % (mol.)
Methane	22.3-27.8
Ethane	1.2-1.8
Propane	0.5-0.9
Butane	0.13-0.2
Higher hydrocarbons	0-0.6
Carbon dioxide	8-11.6
Nitrogen	15.6-20.9
Oxygen	2.3-3.2
Hydrogen	35.4-40.5
Carbon monoxide	2.6-2.8

The lower calorific value has been between 15.6 and 17.8 MJ per Nm^3. The CO_2 emission factors - derived from the few available measurements - are in the range of 52-57 kg per GJ.

The Danish approach includes town gas as part of the fuel category natural gas and thus indirectly assumes the same CO_2 emission factor. This is a conservative approach ensuring that the CO_2 emissions are not underestimated.

Due to the scarce data available and the very low consumption of town gas compared to consumption of natural gas, the methodology will be applied unchanged in future inventories.

Waste

All waste incineration in Denmark is applied for heat and/or power production and thus included in the energy sector. In this report, the fuel category is referred to as *municipal waste*, but in fact, the fuel category includes all waste fractions incinerated in Denmark[6]. The waste incinerated in Denmark for energy production consists of the waste fractions shown in Figure 3.2.38. In 2008, 3 % of the incinerated waste was hazardous waste[7].

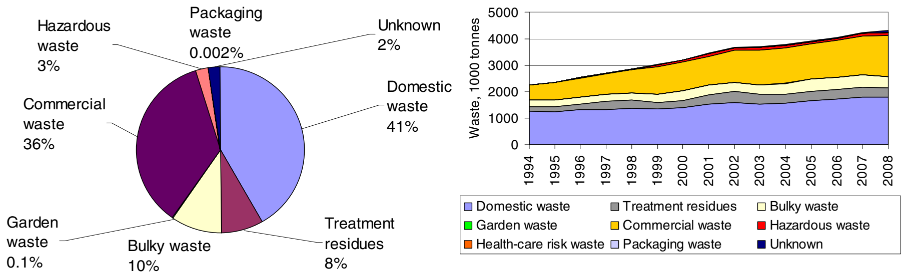


Figure 3.2.38 Waste fractions (weight) for incinerated waste in 2008 and the corresponding time-series 1994-2008 (ISAG 2011).

Biogas

Biogas includes landfill gas, sludge gas and manure gas. The Danish energy statistics specifies production and consumption of each of the biogas types. In 2009, 74 % of the applied biogas was manure gas.

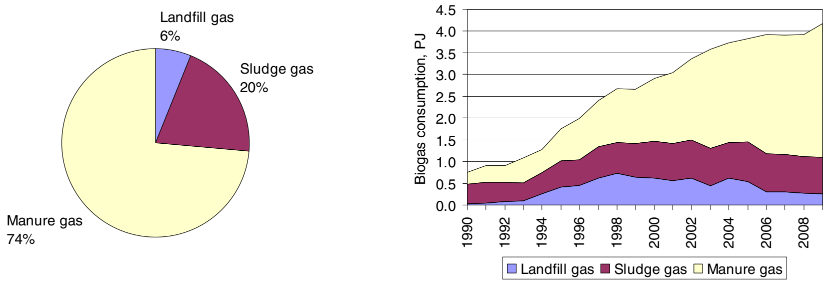


Figure 3.2.39 Biogas types 2009 and the corresponding time-series 1990-2009 (DEA 2010a).

Emission factors

For each fuel and SNAP category (sector and e.g. type of plant) a set of general area source emission factors has been determined. The emission factors are either nationally referenced or based on the international guidebooks: EEA/CORINAIR Guidebook (EEA 2009)[8] and IPCC Reference Manual (IPCC 1996).

A complete list of emission factors including time-series and references is provided in Annex 3A-4.

CO_2, use of EU ETS data

The CO_2 emission factors for some large power plants and for combustion in the cement industry and refineries are plant specific and based on the reporting to the EU Emission Trading Scheme (EU ETS). In addition emission factors for off-shore gas turbines and refinery gas is based on

[6] In the next inventory, the fuel category name will be changed.
[7] In 2001 onwards, health-care risk waste is included in hazardous waste in the ISAG database.
[8] And former editions of the EMEP/Corinair Guidebook.

EU ETS data[9]. The EU ETS data have been applied for the years 2006 - 2009.

The EU ETS data are also applied for other source categories and are further discussed in chapter 1.4.10.

Methodology, criteria for implementation and QA/QC

The Danish emission inventory for stationary combustion only includes data from plants using higher tier methods as defined in the EU decision (EU Commission 2007), where the specific methods for determining carbon contents, oxidation factor and calorific value are specified. The EU decision includes rules for measuring, reporting and verification.

For each of the plants included individually in the Danish inventory all applied methodologies are specified in individual *monitoring plans* that are accepted by Danish authorities (DEA) prior to the reporting of the emissions. The plants/fuels included individually in the Danish inventory all apply the *Tier 3* methodology for calculating the CO_2 emission factor. This selection criteria results in a dataset for which the emission factor values are based on fuel quality measurements[10], not default values from the Danish UNFCCC reporting. All fuel analyses are performed according to ISO 17025.

The power plants/fuels selected based on emission factor methodology apply the tiers for activity data, LCV, emission factor and oxidation factor listed below.

Coal

The CO_2 emission for coal is based on analysis of C content of the coal (g C per kg) and coal weight measurements. However, LCV values are also measured according to high tier methods in spite of the fact that this value is not input data for the calculation of total CO_2 emission.

- Fuel flow: *Tier 4* methodology (± 1.5 %). For coal the activity data (weight) is based on measurements on belt conveyor scale. The uncertainty is below the required ± 1.5 %.
- LCV: *Tier 3* methodology. Data are based on measurements according to ISO 13909 / ISO 18283 (sampling) and ISO 1928 (LCV). The uncertainty for data is below ± 0.5 %.
- Emission factor: The emission factor is C-content of the coal. *Tier 3* methodology (± 0.5 %) is applied and the measurements are performed according to ISO 13909 (sampling) and ISO/TS 12902 (C-content).
- Oxidation factor: Based on *Tier 3* methodology except for one plant that applies *Tier 1* methodology. The *Tier 3* methodology is based on measurements of C-content in bottom ash and fly ash according to ISO/TS 12902 or on burning loss measurements according to ISO 1171. The uncertainty has been estimated to 0.5 %. For *Tier 1* the oxidation factor is assumed to be 1.

[9] See page 154 and 154

[10] Applying specific methods defined in the EU decision

Residual oil

- Fuel flow: *Tier 4* methodology (± 1.5 %) for most plants. However, a few of the included plants apply *Tier 3* methodology (± 2.5 %).
- LCV: *Tier 3* methodology. Data are based on sampling according to API Manual of Petroleum Measurement Standards / ASTM D 270 and fuel analysis (LCV) according to ASTM D 240 / ISO 1928 / data stated by the fuel supplier.
- Emission factor: *Tier 3* methodology according to API Manual of Petroleum Measurement Standards / ASTM D 4057 (sampling) and ISO 12902 / ASTM D 5291 (C-content).
- Oxidation factor: Based on *Tier 2* or *Tier 3* methodology, both resulting in the oxidation factor 1 with an uncertainty of 0.8 %.

For coal and residual oil fuel analyses are required for each 20,000 tonnes or at least six times each year. The fuel analyses are performed by accredited laboratories[11].

NERI performs some QA/QC checks on the reported emission data, see chapter 1.4.10. NERI excluded data for one stationary combustion plant for 2009.

Additional data analysis performed as a result of the latest review will result in exclusion of one dataset for 2008, two datasets for 2007 and one dataset for 2006. The oxidation factor for these datasets is outliers.

Data presentation

The EU ETS data for power plants include plant specific emission factors for coal, residual oil and gas oil. The EU ETS data for power plants account for 52 % of the CO_2 emission from stationary combustion.

<u>Power plants, coal</u>

EU ETS data for 2009 were available from 17 coal fired power plant units. The plant specific information accounts for 97 %[12] of the Danish coal consumption and 49 % of the total CO_2 emission from stationary combustion plants. The average CO_2 emission factor for coal for these 17 units was 93.6 kg per GJ (Table 3.2.13). The plants all apply bituminous coal.

Table 3.2.13 EU ETS data for 17 coal fired power plant units, 2009.

	Average	Min	Max
Heating value, GJ per tonne	24.7	23.9	25.3
CO_2 implied emission factor, kg per GJ[1)]	93.6	91.9	95.0
Oxidation factor	0.994	0.987	1.000

1) Including oxidation factor

Table 3.2.14 CO_2 implied emission factor time-series for coal fired power plant units based on EU ETS data.

Year	CO_2 implied emission factor, kg per GJ[1)]
2006	94.4
2007	94.3
2008	94.0
2009	93.6

1) Including oxidation factor

[11] EN ISO 17025

[12] Including EU ETS data for cement production: 99 %

Power plants, residual oil

EU ETS data for 2009 based on higher tier methodologies were available from 24 units combusting residual oil. Aggregated data and time-series are shown in Table 3.2.15 and Table 3.2.16. The EU ETS data accounts for 62 %[13] of the residual oil consumption in stationary combustion.

Table 3.2.15 EU ETS data for 24 power plant units combusting residual oil.

	Average	Min	Max
Heating value, GJ per tonne	40.5	40.0	40.8
CO_2 implied emission factor, kg per GJ	78.9	77.3	81.4
Oxidation factor	1.00	1.00	1.00

Table 3.2.16 CO_2 implied emission factor time-series for residual oil fired power plant units based on EU ETS data.

Year	CO_2 implied emission factor, kg per GJ[1)]
2006	78.2
2007	78.1
2008	78.5
2009	78.9

1) Including oxidation factor

Power plants, gas oil

EU ETS data for 2009 based on higher tier methodologies were available from 2 plants combusting gas oil. Aggregated data and time-series are shown in Table 3.2.17 and Table 3.2.18. The EU ETS data accounts for 9 % of the gas oil consumption in stationary combustion.

Table 3.2.17 EU ETS data for 2 power plant units combusting gas oil.

	Average	Min	Max
CO_2 implied emission factor, kg per GJ	75.1	74.9	75.2
Oxidation factor	1.00	1.00	1.00

Table 3.2.18 CO_2 implied emission factor time-series for gas oil fired power plant units based on EU ETS data.

Year	CO_2 implied emission factor, kg per GJ[1)]
2006	75.1
2007	74.9
2008	73.7
2009	75.1

1) Including oxidation factor

Industrial plants

Plant specific CO_2 emission factors have also been applied for the cement production plants, sugar production plants and vegetable oil production plants, that are part of source category 1A2 Industry. The EU ETS data includes CO_2 emission factors for coal, petroleum coke, residual oil and waste.

Off-shore gas turbines

Individual EU ETS data are not applied for each of the off-shore gas turbines, but EU ETS data have been applied to estimate an average CO_2 emission factor for this source category.

[13] 73 % including EU ETS data for cement industry

CO_2, other emission factors

The CO_2 emission factors that are not included in EU ETS data or that are included but based on lower tier methodologies are not plant specific in the Danish inventory. The emission factors that are not plant specific accounts for 57 % of the fossil CO_2 emission.

The CO_2 emission factors applied for 2009 are presented in Table 3.2.19. For coal, residual oil, municipal waste, refinery gas and natural gas time-series have been estimated. For all other fuels the same emission factor has been applied for 1990-2009.

In reporting for the Climate Convention, the CO_2 emission is aggregated to five fuel types: Solid fuel, Liquid fuel, Gas, Biomass and Other fuels. The correspondence list between the NERI fuel categories and the IPCC fuel categories is also provided in Table 3.2.19.

Only emissions from fossil fuels are included in the total national CO_2 emission. The biomass emission factors are also included in the table, because emissions from biomass are reported to the Climate Convention as a memo item.

The CO_2 emission from incineration of municipal waste (79.6 + 32.5 kg per GJ) is divided into two parts: The emission from combustion of the fossil content of the waste, which is included in the national total, and the emission from combustion of the rest of the waste – the biomass part, which is reported as a memo item. In the IPCC reporting, the fuel consumption and emissions from the fossil content of the waste is reported in the fuel category, *Other fuels*.

Table 3.2.19 CO_2 emission factors, 2009.

Fuel	Emission factor kg per GJ Biomass	Emission factor kg per GJ Fossil fuel	Reference type	IPCC fuel category
Coal, source category 1A1a Public electricity and heat production		93.6 [1)]	Country specific	Solid
Coal, Other source categories		94.6[3)]	IPCC 1996	Solid
Brown coal briquettes		94.6	IPCC 1996	Solid
Coke oven coke		108	IPCC 1996	Solid
Petroleum coke		92 [3)]	Country specific	Liquid
Residual oil, source category 1A1a Public electricity and heat production		78.9 [1)]	Country specific	Liquid
Residual oil, other source categories		77.4[3)]	IPCC 1996	Liquid
Gas oil		74 [1)]	EEA 2007	Liquid
Kerosene		71.9	IPCC 1996	Liquid
Orimulsion		80 [2)]	Country specific	Liquid
LPG		63.1	IPCC 1996	Liquid
Refinery gas		56.814	Country specific	Liquid
Natural gas		56.69	Country specific	Gas
Municipal waste	79.6 [3)4)]	+ 32.5[3)4)]	Country specific	Biomass and Other fuels
Bio oil	74		Country specific	Biomass
Straw	102		EEA 2002	Biomass
Wood	102		EEA 2002	Biomass
Biogas	83.6		Country specific	Biomass
Biomass producer gas	142.9[5)]		Country specific	Biomass

1) Plant specific data from EU ETS incorporated for individual plants.

2) Not applied in 2009.

3) Plant specific data from EU ETS incorporated for cement production.

4) The emission factor for municipal waste is (76.6+32.5) kg CO_2 per GJ municipal waste. The fuel consumption and the CO_2 emission have been disaggregated to the two IPCC fuel categories *Biomass* and *Other fuels* in CRF. The IEF for CO_2, Other fuels is 78.88 kg CO_2 per GJ fossil municipal waste.

5) Includes a high content of CO_2 in the gas.

Coal

The emission factor time-series for coal have been recalculated this year based on the EU ETS data that are now available for 4 years.

As mentioned above[14] EU ETS data have been utilised for the 2006 - 2009 emission inventories. In 2009, the implied emission factor (including oxidation factor) for the power plants using coal was 93.6 kg per GJ. The implied emission factor values were between 91.9 and 95.0 kg per GJ.

In 2009, only 1 % of the CO_2 emission from coal consumption was based on the emission factor, whereas 99 % of the coal consumption was covered by EU ETS data[15]. All coal applied in Denmark is bituminous coal (DEA 2010d).

The emission factors for coal combustion in source category *1A1a Public electricity and heat production* in the years 2006-2009 refer to the implied emission factors of the EU ETS data estimated for each year. For the years 1990-2005, the emission factor for coal in source category *1A1a Public electricity and heat production* refer to the average IEF for 2006-2009.

Time-series for lower calorific value (LCV) of coal are available in the Danish energy statistics. LCV for *Electricity plant coal* fluctuates in the interval 24.3-25.8 GJ per tonne.

[14] CO_2, use of EU ETS data

[15] Including EU ETS data for cement production.

The correlation between LCV and CO_2 IEF (including the oxidation factor) in the EU ETS data (2006-2009) have analysed and the results are shown in Annex 3A-10. However, a significant correlation between LCV and IEF have not been found in the dataset and thus an emission factor time-series based on the LCV time-series was not relevant. In addition the correlation of LCV and CO_2 emission factors have been analysed. This analysis is also shown in Annex 3A-10. As expected the correlation was better in this dataset, but still unsuffiecient for estimating a time-series for the CO_2 emission factor based on the LCV time-series.

As mentioned above all coal applied in Denmark is bituminous coal and within the range of coal qualities applied in the plants reporting data to EU ETS a correlation could not be documented.

For other source categories[16], the applied emission factor 94.6 kg per GJ refers to IPCC Guidelines (1996). This emission factor has been applied for all years.

Time-series for the CO_2 emission factor are shown in Table 3.2.20.

Table 3.2.20 CO_2 emission factors for coal, time-series.

Year	Source category 1A1a Public electricity and heat production kg per GJ	Other source categories kg per GJ
1990-2005	94.0	94.6
2006	94.4	94.6
2007	94.3	94.6
2008	94.0	94.6
2009	93.6	94.6

Brown coal briquettes

The emission factor for brown coal briquettes, 94.6 kg per GJ, is based on a default value from the IPCC Guidelines (IPCC 1996) assuming full oxidation. The default value in the IPCC Guidelines is 25.8 t C per TJ, corresponding to $25.8\cdot(12+2\cdot16)/12 = 94.6$ kg CO_2 per GJ assuming full oxidation. The same emission factor has been applied for 1990-2009.

Coke oven coke

The emission factor for coke oven coke, 108 kg per GJ, is based on a default value from the IPCC Guidelines (IPCC 1996) assuming full oxidation. The default value in the IPCC guidelines is 29.5 t C per TJ, corresponding to $29.5\cdot(12+2\cdot16)/12 = 108$ kg CO_2 per GJ assuming full oxidation. The same emission factor has been applied for 1990-2009.

Petroleum coke

The emission factor for petroleum coke, 92 kg per GJ, has been estimated by SK Energy (a former major power plant operator in eastern Denmark) in 1999 based on a fuel analysis carried out by dk-Teknik in 1993 (Bech, 1999). The emission factor level was confirmed by a new fuel analysis, which, however, is considered confidential. The same emission factor has been applied for 1990-2009.

[16] Not source category *1A1a Public electricity and heat production*

Plant specific EU ETS data have been utilised for the cement production in the 2006 - 2009 emission inventories.

Wood

The emission factor for wood, 102 kg per GJ, refers to Fenhann & Kilde (1994). The factor is based on the interval stated in a former edition of the EMEP/CORINAIR Guidebook (EEA 2002) and the actual value is the default value from the CollectER database. The same emission factor has been applied for 1990-2009.

Municipal waste

The CO_2 emission from incineration of municipal waste is divided into two parts: The emission from combustion of the fossil content of the waste, which is included in the national total, and the emission from combustion of the rest of the waste – the biomass part, which is reported as a memo item.

The total CO_2 emission factor for municipal waste refers to a Danish study (Jørgensen & Johansen 2003). Based on emission measurements on five municipal waste incineration plants the total CO_2 emission factor for municipal waste incineration has been determined to 112.1 kg per GJ.

The current disaggregation of the emission factor in a fossil part and a biomass part has been estimated by a working group to be between 30 and 35 kg CO_2 per GJ municipal waste (Nielsen 2009). NERI has assumed that the fossil fuel emission factor is 32.5 kg CO_2 per GJ municipal waste.

An ongoing project, *Biogenic carbon in Danish combustible waste* (DTU 2008), will further improve knowledge concerning the disaggregation of the CO_2 emission factor in a fossil and a biomass fraction.

The lower calorific value of municipal waste refers to the Danish energy statistics (DEA 2010b). Time-series for the CO_2 emission factors have been based on the assumption that the increasing calorific value of the waste is a result of the increased fraction of fossil waste since 1990. This assumption is highly uncertain, but better data are not available at present. Table 3.2.21 shows time-series for the CO_2 emission factors. The CO_2 emission from the biomass part is the total CO_2 emission minus the CO_2 emission from the fossil part.

Emission data from four waste incineration plants (Jørgensen & Johansen, 2003) demonstrate the fraction of the carbon content of the waste not oxidised to be approximately 0.3 %. The un-oxidised fraction of the carbon content is assumed to originate from the biomass content, and all carbon originating from fossil part are assumed to be oxidised.

Table 3.2.21 CO_2 emission factors for municipal waste, time-series.

Year	Lower heating value of municipal waste [1]	CO_2 emission factor, fossil	CO_2 emission factor for municipal waste, total [2]	CO_2 emission factor, biomass
	GJ per Mg waste	kg per GJ waste	kg per GJ waste	kg per GJ waste
1990	8.2	25.4	112.1	86.7
1991	8.2	25.4	112.1	86.7
1992	9.0	27.9	112.1	84.2
1993	9.4	29.1	112.1	83.0
1994	9.4	29.1	112.1	83.0
1995	10.0	31.0	112.1	81.1
1996 -2009	10.5	32.5	112.1	79.6

1) DEA 2010b.

2) Based on data from Jørgensen & Johansen (2003).

The composition of the fossil part of the municipal waste has been estimated by NERI. The lower heating values and CO_2 emission factors for different plastic types refer to Hulgaard (2003), see Table 3.2.22.

Table 3.2.22 Composition of the fossil part of municipal waste in Denmark.

Plastic type	Mass share in municipal waste in Denmark		Lower heating value of plastic	Energy content of plastic	CO_2 emission factor for plastic
	kg plastic per kg municipal waste	% of plastic	GJ per tonne	GJ per ton municipal waste	kg per GJ municipal waste
PE	0.058	46	41	2.36	16.3
PS/EPS	0.035	28	37	1.29	10.6
PVC	0.019	15	18	0.34	2.5
Other (PET, PUR, PC, POM, ABS, PA etc.)	0.014	11	24	0.34	3.1
Total	0.13	100	34.5	4.33	32.5

Plant specific EU ETS data have been utilised for cement production in the 2006 - 2009 emission inventories.

Straw

The emission factor for straw, 102 kg per GJ refers to Fenhann & Kilde (1994). The factor is based on the interval stated in the EMEP/Corinair Guidebook (EEA 2002) and the actual value is the default value from the Collecter database. The same emission factor has been applied for 1990-2009.

Residual oil

The emission factor time-series for residual oil have been recalculated this year based on the EU ETS data that are now available for 4 years.

As mentioned above[17] EU ETS data have been utilised for the 2006 - 2009 emission inventories. In 2009, the implied emission factor (including oxidation factor) for the power plants combusting residual oil was 78.9 kg per GJ. The implied emission factor values were between 77.3 and 81.4[18] kg per GJ.

In 2009, 27 % of the CO_2 emission from residual oil consumption was based on the emission factor, whereas 73 % of the residual oil consumption was covered by EU ETS data[19].

[17] CO_2, use of EU ETS data

[18] Only one production unit at this high level. All other IEFs are below 79.9 kg per GJ

[19] Including EU ETS data for cement production.

The emission factors for residual oil combustion in source category *1A1a Public electricity and heat production* in the years 2006-2009 refer to the implied emission factors of the EU ETS data estimated for each year. For the years 1990-2005, the emission factor for residual oil in source category *1A1a Public electricity and heat production* refer to the average IEF for 2006-2009.

For other source categories[20], the applied emission factor 77.4 kg per GJ refers to IPCC Guidelines (1996). This emission factor has been applied for all years.

Time-series for the CO_2 emission factor are shown in Table 3.2.23.

Table 3.2.23 CO_2 emission factors for residual oil, time-series.

Year	Source category 1A1a Public electricity and heat production kg per GJ	Other source categories kg per GJ
1990-2005	78.4	77.4
2006	78.2	77.4
2007	78.1	77.4
2008	78.5	77.4
2009	78.9	77.4

Gas oil

The emission factor for gas oil, 74 kg per GJ, refers to Fenhann & Kilde (1994). The factor is based on the interval stated in the EMEP/Corinair Guidebook (EEA 2007). The factor agrees with the IPCC default emission factor for gas oil (74.1 kg per GJ assuming full oxidation). The CO_2 emission factor has been confirmed by the two major power plant operators in 1996 (Christiansen, 1996 and Andersen, 1996). The same emission factor has been applied for 1990-2009.

Plant specific EU ETS data have been utilised for an increasing number of power plant units in the 2006 - 2009 emission inventories. In 2009 the implied emission factor for the power plants using gas oil was 75.1 kg per GJ. The EU ETS CO_2 emission factors for power plants were in the interval 74.9 - 75.2 kg per GJ. In 2009 9 % of the CO_2 emission from gas oil consumption was based on EU ETS data[21].

Kerosene

The emission factor for kerosene, 71.9 kg per GJ, refers to IPCC Guidelines (IPCC 1996). The same emission factor has been applied for 1990-2009.

Bio oil

The emission factor is assumed to be the same as for gas oil – 74 kg per GJ. The consumption of bio oil is below 2 PJ.

Orimulsion

The emission factor for orimulsion, 80 kg per GJ, refers to the Danish Energy Agency (DEA 2010b). The IPCC default emission factor is almost the same: 80.7 kg per GJ assuming full oxidation. The CO_2 emission factor has been confirmed by the only major power plant operator using orimulsion (Andersen 1996). The same emission factor has been applied

[20] Not source category *1A1a Public electricity and heat production*

[21] Including EU ETS data for cement production

for all years. Orimulsion has not been applied in Denmark in recent years.

Natural gas, off shore gas turbines

EU ETS data for the fuel consumption and CO_2 emission for off shore gas turbines are available for the years 2006-2009. Based on data for each oil-field implied emission factors have been estimated for 2006-2009. The average value has been applied for the years 1990-2005. The time-series is shown in Table 3.2.24.

Table 3.2.24 CO_2 emission factors for off shore gas turbines, time-series.

Year	CO_2 emission factor, kg per GJ
1990-2005	57.469
2006	57.879
2007	57.784
2008	56.959
2009	57.254

Natural gas, other source categories

The emission factor for natural gas is estimated by the Danish gas transmission company, Energinet.dk[22]. Only natural gas from the Danish gas fields have been utilised in Denmark in 2009. The calculation is based on gas analysis carried out daily by Energinet.dk. Energinet.dk and the Danish Gas Technology Centre have calculated emission factors for 2000-2009. The emission factor applied for 1990-1999 refers to Fenhann & Kilde (1994). This emission factor was confirmed by the two major power plant operators in 1996 (Christiansen 1996 and Andersen 1996). Time-series for the CO_2 emission factors are provided in Table 3.2.25.

Table 3.2.25 CO_2 emission factor time-series for natural gas.

Year	CO_2 emission factor, kg per GJ
1990-1999	56.9
2000	57.1
2001	57.25
2002	57.28
2003	57.19
2004	57.12
2005	56.96
2006	56.78
2007	56.78
2008	56.77
2009	56.69

LPG

The emission factor for LPG, 63.1 kg per GJ, refers to IPCC Guidelines (IPCC 1996). The same emission factor has been applied for 1990-2009.

Refinery gas

The emission factor applied for refinery gas refer to EU ETS data for the two refineries in operation in Denmark. Implied emission factors for Denmark have been estimated annually based on the EU ETS data since 2006. The average implied emission factor (57.6 kg per GJ) for 2006-2009 have been applied for the years 1990-2005. This emission factor is identical to the emission factor stated in IPCC Guidelines (2006). The time-series is shown in Table 3.2.26.

[22] Former Gastra and before that part of DONG. Historical data refer to these companies.

Table 3.2.26 CO_2 emission factors for refinery gas, time-series.

Year	CO_2 emission factor, kg per GJ
1990-2005	57.6
2006	57.812
2007	57.848
2008	57.948
2009	56.814

Biogas

In Denmark 3 different types biogas is applied: Manure based biogas, landfill based biogas and wastewater treatment biogas. Manure based biogas represent more than 70 % of the consumption (Nielsen et al. 2010).

The emission factor for biogas, 83.6 kg per GJ, is based on a biogas with 65 % (vol.) CH_4 and 35 % (vol.) CO_2. Danish Gas Technology Centre has stated that this is a typical manure-based biogas as utilised in stationary combustion plants (Kristensen 2001). The same emission factor has been applied for 1990-2009.

Biomass producer gas

Biomass procucer gas applied in Denmark is based on wood. The gas composition is known for three different plants and the applied emission factor have been estimated by Danish Gas Technology Centre (Kristensen 2010) based on the gas composition measured on the plant that with the highest consumption.

The consumption of biomass producer gas is below 0.3 PJ all years.

CH_4

The CH_4 emission factors applied for 2009 are presented in Table 3.2.27. In general, the same emission factors have been applied for 1990-2009. However, time-series have been estimated for both natural gas fuelled engines and biogas fuelled engines, residential wood combustion, natural gas fuelled gas turbines[23] and MSW incineration plants[23].

Emission factors for CHP plants < 25 MW_e refer to emission measurements carried out on Danish plants (Nielsen et al. 2010; Nielsen & Illerup 2003; Nielsen et al. 2009). The emission factors for residential wood combustion are based on technology distribution data.

Emission factors that are not nationally referenced now all refer to the IPCC Guidelines (IPCC 1996).

Gas engines combusting natural gas or biogas accounts for more than half the CH_4 emission from stationary combustion plants. The relatively high emission factor for gas engines is well-documented and further discussed below.

[23] A minor emission source

Table 3.2.27 CH_4 emission factors 2009.

Fuel group	Fuel	CRF source category	CRF source category	SNAP	Emission factor, g per GJ	Reference
SOLID	COAL	1A1a	Electricity and heat production	010101	0.9	IPCC (1996), Tier 2, Table 1-15, Utility Boiler, Pulverised Bituminous Combustion, Wet bottom.
				010102	0.9	IPCC (1996), Tier 2, Table 1-15, Utility Boiler, Pulverised Bituminous Combustion, Wet bottom.
		1A2	Industry	030100	10	IPCC (1996), Tier 2, Table 1-19, Commercial coal boilers.
		1A4b i	Residential	020200	300	IPCC (1996), Tier 1, Table 1-7, Residential, coal.
		1A4c i	Agriculture/ Forestry	020300	10	IPCC (1996), Tier 2, Table 1-19, Commercial coal boilers.[1)]
				020304	10	IPCC (1996), Tier 2, Table 1-19, Commercial coal boilers.[1)]
	BROWN COAL BRI.	1A4b i	Residential	020200	300	IPCC (1996), Tier 1, Table 1-7, Residential, coal.
	COKE OVEN COKE	1A2	Industry	030100	10	IPCC (1996), Tier 2, Table 1-19, Commercial coal boilers.
		1A4b i	Residential	020200	300	IPCC (1996), Tier 1, Table 1-7, Residential, coal.
LIQUID	PETROLEUM COKE	1A4a	Commercial/ Institutional	020100	10	IPCC (1996), Tier 1, Table 1-7, Commercial, oil.
	RESIDUAL OIL	1A1a	Electricity and heat production	010101	0.9	IPCC (1996), Tier 2, Table 1-15, Utility Boiler, Residual fuel oil.
				010102	1.3	Nielsen et al. (2010)
				010103	1.3	Nielsen et al. (2010)
				010104	3	IPCC (1996), Tier 1, Table 1-7, Energy industries, oil.
				010105	4	IPCC (1996), Tier 2, Table 1-15, Utility, Large diesel engines.
				010202	0.9	IPCC (1996), Tier 2, Table 1-15, Utility Boiler, Residual fuel oil.
				010203	0.9	IPCC (1996), Tier 2, Table 1-15, Utility Boiler, Residual fuel oil.
		1A1b	Petroleum refining	010306	3	IPCC (1996), Tier 1, Table 1-7, Energy industries, oil.
		1A2	Industry	030100	1.3	Nielsen et al. (2010)
				030102	1.3	Nielsen et al. (2010)
				030103	1.3	Nielsen et al. (2010)
		1A4a	Commercial/ Institutional	020100	1.4	IPCC (1996), Tier 2, Table 1-19, Commercial, residual fuel oil.
		1A4b i	Residential	020200	1.4	IPCC (1996), Tier 2, Table 1-18, Residential, residual fuel oil.
		1A4c i	Agriculture/ Forestry	020300	1.4	IPCC (1996), Tier 2, Table 1-19, Commercial, residual fuel oil[1)].
				020302	1.4	IPCC (1996), Tier 2, Table 1-19, Commercial, residual fuel oil[1)].
	GAS OIL	1A1a	Electricity and heat production	010101	0.9	IPCC (1996), Tier 2, Table 1-15, Utility Boiler, distillate fuel oil.
				010102	0.9	IPCC (1996), Tier 2, Table 1-15, Utility Boiler, distillate fuel oil.
				010103	0.9	IPCC (1996), Tier 2, Table 1-15, Utility Boiler, distillate fuel oil.
				010104	3	IPCC (1996), Tier 1, Table 1-7, Energy industries, oil.
				010105	24	Nielsen et al. (2010)
				010202	0.9	IPCC (1996), Tier 2, Table 1-15, Utility Boiler, distillate fuel oil.
				010203	0.9	IPCC (1996), Tier 2, Table 1-15, Utility Boiler, distillate fuel oil.
		1A1b	Petroleum refining	010306	3	IPCC (1996), Tier 1, Table 1-7, Energy industries, oil.
		1A2	Industry	030100	0.2	IPCC (1996), Tier 2, Table 1-16, Industry, distillate fuel oil.
				030102	0.2	IPCC (1996), Tier 2, Table 1-16, Industry, distillate fuel oil.
				030104	2	IPCC (1996), Tier 1, Table 1-7, Industry, oil.
				030105	24	Nielsen et al. (2010)
		1A4a	Commercial/ Institutional	020100	0.7	IPCC (1996), Tier 2, Table 1-19, Commercial, distillate fuel oil.
				020103	0.7	IPCC (1996), Tier 2, Table 1-19, Commercial, distillate fuel oil.
				020105	24	Nielsen et al. (2010)
		1A4b i	Residential	020200	0.7	IPCC (1996), Tier 2, Table 1-18, Residential, distillate fuel oil.
				020204	24	Nielsen et al. (2010)
	KEROSENE	1A2	Industry	030100	0.2	IPCC (1996), Tier 2, Table 1-16, Industry, distillate fuel oil.
		1A4a	Commercial/ Institutional	020100	0.7	IPCC (1996), Tier 2, Table 1-19, Commercial, distillate fuel oil.
		1A4b i	Residential	020200	0.7	IPCC (1996), Tier 2, Table 1-18, Residential, distillate fuel oil.
		1A4c i	Agriculture/ Forestry	020300	0.7	IPCC (1996), Tier 2, Table 1-19, Commercial, distillate fuel oil[1)].
	LPG	1A1a	Electricity and heat production	010102	3	IPCC (1996), Tier 1, Table 1-7, Energy Industries, oil.
				010203	3	IPCC (1996), Tier 1, Table 1-7, Energy Industries, oil.
		1A2	Industry	030100	2	IPCC (1996), Tier 1, Table 1-7, Industry, oil
		1A4a	Commercial/ Institutional	020100	10	IPCC (1996), Tier 1, Table 1-7, Commercial, oil.
				020105	10	IPCC (1996), Tier 1, Table 1-7, Commercial, oil.
		1A4b i	Residential	020200	1.1	IPCC (1996), Tier 2, Table 1-18, Resididential propane/butane furnaces.
		1A4c i	Agriculture/ Forestry	020300	10	IPCC (1996), Tier 1, Table 1-7, Agriculture, oil.

Fuel group	Fuel	CRF source category	CRF source category	SNAP	Emission factor, g per GJ	Reference
	REFINERY GAS	1A1b	Petroleum refining	010304	1.7	Assumed equal to natural gas fuelled gas turbines. Nielsen et al. (2010)
				010306	1	Assumed equal to natural gas fuelled plants. IPCC (1996), Tier 1, Table 1-7, Natural gas
GAS	NATURAL GAS	1A1a	Electricity and heat production	010101	0.1	IPCC (1996), Tier 2, Table 1-15, Utility Boiler, natural gas.
				010102	0.1	IPCC (1996), Tier 2, Table 1-15, Utility Boiler, natural gas.
				010103	0.1	IPCC (1996), Tier 2, Table 1-15, Utility Boiler, natural gas.
				010104	1.7	Nielsen et al. (2010)
				010105	481	Nielsen et al. (2010)
				010202	0.1	IPCC (1996), Tier 2, Table 1-15, Utility Boiler, natural gas.
				010203	0.1	IPCC (1996), Tier 2, Table 1-15, Utility Boiler, natural gas.
		1A1c	Other energy industries	010504	1.7	Nielsen et al. (2010)
		1A2	Industry	030100	1.4	IPCC (1996), Tier 2, Table 1-16, Industry, natural gas boilers.
				030103	1.4	IPCC (1996), Tier 2, Table 1-16, Industry, natural gas boilers.
				030104	1.7	Nielsen et al. (2010)
				030105	481	Nielsen et al. (2010)
				030106	1.4	IPCC (1996), Tier 2, Table 1-16, Industry, natural gas boilers.
		1A4a	Commercial/ Institutional	020100	1.2	IPCC (1996), Tier 2, Table 1-19, Commercial, natural gas boilers.
				020103	1.2	IPCC (1996), Tier 2, Table 1-19, Commercial, natural gas boilers.
				020105	481	Nielsen et al. (2010)
		1A4b i	Residential	020200	5	IPCC (1996), Tier 1, Table 1-7, Residential, natural gas.
				020202	5	IPCC (1996), Tier 1, Table 1-7, Residential, natural gas.
				020204	481	Nielsen et al. (2010)
		1A4c i	Agriculture/ Forestry	020300	1.2	IPCC (1996), Tier 2, Table 1-19, Commercial, natural gas boilers[1)].
				020304	481	Nielsen et al. (2010)
WASTE	MUNICIP. WASTES	1A1a	Electricity and heat production	010101	0.34	Nielsen et al. (2010)
				010102	0.34	Nielsen et al. (2010)
				010103	0.34	Nielsen et al. (2010)
				010203	0.34	Nielsen et al. (2010)
		1A4a	Commercial/ Institutional	020103	30	IPCC (1996), Tier 1, Table 1-7, Industry, wastes.
BIOMASS	WOOD	1A1a	Electricity and heat production	010102	3.1	Nielsen et al. (2010)
				010103	3.1	Nielsen et al. (2010)
				010104	3.1	Nielsen et al. (2010)
				010203	30	IPCC (1996), Tier 1, Table 1-7, Energy industries, wood.
		1A2	Industry	030100	15	IPCC (1996), Tier 2, Table 1-16, Industry, wood stoker boilers.
				030102	15	IPCC (1996), Tier 2, Table 1-16, Industry, wood stoker boilers.
				030103	15	IPCC (1996), Tier 2, Table 1-16, Industry, wood stoker boilers.
		1A4a	Commercial/ Institutional	020100	30	IPCC (1996), Tier 1, Table 1-7, Industry, wood[2)].
				020105	30	IPCC (1996), Tier 1, Table 1-7, Industry, wood[2)].
		1A4b i	Residential	020200	154	NERI estimate based on technology distribution [3)]
				020202	154	NERI estimate based on technology distribution [3)]
				020204	154	NERI estimate based on technology distribution [3)]
		1A4c i	Agriculture/ Forestry	020300	30	IPCC (1996), Tier 1, Table 1-7, Industry, wood[2)].
	STRAW	1A1a	Electricity and heat production	010101	0.47	Nielsen et al. (2010)
				010102	0.47	Nielsen et al. (2010)
				010103	0.47	Nielsen et al. (2010)
				010104	0.47	Nielsen et al. (2010)
				010203	30	IPCC (1996), Tier 1, Table 1-7, Energy industries, other biomass
		1A4b i	Residential	020200	300	IPCC (1996), Tier 1, Table 1-7, Residential, other biomass.
		1A4c i	Agriculture/ Forestry	020300	300	IPCC (1996), Tier 1, Table 1-7, Agriculture, other biomass.
	BIO OIL	1A1a	Electricity and heat production	010105	24	Nielsen et al. (2010) assumed same emission factor as for gas oil fuelled engines.
				010202	0.7	IPCC (1996), Tier 2, Table 1-19, Commercial, distil-late fuel oil.
				010203	0.7	IPCC (1996), Tier 2, Table 1-19, Commercial, distil-late fuel oil.
		1A2	Industry	030105	24	Nielsen et al. (2010) assumed same emission factor as for gas oil fuelled engines.
		1A4b i	Residential	020200	0.7	IPCC (1996), Tier 2, Table 1-18, Residentail, distillate fuel oil.
	BIOGAS	1A1a	Electricity and heat production	010102	1	IPCC (1996), Tier 1, Table 1-7, Energy industries, natural gas. Assumed similar to natural gas (NERI assumption).
				010105	434	Nielsen et al. (2010)

Fuel group	Fuel	CRF source category	CRF source category	SNAP	Emission factor, g per GJ	Reference
				010203	1	IPCC (1996), Tier 1, Table 1-7, Energy industries, natural gas. Assumed similar to natural gas (NERI assumption).
		1A2	Industry	030100	5	IPCC (1996), Tier 1, Table 1-7, Industry, natural gas. Assumed similar to natural gas (NERI assumption).
				030102	5	IPCC (1996), Tier 1, Table 1-7, Industry, natural gas. Assumed similar to natural gas (NERI assumption).
				030103	5	IPCC (1996), Tier 1, Table 1-7, Industry, natural gas. Assumed similar to natural gas (NERI assumption).
				030105	434	Nielsen et al. (2010)
		1A4a	Commercial/ Institutional	020100	5	IPCC (1996), Tier 1, Table 1-7, Commercial, natural gas. Assumed similar to natural gas (NERI assumption).
				020103	5	IPCC (1996), Tier 1, Table 1-7, Commercial, natural gas. Assumed similar to natural gas (NERI assumption).
				020105	434	Nielsen et al. (2010)
		1A4c i	Agriculture/ Forestry	020300	5	IPCC (1996), Tier 1, Table 1-7, Agriculture, natural gas. Assumed similar to natural gas (NERI assumption).
				020304	434	Nielsen et al. (2010)
	BIO PROD GAS	1A1a	Electricity and heat production	010105	13	Nielsen et al. (2010)
		1A2	Industry	030105	13	Nielsen et al. (2010)

1) Assumed same emission factors as for commercial plants. Plant capacity and technology are similar for Danish plants.
2) Assumed same emission factor as for industrial plants. Plant capacity and technology is similar to industrial plants rather than to residential plants.
3) Aggregated emission factor based on the technology distribution in the sector and technology specific emission factors. Technology distribution based on Illerup et al. (2009).

CHP plants

A considerable part of the electricity production in Denmark is based on decentralised CHP plants, and well-documented emission factors for these plants are, therefore, of importance. In a project carried out for the electricity transmission company, Energinet.dk, emission factors for CHP plants <25MW$_e$ have been estimated. The work was reported in 2010 (Nielsen et al. 2010).

The work included MSW incineration plants, CHP plants combusting wood and straw, natural gas and biogas-fuelled (reciprocating) engines, natural gas fuelled gas turbines, gas oil fuelled engines, gas oil fuelled gas turbines, steam turbines fuelled by residual oil and engines fuelled by biomass producer gas. CH_4 emission factors for these plants all refer to Nielsen et al. (2010). The estimated emission factors were based on existing emission measurements as well as on emission measurements carried out within the project. The number of emission data sets was comprehensive. Emission factors for subgroups of each plant type were estimated, e.g. the CH_4 emission factor for different gas engine types has been determined.

Time-series for the CH_4 emission factors are based on a similar project estimating emission factors for year 2000 (Nielsen & Illerup 2003).

Natural gas, gas engines

SNAP 010105, 030105, 020105, 020204 and 020304

The emission factor for natural gas engines refers to the Nielsen et al. (2010). The emission factor includes the increased emission during start/stop of the engines estimated by Nielsen et al. (2009). Emission factor time-series for the years 1990-2007 have been estimated based on Nielsen & Illerup (2003). These three references are discussed below.

Nielsen et al. (2010):

> *CH_4 emission factors for gas engines were estimated for 2003-2006 and for 2007-2009. The dataset was split in two due to new emission limits for the engines from October 2006. The emission factors were based on emission measurements from 366 (2003-2006) and 157 (2007-2009) engines respectively. The engines from which emission measurements were available for 2007-2009 represent 38 % of the gas consumption. The emission factors were estimated based on fuel consumption for each gas engine type and the emission factor for each engine type. The majority of emission measurements that were not performed within the project related solely to the emission of total unburned hydrocarbon (CH_4 + NMVOC). A constant disaggregation factor was estimated based on 9 emission measurements including both CH_4 and NMVOC.*

Nielsen & Illerup (2003):

> *The emission factor for natural gas engines was based on 291 emission measurements in 114 different plants. The plants from which emission measurements were available represented 44 % of the total gas consumption in gas engines in year 2000.*

Nielsen et al. (2009):

> *This study calculated a start/stop correction factor. This factor was applied to the time-series estimated in Nielsen & Illerup (2003). Further the correction factors were applied in Nielsen et al. (2010).*

The emission factor for lean-burn gas engines is relatively high, especially for pre-chamber engines, which account for more than half the gas consumption in Danish gas engines. However, the emission factors for different pre-chamber engine types differ considerably.

The installation of natural gas engines in decentralised CHP plants in Denmark has taken place since 1990. The first engines installed were relatively small open-chamber engines but later mainly pre-chamber engines were installed. As mentioned above, pre-chamber engines have a higher emission factor than open-chamber engines; therefore, the emission factor has increased during the period 1990-1995. After that technical improvements of the engines have been implemented as a result of upcoming emission limits that most installed gas engines had to meet in late 2006 (MST 2005).

The time-series were based on:

- Full load emission factors for different engine types in year 2000 (Nielsen & Illerup 2003), 2003-2006 and 2007-2009 (Nielsen et al. 2010).
- Data for year of installation for each engine and fuel consumption of each engine 1994-2002 from the Danish Energy Agency (DEA 2003).
- Research concerning the CH_4 emission from gas engines carried out in 1997 (Nielsen & Wit, 1997).
- Correction factors including increased emission during start/stop of the engines (Nielsen et al. 2009).

Table 3.2.28 Time-series for the CH_4 emission factor for natural gas fuelled engines.

Year	Emission factor, g per GJ
1990	266
1991	309
1992	359
1993	562
1994	623
1995	632
1996	616
1997	551
1998	542
1999	541
2000	537
2001	522
2002	508
2003	494
2004	479
2005	465
2006	473
2007	481
2008	481
2009	481

Gas engines, biogas

SNAP 010105, 030105, 020105 and 020304

The emission factor for biogas engines was estimated to 434 g per GJ in 2009. The emission factor is lower than the factor for natural gas, mainly because most engines are lean-burn open-chamber engines - not pre-chamber engines.

Time-series for the emission factor have been estimated. The emission factors for biogas engines were based on Nielsen et al. (2010) and Nielsen & Illerup (2003). The two references are discussed below. The time-series are shown in Table 3.2.29.

Nielsen et al. (2010):

> *CH_4 emission factors for gas engines were estimated for 2006 based on emission measurements performed in 2003-2009. The emission factor was based on emission measurements from 10 engines. The engines from which emission measurements were available represent 8 % of the gas consumption. The emission factor was estimated based on fuel consumption for each gas engine type and the emission factor for each engine type. The majority of emission measurements that were not performed within the project related solely to the emission of total unburned hydrocarbon (CH_4 + NMVOC). A constant disaggregation factor was estimated based on 3 emission measurements including both CH_4 and NMVOC.*

Nielsen & Illerup (2003):

> *The emission factor for natural gas engines was based on 18 emission measurements from 13 different engines. The engines from which emission measurements were available represented 18 % of the total biogas consumption in gas engines in year 2000.*

Table 3.2.29 Time-series for the CH_4 emission factor for biogas fuelled engines.

Year	Emission factor, g per GJ
1990	239
1991	251
1992	264
1993	276
1994	289
1995	301
1996	305
1997	310
1998	314
1999	318
2000	323
2001	342
2002	360
2003	379
2004	397
2005	416
2006	434
2007	434
2008	434
2009	434

Gas turbines, natural gas

SNAP 010104, 010504 and 030104

The emission factor for gas turbines was estimated to be below 1.7 g per GJ in 2005 (Nielsen et al. 2010). The emission factor was based on emission measurements on five plants. The emission factor in year 2000 was 1.5 g per GJ (Nielsen & Illerup 2003). A time-series have been estimated.

CHP, wood

SNAP 010102 and, 010103 and 010104

The emission factor for CHP plants combusting wood was estimated to be below 3.1 g per GJ (Nielsen et al. 2010) and the emission factor 3.1 g per GJ has been applied for all years. The emission factor was based on emission measurements on two plants.

CHP, straw

SNAP 010101, 010102, 010103 and 010104

The emission factor for CHP plants combusting straw was estimated to be below 0.47 g per GJ (Nielsen et al. 2010) and the emission factor 0.47 g per GJ has been applied for all years. The emission factor was based on emission measurements on four plants.

CHP, municipal waste

SNAP 010101, 010102 and 010103

The emission factor for CHP plants combusting municipal waste was estimated to be below 0.34 g per GJ in 2006 (Nielsen et al. 2010) and 0.59 g per GJ in year 2000 (Nielsen & Illerup 2003). A time-series have been estimated. The emission factor was based on emission measurements on nine plants.

The emission factor have also been applied for district heating plants.

Residential wood combustion

The emission factor for residential wood combustion is based on technology specific data. The emission factor time-series is shown in Table 3.2.30.

Table 3.2.30 CH_4 emission factor time-series for residential wood combustion.

Year	Emission factor, g per GJ
1990-2000	243
2001	217
2002	206
2003	204
2004	202
2005	193
2006	186
2007	184
2008	169
2009	154

The emission factor for each technology and the corresponding reference are shown in Table 3.2.31. The emission factor time-series are estmated based on time-series (2000-2009) for wood consumption in each technology (Illerup et al. 2009). The time-series for wood consumption in the ten different technologies are illustrated in Figure 3.2.40. The consumption in pellet boilers and new stoves has increased.

Table 3.2.31 Technology specific CH_4 emission factors for residential wood combustion.

Technology	Emission factor, g pr GJ	Reference
Old iron stoves, wood logs	430	Paulrud et al. (2005)
New iron stoves, wood logs	350	NERI assumption.
Moderns iron stoves, wood logs	50	Assumed equal to modern manually fed boilers.
Ecolabbeled stove, woodlogs	2	Olsson & Kjällstrand (2005)
Other stoves	430	Assumed equal to old iron stoves.
Old manually fed boilers with accumulator tank	211	Paulrud et al. (2005)
Old manually fed boilers without accumulator tank	256	Paulrud et al. (2005)
Modern manually fed boilers with accumulator tank	50	Johansson et al (2004)
Modern manually fed boilers without accumulator tank	50	Johansson et al (2004)
Pellet boilers	3	Paulrud et al. (2005)
Other boilers	430	Assumed equal to old iron stoves.

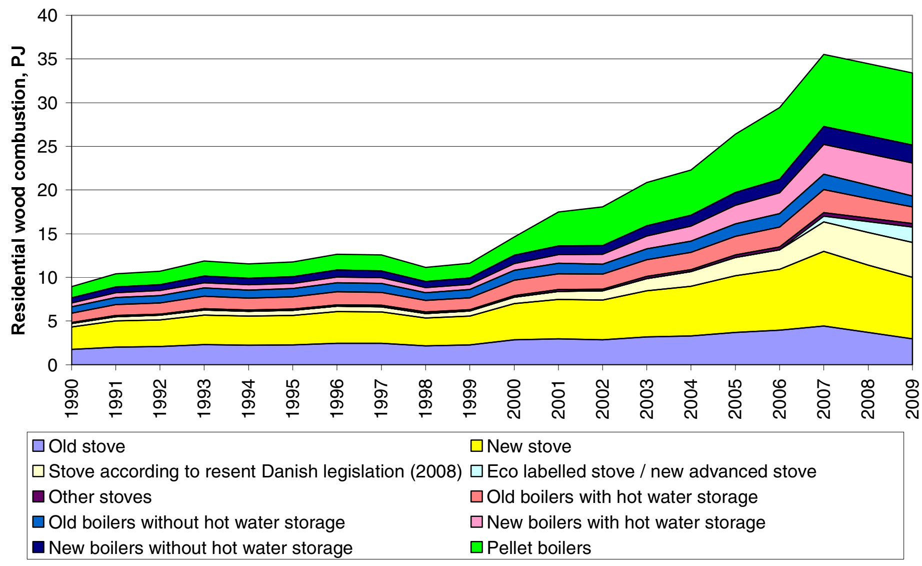


Figure 3.2.40 Technology specific wood consumption in residential plants.

Other stationary combustion plants

Emission factors for other plants refer to the IPCC Guidelines (IPCC 1996).

N_2O

The N_2O emission factors applied for the 2009 inventory are listed in Table 3.2.32. Time-series have been estimated for natural gas fuelled gas turbines. All other emission factors have been applied unchanged for 1990-2009.

Emission factors for natural gas fuelled reciprocating engines, natural gas fuelled gas turbines, CHP plants < 300 MW combusting wood, straw or residual oil, MSW incineration plants, engines fuelled by gas oil and gas engines fuelled by biomass producer gas all refer to emission measurements carried out on Danish plants, Nielsen et al. (2010).

The emission factor for coal-powered plants in public power plants refers to research conducted by Elsam (now part of DONG Energy). The emission factor for off-shore gas turbines refer to the Danish study concerning CHP plants (Nielsen & Illerup 2003).

All emission factors that are not nationally referenced now refer to the IPCC Guidelines (IPCC 1996).

Table 3.2.32 N_2O emission factors 1990-2009.

Fuel group	Fuel	CRF source category	CRF source category	SNAP	Emission factor, g per GJ	Reference
SOLID	COAL	1A1a	Electricity and heat production	010101	0.8	Elsam (2005)
				010102	0.8	Elsam (2005)
		1A2	Industry	030100	1.4	IPCC (1996), Tier 1, Table 1-8, Industry, coal
		1A4b i	Residential	020200	1.4	IPCC (1996), Tier 1, Table 1-8, Residential, coal
		1A4c i	Agriculture/ Forestry	020300	1.4	IPCC (1996), Tier 1, Table 1-8, Commerdial, coal
				020304	1.4	IPCC (1996), Tier 1, Table 1-8, Commerdial, coal
	BROWN COAL BRI.	1A4b i	Residential	020200	1.4	IPCC (1996), Tier 1, Table 1-8, Residential, coal
	COKE OVEN COKE	1A2	Industry	030100	1.4	IPCC (1996), Tier 1, Table 1-8, Industry, coal
		1A4b i	Residential	020200	1.4	IPCC (1996), Tier 1, Table 1-8, Residential, coal
LIQUID	PETROLEUM COKE	1A4a	Commercial/ Institutional	020100	0.6	IPCC (1996), Tier 1, Table 1-8, Commercial, oil
	RESIDUAL OIL	1A1a	Electricity and heat production	010101	0.3	IPCC (1996), Tier 2, Table 1-15, Utility, residual fuel oil
				010102	5	Nielsen et al. (2010)
				010103	5	Nielsen et al. (2010)
				010104	0.6	IPCC (1996), Tier 1, Table 1-8, Energy industries, oil
				010105	0.6	IPCC (1996), Tier 1, Table 1-8, Energy industries, oil
				010202	0.3	IPCC (1996), Tier 2, Table 1-15, Utility, residual fuel oil
				010203	0.3	IPCC (1996), Tier 2, Table 1-15, Utility, residual fuel oil
		1A1b	Petroleum refining	010306	0.6	IPCC (1996), Tier 1, Table 1-8, Energy industries, oil
		1A2	Industry	030100	5	Nielsen et al. (2010)
				030102	5	Nielsen et al. (2010)
				030103	5	Nielsen et al. (2010)
		1A4a	Commercial/ Institutional	020100	0.3	IPCC (1996), Tier 2, Table 1-19, Commercial, fuel oil
		1A4b i	Residential	020200	0.6	IPCC (1996), Tier 1, Table 1-8, Residential, oil
		1A4c i	Agriculture/ Forestry	020300	0.3	IPCC (1996), Tier 2, Table 1-19, Commercial, fuel oil
				020302	0.3	IPCC (1996), Tier 2, Table 1-19, Commercial, fuel oil
	GAS OIL	1A1a	Electricity and heat production	010101	0.4	IPCC (1996), Tier 2, Table 1-15, Utility, distillate fuel oil
				010102	0.4	IPCC (1996), Tier 2, Table 1-15, Utility, distillate fuel oil
				010103	0.4	IPCC (1996), Tier 2, Table 1-15, Utility, distillate fuel oil
				010104	0.6	IPCC (1996), Tier 1, Table 1-8, Energy industries, oil
				010105	2.1	Nielsen et al. (2010)
				010202	0.4	IPCC (1996), Tier 2, Table 1-15, Utility, distillate fuel oil
				010203	0.4	IPCC (1996), Tier 2, Table 1-15, Utility, distillate fuel oil
		1A1b	Petroleum refining	010306	0.6	IPCC (1996), Tier 1, Table 1-8, Energy industries, oil
		1A2	Industry	030100	0.4	IPCC (1996), Tier 2, Table 1-16, Industry, distillate fuel oil boilers
				030102	0.4	IPCC (1996), Tier 2, Table 1-16, Industry, distillate fuel oil boilers
				030104	0.6	IPCC (1996), Tier 1, Table 1-8, Industry, oil
				030105	2.1	Nielsen et al. (2010)
		1A4a	Commercial/ Institutional	020100	0.4	IPCC (1996), Tier 2, Table 1-19, Commercial, distillate fuel oil
				020103	0.4	IPCC (1996), Tier 2, Table 1-19, Commercial, distillate fuel oil
				020105	2.1	Nielsen et al. (2010)
		1A4b i	Residential	020200	0.6	IPCC (1996), Tier 1, Table 1-8, Residential, oil
				020204	2.1	Nielsen et al. (2010)
	KEROSENE	1A2	Industry	030100	0.4	IPCC (1996), Tier 2, Table 1-16, Industry, distillate fuel oil boilers
		1A4a	Commercial/ Institutional	020100	0.4	IPCC (1996), Tier 2, Table 1-19, Commercial, distillate fuel oil
		1A4b i	Residential	020200	0.6	IPCC (1996), Tier 1, Table 1-8, Residential, oil
		1A4c i	Agriculture/ Forestry	020300	0.4	IPCC (1996), Tier 2, Table 1-19, Commercial, distillate fuel oil[1)]
	LPG	1A1a	Electricity and heat production	010102	0.6	IPCC (1996), Tier 1, Table 1-8, Energy industries, oil
				010203	0.6	IPCC (1996), Tier 1, Table 1-8, Energy industries, oil
		1A2	Industry	030100	0.6	IPCC (1996), Tier 1, Table 1-8, Industry, oil
		1A4a	Commercial/ Institutional	020100	0.6	IPCC (1996), Tier 1, Table 1-8, Commercial, oil
				020105	0.6	IPCC (1996), Tier 1, Table 1-8, Commercial, oil
		1A4b i	Residential	020200	0.6	IPCC (1996), Tier 1, Table 1-8, Residential, oil
		1A4c i	Agriculture/ Forestry	020300	0.6	IPCC (1996), Tier 1, Table 1-8, Agriculture, oil
	REFINERY GAS	1A1b	Petroleum refining	010304	1	Assumed equal to natural gas fuelled turbines. Based on Nielsen et al. (2010).
				010306	0.1	IPCC (1996), Tier 1, Table 1-8, Energy industries, natural gas
GAS	NATURAL GAS	1A1a	Electricity and heat production	010101	0.1	IPCC (1996), Tier 1, Table 1-8, Energy industries, natural gas
				010102	0.1	IPCC (1996), Tier 1, Table 1-8, Energy industries, natural gas
				010103	0.1	IPCC (1996), Tier 1, Table 1-8, Energy industries, natural gas
				010104	1	Nielsen et al. (2010)
				010105	0.58	Nielsen et al. (2010)
				010202	0.1	IPCC (1996), Tier 1, Table 1-8, Energy industries, natural gas
				010203	0.1	IPCC (1996), Tier 1, Table 1-8, Energy industries, natural gas
		1A1c	Other energy industries	010504	2.2	Nielsen & Illerup (2003) [2)]
		1A2	Industry	030100	0.1	IPCC (1996), Tier 1, Table 1-8, Industry, natural gas
				030103	0.1	IPCC (1996), Tier 1, Table 1-8, Industry, natural gas
				030104	1	Nielsen et al. (2010)
				030105	0.58	Nielsen et al. (2010)

Fuel group	Fuel	CRF source category	CRF source category	SNAP	Emission factor, g per GJ	Reference
				030106	0.1	IPCC (1996), Tier 1, Table 1-8, Industry, natural gas
		1A4a	Commercial/ Institutional	020100	2.3	IPCC (1996), Tier 2, Table 1-19, Commercial, natural gas boilers
				020103	2.3	IPCC (1996), Tier 2, Table 1-19, Commercial, natural gas boilers
				020105	0.58	Nielsen et al. (2010)
		1A4b i	Residential	020200	0.1	IPCC (1996), Tier 1, Table 1-8, Residential, natural gas
				020202	0.1	IPCC (1996), Tier 1, Table 1-8, Residential, natural gas
				020204	0.58	Nielsen et al. (2010)
		1A4c i	Agriculture/ Forestry	020300	2.3	IPCC (1996), Tier 2, Table 1-19, Commercial, natural gas boilers[1)]
				020304	0.58	Nielsen et al. (2010)
WASTE	MUNICIP. WASTES	1A1a	Electricity and heat production	010101	1.2	Nielsen et al. (2010)
				010102	1.2	Nielsen et al. (2010)
				010103	1.2	Nielsen et al. (2010)
				010203	1.2	Nielsen et al. (2010)
		1A4a	Commercial/ Institutional	020103	4	IPCC (1996), Tier 1, Table 1-8, Commercial, wastes
BIO-MASS	WOOD	1A1a	Electricity and heat production	010102	0.8	Nielsen et al. (2010)
				010103	0.8	Nielsen et al. (2010)
				010104	0.8	Nielsen et al. (2010)
				010203	4	IPCC (1996), Tier 1, Table 1-8, Energy industries, wood
		1A2	Industry	030100	4	IPCC (1996), Tier 1, Table 1-8, Industry, wood
				030102	4	IPCC (1996), Tier 1, Table 1-8, Industry, wood
				030103	4	IPCC (1996), Tier 1, Table 1-8, Industry, wood
		1A4a	Commercial/ Institutional	020100	4	IPCC (1996), Tier 1, Table 1-8, Commercial, wood
				020105	4	IPCC (1996), Tier 1, Table 1-8, Commercial, wood
		1A4b i	Residential	020200	4	IPCC (1996), Tier 1, Table 1-8, Residential, wood
				020202	4	IPCC (1996), Tier 1, Table 1-8, Residential, wood
				020204	4	IPCC (1996), Tier 1, Table 1-8, Residential, wood
		1A4c i	Agriculture/ Forestry	020300	4	IPCC (1996), Tier 1, Table 1-8, Agriculture, wood
	STRAW	1A1a	Electricity and heat production	010101	1.1	Nielsen et al. (2010)
				010102	1.1	Nielsen et al. (2010)
				010103	1.1	Nielsen et al. (2010)
				010104	1.1	Nielsen et al. (2010)
				010203	4	IPCC (1996), Tier 1, Table 1-8, Energy industries, other biomass
		1A4b i	Residential	020200	4	IPCC (1996), Tier 1, Table 1-8, Residential, other biomass
		1A4c i	Agriculture/ Forestry	020300	4	IPCC (1996), Tier 1, Table 1-8, Agriculture, other biomass
	BIO OIL	1A1a	Electricity and heat production	010105	2.1	Assumed equal to gas oil. Based on Nielsen et al. (2010)
				010202	0.4	IPCC (1996), Tier 2, Table 1-15, Utility, distillate fuel oil
				010203	0.4	IPCC (1996), Tier 2, Table 1-15, Utility, distillate fuel oil
		1A2	Industry	030105	2.1	Assumed equal to gas oil. Based on Nielsen et al. (2010)
		1A4b i	Residential	020200	0.6	IPCC (1996), Tier 1, Table 1-8, Residential, oil
	BIOGAS	1A1a	Electricity and heat production	010102	0.1	IPCC (1996), Tier 1, Table 1-8, Energy industries, natural gas
				010105	1.6	Nielsen et al. (2010)
				010203	0.1	IPCC (1996), Tier 1, Table 1-8, Energy industries, natural gas
		1A2	Industry	030100	0.1	IPCC (1996), Tier 1, Table 1-8, Industry, natural gas
				030102	0.1	IPCC (1996), Tier 1, Table 1-8, Industry, natural gas
				030103	0.1	IPCC (1996), Tier 1, Table 1-8, Industry, natural gas
				030105	1.6	Nielsen et al. (2010)
		1A4a	Commercial/ Institutional	020100	0.1	IPCC (1996), Tier 1, Table 1-8, Commercial, natural gas
				020103	0.1	IPCC (1996), Tier 1, Table 1-8, Commercial, natural gas
				020105	1.6	Nielsen et al. (2010)
		1A4c i	Agriculture/ Forestry	020300	0.1	IPCC (1996), Tier 1, Table 1-8, Agriculture, natural gas
				020304	1.6	Nielsen et al. (2010)
	BIO PROD GAS	1A1a	Electricity and heat production	010105	2.7	Nielsen et al. (2010)
		1A2	Industry	030105	2.7	Nielsen et al. (2010)

1) In Denmark plants in Agriculture/Forestry are similar to Commercial plants.

2) The emission factor 1 g/GJ, referring to Nielsen et al. (2010), will be applied in the next inventory.

SO_2, NO_x, NMVOC and CO

Emission factors for SO_2, NO_x, NMVOC and CO are listed in Annex 3A-4. The appendix includes references and time-series.

The emission factors refer to:

- The EMEP/CORINAIR Guidebook (EEA, 2007 and EEA, 2009).
- The IPCC Guidelines, Reference Manual (IPCC, 1996).
- Danish legislation:
    - Miljøstyrelsen, 2001 (Danish Environmental Protection Agency).
    - Miljøstyrelsen, 1990 (Danish Environmental Protection Agency).

- Danish research reports including:
    - Two emission measurement programs for decentralised CHP plants (Nielsen et al. 2010; Nielsen & Illerup, 2003).
    - Research and emission measurements programs for biomass fuels:
        - Nikolaisen et al. (1998).
        - Jensen & Nielsen (1990).
        - Serup et al. (1999).
        - Christiansen et al. (1997).
    - Research and environmental data from the gas sector:
        - Gruijthuijsen & Jensen (2000).
        - Danish Gas Technology Centre (DGC) (2001).
        - Wit & Andersen (2003).
- Aggregated emission factors for residential wood combustion based on technology distribution (Illerup et al. 2007) and technology specific emission factors (EEA 2009; DEPA 2010).
- Calculations based on plant-specific emissions from a considerable number of power plants.
- Calculations based on plant-specific emission data from a considerable number of municipal waste incineration plants. These data refer to annual environmental reports published by plant operators.
- Sulphur content data from oil companies and the Danish gas transmission company, Energinet.dk.
- Additional personal communication.

The emission factors for NMVOC that are not nationally referenced have been updated according to EEA (2009).

Emission factor time-series have been estimated for a considerable number of the emission factors. These are provided in Annex 3A-4.

Disaggregation to specific industrial subcategories

The national statistics, on which the emission inventories are based, do not include a direct disaggregation to specific industrial subsectors. However, separate national statistics from Statistics Denmark include a disaggregation to industrial subsectors. This part of the energy statistics is also included in the official energy statistics from the DEA.

Every other year Statistics Denmark collects fuel consumption data for all industrial companies of a considerable size. The deviation between the total fuel consumption from the DEA and the data collected by Statistics Denmark is rather small. Thus, the disaggregation to industrial subsectors available from Statistics Denmark can be applied for estimating disaggregation keys for fuel consumption and emissions.

The industrial fuel consumption is considered in three aspects:

- Fuel consumption for transport. This part of the fuel consumption is not disaggregated to the industrial subcategories.
- Fuel consumption applied in power or district heating plants. Disaggregation of fuel and emissions is plant specific.
- Fuel consumption for other purposes. The total fuel consumption and the total emissions are disaggregated to industrial subcategories.

All pollutants included in the Climate Convention reporting have been disaggregated to industrial subcategories.

The IEF for CO_2 in cement production fluctuates. For 2006-2009, detailed data are available from the EU ETS reporting and the fluctuations are a result of changing fuel types. Due to insufficient plant specific data for the applied waste fractions in 1990-2005, the CO_2 emission factor for fuel category *Other fuels* (waste) is assumed equal to the emission factor for waste incineration in CHP plants. This is further documented and discussed in Chapter 4.2.2.

3.2.6 Uncertainty

Uncertainty estimates include uncertainty with regard to the total emission inventory as well as uncertainty with regard to trends.

Methodology

Greenhouse gases

The uncertainty for GHG emissions have been estimated according to the IPCC Good Practice Guidance (IPCC 2000). The uncertainty has been estimated by two approaches; tier 1 and a tier 2. Both approaches are further described in the NIR Chapter 1.7.

The **tier 1** approach is based on a normal distribution and a confidence interval of 95 %.

The input data for the tier 1 approach are:

- Emission data for the base year and the latest year.
- Uncertainties for emission factors
- Uncertainty for fuel consumption rates.

The emission source categories applied are listed in Table 3.2.33.

The **tier 2** approach is a Monte Carlo approach based on a lognormal distribution. The input data for the model is also based on 95 % confidence interval. The input data for the tier 2 approach are:

- Fuel consumption data for the base year and the latest year.
- Emission factors or implied emission factors (IEF) for the base year and the latest year
- Uncertainties for emission factors for the base year and the latest year. If the same uncertainty is applied for both years the data can be indicated as statistically dependent or independent.
- Uncertainties for fuel consumption rates in the base year and the latest year. If the same uncertainty is applied for both years the data can be indicated as statistically dependent or independent.

The same emission source categories and emission data have been applied for both approaches. The separate uncertainty estimation for gas engine CH_4 emission and CH_4 emission from other plants does not follow the recommendations in the IPCC Good Practice Guidance. Disaggregation is applied, because in Denmark the CH_4 emission from gas engines is much larger than the emission from other stationary combustion plants, and the CH_4 emission factor for gas engines is estimated with a much smaller uncertainty level than for other stationary combustion plants.

In general, the same uncertainty levels have been applied for both approaches. However, the tier 2 approach allows different uncertainty levels for 1990 and 2009 and this is relevant to a few uncertainties as discussed below. The 2009 uncertainty levels have been applied in the tier 1 approach.

Most of the applied uncertainty estimates for activity rates and emission factors are default values from the IPCC Reference Manual or aggregated by NERI based on the default values. Some of the uncertainty estimates are, however, based on national estimates.

In general the uncertainty of the fuel consumption data have been assumed to be the same in 1990 and 2009 and the uncertainty has been assumed to be statistically independent. However, a considerable part of the residential wood consumption is non-traded and the uncertainty of biomass consumption has been assumed statistically dependent.

Fuel consumption data for waste are more uncertain for 1990 than for 2009.

For coal and refinery gas combustion the uncertainty of the CO_2 emission factor is lower in 2009 than in 1990 due to availability of EU ETS data. Further the CO_2 emission factor for the fossil part of municipal waste is less uncertain for 2009 than for 1990.

The uncertainty of the CH_4 emission factors for gas engines have been assumed higher in 1990 than in 2009 due to the emission measurement programmes on which the emission factors in later years are based.

All other uncertainty levels for emission factors have been assumed equal in 1990 and 2009 and statistically dependent.

Table 3.2.33 Uncertainty rates for fuel consumption and emission factors, 2009.

IPCC Source category	Gas	Fuel consumption uncertainty, %		Emission factor uncertainty, %	
		1990	2009	1990	2009
Stationary Combustion, Coal, CO_2	CO_2	0.9%[2]	0.9%[7]	4[10]	1.1[7]
Stationary Combustion, BKB, CO_2	CO_2	2.9%[2]	3.0%[2]	5[1]	
Stationary Combustion, Coke, CO_2	CO_2	1.8%[2]	2.0%[2]	5[1]	
Stationary Combustion, Fossil waste, CO_2	CO_2	4.4%[2]	4.8%[2]	35[5]	25[5]
Stationary Combustion, Petroleum coke, CO_2	CO_2	1.7%[2]	2.0%[2]	5[1]	
Stationary Combustion, Residual oil, CO_2	CO_2	1.2%[2]	0.9%[2]	2[4]	2[7]
Stationary Combustion, Gas oil, CO_2	CO_2	2.9%[2]	2.5%[2]	4[10]	
Stationary Combustion, Kerosene, CO_2	CO_2	3.0%[2]	2.6%[2]	5[1]	
Stationary Combustion, LPG, CO_2	CO_2	1.7%[2]	2.2%[2]	5[1]	
Stationary Combustion, Refinery gas, CO_2	CO_2	1.0%[2]	1.0%[2]	5[1]	2[12]
Stationary Combustion, Natural gas, CO_2	CO_2	1.2%[2]	1.0%[2]	0.4[8]	
Stationary Combustion, SOLID, CH_4	CH_4	0.9%[2]	1.0%[2]	100[1]	
Stationary Combustion, LIQUID, CH_4	CH_4	1.5%[2]	1.1%[2]	100[1]	
Stationary Combustion, GAS, CH_4	CH_4	1.0%[8]	1.0%[8]	100[1]	
Natural gas fuelled engines, GAS, CH_4	CH_4	1.0%[9]	1.0%[9]	10[11]	2[3]
Stationary Combustion, WASTE, CH_4	CH_4	10.0%[5]	5.0%[5]	100[1]	
Stationary Combustion, BIOMASS, CH_4	CH_4		19.8%[2]	100[1]	
Biogas fuelled engines, BIOMASS, CH_4	CH_4	0.0%[2]	3.7%[2]	20[11]	10[11]
Stationary Combustion, SOLID, N_2O	N_2O	0.9%[2]	1.0%[2]	400[6) 13]	
Stationary Combustion, LIQUID, N_2O	N_2O	1.5%[2]	1.1%[2]	1000[1) 13]	
Stationary Combustion, GAS, N_2O	N_2O	1.0%[8]	1.0%[8]	750[6) 13]	
Stationary Combustion, WASTE, N_2O	N_2O	10.0%[5]	5.0%[5]	400[6) 13]	
Stationary Combustion, BIOMASS, N_2O	N_2O		19.8%[2]	400[6) 13]	

1) IPCC Good Practice Guidance, default value (IPCC 2000).
2) Estimated by NERI based on default uncertainty levels in IPCC Good Practice Guidance, Table 2.6 (IPCC 2000).
3) Jørgensen et al. (2010). Uncertainty data for NMVOC + CH_4.
4) Jensen & Lindroth (2002).
5) Estimated by NERI based on ongoing work, biogenic carbon in waste (Nielsen 2009).
6) NERI, rough estimate based on a default value of 400 % when the emission factor is based on emission measurements from plants in Denmark.
7) NERI calculation based on EU ETS data.
8) Lindgren (2010). Personal communication, Tine Lindgren, Energinet.dk, e-mail 2010-03-16.
9) Equal to natural gas total. NERI assumption.
10) NERI assumption based on EU ETS data interval and IPCC Guidelines (IPCC 1996) data interval.
11) NERI estimate based on Nielsen et al. (2010).
12) NERI assumption based on the fact that data are based on EU ETS data.
13) With a truncation of twice the uncertainty rate. The truncation is relevant for the very large uncertainty rates for N_2O emission factors due to the log-normal distribution applied in the tier 2 model.

Other pollutants

With regard to other pollutants, IPCC methodologies for uncertainty estimates have been adopted for the LRTAP Convention reporting activities (Pulles & Aardenne, 2003). The Danish uncertainty estimates are based on the simple Tier 1 approach.

The uncertainty estimates are based on emission data for the base year and year 2009 as well as on uncertainties for fuel consumption and emission factors for each of the main SNAP source categories. The applied uncertainties for activity rates and emission factors are default values referring to Pulles & Aardenne (2003). The default uncertainties for emission factors are given in letter codes representing an uncertainty range. It has been assumed that the uncertainties were in the lower end of the range for all sources and pollutants. The applied uncertainties for emission factors are listed in Table 3.2.34. The uncertainty for fuel consumption in stationary combustion plants is assumed to be 2 %.

Table 3.2.34 Uncertainty rates for emission factors, %.

SNAP source category	SO_2	NO_x	NMVOC	CO
01	10	20	50	20
02	20	50	50	50
03	10	20	50	20

Results

The tier 1 uncertainty estimates for stationary combustion emission inventories are shown in Table 3.2.35. Detailed calculation sheets are provided in Annex 3A-7. The tier 2 uncertainty estimates are shown in Table 3.2.36 and detailed results are provided in Annex 3A-7.

The tier 1 uncertainty interval for GHG is estimated to be ±2.1 % and trend in GHG emission is -16.8 % ± 1.3 %-age points. The main sources of uncertainty for GHG emission 2009 are the CO_2 emission from the fossil part of municipal waste, the CO_2 emission from coal combustion and the N_2O emission from biomass and gas combustion. The main source of uncertainty in the trend in GHG emission is also CO_2 emission from the combustion of coal and municipal waste and N_2O emission from biomass and gas combustion.

The total emission uncertainty is 7.8 % for SO_2, 16 % for NO_x, 44 % for NMVOC and 43 % for CO.

The tier 1 and tier 2 approaches points out the same emission source categories as main contributors to the total uncertainty for GHG emission from stationary combustion.

Table 3.2.35 Danish uncertainty estimates, tier 1 approach, 2009.

Pollutant	Uncertainty Total emission, %	Trend 1990-2009, %	Uncertainty trend, %-age points
GHG	±2.1	-16.8	±1.3
CO_2	±1.3	-17.6	±1.0
CH_4	±40	+201	±141
N_2O	±258	+15.4	±239
SO_2	±7.8	-93	±0.4
NO_x	±16	-63	±2.6
NMVOC	±44	+31	±6.9
CO	±43	+3	±3.2

Table 3.2.36 Danish uncertainty estimates, tier 2 approach, 2009.

Pollutant	Uncertainty of total emission, %		Trend 1990-2009, %	Uncertainty of trend, %-age points	
GHG	-1.6%	2.2%	-16.7%	-2.9%	+2.8%
CO_2	-1.2%	1.4%	-17.7%	-2.9%	+2.8%
CH_4	-24%	62%	+198%	-23%	+53%
N_2O	-73%	188%	+10.8%	-125%	+118%

The results are illustrated and compared in figure 3.2.41. The uncertainties are in the same level for each pollutant. The emission data shown for the tier 1 approach are the CRF emission data. The tier 2 emission levels are median values based on the Monte Carlo approach.

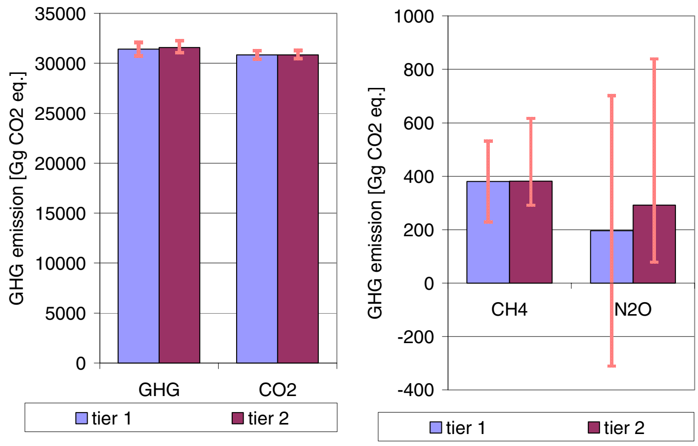


Figure 3.2.41 Uncertainty level, the two approaches are compared for 2009.

3.2.7 Source specific QA/QC and verification

A QA/QC plan for the Danish emission inventories has been implemented. The quality manual (Sørensen et al. 2005) describes the concepts of quality work and definitions of sufficient quality, critical control points and a list of *Point for Measuring* (PM). Please see the general chapter on QA/QC. Source specific QA/QC is discussed below. The work on expanding the QC will be ongoing in future years.

Documentation concerning verification of the Danish emission inventories has been published by Fauser et al. (2007). The reference approach for the energy sector is shown is shown in Chapter 3.4.

Previous updates of the sector report for stationary combustion (Nielsen et al. 2010) has been reviewed by external Danish experts in 2005, 2007 and 2009.

Data storage, level 1

Table 3.2.37 List of external data sources.

Dataset	Description	AD or Emf.	Reference	Contact(s)	Data agreement/ Comment
Energiproducenttællingen.xls	Data set for all electricity and heat producing plants.	Activity data	The Danish Energy Agency (DEA)	Peter Dal	Data agreement in place
Gas consumption for gas engines and gas turbines 1990-1994		Activity data	The Danish Energy Agency (DEA)	Peter Dal	No data agreement. Historical data
Basic data (Grunddata.xls)	Data set used for IPCC reference approach	Activity data	The Danish Energy Agency (DEA)	Peter Dal	Not necessary. Published as part of national energy statistics
Energy statistics	The Danish energy statistics on SNAP level	Activity data	The Danish Energy Agency (DEA)	Peter Dal	Data agreement in place
SO_2 & NO_x data, plants>25 MW_e		Emissions	The Danish Energy Agency (DEA)	Rasmus Sørensen	No data agreement in place
Emission factors	Emission factors stems from a large number of sources	Emission factors	See chapter regarding emission factors		
Annual environmental reports / environmental data	Emissions from plants defined as large point sources	Emissions	Various plants		No data agreement necessary. Plants are obligated by law.
EU ETS data	Plant specific CO_2 emission factors	Emission factors	The Danish Energy Agency (DEA)	Dorte Maimann Helen Falster	Plants are obligated by law. The availability of detailed information is part of the renewed data agreement with DEA.

Data Storage level 1	1. Accuracy	DS.1.1.1	General level of uncertainty for every dataset including the reasoning for the specific values

Since the DEA are responsible for the official Danish energy statistics as well as reporting to the IEA, NERI regards the data as being complete and in accordance with the official Danish energy statistics and IEA reporting. The uncertainties connected with estimating fuel consumption do not, therefore, influence the accordance between IEA data, the energy statistics and the dataset on SNAP level utilised by NERI. For the remaining datasets, it is assumed that the level of uncertainty is relatively low. For further comments regarding uncertainties, see Chapter 3.2.6.

Data Storage level 1	1. Accuracy	DS.1.1.2	Quantification of the uncertainty level of every single data value including the reasoning for the specific values.

The uncertainty for external data is not quantified. The uncertainties of activity data and emission factors are quantified see Chapter 3.2.6.

Data Storage level 1	2.Comparability	DS.1.2.1	Comparability of the data values with similar data from other countries, which are comparable with Denmark, and evaluation of discrepancy.

On the external data the comparability has not been checked. However, at CRF level a project has been carried out comparing the Danish inventories with those of other countries (Fauser et al. 2007).

Data Storage level 1	3.Completeness	DS.1.3.1	Documentation showing that all possible national data sources are included by setting up the reasoning for the selection of datasets.

See the above Table 3.2.37 for an overview of external datasets.

Danish Energy Authority

Statistic on fuel consumption from district heating and power plants

A spreadsheet from DEA is listing fuel consumption of all plants included as large point sources in the emission inventory. The statistic on fuel consumption from district heating and power plants is regarded as complete and with no significant uncertainty since the plants are bound by law to report their fuel consumption and other information.

Gas consumption for gas engines and gas turbines 1990-1994

For the years 1990-1994 DEA has estimated consumption of natural gas and biogas in gas engines and gas turbines. NERI assesses that the estimation by the DEA are the best available data.

Basic data

A spreadsheet from DEA is used for the CO_2 emission calculation in accordance with the IPCC reference approach. It is published annually on DEA's webpage; therefore, a formal data delivery agreement is not deemed necessary.

Energy statistics on SNAP level

The data agreement have been renewed in 2011. NERI aggregates fuel consumption statistics to SNAP level based on a correspondence table developed in co-operation with DEA. Both traded and non-traded fuels are included in the Danish energy statistics. Thus, for example, estimation of the annual consumption of non-traded wood is included.

Emissions from non-energy use of fuels have been included in other source categories of the Danish inventory. The non-energy use of fuels is, however, included in the reference approach for Climate Convention reporting.

SO_2 and NO_x emission data from electricity producing plants > 25MWe

Plants larger than 25 MW_e are obligated to report emission data for SO_2 and NO_x to the DEA annually. Data are on block level and classified. The data on plant level are part of the plants annually environmental reports. NERI's QC of the data consists of a comparison with data from previous years and with data from the plants' annual environmental reports.

Emission factors from a wide range of sources

For specific references, see the chapter regarding emission factors.

Annual environmental reports from plants defined as large point sources

A large number of plants are obligated by law to report annual environmental data including emission data. NERI compares the data with those from previous years and large discrepancies are checked.

EU ETS data

EU ETS data are information on fuel consumption, heating values, carbon content of fuel, oxidation factor and CO_2 emissions. NERI receives the verified reports for all plants which utilises a detailed estimation methodology (see chapter 1.4.10). NERI's QC of the received data consists of comparing to calculation using standard emission factors as well as comparing reported values with those for previous years. Outliers are checked.

Data Storage level 1	4.Consistency	DS.1.4.1	The origin of external data has to be preserved whenever possible without explicit arguments (referring to other PM's)

It is ensured that all external data are archived at NERI. Subsequent data processing takes place in other spreadsheets or databases. The datasets are archived annually in order to ensure that the basic data for a given report are always available in their original form.

Data Storage level 1	6.Robustness	DS.1.6.1	Explicit agreements between the external institution of data delivery and NERI about the condition of delivery

For stationary combustion a data delivery agreement is made with the DEA. Most of the other external data sources are available due to legislatory requirements. See Table 3.2.37.

Data Storage level 1	7.Transparency	DS.1.7.1	Summary of each dataset including the reasoning for selecting the specific dataset

See DS 1.3.1

Data Storage level 1	7.Transparency	DS.1.7.3	References for citation for any external data set have to be available for any single number in any dataset.

See Table 3.2.37 for general references. Much documentation already exists. However, some of the information used is classified and therefore not publicly available.

Data Storage level 1	7.Transparency	DS.1.7.4	Listing of external contacts for every dataset

See Table 3.2.37.

Data processing, level 1

Data Processing level 1	1. Accuracy	DP.1.1.1	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to type of variability. (Distribution as: normal, log normal or other type of variability)

The uncertainty assessment of activity data and emission factors are discussed in the chapter concerning uncertainties.

Data Processing level 1	1. Accuracy	DP.1.1.2	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to scale of variability (size of variation intervals)

The uncertainty assessment of activity data and emission factors are discussed in the chapter concerning uncertainties.

Data Processing level 1	1. Accuracy	DP.1.1.3	Evaluation of the methodological approach using international guidelines

The methodological approach is consistent with international guidelines. For the majority of sources tier 2 or tier 3 methodologies are used.

Data Processing level 1	1. Accuracy	DP.1.1.4	Verification of calculation results using guideline values

Calculated emission factors are compared with guideline emission factors to ensure that they are within reason.

Data Processing level 1	2.Comparability	DP.1.2.1	The inventory calculation has to follow the international guidelines suggested by UNFCCC and IPCC.

The calculations follow the principle in international guidelines.

Data Processing level 1	3.Completeness	DP.1.3.1	Assessment of the most important quantitative knowledge which is lacking.

Regarding the distribution of energy consumption for industrial sources (CRF sector 1A2), a more detailed and frequently updated data material would be preferred. There is ongoing work to increase the accuracy and completeness of this IPCC source category. It is not assessed that this has any influence on the overall emission level of greenhouse gases.

Data Processing level 1	3.Completeness	DP.1.3.2	Assessment of the most important cases where accessibility to critical data sources that could improve quantitative knowledge is missing.

There is no missing accessibility to critical data sources.

Data Processing level 1	4.Consistency	DP.1.4.1	In order to keep consistency at a higher level, an explicit description of the activities needs to accompany any change in the calculation procedure.

A change in calculation procedure would entail that an updated description would be elaborated.

Data Processing level 1	5.Correctness	DP.1.5.1	Show at least once, by independent calculation, the correctness of every data manipulation.

During data processing it is checked that calculations are done correctly. This is to a wide degree documented in the data processing spreadsheets.

Data Processing level 1	5.Correctness	DP.1.5.2	Verification of calculation results using time-series

Time-series for activity data on SNAP level, as well as emission factors, are used to identify possible errors in the calculation procedure.

Data Processing level 1	5.Correctness	DP.1.5.3	Verification of calculation results using other measures

The IPCC reference approach validates the fuel consumption rates and CO_2 emissions of fuel combustion. Fuel consumption rates and CO_2 emissions differ by less than 2.0 % (1990-2009). The reference approach is further discussed below.

Data Processing level 1	5.Correctness	DP.1.5.4	Show one-to-one correctness between external data sources and the databases at Data Storage level 2.

There is a direct line between the external datasets, the calculation process and the input data used to Data Storage level 2. During the calculation process numerous controls are conducted to ensure correctness, e.g. sum checks of the various stages in the calculation procedure.

Data Processing level 1	7.Transparency	DP.1.7.1	The calculation principle and equations used must be described.
Data Processing level 1	7.Transparency	DP.1.7.2	The theoretical reasoning for all methods must be described.
Data Processing level 1	7.Transparency	DP.1.7.3	Explicit listing of assumptions behind all methods

Where appropriate, this is included in the present report with annexes.

Data Processing level 1	7.Transparency	DP.1.7.4	Clear reference to dataset at Data Storage level 1

There is a clear line between the external data and the data processing.

Data Processing level 1	7.Transparency	DP.1.7.5	A manual log to collect information about recalculations

At present, a manual log table is not in place at this level. However, this feature will be implemented in the future. A manual log table is incorporated in the national emission database, Data Storage level 2.

Data storage, level 2

Data Storage level 2	5.Correctness	DS.2.5.1	Documentation of a correct connection between all data types at level 2 to data at level 1

To ensure a correct connection between data on level 2 and data on level 1, different controls are in place, e.g. control of sums and random tests.

Data Storage level 2	5.Correctness	DS.2.5.2	Check if a correct data import to level 2 has been made.

Data import is checked by use of sum control and random testing. The same procedure is applied every year in order to minimise the risk of data import errors.

Other QC procedures

The emission from each large point source is compared with the emission reported the previous year.

Some automated checks have been prepared for the emission databases:

- Check of units for fuel rate, emission factors and plant-specific emissions.
- Check of emission factors for large point sources. Emission factors for pollutants that are not plant-specific should be the same as those defined for area sources.
- Additional checks on database consistency.
- Emission factor references are included in this report (Chapter 3.2.5 and Appendix 3A-4).
- Annual environmental reports are kept for subsequent control of plant-specific emission data.
- QC checks of the country-specific emission factors have not been performed, but most factors are based on input from companies that have implemented some QA/QC work. The major power plant owner/operators in Denmark, DONG Energy and Vattenfall have obtained the ISO 14001 certification for an environmental management system. The Danish Gas Technology Centre and Force Technology both run accredited laboratories for emission measurements.

National external review

The 2005, 2007 and 2009 updates of the sector report for stationary combustion (Nielsen et al. 2005; Nielsen et al. 2007; Nielsen et al. 2009) have been reviewed by Jan Erik Johnsson from the Technical University of Denmark, Bo Sander from Elsam Engineering and Annemette Geertinger from FORCE Technology.

3.2.8 Source specific recalculations and improvements

Improvements and recalculations since the 2010 emission inventory submission include:

- The national energy statistics has been updated for the years 1980-2008. The update included both end use and transformation sectors as well as a source category update.
- The petroleum coke purchased abroad and combusted in Danish residential plants is no longer included in the inventory. The border trade was 628 TJ in 2009.
- CO_2 emission factors for coal have been recalculated and an improved time-series consistency included. Due to the considerable consumption of coal, this recalculation is considerable for some years, mainly in 1990-2005 before EU ETS data became available[24].
- CO_2 emission factors for residual oil have also been recalculated and an improved time-series implemented.
- The CO_2 emission factors for LPG and kerosene have been changed and both emission factors now refer to IPCC Guidelines (1996).
- The CO_2 emission factor for refinery gas have been updated according to EU ETS data.
- The CO_2 emission factor for off-shore gas turbines have been updated according to EU ETS data.
- Emission factors for CH_4 and N_2O that are not country specific have been updated and now all refer to IPCC Guidelines (1996).
- A time-series have been estimated for the CH_4 emission factor for residential wood combustion.
- Improved input data for the tier 2 approach for uncertainty has been applied for greenhouse gases.

3.2.9 Source specific planned improvements

A number improvements are planned for the stationary combustion emission inventories:

- 1) Improved documentation for emission factor.

The reporting of, and references for, the applied emission factors will be further developed in future inventories.

- 2) Improved CO_2 emission factor for waste.

Ongoing work will further improve the CO_2 emission factor for waste incineration (DTU 2008).

- 3) Implementation of emission factors from EEA 2009

Some emission factors refer to older version of the EMEP/CORINAIR Guidebook. The emission factors will be updated according to EEA (2009).

- 4) Inconsistent time-series for petroleum refining will be recalculated.

[24] 2009: - 1.9 Gg CO_2, 1990: -245 Gg CO_2

As mentioned in Chapter 3.2.4 inconsistencies occurs in this sector. This will be improved in the next inventory.

3.2.10 References for Chapter 3.2

Andersen, M.A., 1996: Elkraft, personal communication letter 07-05-1996.

Bech, N., 1999: Personal communication, letter 05-11-1999, Sjællandske Kraftværker, SK Energi.

Christiansen, M., 1996: Elsam, personal communication, letter 07-05-1996.

Christiansen, B.H., Evald, A., Baadsgaard-Jensen, J. Bülow, K. 1997. Fyring med biomassebaserede restprodukter, Miljøprojekt nr. 358, 1997, Miljøstyrelsen.

Christiansen, M., 2001: Elsam, personal communication, e-mail 23-08-2001 to Jytte Boll Illerup.

Danish Energy Agency (DEA), 2003: Data for installation and fuel consumption for each gas engine 1994-2002. Unpublished.

Danish Energy Agency (DEA), 2010a: The Danish energy statistics aggregated to SNAP sectors. Unpublished.

Danish Energy Agency (DEA), 2010b: The Danish energy statistics, Available at: http://www.ens.dk/graphics/UK_Facts_Figures/Statistics/yearly_statistics/2009/BasicData2009.xls (2009-03-03).

Danish Energy Agency (DEA), 2010c: The Danish energy statistics, Energiproducenttællingen 2009. Unpublished.

Danish Energy Agency (DEA), 2010d: The Danish energy statistics, International reporting. Available at: http://www.ens.dk/da-DK/Info/TalOgKort/Statistik_og_noegletal/Internationale_indberetninger/Documents/International_Reporting_2009.xls (2010-12-13)

Danish Environmental Protection Agency (DEPA), 2010: Emissioner fra træfyrede brændeovne/kedler (Emissions from wood fired stoves/boilers). Danish Environmental Protection Agency, 2010. Available at: http://www.mst.dk/Publikationer/Publikationer/2010/04/978-87-92617-85-9.htm (2010-04-27).

Danish Gas Technology Centre (DGC), 2001: Naturgas – Energi og miljø (In Danish). Available at: http://www.dgc.dk/publikationer/rapporter/data/PDF/enermilbroch.pdf (2009-03-03).

DTU, 2008: Biogenic Carbon in Danish Combustible Waste. Ongoing project.

Elsam 2005: e-mail from Arne Henriksen, Elsam Engineering, 2005-08-11. Unpublished emission measurement data for N_2O from 3 power plants combusting coal.

EU Commission, 2007: COMMISSION DECISION of 18 July 2007 establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council. Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:229:0001:0085:EN:PDF (10-02-2011)

European Environment Agency (EEA), 2002: EMEP/CORINAIR Atmospheric Emission Inventory Guidebook – 2002, prepared by the UN-ECE/EMEP Task Force on Emissions Inventories and Projections. Technical Report No 30/2002. Available at: http://www.eea.europa.eu/publications/technical_report_2001_3 (2010-02-30).

European Environment Agency (EEA), 2007: EMEP/CORINAIR Atmospheric Emission Inventory Guidebook – 2007, prepared by the UN-ECE/EMEP Task Force on Emissions Inventories and Projections. Technical Report No 16/2007. Available at: http://www.eea.europa.eu/publications/EMEPCORINAIR5 (2010-02-03).

European Environment Agency (EEA), 2009: EMEP/EEA air pollutant emission inventory guidebook 2009. Technical guidance to prepare national emission inventories. EEA Technical Report 9/2009. Available at: http://www.eea.europa.eu/publications/emep-eea-emission-inventory-guidebook-2009 (2010-02-03).

Fauser, P., Thomsen, M., Nielsen, O-K., Winther, M., Gyldenkærne, S., Hoffmann, L., Lyck, E. & Illerup, J.B. 2007: Verification of the Danish emission inventory data by national and international data comparisons. National Environmental Research Institute, University of Aarhus, Denmark. 53 pp. – NERI Technical Report no. 627. Available at: http://www.dmu.dk/Pub/FR627.pdf

Fenhann, J. & Kilde, N.A., 1994: Inventory of Emissions to the air from Danish Sources 1972-1992, RISØ

Gruijthuijsen, L.v. & Jensen, J.K., 2000: Energi- og miljøoversigt, Danish Gas Technology Centre 2000 (In Danish). Available at: http://www.dgc.dk/publikationer/rapporter/data/PDF/energi_og_miljoedata.pdf (2009-03-03).

Hulgaard, T., 2003: Personal communication, e-mail 02-10-2003, Rambøll.

Illerup, J.B., Henriksen, T.C., Lundhede, T., Breugel, C.v., Jensen, N.Z., 2007: Brændeovne og små kedler – partikelemission og reduktionstiltag. Miljøstyrelsen, Miljøprojekt 1164, 2007.

IPCC, 1996: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual (Volume 3). Available at: http://www.ipcc-nggip.iges.or.jp/public/gl/invs6.html (2009-03-03).

Intergovernmental Panel on Climate Change (IPCC), 2000: Penman, J., Kruger, D., Galbally, I., Hiraishi, T., Nyenzi, B., Emmanuel, S., Buendia, L., Hoppaus, R., Martinsen, T., Meijer, J., Miwa, K. & Tanabe, K. (Eds). Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. Published: IPCC/OECD/IEA/IGES, Hayama, Japan. Available at: http://www.ipcc-nggip.iges.or.jp/public/gp/english/index.html (2009-03-03).

ISAG 2011: Danish waste statistics for 2008, ISAG database. Available at: http://www.mst.dk/Virksomhed_og_myndighed/Affald/Data_om_affald/Statistikker_og_ISAG-dataudtraek/ISAG.htm

Jensen, B.G. & Lindroth, M., 2002: Kontrol af indberetning af CO_2-udledning fra el-producenter i 2001, Carl Bro for Energistyrelsens 6. Kontor (in Danish).

Jensen, L. & Nielsen, P.A., 1990: Emissioner fra halm- og flisfyr, dk-Teknik & Levnedsmiddelstyrelsen 1990 (In Danish).

Jeppesen, J.S., 2008: København energi (Copenhagen Energy), Jørgen Steen Jeppesen, personal communication.

Johansson, L. S., Leckner, B., Gustavsson, L., Cooper, D., Tullin, C. & Potter, A. 2004: Emission characteristics of modern and old-type residential boilers fired with wood logs and wood pellets, Atmospheric Environment 38 (2004) 4183-4195.

Jørgensen, L. & Johansen, L. P., 2003: Eltra PSO 3141, Kortlægning af emissioner fra decentrale kraftvarmeværker, Anlæg A1-A5, dk-Teknik (In Danish). Available at: http://www.energinet.dk/da/menu/Forskning/ForskEL-programmet/Projekter/Afsluttede/Projekt+3141.htm (2009-03-03).

Københavns Energi (KE), 2009: Københavns energi (Copenhagen Energy) fact sheet on town gas. Available at: http://www.ke.dk/portal/pls/portal/docs/346012.PDF

Kristensen, P.G., 2001: Personal communication, e-mail 10-04-2001, Danish Gas Technology Centre.

Kristensen, P.G., 2007: Danish Gas Technology Centre, Per Gravers Kristensen, personal communication.

Kristensen, P.G., 2010: Danish Gas Technology Centre, Per Gravers Kristensen, email 2010-02-10.

Lindgren, 2010: Energinet.dk, Tine Lindgren, email 2010-03-16.

Miljøstyrelsen (MST), 1990: Bekendtgørelse om begrænsning af emissioner af svovl-dioxid, kvælstofoxider og støv fra store fyringsanlæg, Bekendtgørelse 689 af 15/10/1990, (Danish legislation).

Miljøstyrelsen (MST), 1998: Bekendtgørelseom begrænsning af svovlindholdet i visse flydende og faste brændstoffer, Bekendtgørelse 698 af 22/09/1998 (Danish legislation).

Miljøstyrelsen (MST), 2001: Luftvejledningen, Begrænsning af luftforurening fra virksomheder, Vejledning fra Miljøstyrelsen nr. 2, 2001 (Danish legislation).

Miljøstyrelsen (MST), 2005: Bekendtgørelse om begrænsning af emission af nitrogenoxider, uforbrændte carbonhydrider og carbonmonooxid mv. fra motorer og turbiner. Bekendtgørelse 621 af 23/06/2005. (Danish legislation). Available at: https://www.retsinformation.dk/Forms/R0710.aspx?id=12836&exp=1

Miljøstyrelsen (MST), 2010: Bekendtgørelse om visse virksomheders afgivelse af miljøoplysninger. Bekendtgørelse 210 af 03/03/2010. (Danish legislation). Available at: https://www.retsinformation.dk/Forms/R0710.aspx?id=128761 (2010-12-15).

Nielsen, M. & Wit, J., 1997: Emissionsforhold for gasdrevne kraftvarmeænlæg < $25MW_e$, Miljøstyrelsen, Arbejdsrapport Nr. 17 1997 (In Danish). Available at: http://www2.mst.dk/Udgiv/publikationer/1997/87-7810-759-8/pdf/87-7810-759-8.pdf (2009-03-03).

Nielsen, M. & Illerup, J.B., 2003: Emissionsfaktorer og emissionsopgørelse for decentral kraftvarme. Eltra PSO projekt 3141. Kortlægning af emissioner fra decentrale kraftvarmeværker. Delrapport 6. Danmarks Miljøundersøgelser. 116 s. –Faglig rapport fra DMU nr. 442. (In Danish, with an English summary). Available at: http://www2.dmu.dk/1_viden/2_Publikationer/3_fagrapporter/rapporter/FR442.pdf (2009-03-03).

Nielsen, M. & Illerup, J.B. 2006: Danish emission inventories for stationary combustion plants. Inventories until year 2003. National Environmental Research Institute, Denmark. 162 pp. – Research Notes from NERI no. 229. Available at: http://researchnotes.dmu.dk

Nielsen, O.-K., Nielsen, M. & Illerup, J.B. 2007: Danish Emission Inventories for Stationary Combustion Plants. Inventories until year 2004. National Environmental Research Institute, University of Aarhus, Denmark. 176 pp. – NERI Technical Report no. 628. Available at: http://www.dmu.dk/Pub/FR628 .

Nielsen, M., Illerup, J.B. & Birr-Petersen, K., 2009: Revised emission factors for gas engines including start/stop emissions. Sub-report 3 (NERI). National Environmental Research Institute, University of Aarhus. 69 pp. - NERI Technical Report No. 672. Available at: http://www.dmu.dk/Pub/FR672.pdf (2009-02-27).

Nielsen, M., Nielsen, O.-K., Plejdrup, M. & Hjelgaard, K., 2009: Danish Emission Inventories for Stationary Combustion Plants. Inventories until year 2007. National Environmental Research Institute, Aarhus University, Denmark. 216 pp. – NERI Technical Report no. 744. Available at: http://www.dmu.dk/Pub/FR744.pdf (2010-02-14).

Nielsen, O.-K. 2009: Angående CO_2 emissioner fra affaldsforbrænding, 2009-08-19. Research notes, not published.

Nielsen, M., Nielsen, O.-K. & Thomsen, M. 2010: Emissions from decentralised CHP plants 2007 - Energinet.dk Environmental project no. 07/1882. Project report 5 – Emission factors and emission inventory for decentralised CHP production. National Environmental Research Institute, Aarhus University. 113 pp. – NERI Technical report No. 786. http://www.dmu.dk/Pub/FR786.pdf (2011-02-28).

Nikolaisen, L., Nielsen, C., Larsen, M.G., Nielsen, V. Zielke, U., Kristensen, J.K. & Holm-Christensen, B., 1998: Halm til energiformål, Teknik – Miljø – Økonomi, 2. udgave, 1998, Videncenter for halm og flisfyring (In Danish).

Olsson, M. & Kjällstrand, J., 2005: Low emissions from wood burning in an ecolabelled residential boiler, Atmospheric Environment 40 (2006) 1148-1158.

Paulrud, S., Kindbom, K., Cooper, K., Gustafsson, T., 2005: Methane emissions from residential biomass combustion, SMED report 2005-10-14, IVL Swedish Environmental Research Institute and SCB, Statistics Sweden SMHI. Assignment for Swedish Environmental Protection Agency.

Pulles, T. & Aardenne,. J.v., 2004: Good Practice Guidance for LRTAP Emission Inventories, 24. Juni 2004. Available at: http://www.eea.europa.eu/publications/EMEPCORINAIR5/BGPG.pdf (2009-03-03).

Serup, H., Falster, H., Gamborg, C., Gundersen, P., Hansen, L. Heding, N., Jacobsen, H.H., Kofman, P., Nikolaisen, L. & Thomsen, I.M., 1999: Træ til energiformål, Teknik – Miljø – Økonomi, 2. udgave, 1999, Videncenter for halm og flisfyring (In Danish).

Sørensen, P.B., Illerup, J.B., Nielsen, M., Lyck, E., Bruun, H.G., Winther, M., Mikkelsen, M.H. & Gyldenkærne, S. 2005: Quality manual for the greenhouse gas inventory. Version 1. National Environmental Research Institute, Denmark. 25 pp. – Research Notes from NERI no. 224. Available at: http://research-notes.dmu.dk (2010-02-14).

Wit, J. d & Andersen, S. D. 2003: Emission fra større gasfyrede kedler, Dansk Gasteknisk Center, 2003. Available at: http://www.dgc.dk/publikationer/rapporter/data/03/emission.htm (2010-02-14).

3.3 Transport and other mobile sources (CRF sector 1A2, 1A3, 1A4 and 1A5)

The emission inventory basis for mobile sources is fuel consumption information from the Danish energy statistics. In addition, background data for road transport (fleet and mileage), air traffic (aircraft type, flight numbers, origin and destination airports) and non-road machinery (engine no., engine size, load factor and annual working hours) are used to make the emission estimates sufficiently detailed. Emission data mainly comes from the EMEP/EEA air pollutant emission inventory guidebook. However, for railways, specific Danish measurements are used.

In the Danish emissions database, all activity rates and emissions are defined in SNAP sector categories (Selected Nomenclature for Air Pollution) according to the CORINAIR system. The emission inventories are prepared from a complete emission database based on the SNAP sectors. The aggregation to the sector codes used for both the UNFCCC and UNECE Conventions is based on a correspondence list between SNAP and IPCC classification codes (CRF), shown in Table 3.3.1 (mobile sources only).

Table 3.3.1 SNAP – CRF correspondence table for transport.

SNAP classification	CRF/NFR classification
07 Road transport	1A3b Transport-Road
0801 Military	1A5 Other
0802 Railways	1A3c Railways
0803 Inland waterways	1A3d Transport-Navigation
080402 National sea traffic	1A3d Transport-Navigation
080403 National fishing	1A4c Agriculture/forestry/fisheries
080404 International sea traffic	1A3d Transport-Navigation (international)
080501 Dom. airport traffic (LTO < 1000 m)	1A3a Transport-Civil aviation
080502 Int. airport traffic (LTO < 1000 m)	1A3a Transport-Civil aviation (international)
080503 Dom. cruise traffic (> 1000 m)	1A3a Transport-Civil aviation
080504 Int. cruise traffic (> 1000 m)	1A3a Transport-Civil aviation (international)
0806 Agriculture	1A4c Agriculture/forestry/fisheries
0807 Forestry	1A4c Agriculture/forestry/fisheries
0808 Industry	1A2f Industry-Other
0809 Household and gardening	1A4b Residential
0811 Commercial and institutional	1A4a Commercial and institutional

Military transport activities (land and air) refer to the CRF/NFR sector Other (1A5), while the Transport-Navigation sector (1A3d) comprises national sea transport (ship movements between two Danish ports) and recreational craft (SNAP code 0803). For aviation, LTO (Landing and Take Off)[25] refer to the part of flying which is below 1000 m. The working machinery and equipment in industry (SNAP code 0808) is grouped in Industry-Other (1A2f), while agricultural and forestry non-road machinery (SNAP codes 0806 and 0807) is accounted for in the Agriculture/forestry/fisheries (1A4c) sector together with fishing activities.

For mobile sources, internal NERI databases for road transport, air traffic, sea transport and non road machinery have been set up in order to produce the emission inventories. The output results from the NERI databases are calculated in a SNAP format, as activity rates (fuel consumption) and emission factors, which are then exported directly to the central Danish CollectER database. Apart from national inventories, the NERI databases are used also as a calculation tool in research projects, environmental impact assessment studies, and to produce basic emission information which requires various aggregation levels.

[25] A LTO cycle consists of the flying modes approach/descent, taxiing, take off and climb out. In principle the actual times-in-modes rely on the actual traffic circumstances, the airport configuration, and the aircraft type in question.

3.3.1 Source category description

The following description of source categories explains the development in fuel consumption and emissions for road transport and other mobile sources.

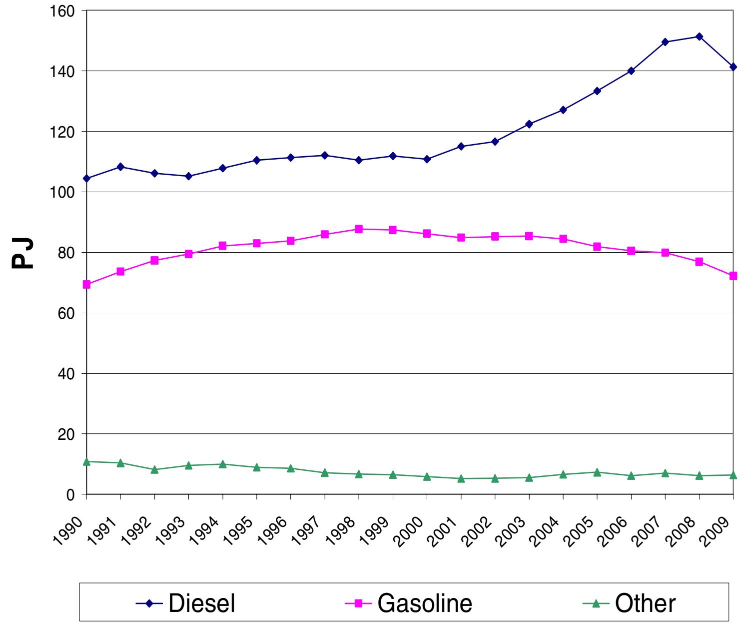
Fuel consumption

Table 3.3.2 Fuel consumption (PJ) for domestic transport in 2009 in CRF sectors.

CRF ID	Fuel use (PJ)
Industry-Other (1A2f)	11.2
Civil Aviation (1A3a)	2.2
Road (1A3b)	165.1
Railways (1A3c)	3.1
Navigation (1A3d)	8.0
Comm./Inst. (1A4a)	2.4
Residential (1A4b)	0.9
Agri./for./fish. (1A4c)	24.9
Military (1A5)	2.2
Total	219.9

Table 3.3.2 shows the fuel consumption for domestic transport based on DEA statistics for 2009 in CRF sectors. The fuel consumption figures in time-series 1990-2009 are given in Annex 3.B.15 (CRF format) and are shown for 1990 and 2009 in Annex 3.B.14 (CollectER format). Road transport has a major share of the fuel consumption for domestic transport. In 2009 this sector's fuel consumption share is 75 %, while the fuel consumption shares for Agriculture/forestry/fisheries and Industry-Other are 11 and 5 %, respectively. For the remaining sectors the total fuel consumption share is 9 %.

From 1990 to 2009, diesel and gasoline fuel consumption has increased by 35 % and 4 %, respectively, and in 2009 the fuel use shares for diesel and gasoline were 65 % and 33 %, respectively (Figures 3.3.1 and 3.3.2). Other fuels only have a 2 % share of the domestic transport total. Almost all gasoline is used in road transportation vehicles. Gardening machinery and recreational craft are merely small consumers. Regarding diesel, there is considerable fuel consumption in most of the domestic transport categories, whereas a more limited use of residual oil and jet fuel is being used in the navigation sector and by aviation (civil and military flights), respectively.



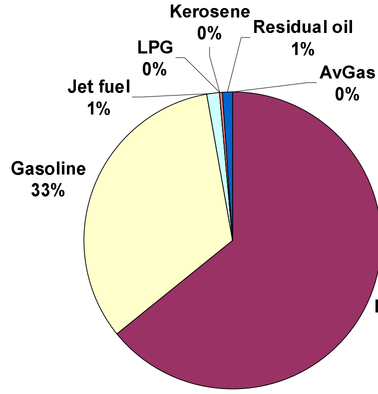


Figure 3.3.1 Fuel consumption pr fuel type for domestic transport 1990-2009.

Figure 3.3.1 Fuel consumption share pr fuel type for domestic transport in 2009.

Road transport

As shown in Figure 3.3.3, the energy use for road transport has generally increased until 2007, except from a small fuel consumption decline noted in 2000. The impact of the global financial crisis on fuel consumption for road transport becomes visible for 2008 and 2009. The fuel consumption development is due to a slight decreasing trend in the use of gasoline fuels from 1999 onwards combined with a steady growth in the use of diesel until 2007. Within sub-sectors, passenger cars represent the most fuel-consuming vehicle category, followed by heavy-duty vehicles, light duty vehicles and 2-wheelers, in decreasing order (Figure 3.3.4).

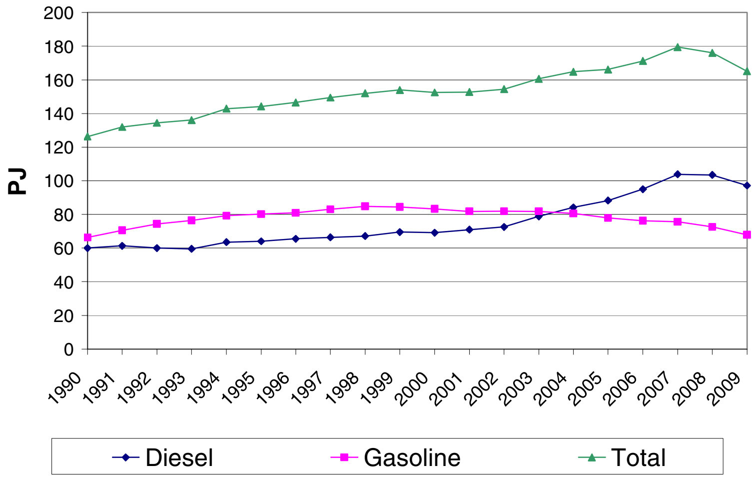


Figure 3.3.3 Fuel consumption pr fuel type and as totals for road transport 1990-2009.

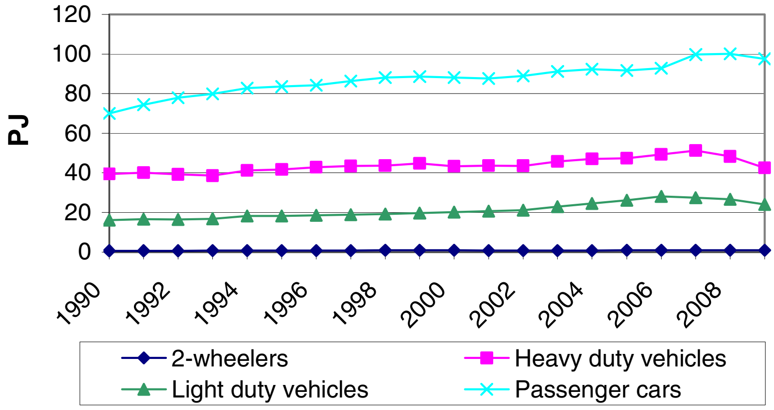


Figure 3.3.4 Total fuel consumption pr vehicle type for road transport 1990-2009.

As shown in Figure 3.3.5, fuel consumption for gasoline passenger cars dominates the overall gasoline consumption trend. The development in diesel fuel consumption in recent years (Figure 3.3.6) is characterised by increasing fuel consumption for diesel passenger cars, while declines in the fuel consumption for trucks and buses (heavy-duty vehicles) and light duty vehicles are noted for 2008 and 2009.

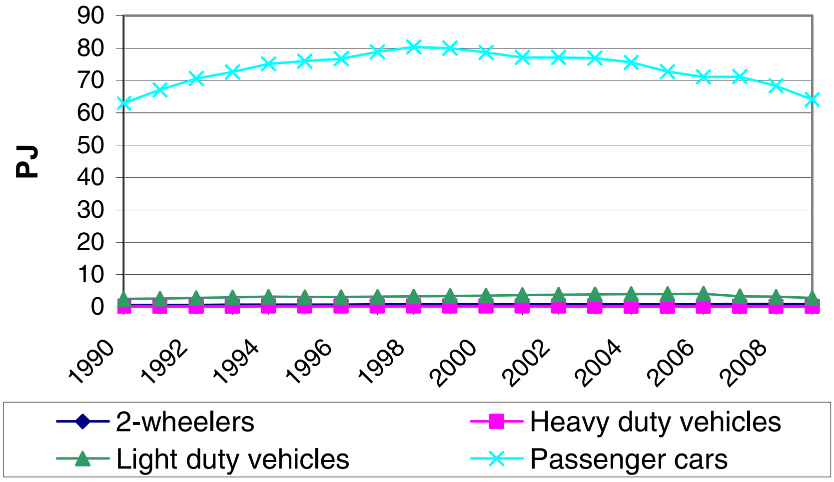


Figure 3.3.5 Gasoline fuel consumption pr vehicle type for road transport 1990-2009.

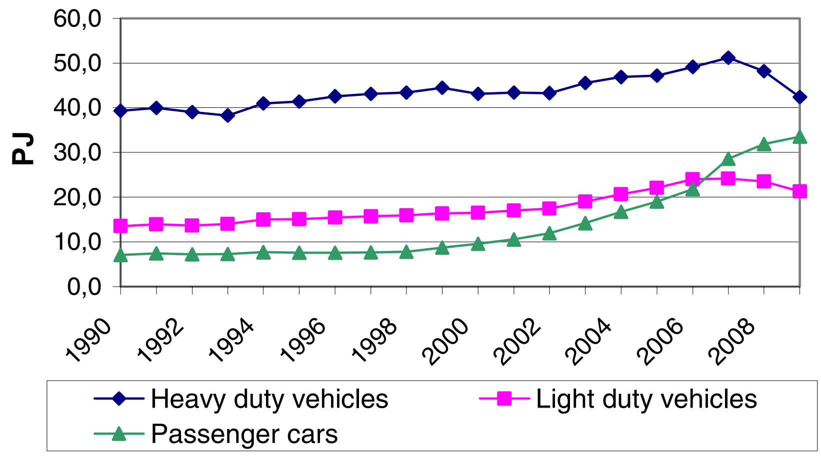


Figure 3.3.6 Diesel fuel consumption pr vehicle type for road transport 1990-2009.

In 2009, fuel consumption shares for gasoline passenger cars, heavy-duty vehicles, diesel passenger cars, diesel light duty vehicles and gasoline light duty vehicles were 38, 26, 20, 13 and 2 %, respectively (Figure 3.54).

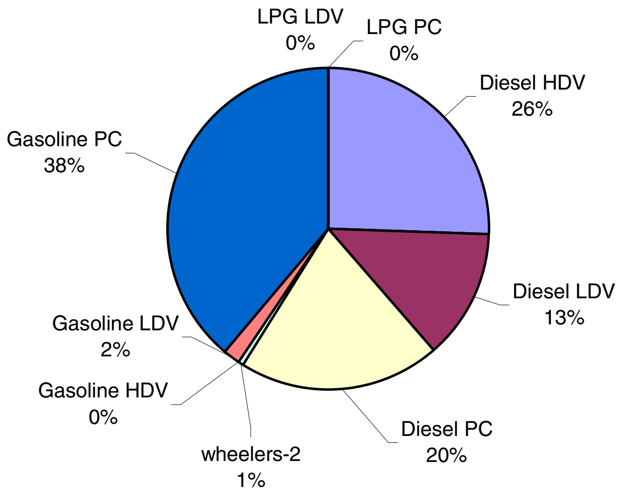


Figure 3.3.7 Fuel consumption share (PJ) pr vehicle type for road transport in 2009.

Other mobile sources

It must be noted that the fuel consumption figures behind the Danish inventory for mobile equipment in the agriculture, forestry, industry, household and gardening (residential), and inland waterways (part of navigation) sectors, are less certain than for other mobile sectors. For these types of machinery, the DEA statistical figures do not directly provide fuel consumption information, and fuel consumption totals are subsequently estimated from activity data and fuel consumption factors. For recreational craft the latest historical year is 2004.

As seen in Figure 3.3.8, classified according to CRF the most important sectors are Agriculture/forestry/fisheries (1A4c), Industry-other (mobile machinery part of 1A2f) and Navigation (1A3d). Minor fuel consuming sectors are Civil Aviation (1A3a), Railways (1A3c), Other (military mobile fuel consumption: 1A5), commercial/institutional (1A4a) and Residential (1A4b).

The 1990-2009 time-series are shown pr fuel type in Figures 3.3.9-3.3.12 for diesel, gasoline and jet fuel, respectively.

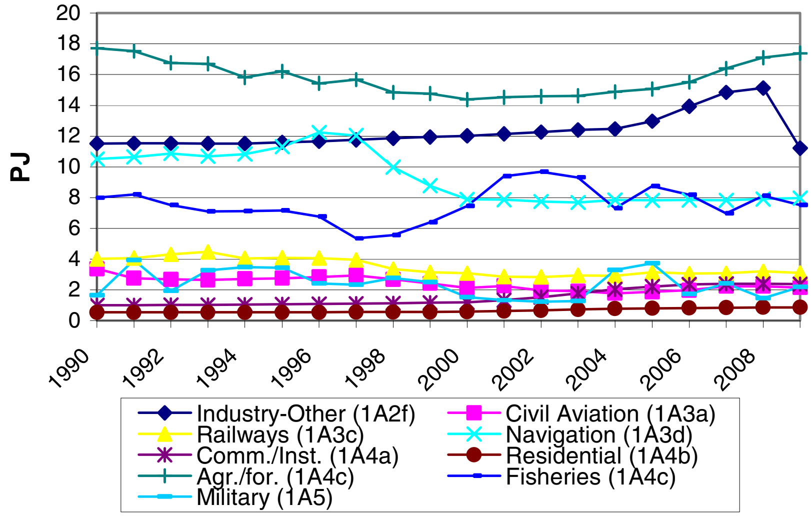


Figure 3.3.8 Total fuel consumption in CRF sectors for other mobile sources 1990-2009.

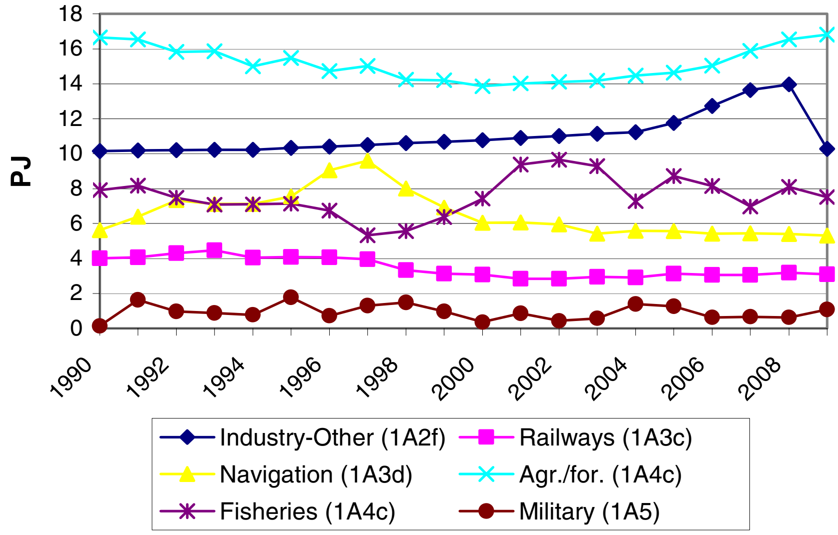


Figure 3.3.9 Diesel fuel consumption in CRF sectors for other mobile sources 1990-2009.

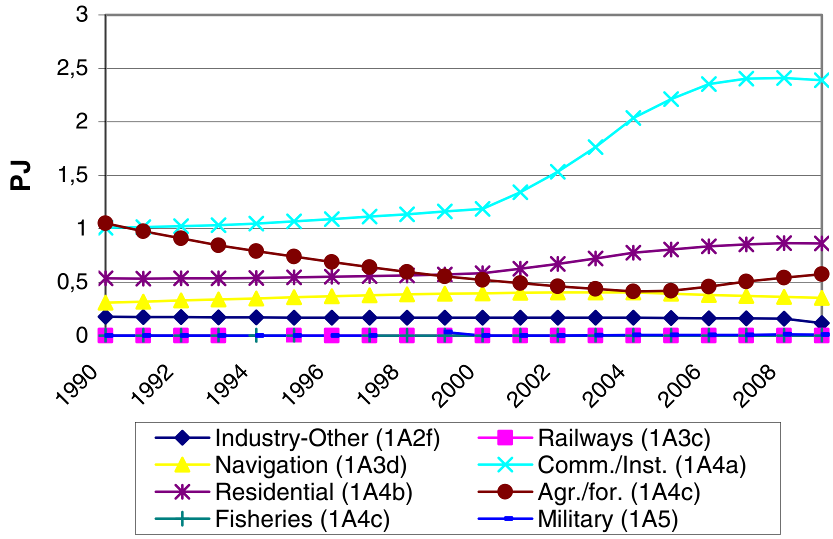


Figure 3.3.10 Gasoline fuel consumption in CRF sectors for other mobile source 1990-2009.

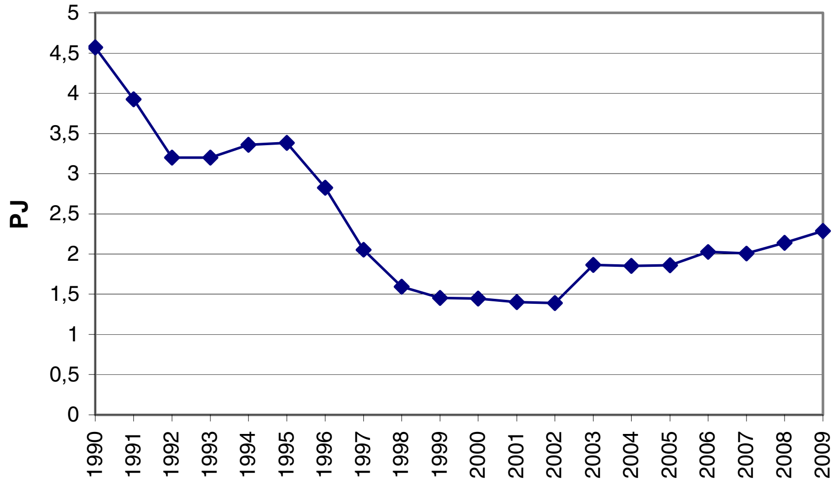


Figure 3.3.11 Residual oil fuel consumption in CRF sectors for other mobile sources 1990-2009.

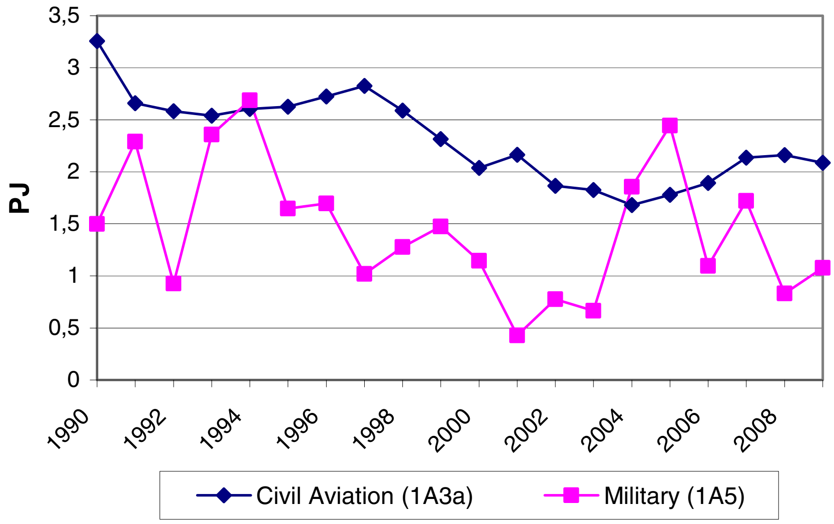


Figure 3.3.12 Jet fuel consumption in CRF sectors for other mobile sources 1990-2009.

In terms of diesel, the fuel consumption decreases for agricultural machines until 2000, due to fewer numbers of tractors and harvesters. After that, the increase in the engine sizes of new sold machines has more than outbalanced the trend towards smaller total stock numbers. The fuel consumption for industry has increased from the beginning of the 1990's, due to an increase in the activities for construction machinery. The fuel consumption increase has been very pronounced in 2005-2008, for 2009, however, the global financial crisis has a significant impact on the building and construction activities. For fisheries, the development in fuel consumption reflects the activities in this sector.

The Navigation sector comprises national sea transport (fuel consumption between two Danish ports) and recreational craft. For the latter category, fuel consumption has increased significantly from 1990 to 2004 due to the rising number diesel-fuelled private boats. For national sea transport, the diesel fuel consumption curve reflects the combination of traffic and ferries in use for regional ferries. From 1998 to 2000, a significant decline in fuel consumption is apparent. The most important explanation here is the closing of ferry service routes in connection with the opening of the Great Belt Bridge in 1997. For railways, the gradual shift towards electrification explains the lowering trend in diesel fuel consumption and the emissions for this transport sector. The fuel consumed (and associated emissions) to produce electricity is accounted for in the stationary source part of the Danish inventories.

The largest gasoline fuel use is found for household and gardening machinery in the Commercial/Institutional (1A4a) and Residential (1A4b) sectors. Especially from 2001-2006, a significant fuel consumption increase is apparent due to considerable growth in the machinery stock. The decline in gasoline fuel consumption for Agriculture/forestry-/fisheries (1A4c) is due to the gradual phasing out of gasoline-fuelled agricultural tractors.

In terms of residual oil there has been a substantial decrease in the fuel consumption for regional ferries. The fuel consumption decline is most significant from 1990-1992 and from 1997-1999.

The considerable variations from one year to another in military jet fuel consumption are due to planning and budgetary reasons, and the passing demand for flying activities. Consequently, for some years, a certain amount of jet fuel stock-building might disturb the real picture of aircraft fuel consumption. Civil aviation has decreased until 2004, since the opening of the Great Belt Bridge in 1997, both in terms of number of flights and total jet fuel consumption. After 2004 an increase in the consumption of jet fuel is noted until 2007/2008.

Bunkers

The residual oil and diesel oil fuel consumption fluctuations reflect the quantity of fuel sold in Denmark to international ferries, international warships, other ships with foreign destinations, transport to Greenland and the Faroe Islands, tank vessels and foreign fishing boats. For jet petrol, the sudden fuel use drop in 2002 is explained by the recession in the air traffic sector due to the events of September 11, 2001 and structural changes in the aviation business. In 2009, the impact of the global financial crisis on flying activities becomes very visible.

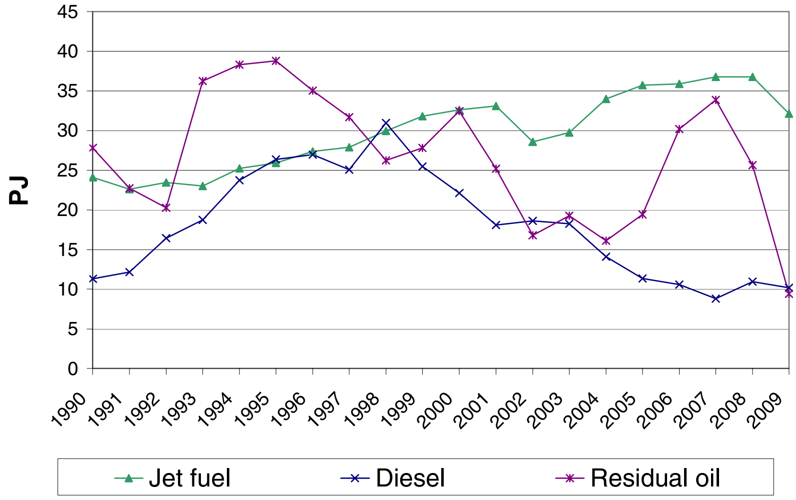


Figure 3.3.13 Bunker fuel consumption 1990-2009.

Emissions of CO_2, CH_4 and N_2O

In Table 3.3.3 the CO_2, CH_4 and N_2O emissions for road transport and other mobile sources are shown for 2009 in CRF sectors. The emission figures in time-series 1990-2009 are given in Annex 3:B.13 (CRF format) and are shown for 1990 and 2009 in Annex 3.B.14 (CollectER format).

From 1990 to 2009 the road transport emissions of CO_2 and N_2O have increased by 31 and 27 %, respectively, whereas the emissions of CH_4 have decreased by 72 % (from Figures 3.3.14 - 3.3.16). From 1990 to 2009 the other mobile CO_2 emissions have decreased by 6 %, (from Figures 3.3.18 - 3.3.20).

Table 3.3.3 Emissions of CO_2, CH_4 and N_2O in 2009 for road transport and other mobile sources.

CRF Sector	CH_4 tonnes	CO_2 tonnes	N_2O tonnes
Industry-Other (1A2f)	30	823	35
Civil Aviation (1A3a)	10	156	8
Railways (1A3c)	7	230	6
Navigation (1A3d)	35	598	35
Comm./Inst. (1A4a)	167	174	3
Residential (1A4b)	66	63	1
Ag./for./fish. (1A4c)	114	1842	89
Military (1A5)	5	160	6
Total other mobile	434	4046	183
Road (1A3b)	712	12125	384
Total mobile	1146	16171	567

Road transport

CO_2 emissions are directly fuel consumption dependent and, in this way, the development in the emission reflects the trend in fuel consumption. As shown in Figure 3.3.14, the most important emission source for road transport is passenger cars, followed by heavy-duty vehicles, light-duty vehicles and 2-wheelers in decreasing order. In 2009, the respective emission shares were 58, 26, 15 and 1 %, respectively (Figure 3.3.17).

The majority of CH_4 emissions from road transport come from gasoline passenger cars (Figure 3.3.15). The emission drop from 1992 onwards is explained by the penetration of catalyst cars into the Danish fleet. The

2009 emission shares for CH_4 were 56, 24, 16 and 4 % for passenger cars, heavy-duty vehicles, 2-wheelers and light-duty vehicles, respectively (Figure 3.3.17).

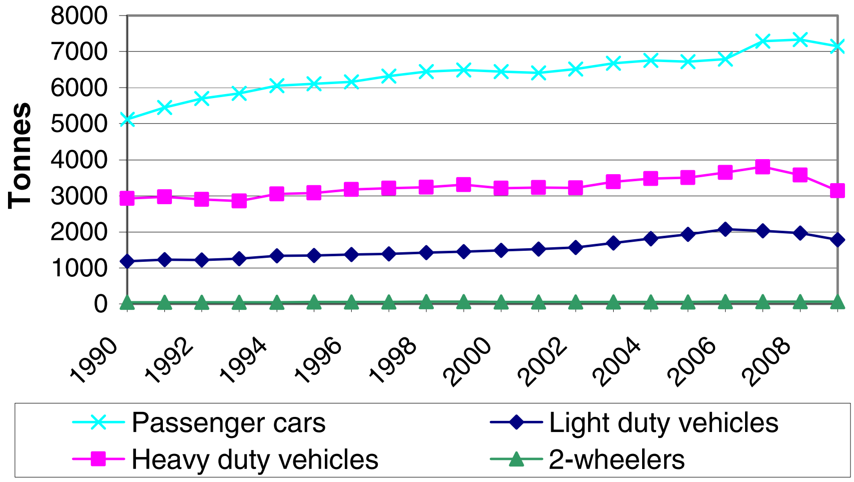


Figure 3.3.14 CO_2 emissions (k-tonnes) pr vehicle type for road transport 1990-2009.

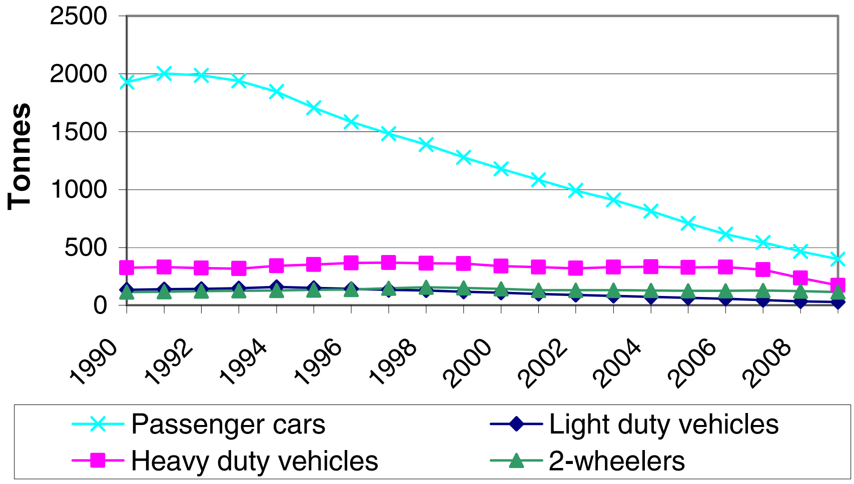


Figure 3.3.15 CH_4 emissions (tonnes) pr vehicle type for road transport 1990-2009.

An undesirable environmental side effect of the introduction of catalyst cars is the increase in the emissions of N_2O from the first generation of catalyst cars (Euro 1) compared to conventional cars. The emission factors for later catalytic converter technologies are considerably lower than the ones for Euro 1, thus causing the emissions to decrease from 1998 onwards (Figure 3.3.16). In 2009, emission shares for passenger cars, heavy and light-duty vehicles were 55, 30 and 15 %, of the total road transport N_2O, respectively (Figure 3.3.17).

Referring to the third IPCC assessment report, 1 g CH_4 and 1 g N_2O has the greenhouse effect of 21 and 310 g CO_2, respectively. In spite of the relatively large CH_4 and N_2O global warming potentials, the largest contribution to the total CO_2 emission equivalents for road transport comes from CO_2, and the CO_2 emission equivalent shares pr vehicle category are almost the same as the CO_2 shares.

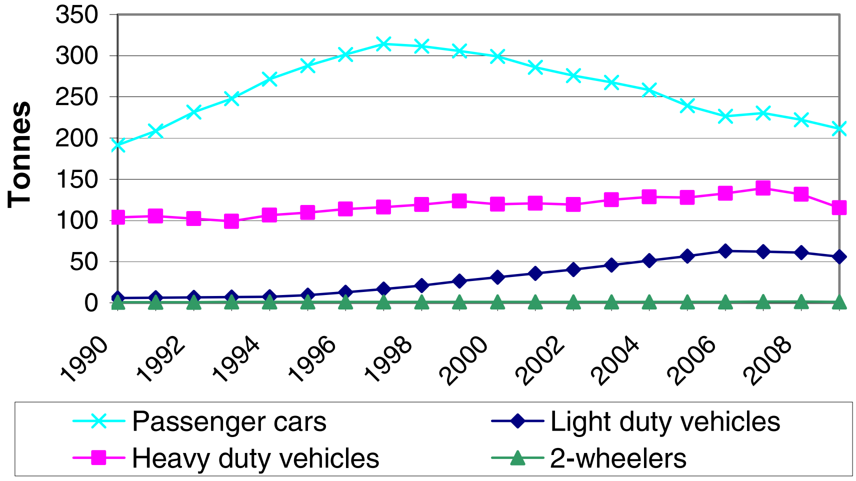


Figure 3.3.16 N_2O emissions (tonnes) pr vehicle type for road transport 1990-2009.

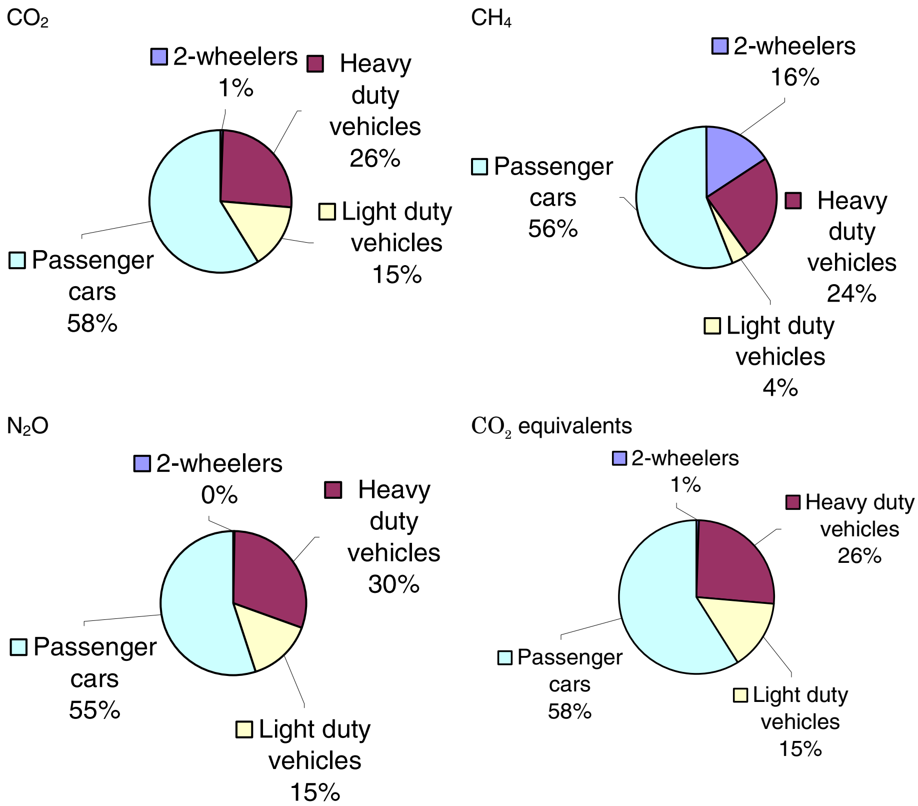


Figure 3.3.17 CO_2, CH_4 and N_2O emission shares and GHG equivalent emission distribution for road transport in 2009.

Other mobile sources

For other mobile sources, the highest CO_2 emissions in 2009 come from Agriculture/forestry/fisheries (1A4c), Industry-other (1A2f) and Navigation (1A3d), with shares of 45, 20 and 15 %, respectively (Figure 3.3.21). The 1990-2009 emission trend is directly related to the fuel consumption development in the same time-period. Minor CO_2 emission contributors are sectors such as Commercial/Institutional (1A4a), Residential (1A4b), Railways (1A3c), Civil Aviation (1A3a) and Military (1A5). In 2009, the CO_2 emission shares for these sectors were 4, 2, 6, 4 and 4 %, respectively (Figure 3.3.21).

For CH_4, far the most important sources are the gasoline fuelled gardening machinery in the Commercial/Institutional (1A4a) and Residential (1A4b) sectors, see Figure 3.3.21. The emission share are 39 % and 15 %, respectively in 2009. The 2009 emission shares for Agriculture/forestry/fisheries (1A4c), Navigation (1A3d) and Industry (1A2f) are 26, 8 and 7 %, respectively, whereas the remaining sectors have emission shares of 2 % or less.

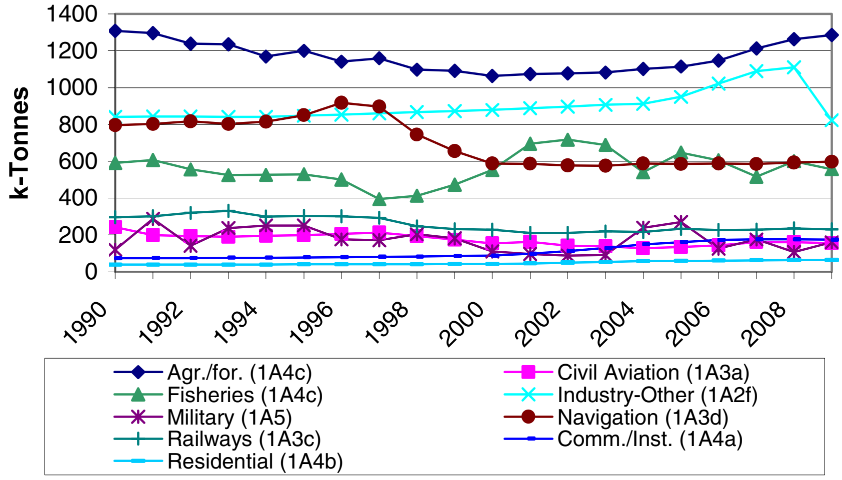


Figure 3.3.18 CO_2 emissions (k-tonnes) in CRF sectors for other mobile sources 1990-2009.

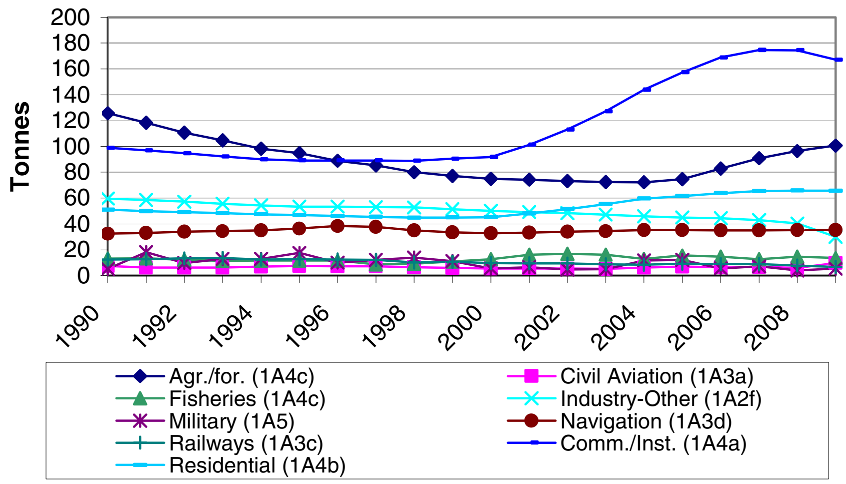


Figure 3.3.19 CH_4 emissions (tonnes) in CRF sectors for other mobile sources 1990-2009.

For N_2O, the emission trend in sub-sectors is the same as for fuel consumption and CO_2 emissions (Figure 3.3.20).

As for road transport, CO_2 alone contributes with by far the most CO_2 emission equivalents in the case of other mobile sources, and pr sector the CO_2 emission equivalent shares are almost the same as those for CO_2, itself (Figure 3.3.21).

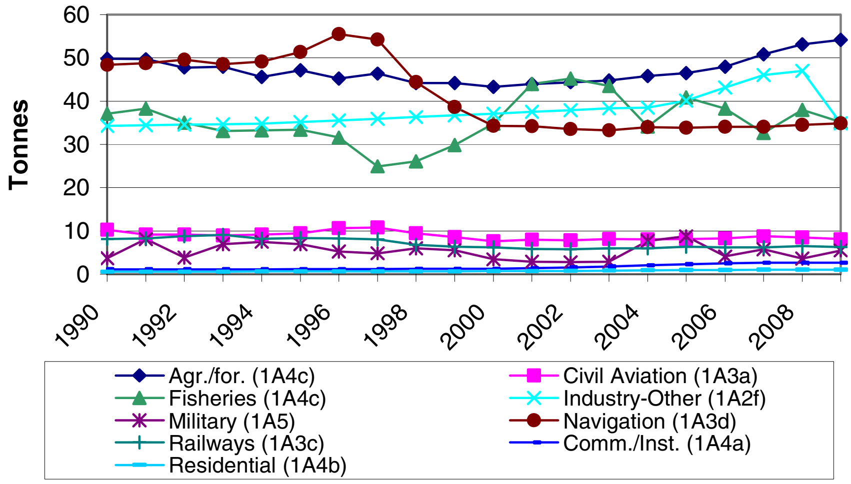


Figure 3.3.20 N_2O emissions (tonnes) in CRF sectors for other mobile sources 1990-2008.

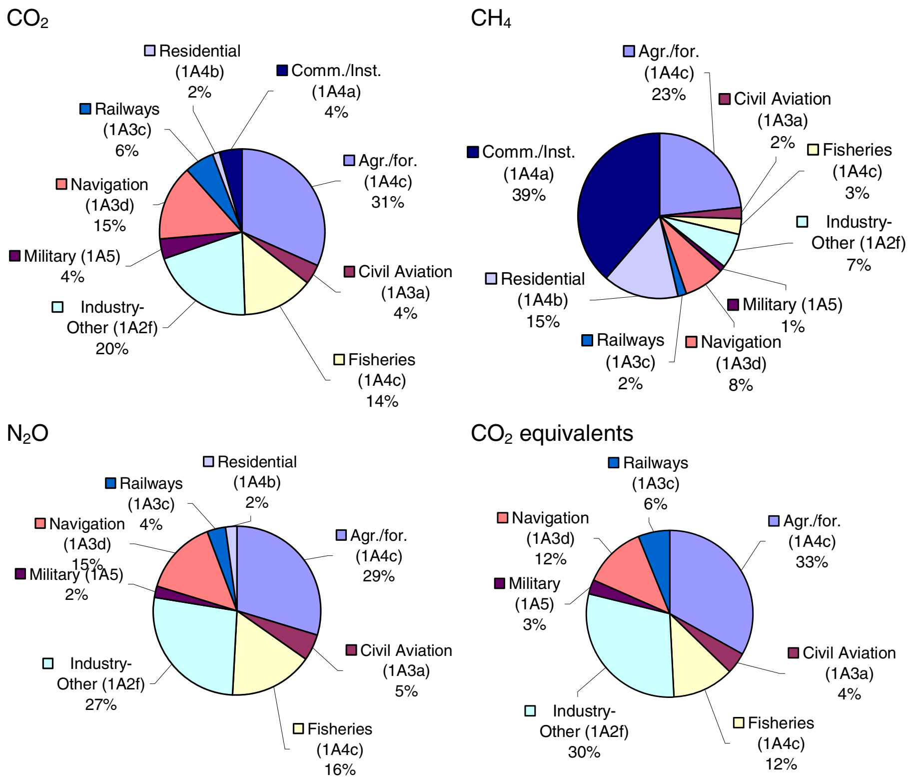


Figure 3.3.21 CO_2, CH_4 and N_2O emission shares and GHG equivalent emission distribution for other mobile sources in 2008.

Emissions of SO_2, NO_X, NMVOC and CO

In Table 3.3.4 the SO_2, NO_X, NMVOC and CO emissions for road transport and other mobile sources are shown for 2008 in CRF sectors. The emission figures in the time-series 1990-2008 are given in Annex 3.B.15 (CRF format) and are shown for 1990 and 2008 in Annex 3.B.14 (CollectER format).

From 1990 to 2008, the road transport emissions of NMVOC, CO and NO_X emissions have decreased by 78, 70 and 42 %, respectively (Figures 3.3.23-3.3.25).

For other mobile sources, the emissions of NO_X decreased by 22 % from 1990 to 2008 and for SO_2 the emission drop is as much as 88 %. In the same period, the emissions of NMVOC have declined by 11 %, whereas the CO emissions have increased by 8 % (Figures 3.3.27-3.3.30).

Table 3.3.20 Emissions of SO_2, NO_X, NMVOC and CO in 2009 for road transport and other mobile sources.

CRF ID	SO_2 tonnes	NO_x tonnes	NMVOC tonnes	CO tonnes
Industry-Other (1A2f)	24	7 137	976	5 123
Civil Aviation (1A3a)	50	651	168	758
Railways (1A3c)	1	2 603	174	450
Navigation (1A3d)	1 593	9 534	1 013	6 213
Comm./Inst. (1A4a)	1	220	5 159	72 227
Residential (1A4b)	0	84	2 071	25 341
Ag./for./fish. (1A4c)	392	20 802	2 504	19 453
Military (1A5)	25	704	55	387
Total other mobile	2 086	41 735	12 120	129 953
Road (1A3b)	76	46 637	13 685	110 199
Total mobile	2 163	88 372	25 805	240 151

Road transport

The step-wise lowering of the sulphur content in diesel fuel has given rise to a substantial decrease in the road transport emissions of SO_2 (Figure 3.3.22). In 1999, the sulphur content was reduced from 500 ppm to 50 ppm (reaching gasoline levels), and for both gasoline and diesel the sulphur content was reduced to 10 ppm in 2005. Since Danish diesel and gasoline fuels have the same sulphur percentages, at present, the 2009 shares for SO_2 emissions and fuel consumption for passenger cars, heavy-duty vehicles, light-duty vehicles and 2-wheelers are the same in each case: 58, 26, 15 and 1 %, respectively (Figure 3.3.26).

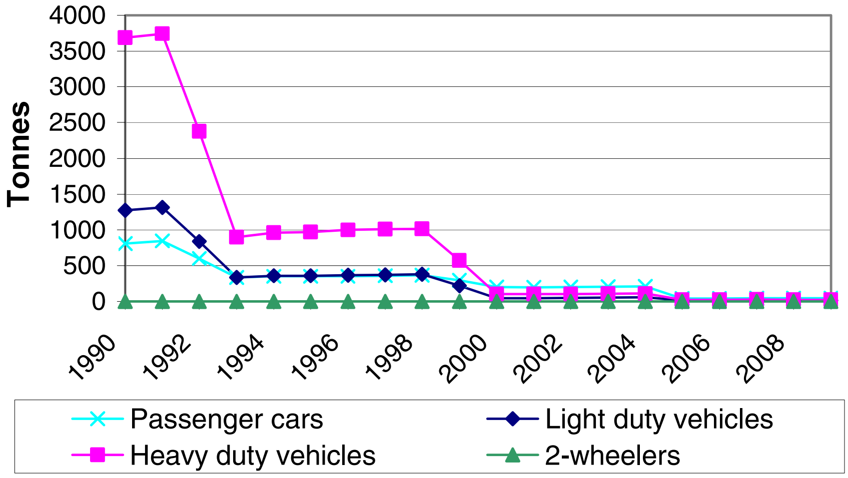


Figure 3.3.22 SO_2 emissions (tonnes) pr vehicle type for road transport 1990-2009.

Historically, the emission totals of NMVOC and CO have been very dominated by the contributions coming from private cars, as shown in Figures 3.3.24-3.3.25. However, the NMVOC and CO (and NO_x) emissions from this vehicle type have shown a steady decreasing tendency since the introduction of private catalyst cars in 1990 (EURO I) and the introduction of even more emission-efficient EURO II, III and IV private cars (introduced in 1997, 2001 and 2006, respectively).

In the case of NO_x, the real traffic emissions for heavy duty vehicles do not decline as intended by the EU emission legislation. This is due to the so-called engine cycle-beating effect. Outside the legislative test cycle stationary measurement points, the electronic engine control for heavy duty Euro II and III engines switches to a fuel efficient engine running mode, thus leading to increasing NO_x emissions. However, the reduction in transport activities due to the global financial crisis causes the NO_x emissions for heavy duty vehicles to decrease significantly in 2008 and 2009.

The 2009 emission shares for heavy-duty vehicles, passenger cars, light-duty vehicles and 2-wheelers for NO_x (52, 37, 11 and 0 %), NMVOC (8, 64, 7 and 21 %) and CO (6, 75, 7, 12 %), PM (37, 30, 31 and 2 %) and NH_3 (1, 95, 4 and 0 %), are also shown in Figure 3.3.26.

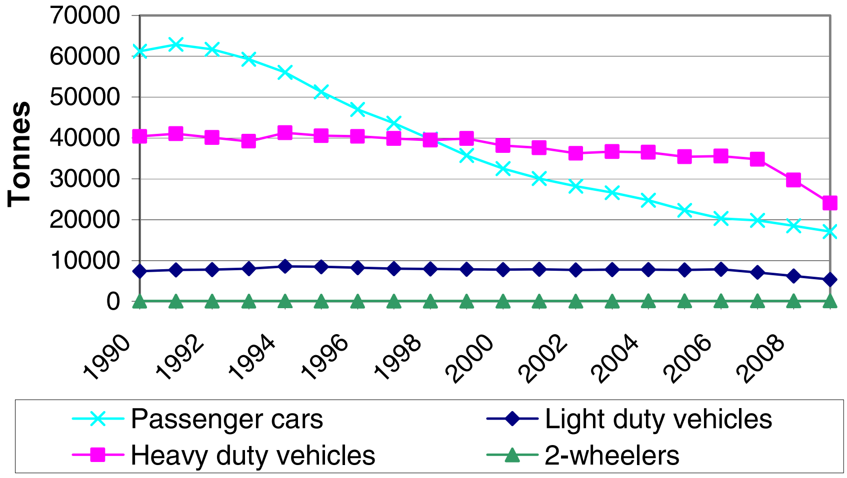


Figure 3.3.23 NO_X emissions (tonnes) pr vehicle type for road transport 1990-2009.

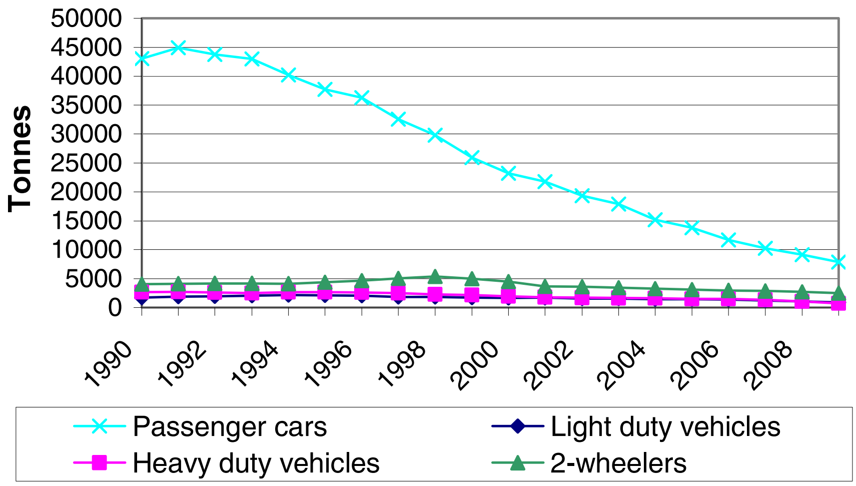


Figure 3.3.24 NMVOC emissions (tonnes) pr vehicle type for road transport 1990-2009

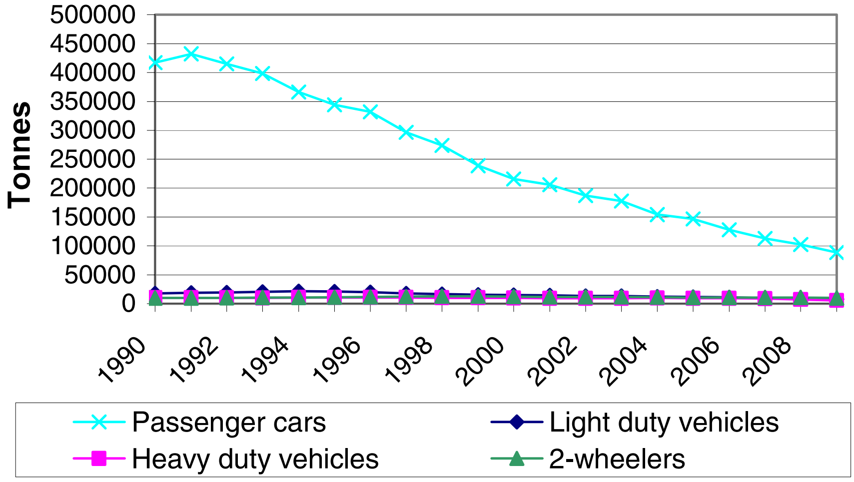


Figure 3.3.25 CO emissions (tonnes) pr vehicle type for road transport 1990-2009.

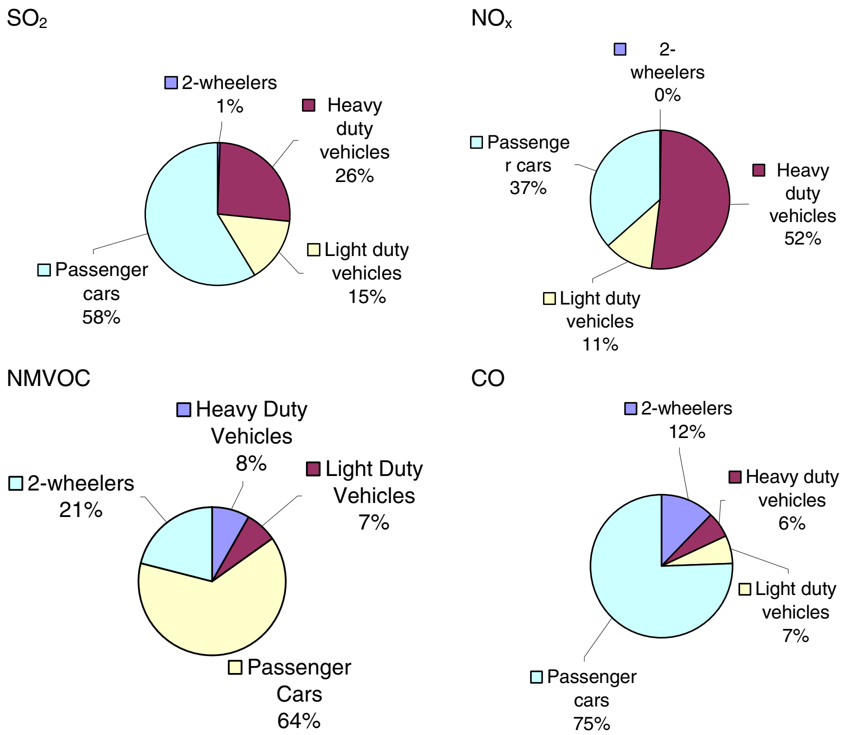


Figure 3.3.26 SO_2, NO_X, NMVOC and CO emission shares pr vehicle type for road transport in 2009.

Other mobile sources

For SO_2 the trends in the Navigation (1A3d) emissions shown in Figure 3.3.27 mainly follow the development of the heavy fuel consumption (Figure 3.25). Though, from 1993 to 1995 relatively higher contents of sulphur in the fuel (estimated from sales) cause a significant increase in the emissions of SO_2. The SO_2 emissions for Fisheries (1A4c) correspond with the development in the consumption of marine gas oil. The main explanation for the development of the SO_2 emission curves for Railways (1A3c) and non-road machinery in Agriculture/forestry (1A4c) and Industry (1A2f), are the stepwise sulphur content reductions for diesel used by machinery in these sectors.

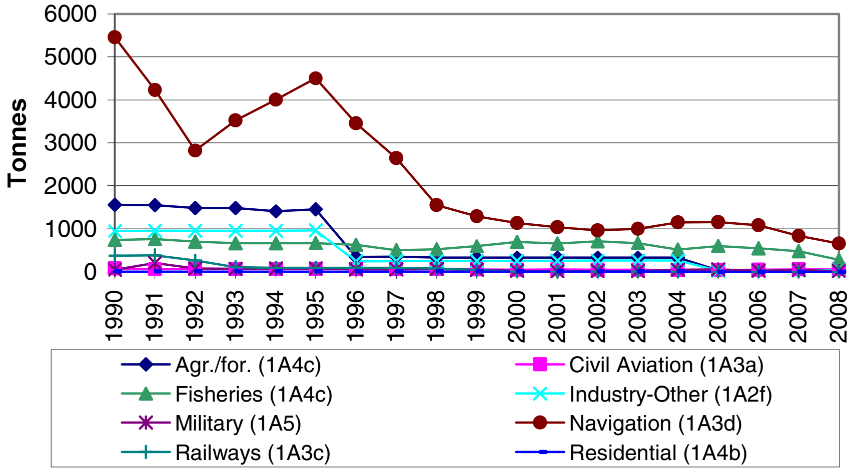


Figure 3.3.27 SO_2 emissions (tonnes) in CRF sectors for other mobile sources 1990-2008.

In general, the emissions of NO_X, NMVOC and CO from diesel-fuelled working equipment and machinery in agriculture, forestry and industry have decreased slightly since the end of the 1990s due to gradually strengthened emission standards given by the EU emission legislation directives. For industry, the emission impact from the global financial crisis becomes very visible for 2009.

NO_X emissions mainly come from diesel machinery, and the most important sources are Agriculture/forestry/fisheries (1A4c), Navigation (1A3d), Industry (1A2f) and Railways (1A3c), as shown in Figure 3.3.20. The 2009 emission shares are 49, 23, 17 and 6 %, respectively (Figure 3.3.23). Minor emissions come from the sectors, Civil Aviation (1A3a), Military (1A5) and Residential (1A4b).

The NO_X emission trend for Navigation, Fisheries and Agriculture is determined by fuel use fluctuations for these sectors, and the development of emission factors. For ship engines the emission factors tend to increase for new engines until mid-1990s. After that, the emission factors gradually reduce until 2000, bringing them to a level comparable with the emission limits for new engines in this year. For agricultural machines, there have been somewhat higher NO_x emission factors for 1991-stage I machinery, and an improved emission performance for stage I and II machinery since the late 1990s.

The emission development for industry NO_x is the product of a fuel consumption increase from 1985 to 2008, most pronounced from 2005 onwards, and a development in emission factors as explained for agricultural machinery. For railways, the gradual shift towards electrification explains the declining trend in diesel fuel use and NO_X emissions for this transport sector until 2001.

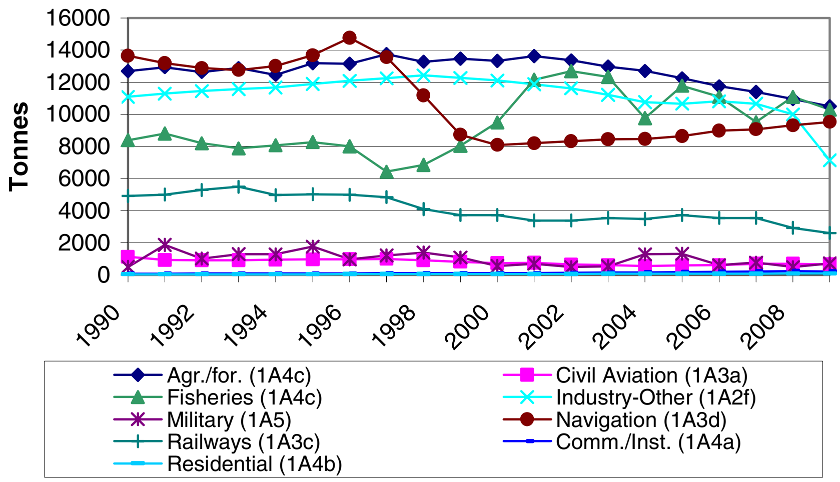


Figure 3.3.28 NO_X emissions (tonnes) in CRF sectors for other mobile sources 1990-2009.

The 1990-2009 time-series of NMVOC and CO emissions are shown in Figures 3.3.29 and 3.3.30 for other mobile sources. The 2009 sector emission shares are shown in Figure 3.3.31. For NMVOC, the most important sectors are Commercial/Institutional (1A4a), Agriculture/forestry/-fisheries (1A4c), Residential (1A4b), Industry (1A2f) and Navigation (1A3d), with 2009 emission shares of 44, 21, 17, 8 and 8 %, respectively. The same five sectors also contribute with most of the CO emissions. For Commercial/Institutional (1A4a), Residential (1A4b), Agriculture/-forestry/fisheries (1A4c), Navigation (1A3d) and Industry (1A2f) the emission shares are 55, 20, 15 13, 5 and 4 %, respectively. Minor NMVOC and CO emissions come from Railways (1A3c), Civil Aviation (1A3a) and Military (1A5).

For NMVOC and CO, the significant emission increases for the comercial/institutional and residential sectors after 2000 are due to the increased number of gasoline working machines. Improved NMVOC emission factors for diesel machinery in agriculture and gasoline equipment in forestry (chain saws) are the most important explanations for the NMVOC emission decline in the Agriculture/forestry/fisheries sector. This explanation also applies for the industrial sector, which is dominated by diesel-fuelled machinery. From 1997 onwards, the NMVOC emissions from Navigation decrease due to the gradually phase-out of the 2-stroke engine technology for recreational craft. The main reason for the significant 1985-2006 CO emission decrease for Agriculture/forestry-/fisheries is the phasing out of gasoline tractors.

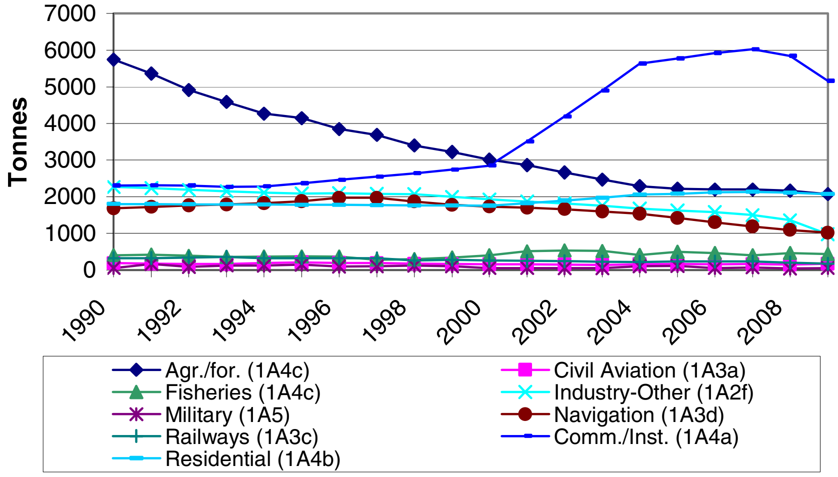


Figure 3.3.29 NMVOC emissions (tonnes) in CRF sectors for other mobile sources 1990-2009.

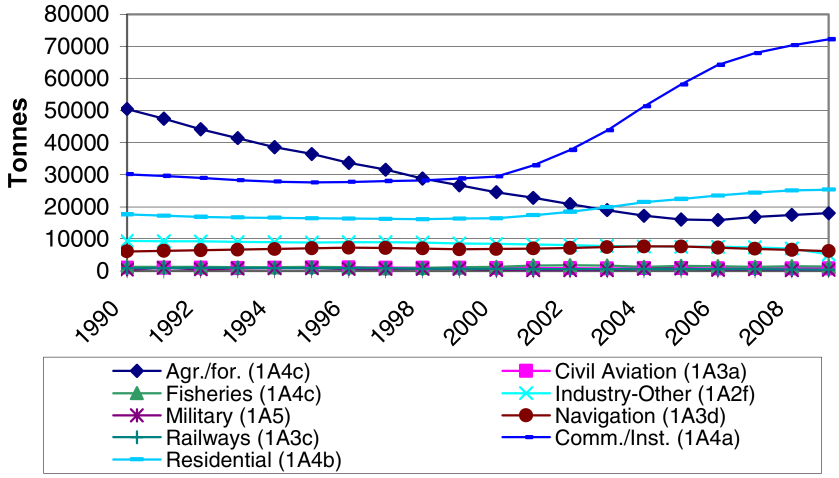


Figure 3.3.30 CO emissions (tonnes) in CRF sectors for other mobile sources 1990-2009.

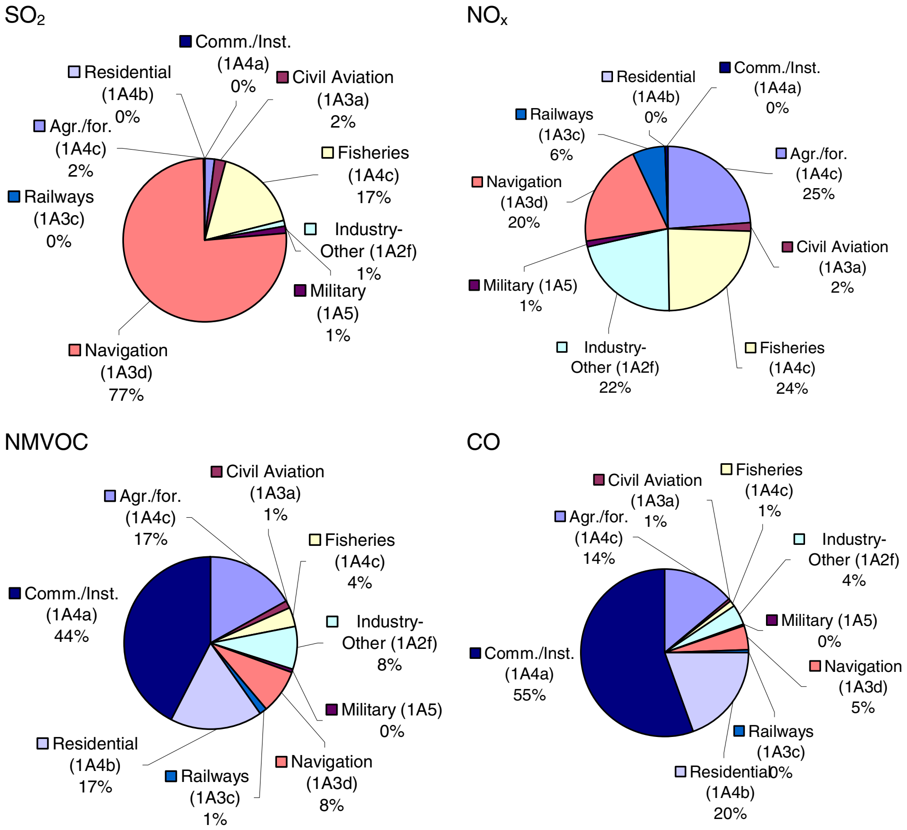


Figure 3.3.31 SO_2, NO_X, NMVOC and CO emission shares pr vehicle type for other mobile sources in 2009.

Bunkers

The most important emissions from bunker fuel consumption (fuel consumption for international transport) are SO_2, NO_X and CO_2 (and TSP, not shown). However, compared with the Danish national emission total (all sources), the greenhouse gas emissions from bunkers are small. The bunker emission totals are shown in Figure 3.3.7 for 2009, split into sea transport and civil aviation. All emission figures in the 1990-2009 time-series are given in Annex 3.B.15 (CRF format). In Annex 3.B.14, the emissions are also given in CollectER format for the years 1990 and 2009.

Table 3.3.5 Emissions in 2009 for international transport.

CRF sector	SO_2	NO_X	NMVOC	CH_4	CO	CO_2	N_2O
	tonnes	tonnes	tonnes	tonnes	tonnes	k-tonnes	tonnes
Navigation int. (1A3d)	7 383	35 658	1 160	36	3 826	1 487	94
Civil Aviation int. (1A3a)	739	9 854	503	53	1 791	2 314	79
International total	8 122	45 512	1 663	89	5 617	3 800	173

The differences in emissions between navigation and civil aviation are much larger than the differences in fuel consumption (and derived CO_2 emissions), and display a poor emission performance for international sea transport. In broad terms, the emission trends shown in Figure 3.3.32 are similar to the fuel consumption development.

However, for navigation minor differences occur for the emissions of SO_2, NO_X and CO_2 due to varying amounts of marine gas oil and residual oil, and for SO_2 and NO_X the development in the emission factors also have an impact on the emission trends. For civil aviation, apart from the annual consumption of jet fuel, the development of the NO_X emissions is also due to yearly variations in LTO/aircraft type (earlier than 2001) and city-pair statistics (2001 onwards).

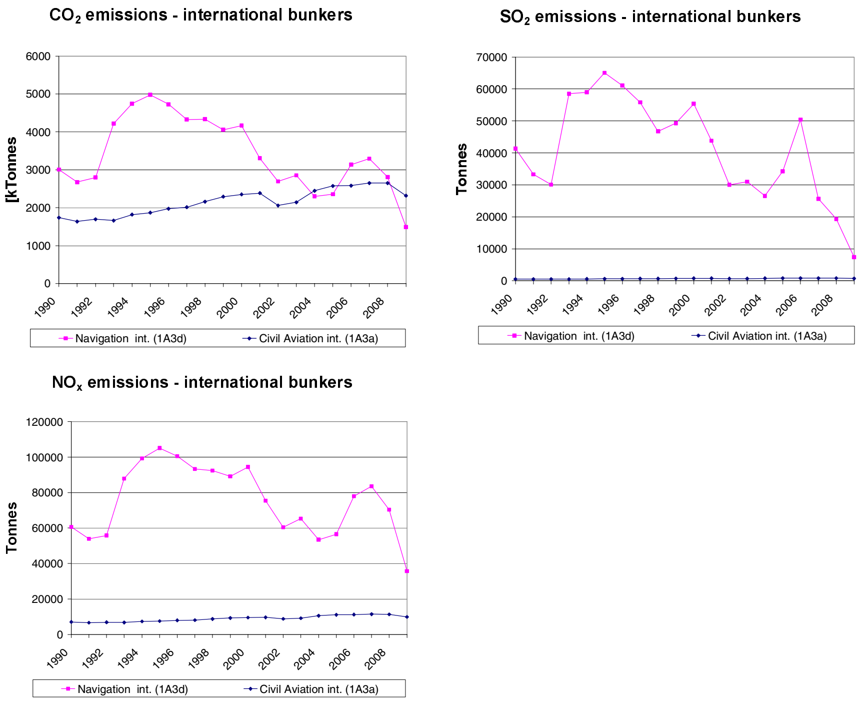


Figure 3.3.32 CO_2, SO_2 and NO_X emissions for international transport 1990-2009.

3.3.2 Methodological issues

The description of methodologies and references for the transport part of the Danish inventory is given in two sections: one for road transport and one for the other mobile sources.

Methodology and references for Road Transport

For road transport, the detailed methodology is used to make annual estimates of the Danish emissions, as described in the EMEP/EEA Air Pollutant Emission Inventory Guidebook (EMEP/EEA, 2009). The actual calculations are made with a model developed by NERI, using the European COPERT IV model methodology explained by (EMEP/EEA, 2009). In COPERT, fuel use and emission simulations can be made for operationally hot engines, taking into account gradually stricter emission standards and emission degradation due to catalyst wear. Furthermore, the emission effects of cold-start and evaporation are simulated.

Vehicle fleet and mileage data

Corresponding to the COPERT IV fleet classification, all present and future vehicles in the Danish fleet are grouped into vehicle classes, sub-classes and layers. The layer classification is a further division of vehicle sub-classes into groups of vehicles with the same average fuel consumption and emission behaviour, according to EU emission legislation levels. Table 3.3.6 gives an overview of the different model classes and sub-classes, and the layer level with implementation years are shown in Annex 3.B.1.

Table 3.3.6 Model vehicle classes and sub-classes and trip speeds.

			Trip speed [km pr h]		
Vehicle classes	Fuel type	Engine size/weight	Urban	Rural	Highway
PC	Gasoline	< 1.4 l.	40	70	100
PC	Gasoline	1.4 – 2 l.	40	70	100
PC	Gasoline	> 2 l.	40	70	100
PC	Diesel	< 2 l.	40	70	100
PC	Diesel	> 2 l.	40	70	100
PC	LPG		40	70	100
PC	2-stroke		40	70	100
LDV	Gasoline		40	65	80
LDV	Diesel		40	65	80
LDV	LPG		40	65	80
Trucks	Gasoline		35	60	80
Trucks	Diesel	Rigid 3,5 - 7,5t	35	60	80
Trucks	Diesel	Rigid 7,5 - 12t	35	60	80
Trucks	Diesel	Rigid 12 - 14 t	35	60	80
Trucks	Diesel	Rigid 14 - 20t	35	60	80
Trucks	Diesel	Rigid 20 - 26t	35	60	80
Trucks	Diesel	Rigid 26 - 28t	35	60	80
Trucks	Diesel	Rigid 28 - 32t	35	60	80
Trucks	Diesel	Rigid >32t	35	60	80
Trucks	Diesel	TT/AT 14 - 20t	35	60	80
Trucks	Diesel	TT/AT 20 - 28t	35	60	80
Trucks	Diesel	TT/AT 28 - 34t	35	60	80
Trucks	Diesel	TT/AT 34 - 40t	35	60	80
Trucks	Diesel	TT/AT 40 - 50t	35	60	80
Trucks	Diesel	TT/AT 50 - 60t	35	60	80
Trucks	Diesel	TT/AT >60t	35	60	80
Urban buses	Gasoline		30	50	70
Urban buses	Diesel	< 15 tonnes	30	50	70
Urban buses	Diesel	15-18 tonnes	30	50	70
Urban buses	Diesel	> 18 tonnes	30	50	70
Coaches	Gasoline		35	60	80
Coaches	Diesel	< 15 tonnes	35	60	80
Coaches	Diesel	15-18 tonnes	35	60	80
Coaches	Diesel	> 18 tonnes	35	60	80
Mopeds	Gasoline		30	30	-
Motorcycles	Gasoline	2 stroke	40	70	100
Motorcycles	Gasoline	< 250 cc.	40	70	100
Motorcycles	Gasoline	250 – 750 cc.	40	70	100
Motorcycles	Gasoline	> 750 cc.	40	70	100

To support the emission calculations a project has been carried out by DTU Transport, in order to provide fleet and annual mileage data for the vehicle categories present in COPERT IV (Jensen, 2009). The latter source also provides information of the mileage split between urban, rural and highway driving. The respective average speeds come from The Danish Road Directorate (Ekman 2005). Additional data for the moped fleet and motorcycle fleet disaggregation information is given by The National Motorcycle Association (Markamp, 2009).

In addition new data prepared by DTU Transport for the Danish Infrastructure Commission has given information of the total mileage driven by foreign trucks on Danish roads. This mileage contribution has been added to the total mileage for Danish trucks on Danish roads, for trucks > 16 tonnes of gross vehicle weight. The data from DTU Transport was estimated for 2005, and by using appropriate assumptions the mileage have been backcasted to 1985 and forecasted to 2009.

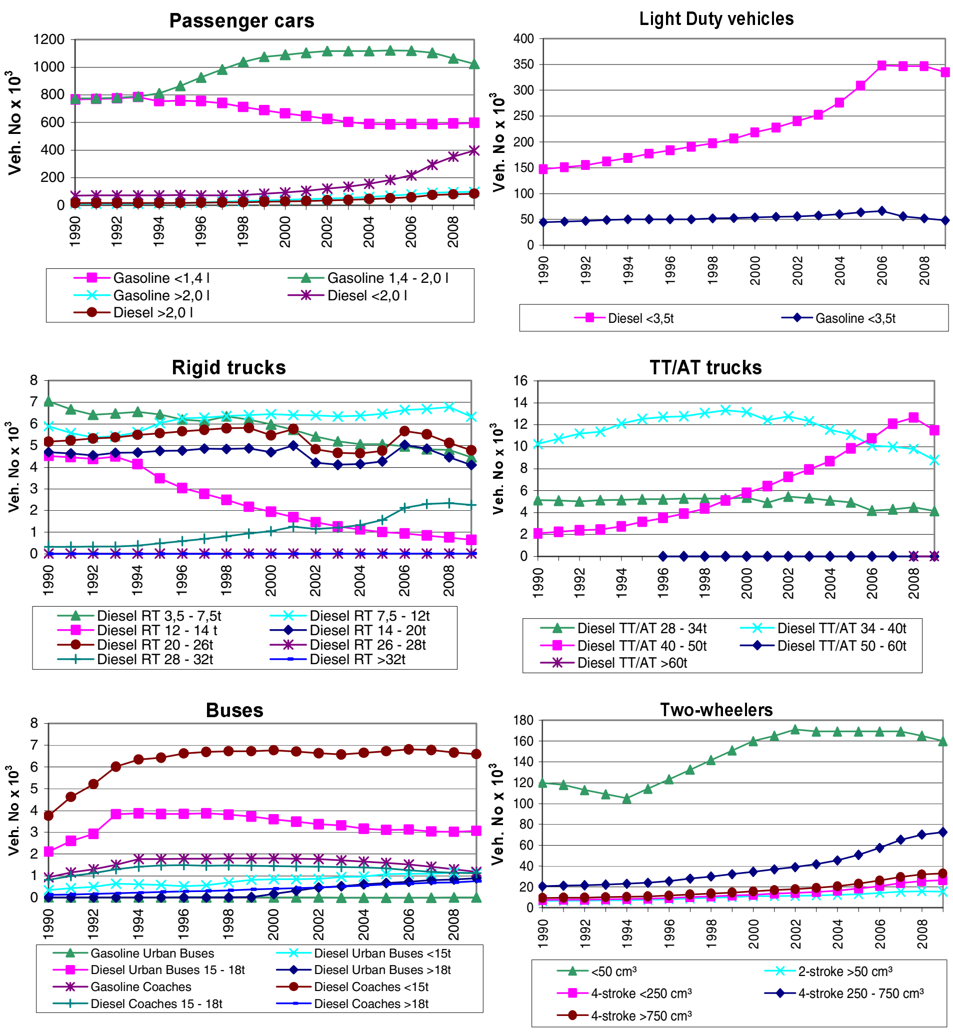


Figure 3.3.33 Number of vehicles in sub-classes in 1990-2009.

For passenger cars, the engine size differentiation is associated with some uncertainty. The increase in the total number of passenger cars is mostly due to a growth in the number of gasoline cars with engine sizes between 1.4 and 2 litres (from 1990-2002) and an increase in the number of gasoline cars (>2 litres) and diesel cars (< 2 litres). Until 2005, there has been a decrease in the number of cars with an engine size smaller than 1.4 litres.

There has been a considerable growth in the number of diesel light-duty vehicles from 1985 to 2006, the number of vehicles has however decreased somewhat after 2006.

For the truck-trailer and articulated truck combinations there is a tendency towards the use of increasingly larger trucks throughout the time period. The decline in fleet numbers for many of the truck categories in 2007/2008 and until 2009, is caused by the impact of the global financial crisis and the reflagging of Danish commercial trucks to companies based in the neighbouring countries.

The number of urban buses has been almost constant between 1985 and 2008. The sudden change in the level of coach numbers from 1994 to 1995 is due to uncertain fleet data.

The reason for the significant growth in the number of mopeds from 1994 to 2002 is the introduction of the so-called Moped 45 vehicle type. For motorcycles, the number of vehicles has grown in general throughout the entire 1985-2009 period. The increase is, however, most visible from the mid-1990s and onwards.

The vehicle numbers are summed up in EU emission layers for each year (Figure 3.3.34) by using the correspondence between layers and first year of registration:

$$N_{j,y} = \sum_{i=FYear(j)}^{LYear(j)} N_{i,y} \quad (1)$$

Where N = number of vehicles, j = layer, y = year, i = first year of registration.

Weighted annual mileages pr layer are calculated as the sum of all mileage driven pr first registration year divided by the total number of vehicles in the specific layer.

$$M_{j,y} = \frac{\sum_{i=FYear(j)}^{LYear(j)} N_{i,y} \cdot M_{i,y}}{\sum_{i=FYear(j)}^{LYear(j)} N_{i,y}} \quad (2)$$

For heavy duty trucks, there is a slight deviation from the strict correspondence between EU emission layers and first registration year.

In this case, specific Euro class information for most of the vehicles from 2001 onwards is incorporated into the fleet and mileage data model developed by Jensen et al. (2009). For inventory years before 2001, and for vehicles with no Euro information the normal correspondence between layers and first year of registration is used.

Vehicle numbers and weighted annual mileages pr layer are shown in Annex 3.B.1 and 3.B.2 for 1990-2009. The trends in vehicle numbers pr layer are also shown in Figure 3.3.34. The latter figure shows how vehicles complying with the gradually stricter EU emission levels (EURO I, II, III etc.) have been introduced into the Danish motor fleet.

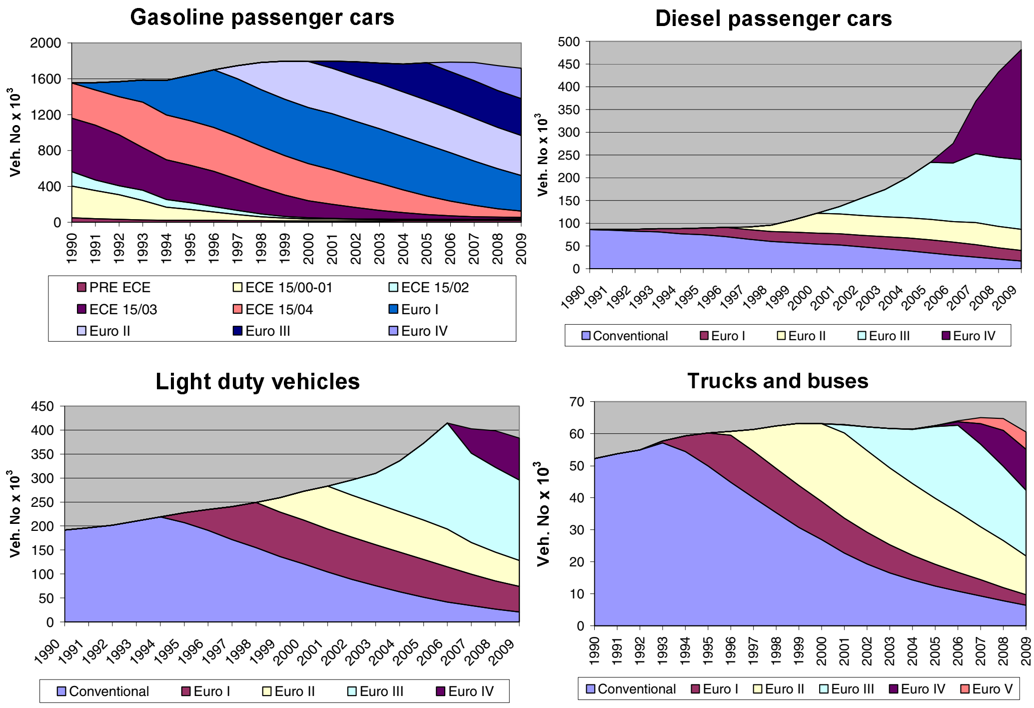


Figure 3.3.34 Layer distribution of vehicle numbers pr vehicle type in 1990-2009.

Emission legislation

The EU 443/2009 regulation sets new emission performance standards for new passenger cars as part of the Community's integrated approach to reduce CO_2 emissions from light-duty vehicles. Some key elements of the adopted text are as follows:

- **Limit value curve**: the fleet average to be achieved by all cars registered in the EU is 130 grams pr kilometre (g pr km). A so-called limit value curve implies that heavier cars are allowed higher emissions than lighter cars while preserving the overall fleet average.
- **Further reduction:** A further reduction of 10 g CO_2 pr km, or equivalent if technically necessary, will be delivered by other technological improvements and by an increased use of sustainable biofuels.
- **Phasing-in of requirements**: in 2012, 65% of each manufacturer's newly registered cars must comply on average with the limit value curve set by the legislation. This will rise to 75% in 2013, 80% in 2014, and 100% from 2015 onwards.
- **Lower penalty payments for small excess emissions** until 2018: If the average CO2 emissions of a manufacturer's fleet exceed its limit value in any year from 2012, the manufacturer has to pay an excess emissions premium for each car registered. This premium amounts to €5 for the first g pr km of exceedance, €15 for the second g pr km, €25 for the third g pr km, and €95 for each subsequent g pr km. From 2019, already the first g pr km of exceedance will cost €95.
- **Long-term target**: a target of 95g pr km is specified for the year 2020. The modalities for reaching this target and the aspects of its implementation including the excess emissions premium will have to be defined in a review to be completed no later than the beginning of 2013.
- **Eco-innovations**: because the test procedure used for vehicle type approval is outdated, certain innovative technologies cannot demonstrate their CO2-reducing effects under the type approval test. As an

interim procedure until the test procedure is reviewed by 2014, manufacturers can be granted a maximum of 7g pr km of emission credits on average for their fleet if they equip vehicles with innovative technologies, based on independently verified data.

On 28 October 2009 the European Commission adopted a new legislative proposal to reduce CO2 emissions from light commercial vehicles (vans). The main content of the proposal is given below in bullet points:

- Target dates: the EU fleet average for all new light commercial vehicles (vans) of 175 g pr km will apply as of 2014. The requirement will be phased-in as of 2014 when 75% of each manufacturer's newly registered vans must comply on average with the limit value curve set by the legislation. This will rise to 80 % in 2015, and 100% from 2016 onwards.
- Limit value curve: emissions limits are set according to the mass of vehicle, using a limit value curve. The curve is set in such a way that a fleet average of 175 grams of CO_2 pr kilometre is achieved. A so-called limit value curve of 100% implies that heavier vans are allowed higher emissions than lighter vans while preserving the overall fleet average. Only the fleet average is regulated, so manufacturers will still be able to make vehicles with emissions above the limit value curve provided these are balanced by other vehicles which are below the curve.
- Vehicles affected: the vehicles affected by the legislation are vans, which account for around 12% of the market for light-duty vehicles. This includes vehicles used to carry goods weighing up to 3.5t (vans and car-derived vans, known as N1) and which weigh less than 2610 kg when empty.
- Long-term target: a target of 135g pr km is specified for the year 2020. Confirmation of the target with the updated impact assessment, the modalities for reaching this target, and the aspects of its implementation, including the excess emissions premium, will have to be defined in a review to be completed no later than the beginning of 2013.
- Excess emissions premium for small excess emissions until 2018: if the average CO2 emissions of a manufacturer's fleet exceed its limit value in any year from 2014, the manufacturer has to pay an excess emissions premium for each van registered. This premium amounts to €5 for the first g pr km of exceedance, €15 for the second g pr km, €25 for the third g pr km, and €120 for each subsequent g pr km. From 2019, already the first g pr km of exceedance will cost €120. This value is higher than the one for cars (€95) because of the differences in compliance costs.
- Super-credits: vehicles with extremely low emissions (below 50g pr km) will be given additional incentives whereby 1 low-emitting van will be counted as 2.5 vehicles in 2014, as 1.5 vehicles in 2015, and 1 vehicle from 2016.
- Eco-innovations: because the test procedure used for vehicle type approval is outdated, certain innovative technologies cannot demonstrate their CO2-reducing effects under the type approval test. As an interim procedure until the test procedure is reviewed by 2014, manufacturers can be granted a maximum of 7g pr km of emission credits on average for their fleet if they equip vehicles with innovative technologies, based on independently verified data.

- Other flexibilities: manufacturers may group together to form a pool and act jointly in meeting the specific emissions targets. Independent manufacturers who sell fewer than 22,000 vehicles pr year can also apply to the Commission for an individual target instead.

For Euro 1-4 passenger cars and light duty trucks, the chassis dynamometer test cycle used in the EU for measuring fuel is the NEDC (New European Driving Cycle), see Nørgaard and Hansen (2004). The test cycle is also used also for emissions testing. The NEDC cycle consists of two parts, the first part being a 4-time repetition (driving length: 4 km) of the ECE test cycle. The latter test cycle is the so-called urban driving cycle26 (average speed: 19 km pr h). The second part of the test is the run-through of the EUDC (Extra Urban Driving Cycle) test driving segment, simulating the fuel consumption under rural and highway driving conditions. The driving length of EUDC is seven km at an average speed of 63 km pr h. More information regarding the fuel measurement procedure can be found in the EU-directive 80/1268/EØF.

For NO_X, VOC (NMVOC + CH_4), CO and PM, the emissions from road transport vehicles have to comply with the different EU directives listed in Table 3.3.7. The emission directives distinguish between three vehicle classes according to vehicle reference mass[27]: Passenger cars and light duty trucks (<1305 kg), light duty trucks (1305-1760 kg) and light duty trucks (>1760 kg).The specific emission limits are shown in Annex 3.B.3.

[26] For Euro 3 and on, the emission approval test procedure was slightly changed. The 40 s engine warm up phase before start of the urban driving cycle was removed.

[27] Reference mass: net vehicle weight + mass of fuel and other liquids + 100 kg.

Table 3.3.7 Overview of the existing EU emission directives for road transport vehicles.

Vehicle category	Emission layer	EU directive	First reg. date
Passenger cars (gasoline)	PRE ECE		0
	ECE 15/00-01	70/220 - 74/290	1972[a]
	ECE 15/02	77/102	1981[b]
	ECE 15/03	78/665	1982[c]
	ECE 15/04	83/351	1987[d]
	Euro I	91/441	1.10.1990[e]
	Euro II	94/12	1.1.1997
	Euro III	98/69	1.1.2001
	Euro IV	98/69	1.1.2006
	Euro V	715/2007	1.1.2011
	Euro VI	715/2007	1.9.2015
Passenger cars (diesel and LPG)		Conventional	0
	ECE 15/04	83/351	1987[d]
	Euro I	91/441	1.10.1990[e]
	Euro II	94/12	1.1.1997
	Euro III	98/69	1.1.2001
	Euro IV	98/69	1.1.2006
	Euro V	715/2007	1.1.2011
	Euro VI	715/2007	1.9.2015
Light duty trucks (gasoline and diesel)		Conventional	0
	ECE 15/00-01	70/220 - 74/290	1972[a]
	ECE 15/02	77/102	1981[b]
	ECE 15/03	78/665	1982[c]
	ECE 15/04	83/351	1987[d]
	Euro I	93/59	1.10.1994
	Euro II	96/69	1.10.1998
	Euro III	98/69	1.1.2002
	Euro IV	98/69	1.1.2007
	Euro V	715/2007	1.1.2012
	Euro VI	715/2007	1.9.2016
Heavy duty vehicles	Euro 0	88/77	1.10.1990
	Euro I	91/542	1.10.1993
	Euro II	91/542	1.10.1996
	Euro III	1999/96	1.10.2001
	Euro IV	1999/96	1.10.2006
	Euro V	1999/96	1.10.2009
	Euro VI	595/2009	1.10.2014
Mopeds		Conventional	0
	Euro I	97/24	2000
	Euro II	2002/51	2004
Motor cycles		Conventional	0
	Euro I	97/24	2000
	Euro II	2002/51	2004
	Euro III	2002/51	2007

a,b,c,d: Expert judgement suggest that Danish vehicles enter into the traffic before EU directive first registration dates. The effective inventory starting years are a: 1970; b: 1979; c: 1981; d: 1986.

e: The directive came into force in Denmark in 1991 (EU starting year: 1993).

In practice, the emissions from vehicles in traffic are different from the legislation limit values and, therefore, the latter figures are considered to be too inaccurate for total emission calculations. A major constraint is that the emission approval test conditions reflect only to a small degree the large variety of emission influencing factors in the real traffic situation, such as cumulated mileage driven, engine and exhaust after treatment maintenance levels and driving behaviour.

Therefore, in order to represent the Danish fleet and to support average national emission estimates, emission factors must be chosen which derive from numerous emissions measurements, using a broad range of real world driving patterns and a sufficient number of test vehicles. It is similar important to have separate fuel consumption and emission data for cold-start emission calculations and gasoline evaporation (hydrocarbons).

For heavy-duty vehicles (trucks and buses), the emission limits are given in g pr kWh and the measurements are carried out for engines in a test bench, using the EU ESC (European Stationary Cycle) and ETC (European Transient Cycle) test cycles, depending on the Euro norm and exhaust gas after-treatment system installed. A description of the test cycles is given by Nørgaard and Hansen, 2004). Measurement results in g pr kWh from emission approval tests cannot be directly used for inventory work. Instead, emission factors used for national estimates must be transformed into g pr km, and derived from a sufficient number of measurements which represent the different vehicle size classes, Euro engine levels and real world variations in driving behaviour.

Fuel consumption and emission factors

Trip-speed dependent basis factors for fuel consumption and emissions are taken from the COPERT model using trip speeds as shown in Table 3.3.6. The factors are listed in Annex 3.B.4. For EU emission levels not represented by actual data, the emission factors are scaled according to the reduction factors given in Annex 3.B.5.

The fuel consumption and emission factors used in the Danish inventory come from the COPERT IV model. The scientific basis for COPERT IV is fuel consumption and emission information from the European 5th framework research projects ARTEMIS and Particulates. In cases where no updates are made for vehicle categories and fuel consumption/-emission components, COPERT IV still uses COPERT III data; the source for these data are various European measurement programmes. In general the COPERT data are transformed into trip-speed dependent fuel consumption and emission factors for all vehicle categories and layers.

For passenger cars, real measurement results are behind the emission factors for Euro 1-4 vehicles (updated figures), and those earlier (COPERT III data). For light duty trucks the measurements represent Euro 1 and prior vehicle technologies from COPERT III. For mopeds and motorcycles, updated fuel consumption and emission figures are behind the conventional and Euro 1-3 technologies.

The experimental basis for heavy-duty trucks and buses is updated computer simulated emission factors for Euro 0-V engines.

For all vehicle categories/technology levels not represented by measurements, the emission factors are produced by using reduction factors. The latter factors are determined by assessing the EU emission limits and the relevant emission approval test conditions, for each vehicle type and Euro class.

Deterioration factors

For three-way catalyst cars the emissions of NO_X, NMVOC and CO gradually increase due to catalyst wear and are, therefore, modified as a function of total mileage by the so-called deterioration factors. Even though the emission curves may be serrated for the individual vehicles, on average, the emissions from catalyst cars stabilise after a given cut-off mileage is reached due to OBD (On Board Diagnostics) and the Danish inspection and maintenance programme.

For each forecast year, the deterioration factors are calculated pr first registration year by using deterioration coefficients and cut-off mileages, as given in EMEP/EEA (2009), for the corresponding layer. The deterioration coefficients are given for the two driving cycles: ”Urban Driving Cycle” (UDF) and ”Extra Urban Driving Cycle” (EUDF: urban and rural), with trip speeds of 19 and 63 km pr h, respectively.

Firstly, the deterioration factors are calculated for the corresponding trip speeds of 19 and 63 km pr h in each case determined by the total cumulated mileage less than or exceeding the cut-off mileage. The Formulas 3 and 4 show the calculations for the ”Urban Driving Cycle”:

$$UDF = U_A \cdot MTC + U_B \text{, MTC} < U_{MAX} \quad (3)$$

$$UDF = U_A \cdot U_{MAX} + U_B \text{, MTC} >= U_{MAX} \quad (4)$$

where UDF is the urban deterioration factor, U_A and U_B the urban deterioration coefficients, MTC = total cumulated mileage and U_{MAX} urban cut-off mileage.

In the case of trip speeds below 19 km pr h the deterioration factor, DF, equals UDF, whereas for trip speeds exceeding 63 km pr h, DF=EUDF. For trip speeds between 19 and 63 km pr h the deterioration factor, DF, is found as an interpolation between UDF and EUDF. Secondly, the deterioration factors, one for each of the three road types, are aggregated into layers by taking into account vehicle numbers and annual mileage levels pr first registration year:

$$DF_{j,y} = \frac{\sum_{i=FYear(j)}^{LYear(j)} DF_{i,y} \cdot N_{i,y} \cdot M_{i,y}}{\sum_{i=FYear(j)}^{LYear(j)} DF_{i,y} \cdot N_{i,y}} \quad (5)$$

where DF is the deterioration factor.

For N_2O and NH_3, COPERT IV takes into account deterioration as a linear function of mileage for gasoline fuelled EURO 1-4 passenger cars and light duty vehicles. The level of emission deterioration also relies on the content of sulphur in the fuel. The deterioration coefficients are given in EMEP/EEA (2009), for the corresponding layer. A cut-off mileage of 120 000 km (pers. comm. Ntziachristos, 2007) is behind the calculation of the modified emission factors, and for the Danish situation the low sulphur level interval is assumed to be most representative.

Emissions and fuel consumption for hot engines

Emissions and fuel consumption results for operationally hot engines are calculated for each year and for layer and road type. The procedure is to combine fuel consumption and emission factors (and deterioration factors for catalyst vehicles), number of vehicles, annual mileage levels and the relevant road-type shares given in Table 3.3.7. For non-catalyst vehicles this yields:

$$E_{j,k,y} = EF_{j,k,y} \cdot S_k \cdot N_{j,y} \cdot M_{j,y} \quad (6)$$

Here E = fuel consumption/emission, EF = fuel consumption/emission factor, S = road type share and k = road type.

For catalyst vehicles the calculation becomes:

$$E_{j,k,y} = DF_{j,k,y} \cdot EF_{j,k,y} \cdot S_k \cdot N_{j,y} \cdot M_{j,y} \quad (7)$$

Extra emissions and fuel consumption for cold engines

Extra emissions of NO_X, VOC, CH_4, CO, PM, N_2O, NH_3 and fuel consumption from cold start are simulated separately. For SO_2 and CO_2, the extra emissions are derived from the cold start fuel consumption results.

In terms of cold start data for NO_X, VOC, CO, PM and fuel consumption no updates are made to the COPERT IV methodology, and the calculation approach is the same as in COPERT III. Each trip is associated with a certain cold-start emission level and is assumed to take place under urban driving conditions. The number of trips is distributed evenly across the months. First, cold emission factors are calculated as the hot emission factor times the cold:hot emission ratio. Secondly, the extra emission factor during cold start is found by subtracting the hot emission factor from the cold emission factor. Finally, this extra factor is applied on the fraction of the total mileage driven with a cold engine (the β-factor) for all vehicles in the specific layer.

The cold:hot ratios depend on the average trip length and the monthly ambient temperature distribution. The Danish temperatures for 2009 are given in Cappelen et al. (2010). For previous years, temperature data are taken from similar reports available from www.dmi.dk. The cold:hot ratios are equivalent for gasoline fuelled conventional passenger cars and vans and for diesel passenger cars and vans, respectively, see Ntziachristos et al. (2000). For conventional gasoline and all diesel vehicles the extra emissions become:

$$CE_{j,y} = \beta \cdot N_{j,y} \cdot M_{j,y} \cdot EF_{U,j,y} \cdot (CEr - 1) \quad (8)$$

Where CE is the cold extra emissions, β = cold driven fraction, CEr = Cold:Hot ratio.

For catalyst cars, the cold:hot ratio is also trip speed dependent. The ratio is, however, unaffected by catalyst wear. The Euro I cold:hot ratio is used for all future catalyst technologies. However, in order to comply with gradually stricter emission standards, the catalyst light-off temperature must be reached in even shorter periods of time for future EURO standards. Correspondingly, the β-factor for gasoline vehicles is reduced step-wise for Euro II vehicles and their successors.

For catalyst vehicles the cold extra emissions are found from:

$$CE_{j,y} = \beta_{red} \cdot \beta_{EUROI} \cdot N_{j,y} \cdot M_{j,y} \cdot EF_{U,j,y} \cdot (CEr_{EUROI} - 1) \quad (9)$$

where β_{red} = the β reduction factor.

For CH_4, specific emission factors for cold driven vehicles are included in COPERT IV. The β and β_{red} factors for VOC is used to calculate the cold driven fraction for each relevant vehicle layer. The NMVOC emissions during cold start are found as the difference between the calculated results for VOC and CH_4.

For N_2O and NH_3, specific cold start emission factors are also proposed by COPERT IV. For catalyst vehicles, however, just like in the case of hot emission factors, the emission factors for cold start are functions of cumulated mileage (emission deterioration). The level of emission deterioration also relies on the content of sulphur in the fuel. The deterioration coefficients are given in EMEP/EEA (2009), for the corresponding layer. For cold start, the cut-off mileage and sulphur level interval for hot engines are used, as described in the deterioration factors paragraph.

Evaporative emissions from gasoline vehicles

For each year, evaporative emissions of hydrocarbons are simulated in the forecast model as hot and warm running losses, hot and warm soak loss and diurnal emissions. For evaporation, no updates are made to the COPERT IV methodology, and the calculation approach is the same as in COPERT III. All emission types depend on RVP (Reid Vapour Pressure) and ambient temperature. The emission factors are shown in EMEP/EEA (2009).

Running loss emissions originate from vapour generated in the fuel tank while the vehicle is running. The distinction between hot and warm running loss emissions depends on engine temperature. In the model, hot and warm running losses occur for hot and cold engines, respectively. The emissions are calculated as annual mileage (broken down into cold and hot mileage totals using the β-factor) times the respective emission factors. For vehicles equipped with evaporation control (catalyst cars), the emission factors are only one tenth of the uncontrolled factors used for conventional gasoline vehicles.

$$R_{j,y} = N_{j,y} \cdot M_{j,y} \cdot ((1-\beta) \cdot HR + \beta \cdot WR) \quad (10)$$

where R is running loss emissions and HR and WR are the hot and warm running loss emission factors, respectively.

In the model, hot and warm soak emissions for carburettor vehicles also occur for hot and cold engines, respectively. These emissions are calculated as number of trips (broken down into cold and hot trip numbers using the β-factor) times respective emission factors:

$$S_{j,y}^{\ C} = N_{j,y} \cdot \frac{M_{j,y}}{l_{trip}} \cdot ((1-\beta) \cdot HS + \beta \cdot WS) \quad (11)$$

where S^C is the soak emission, l_{trip} = the average trip length, and HS and WS are the hot and warm soak emission factors, respectively. Since all catalyst vehicles are assumed to be carbon canister controlled, no soak emissions are estimated for this vehicle type. Average maximum and minimum temperatures pr month are used in combination with diurnal emission factors to estimate the diurnal emissions from uncontrolled vehicles $E^d(U)$:

$$E_{j,y}^{\ d}(U) = 365 \cdot N_{j,y} \cdot e^d(U) \quad (12)$$

Each year's total is the sum of each layer's running loss, soak loss and diurnal emissions.

Fuel consumption balance

The calculated fuel consumption in COPERT III must equal the statistical fuel sale totals according to the UNFCCC and UNECE emissions reporting format. The statistical fuel sales for road transport are derived from the Danish Energy Authority data (see DEA, 2010). The DEA data are further processed for gasoline in order to account for e.g. non road and recreational craft fuel consumption, which are not directly stated in the statistics, please refer to paragraph 1.1.4 for further information regarding the transformation of DEA fuel data.

The standard approach to achieve a fuel balance in annual emission inventories is to multiply the annual mileage with a fuel balance factor derived as the ratio between simulated and statistical fuel figures for gasoline and diesel, respectively. This method is also used in the present model.

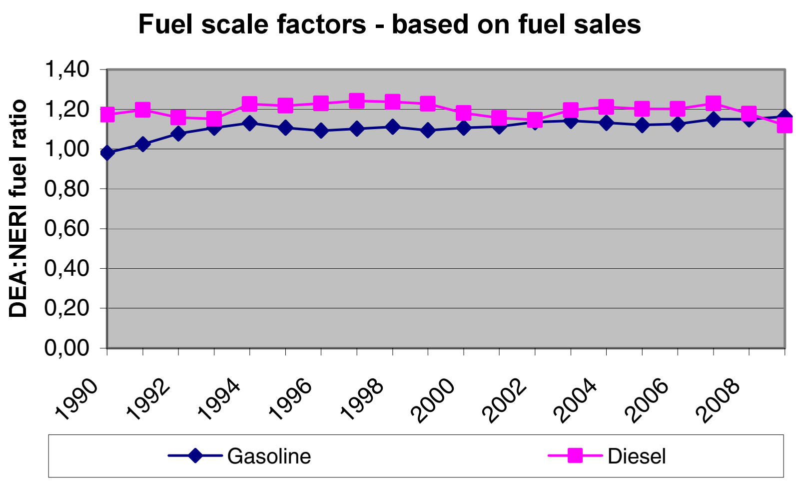


Figure 3.3.35 DEA:NERI Fuel ratios and diesel mileage adjustment factor based on DEA fuel sales data and NERI fuel consumption estimates.

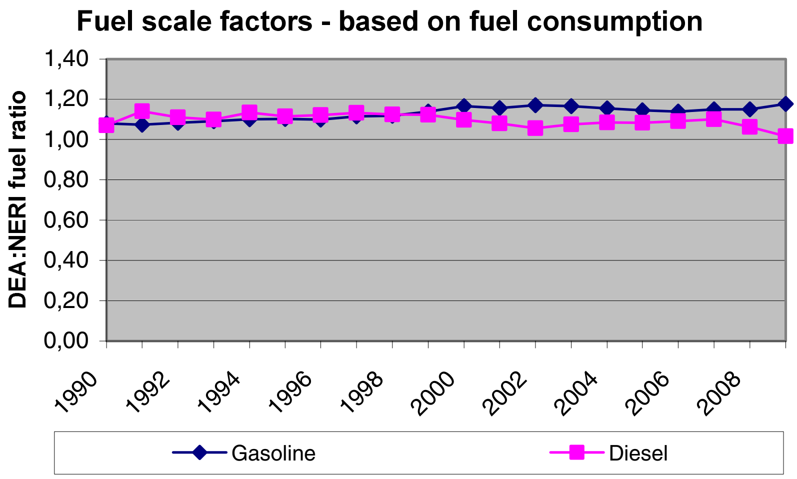


Figure 3.3.36 DEA:NERI Fuel ratios and diesel mileage adjustment factor based on DEA fuel consumption data and NERI fuel consumption estimates.

In Figure 3.3.35 and Figure 3.3.36 the COPERT IV:DEA gasoline and diesel fuel consumption ratios are shown for fuel sales and fuel consumption from 1990-2009. The data behind the figures are also listed in Annex 3.B.8. The fuel consumption figures are related to the traffic on Danish roads.

Pr fuel type, all mileage numbers are equally scaled in order to obtain fuel equilibrium, and hence the mileage factors used are the reciprocal values of the COPERT IV:DEA fuel consumption: fuel sales ratio.

The reasons for the differences between DEA sales figures and bottom-up fuel estimates are mostly due to a combination of the uncertainties related to COPERT IV fuel use factors, allocation of vehicle numbers in sub-categories, annual mileage, trip speeds and mileage splits for urban, rural and highway driving conditions.

The final fuel consumption and emission factors pr vehicle type are shown in Annex 3.B.6 for 1990-2009. The total fuel consumption and emissions are shown in Annex 3.B.7, pr vehicle category and as grand totals, for 1990-2009 (and CRF format in Annex 3.B.15). In Annex 3.B.14, fuel consumption and emission factors as well as total emissions are given in CollectER format for 1990 and 2009.

In the following Figures 3.3.37 - 3.3.40, the fuel and km related emission factors for CO_2 (km related only), CH_4 and N_2O are shown pr vehicle type for the Danish road transport (from 1990-2009). For CO_2 the emission factors are country specific values, and come from the DEA. From 2006, bio ethanol has become available from a limited number of gas filling stations in Denmark. Following the IPCC guideline definitions, bio ethanol is regarded as CO_2 neutral for the transport sector as such. The sulphur content for bioethanol is zero, and hence, the aggregated CO_2 (and SO_2) factors for gasoline have been adjusted, on the basis of the energy content of pure gasoline and bio ethanol.

A literature review carried out in the Danish research project REBECA revealed no significant changes in emission factors between neat gasoline and E5 gasoline-ethanol blends for the combustion related emission components (Winther, 2010). Hence, no modifications of the neat gasoline based COPERT emission factors are made in the inventories in order to account for E5 usage. However, adjustment of the emission factors will be made, if new information becomes available which justify such changes.

The CO_2 factors are shown pr fuel type in Table 3.3.8.

Table 3.3.8 Fuel-specific emission factors for CO_2 (kg pr GJ) for road transport in Denmark.

Fuel type	1990-2005	2006	2007	2008	2009
Gasoline	73	72.9	72.8	72.8	72.8
Diesel	74	74	74	74	73.9
LPG	65	65	65	65	65

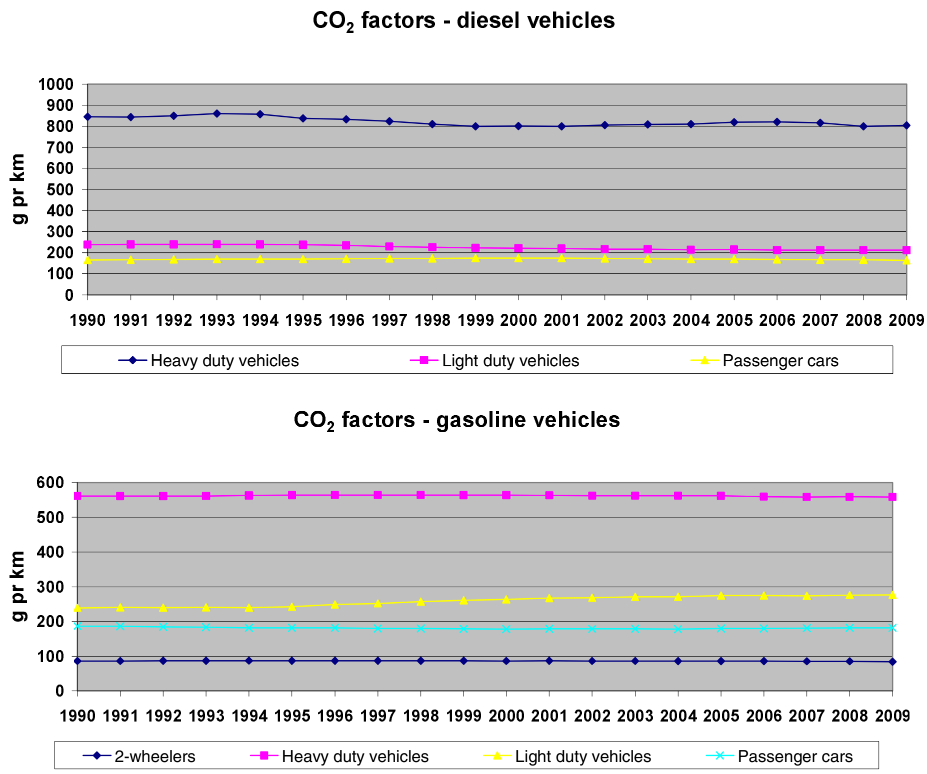


Figure 3.3.37 Km related CO_2 emission factors pr vehicle type for Danish road transport (1990-2009).

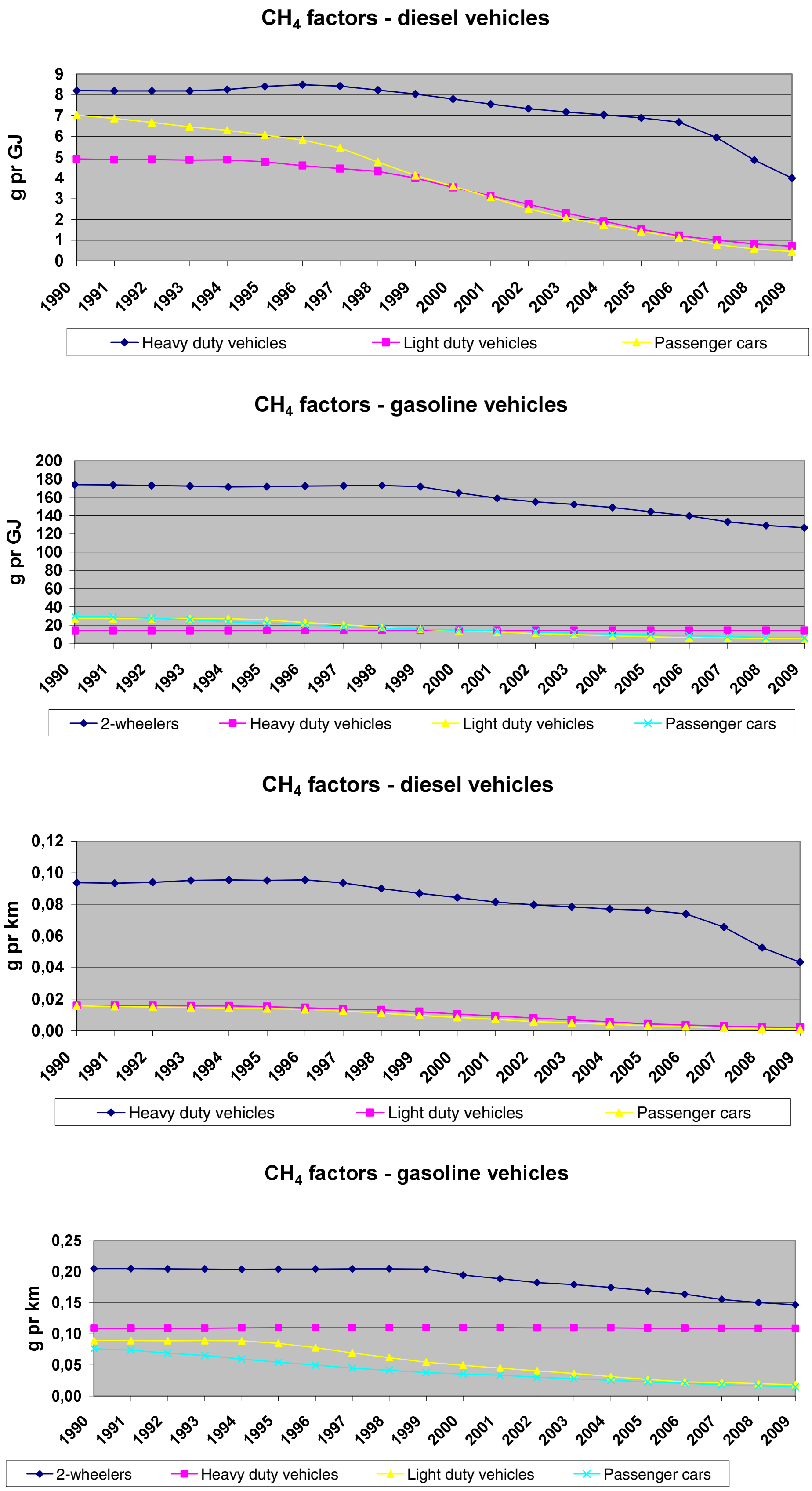


Figure 3.3.38 Fuel and km related CH_4 emission factors pr vehicle type for Danish road transport (1990-2009).

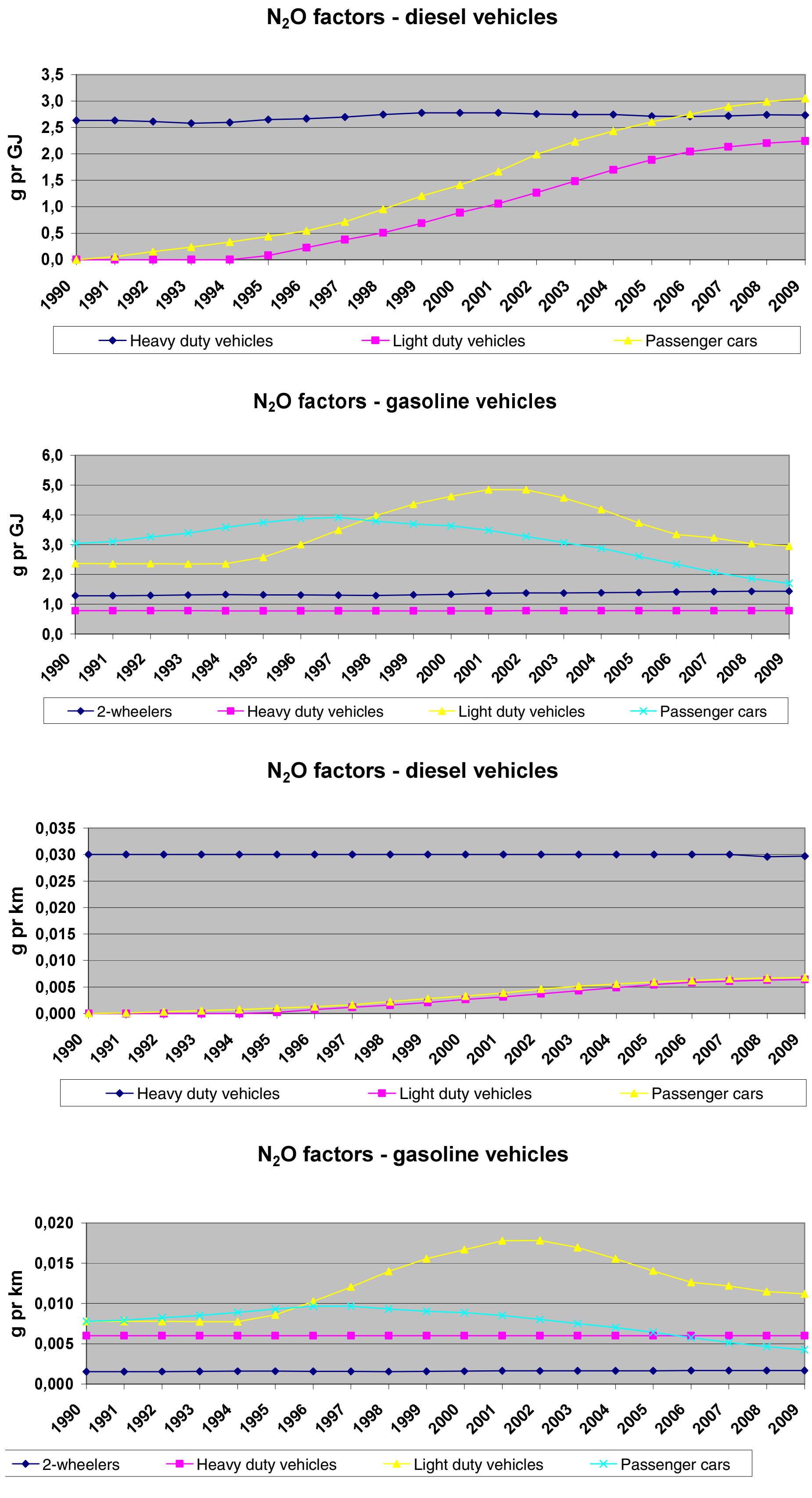


Figure 3.3.39 Fuel and km related N_2O emission factors pr vehicle type for Danish road transport (1990-2009).

Methodologies and references for other mobile sources

Other mobile sources are divided into several sub-sectors: sea transport, fishery, air traffic, railways, military, and working machinery and equipment in the sectors agriculture, forestry, industry and residential. The emission calculations are made using the detailed method as described in the EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2009) for air traffic, off-road working machinery and equipment, and ferries, while for the remaining sectors the simple method is used.

3.3.3 Activity data

Air traffic

The activity data for air traffic consists of air traffic statistics provided by the Danish Civil Aviation Agency (CAA-DK) and Copenhagen Airport. Fuel statistics for jet fuel use and aviation gasoline are obtained from the Danish energy statistics (DEA, 2010).

For 2001 onwards, pr flight records are provided by CAA-DK as data codes for aircraft type, and origin and destination airports (city-pairs).

Subsequently the aircraft types are separated by NERI into larger aircraft using jet fuel (jet engines, turbo props, helicopters) and small aircraft types with piston engines using aviation gasoline. This is done by using different aircraft dictionaries, internet look-ups and by communication with the CAA-DK. Each of the larger aircraft type is then matched with a representative type for which fuel consumption and emission data are available from the EMEP/EEA databank. Relevant for this selection is aircraft maximum take off mass, engine types, and number of engines. A more thorough explanation is given in Winther (2001a, b).

The ideal flying distance (great circle distance) between the city-pairs is calculated by NERI in a separate database. The calculation algorithm uses a global latitude/altitude coordinate table for airports. In cases when airport coordinates are not present in the NERI database, these are looked up on the internet and entered into the database accordingly.

For inventory years prior to 2001, detailed LTO/aircraft type statistics are obtained from Copenhagen Airport (for this airport only), while information of total take-off numbers for other Danish airports is provided by CAA-DK. The assignment of representative aircraft types for Copenhagen Airport is done as described above. For the remaining Danish airports representative aircraft types are not directly assigned. Instead appropriate average assumptions are made relating to the fuel consumption and emission data part.

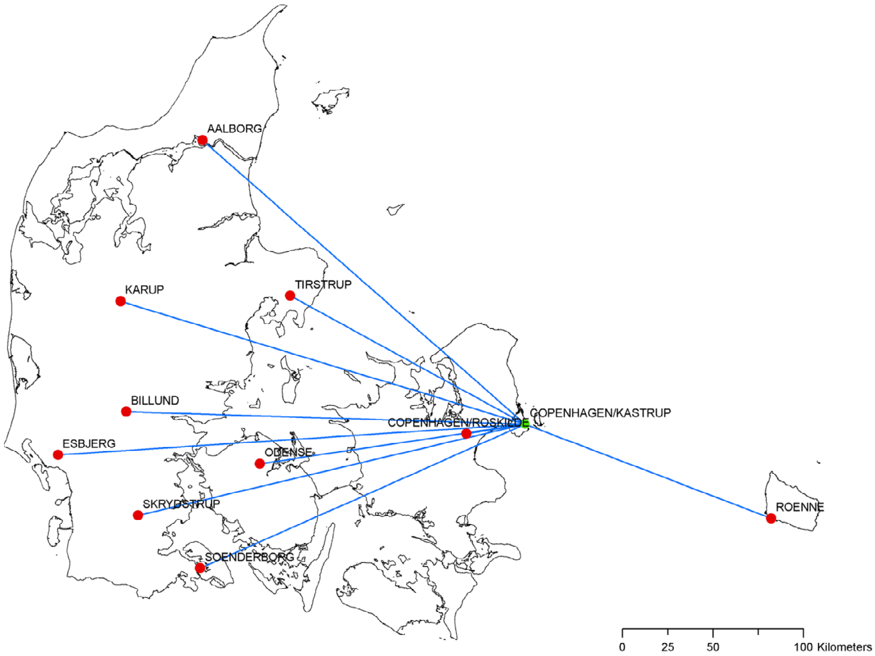


Figure 3.3.40 Most frequent domestic flying routes for large aircraft in Denmark.

Copenhagen Airport is the starting or end point for most of the domestic aviation made by large aircraft in Denmark (Figure 3.3.40). Even though many domestic flights not touching Copenhagen Airport are also reported in the flight statistics kept by CAA-DK, these flights, however, are predominantly made with small piston engine aircraft using aviation gasoline. Hence, the consumption of jet fuel by flights not using Copenhagen is merely marginal.

Non-road working machinery and equipment

Non-road working machinery and equipment are used in agriculture, forestry and industry, for household/gardening purposes and in inland waterways (recreational craft). Information on the number of different types of machines, their respective load factors, engine sizes and annual working hours has been provided by Winther et al. (2006). The stock development from 1990-2009 for the most important types of machinery are shown in Figures 3.3.41 - 3.3.48. The stock data are also listed in Annex 3.B.10, together with figures for load factors, engine sizes and annual working hours. As regards stock data for the remaining machinery types, please refer to (Winther et al., 2006).

It is important to note that from key experts in the field of industrial non road activities a significant decrease in the activities is assumed for 2009 due to the global financial crisis. This reduction is in the order of 25 % for 2009 for industrial non road in general (pers. comm. Per Stjernqvist, Volvo Construction Equipment 2010). For fork lifts, 5 % and 20 % reductions are assumed for 2008 and 2009, respectively (pers. comm. Peter H. Møller, Rocla A/S).

For agriculture, the total number of agricultural tractors and harvesters pr yr are shown in the Figures 3.3.41 - 3.3.42, respectively. The figures clearly show a decrease in the number of small machines, these being replaced by machines in the large engine-size ranges.

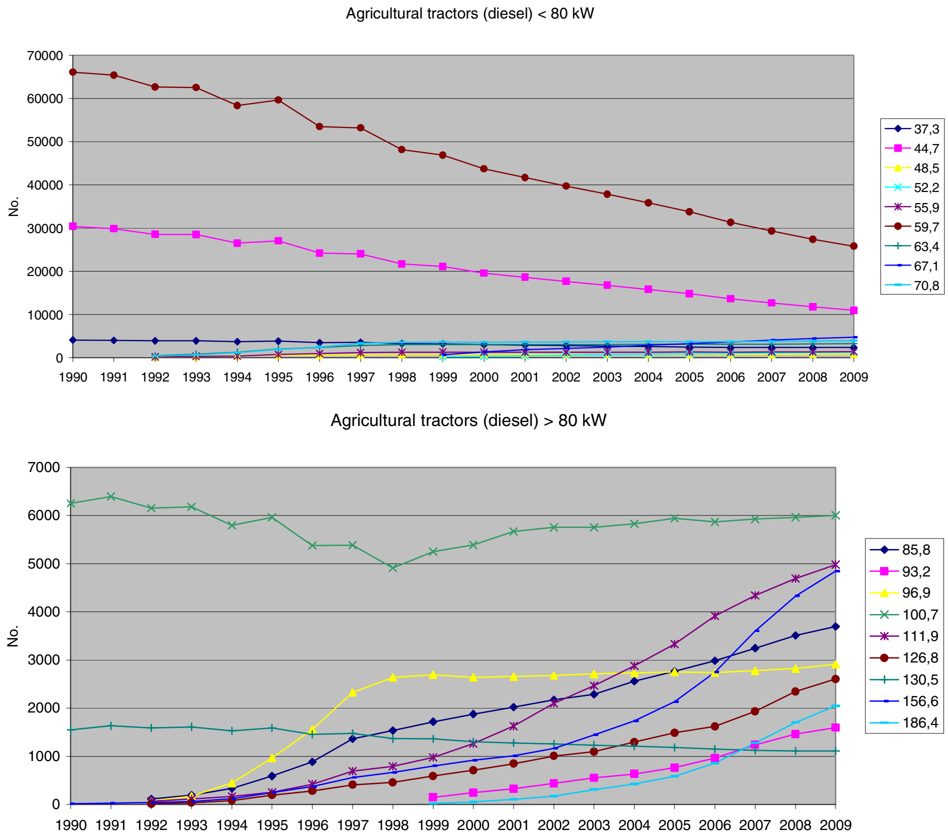


Figure 3.3.41 Total numbers in kW classes for tractors from 1990 to 2009.

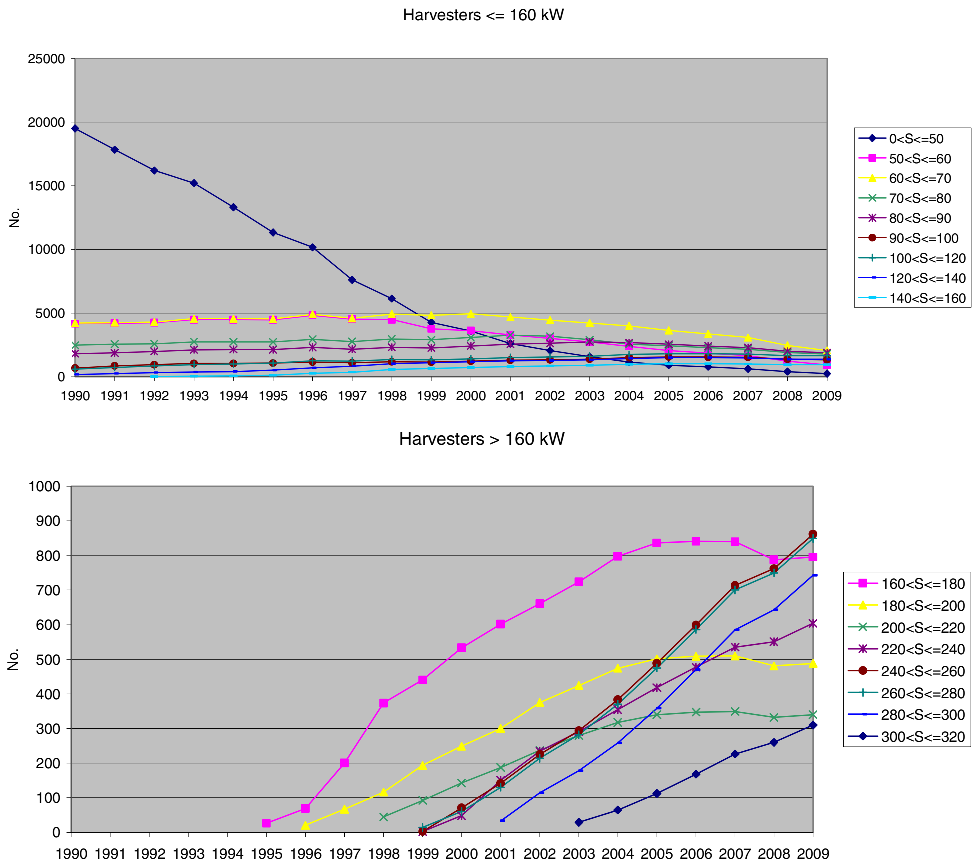
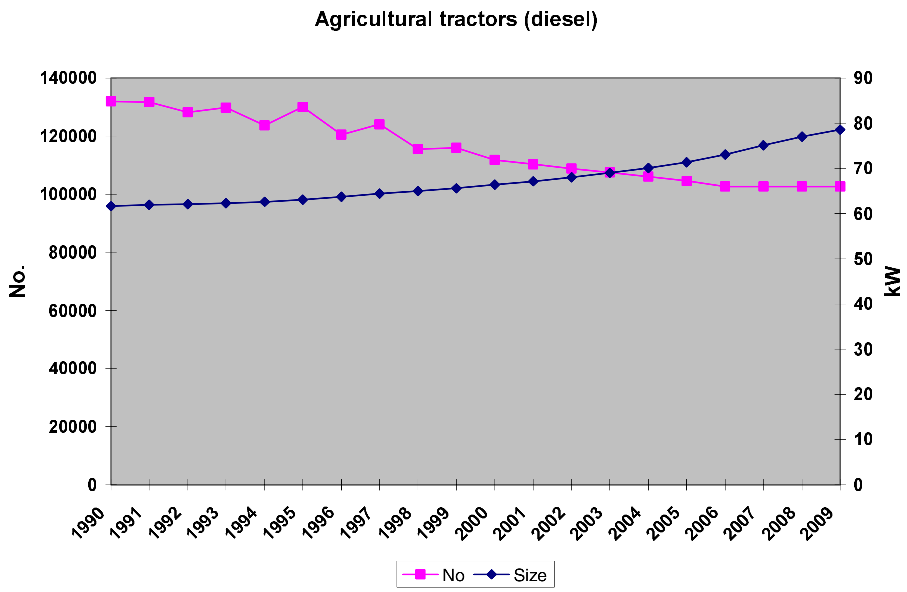


Figure 3.3.42 Total numbers in kW classes for harvesters from 1990 to 2009.

The tractor and harvester developments towards fewer vehicles and larger engines, shown in Figure 3.3.43, are very clear. From 1990 to 2009, tractor and harvester numbers decrease by around 22 % and 49 %, respectively, whereas the average increase in engine size for tractors is 27 % and more than 132 % for harvesters, in the same time period.



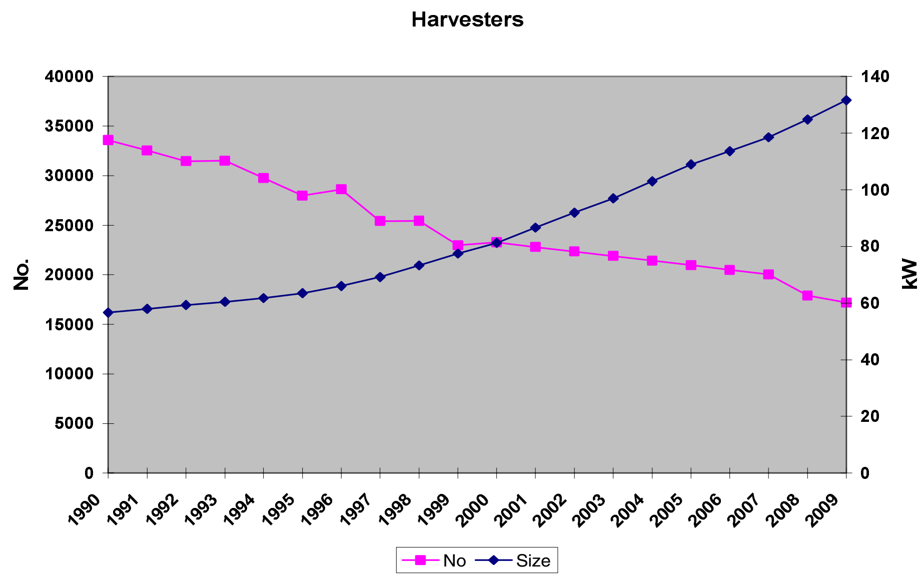
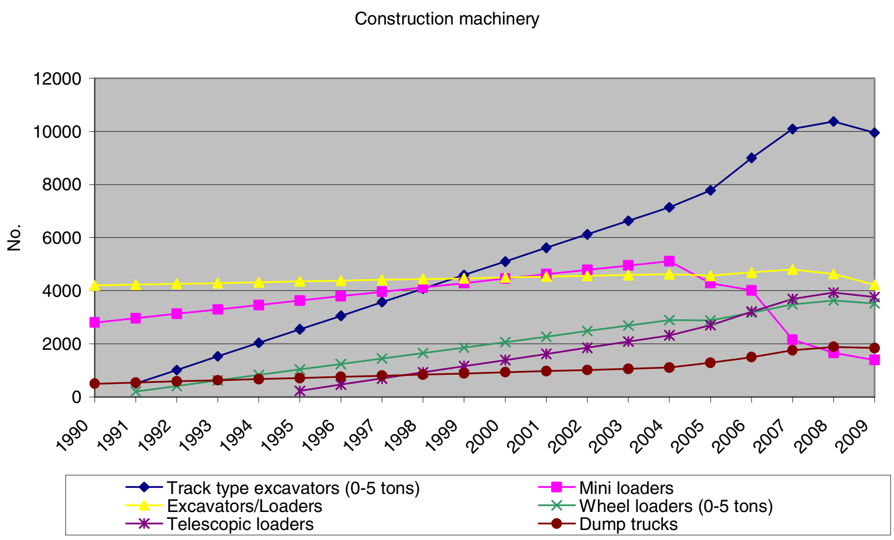


Figure 3.3.43 Total numbers and average engine size for tractors and harvesters (1990 to 2009).

The most important machinery types for industrial use are different types of construction machinery and fork lifts. The Figures 3.3.44 and 3.3.45 show the 1990-2009 stock development for specific types of construction machinery and diesel fork lifts. For most of the machinery types there is an increase in machinery numbers from 1990 onwards, due to increased construction activities. It is assumed that track type excavators/wheel type loaders (0-5 tonnes), and telescopic loaders first enter into use in 1991 and 1995, respectively.



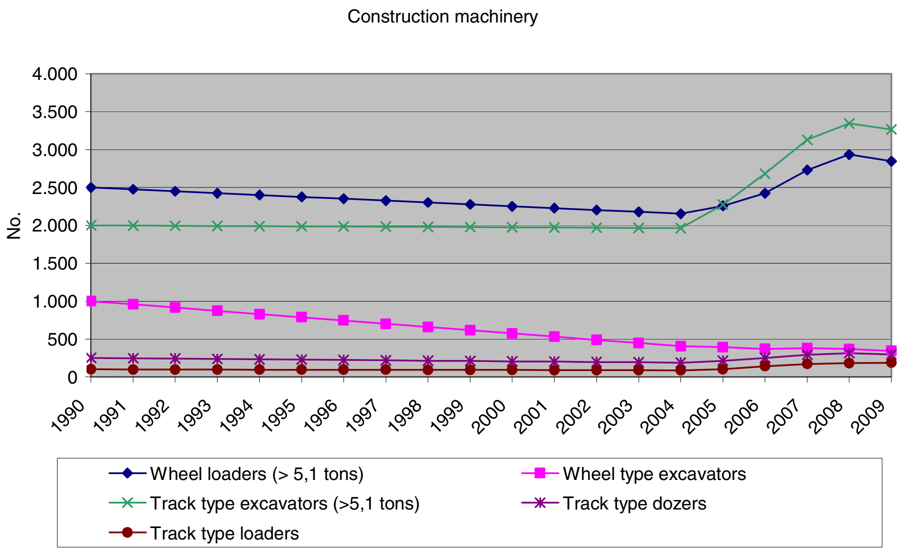


Figure 3.3.44 1990-2009 stock development for specific types of construction machinery.

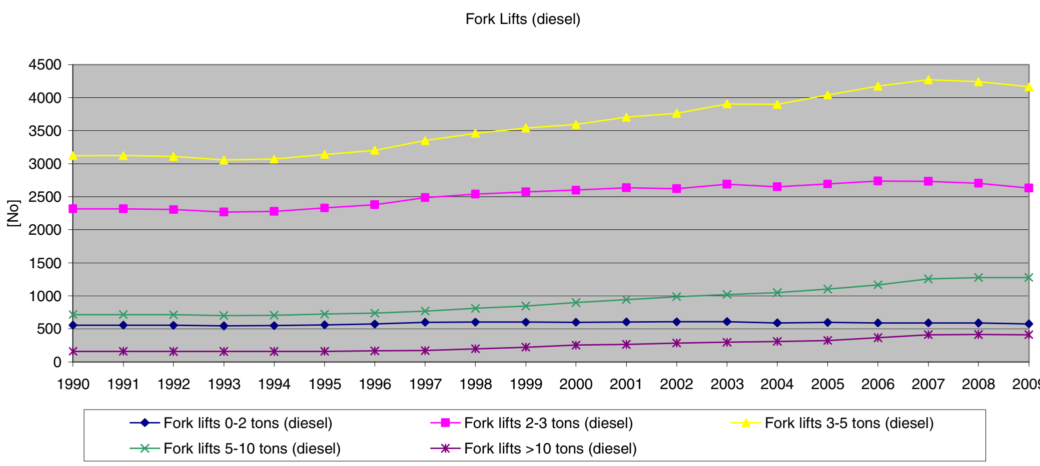


Figure 3.3.45 Total numbers of diesel fork lifts in kW classes from 1990 to 2009.

The emission level shares for tractors, harvesters, construction machinery and diesel fork lifts are shown in Figure 3.3.46, and present an overview of the penetration of the different pre-Euro engine classes, and engine stages complying with the gradually stricter EU stage I and II emission limits. The average lifetimes of 30, 25, 20 and 10 years for tractors, harvesters, fork lifts and construction machinery, respectively, influence the individual engine technology turn-over speeds.

The EU emission directive Stage I and II implementation years relate to engine size, and for all four machinery groups the emission level shares for the specific size segments will differ slightly from the picture shown in Figure 3.3.46. Due to scarce data for construction machinery, the emission level penetration rates are assumed to be linear and the general technology turnover pattern is as shown in Figure 3.3.46.

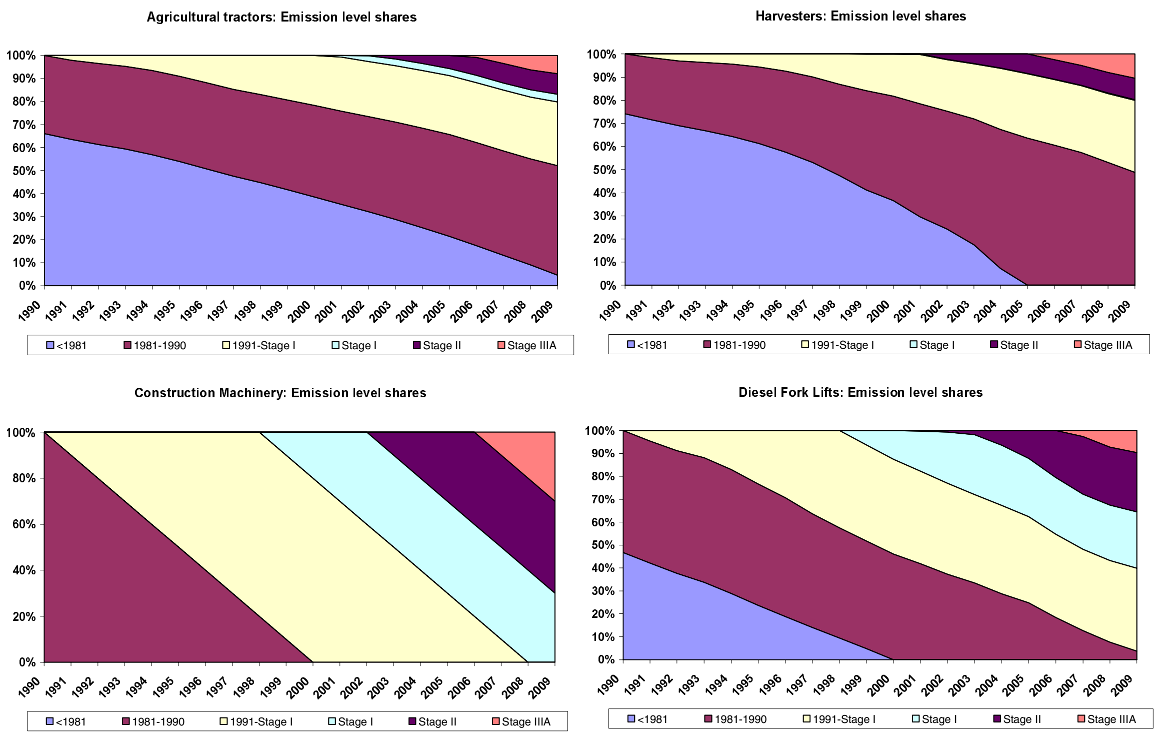


Figure 3.3.46 Emission level shares for tractors, harvesters, construction machinery and diesel fork lifts (1990 to 2009).

The 1990-2009 stock development for the most important household and gardening machinery types is shown in Figure 3.3.47.

For lawn movers and cultivators, the machinery stock remains approximately the same for all years. The stock figures for chain saws, shrub clearers, trimmers and hedge cutters increase from 1990 until 2004, and for riders this increase continues also after 2004. The yearly stock increases, in most cases, become larger after 2000. The lifetimes for gasoline machinery are short and, therefore, there new emission levels (not shown) penetrate rapidly.

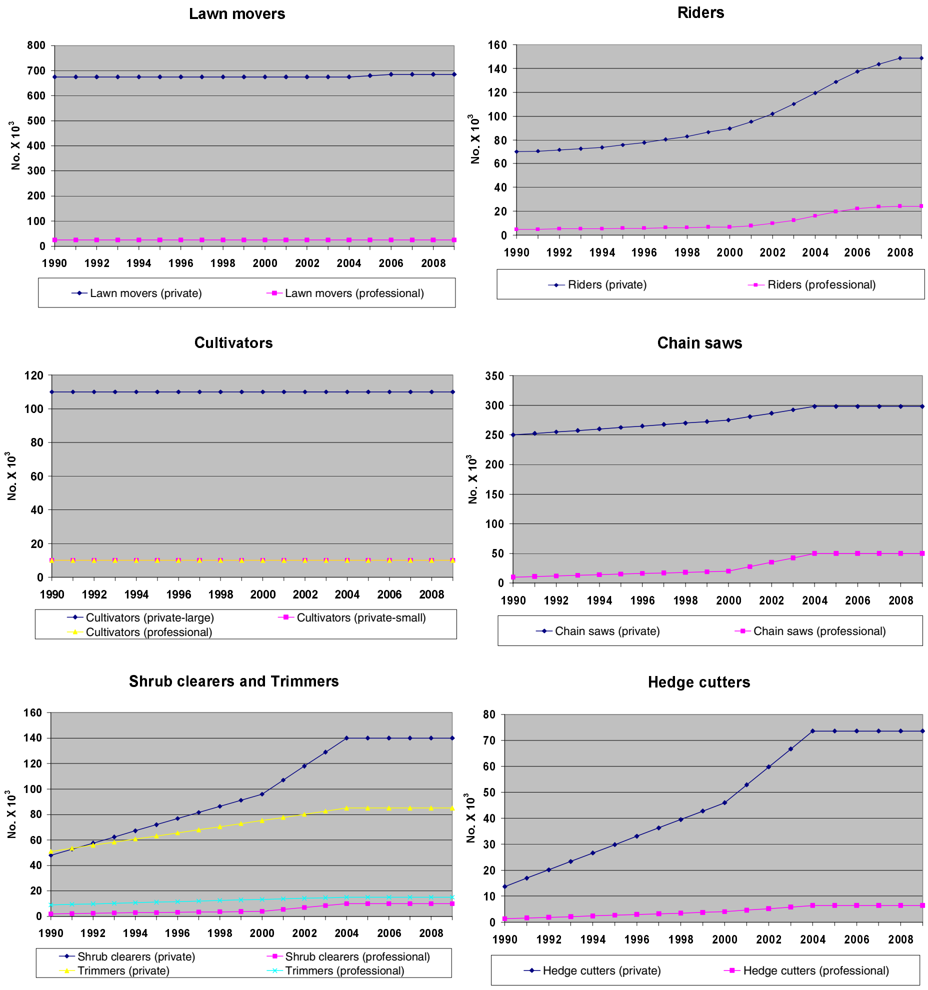


Figure 3.3.47 Stock development 1990-2009 for the most important household and gardening machinery types.

Figure 3.3.48 shows the development in numbers of different recreational craft from 1990-2009. The 2004 stock data for recreational craft are repeated for 2005-2009, since no new fleet information has been obtained.

For diesel boats, increases in stock and engine size are expected during the whole period, except for the number of motor boats (< 27 ft.) and the engine sizes for sailing boats (<26 ft.), where the figures remain unchanged. A decrease in the total stock of sailing boats (<26 ft.) by 21 % and increases in the total stock of yawls/cabin boats and other boats (<20 ft.) by around 25 % are expected. Due to a lack of information specific to Denmark, the shifting rate from 2-stroke to 4-stroke gasoline engines is based on a German non-road study (IFEU, 2004).

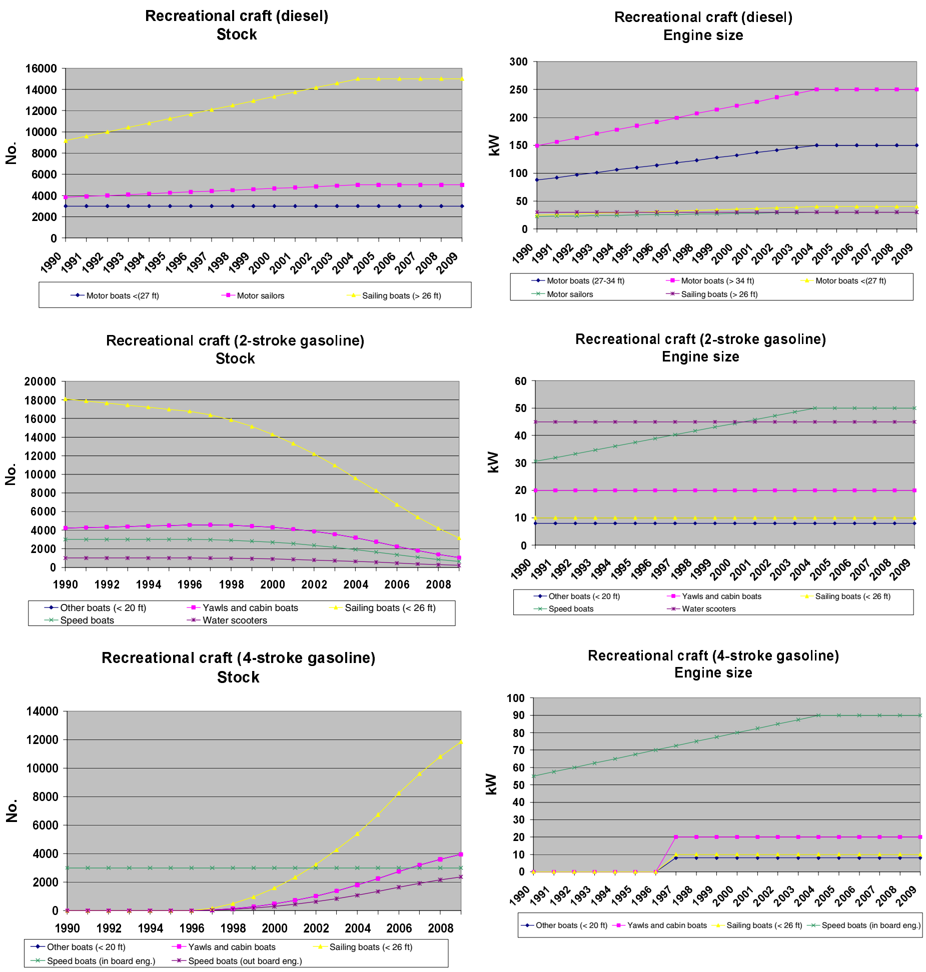


Figure 3.3.48 1990-2009 Stock and engine size development for recreational craft.

National sea transport

A new methodology is used to estimate the fuel consumption figures for national sea transport, based on fleet activity estimates for regional ferries, local ferries and other national sea transport (Winther, 2008a).

Table 3.3.9 lists the most important domestic ferry routes in Denmark in the period 1990-2009. For these ferry routes and the years 1990-2005, the following detailed traffic and technical data have been gathered by Winther (2008a): Ferry name, year of service, engine size (MCR), engine type, fuel type, average load factor, auxiliary engine size and sailing time (single trip).

For 2006-2009, the above mentioned traffic and technical data for specific ferries have been provided by Kristensen (2010) in the case of Mols-Linien (Sjællands Odde-Ebeltoft, Sjællands Odde-Århus, Kalundborg-Århus), by Hjortberg (2010) for Bornholmstrafikken (Køge-Rønne) and by Simonsen (2010) for Langelandstrafikken A/S (Tårs-Spodsbjerg). For Esbjerg-Torshavn and Hanstholm-Torshavn traffic and technical data have been provided by Dávastovu (2010) for Smyril Line.

Table 3.3.9 Ferry routes comprised in the Danish inventory.

Ferry service	Service period
Esbjerg-Torshavn	1990-1995, 2009
Halsskov-Knudshoved	1990-1999
Hanstholm-Torshavn	1991-1992, 1999-2009
Hundested-Grenaa	1990-1996
Kalundborg-Juelsminde	1990-1996
Kalundborg-Samsø	1990-
Kalundborg-Århus	1990-
Korsør-Nyborg, DSB	1990-1997
Korsør-Nyborg, Vognmandsruten	1990-1999
København-Rønne	1990-2004
Køge-Rønne	2004-
Sjællands Odde-Ebeltoft	1990-
Sjællands Odde-Århus	1999-
Tårs-Spodsbjerg	1990-

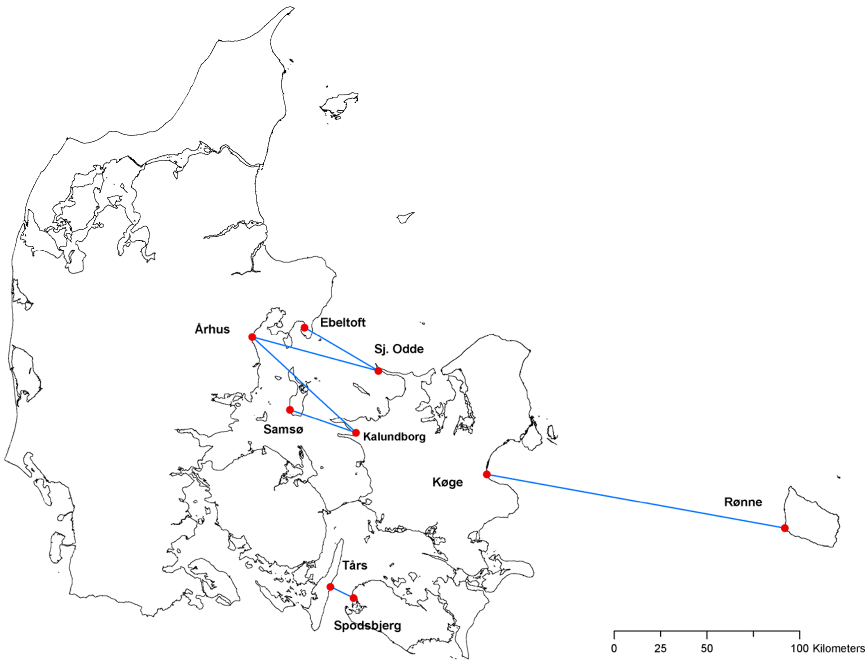


Figure 3.3.50 Domestic regional ferry routes in Denmark (2009).

The number of round trips pr ferry route is shown in Figure 3.3.50. The traffic data are also listed in Annex 3.B.11, together with different ferry specific technical and operational data.

For each ferry, Annex 3.B.12 lists the relevant information as regards ferry route, name, year of service, engine size (MCR), engine type, fuel type, average load factor, auxiliary engine size and sailing time (single trip).

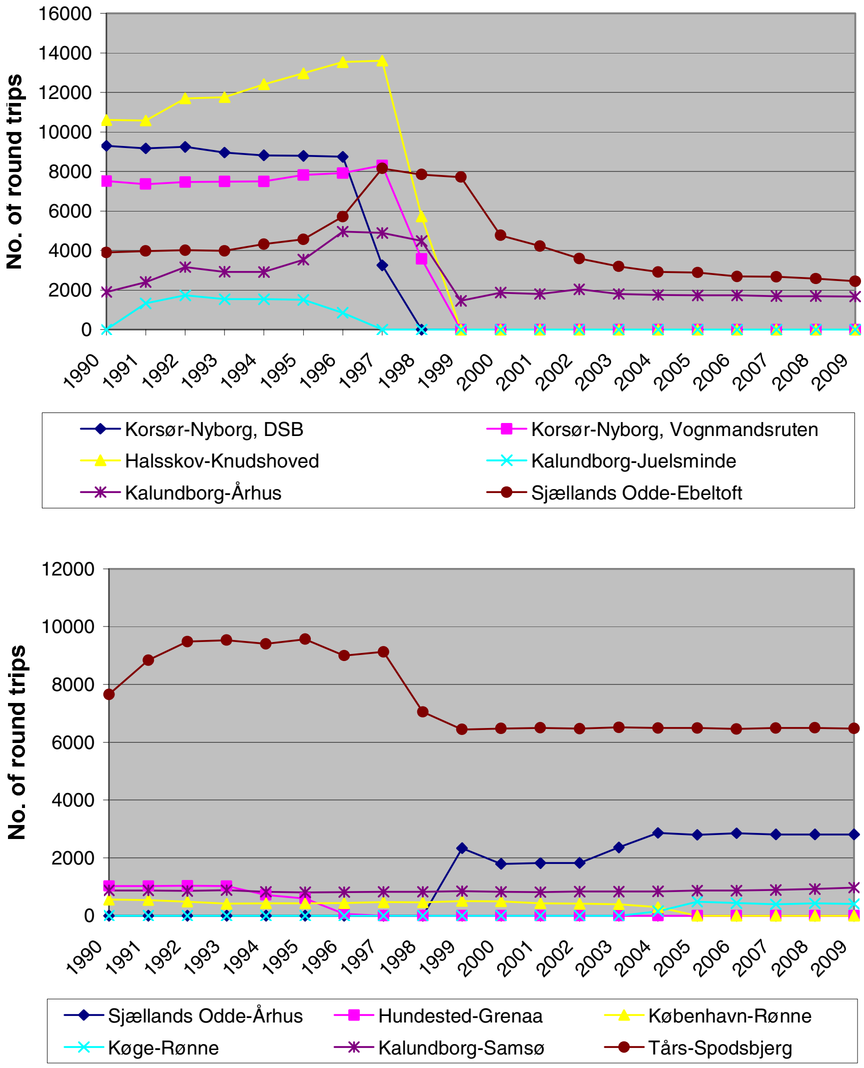


Figure 3.3.51 No. of round trips for the most important ferry routes in Denmark 1990-2009.

It is seen from Table 3.3.9 (and Figure 3.3.51) that several ferry routes were closed in the time period from 1996-1998, mainly due to the opening of the Great Belt Bridge (connecting Zealand and Funen) in 1997. Hundested-Grenaa and Kalundborg-Juelsminde was closed in 1996, Korsør-Nyborg (DSB) closed in 1997, and Halsskov-Knudshoved and Korsør-Nyborg (Vognmandsruten) was closed in 1998. The ferry line København-Rønne was replaced by Køge-Rønne in 2004 and from 1999 a new ferry connection was opened between Sjællands Odde and Århus.

For the local ferries, a bottom-up estimate of fuel consumption for 1996 has been taken from the Danish work in Wismann (2001). The latter project calculated fuel consumption and emissions for all sea transport in Danish waters in 1995/1996 and 1999/2000. In order to cover the entire 1990-2008 inventory period, the fuel figure for 1996 has been adjusted according to the developments in local ferry route traffic shown in Annex 3.B.11.

Fuel sold for freight transport by Royal Arctic Line between Aalborg (Denmark) and Greenland and by Eim Skip - East route between Aarhus (Denmark) and Torshavn (Faroe Islands) are included under other national sea transport in the Danish inventories. In both cases all fuel is being bought in Denmark (Rasmussen, 2010 and Thorarson, 2010).

For the remaining part of the traffic between two Danish ports, other national sea transport, new bottom-up estimates for fuel consumption have been calculated for the years 1995 and 1999 by Wismann (2007). The calculations use the database set up for Denmark in the Wismann (2001) study, with actual traffic data from the Lloyd's LMIS database (not including ferries). The database was split into three vessel types: bulk carriers, container ships, and general cargo ships; and five size classes: 0-1000, 1000-3000, 3000-10000, 10000-20000 and >20000 DTW. The calculations assume that bulk carriers and container ships use heavy fuel oil, and that general cargo ships use gas oil. For further information regarding activity data for local ferries and other national sea transport, please refer to Winther (2008a).

The fleet activity data for regional ferries, and the fleet activity based fuel consumption estimates for local ferries and other national sea transport provided by Winther (2008a) replace the previous fuel based activity data which originated directly from the DEA statistics.

Other sectors

The activity data for military, railways, international sea transport and fishery consists of fuel consumption information from DEA (2010). For international sea transport, the basis is fuel sold in Danish ports for vessels with a foreign destination, as prescribed by the IPCC guidelines.

However, it must be noted that fuel sold for sailing activities between Denmark and Greenland/Faroe Islands are reported as international in the DEA energy statistics. Hence, for inventory purposes in order to follow the IPCC guidelines the bottom-up fuel estimates for the ferry routes Esbjerg/Hanstholm-Torshavn, and fuel reports from Royal Arctic Line and Eim Skip is being subtracted from the fuel sales figures for international sea transport prior to inventory fuel input.

For fisheries, the calculation methodology described by Winther (2008a) remains fuel based. However, the input fuel data differ from the fuel sales figures previously used. The changes are the result of further data processing of the DEA reported gas oil sales for national sea transport and fisheries, prior to inventory input. For years when the fleet activity estimates of fuel consumption for national sea transport (not including trips to Greenland/Faroe Islands) are smaller than DEA reported fuel sold for national sea transport, fuel is added to fisheries in the inventory. In the opposite case, fuel is being subtracted from the original DEA fisheries fuel sales figure in order to make up the final fuel consumption input for fisheries in the inventories.

The updated fuel consumption time-series for national sea transport lead, in turn, to changes in the energy statistics for fisheries (gas oil) and industry (heavy fuel oil), so the national energy balance can remain unchanged.

For all sectors, fuel consumption figures are given in Annex 3.B.14 for the years 1990 and 2009 in CollectER format.

Emission legislation

For the engines used by other mobile sources, no legislative limits exist for specific fuel consumption. And no legislative limits exist for the emissions of CO_2 which are directly fuel dependent. The engines, however, do have to comply with the emission legislation limits agreed by the EU and, except for ships, the VOC emission limits influence the emissions of CH_4, these forming part of total VOC.

For non-road working machinery and equipment, and recreational craft and railway locomotives/motor cars, the emission directives list specific emission limit values (g pr kWh) for CO, VOC, NO_x (or VOC + NO_x) and TSP, depending on engine size (kW for diesel, ccm for gasoline) and date of implementation (referring to engine market date).

For diesel, the directives 97/68 and 2004/26 relate to non-road machinery other than agricultural and forestry tractors, and the directives have different implementation dates for machinery operating under transient and constant loads. The latter directive also comprises emission limits for railway machinery. For tractors the relevant directives are 2000/25 and 2005/13. For gasoline, the directive 2002/88 distinguishes between handheld (SH) and not hand-held (NS) types of machinery.

For engine type approval, the emissions (and fuel consumption) are measured using various test cycles (ISO 8178). Each test cycle consists of a number of measurement points for specific engine loads during constant operation. The specific test cycle used depends on the machinery type in question and the test cycles are described in more details in the directives.

Table 3.3.10 Overview of EU emission directives relevant for diesel fuelled non-road machinery.

Stage/Engine size [kW]	CO	VOC	NO_X	VOC+NO_X	PM	Diesel machinery			Tractors	
							Implement. date		EU	Implement.
	[g pr kWh]					EU Directive	Transient	Constant	directive	date
Stage I										
37<=P<75	6.5	1.3	9.2	-	0.85	97/68	1/4 1999	-	2000/25	1/7 2001
Stage II										
130<=P<560	3.5	1	6	-	0.2	97/68	1/1 2002	1/1 2007	2000/25	1/7 2002
75<=P<130	5	1	6	-	0.3		1/1 2003	1/1 2007		1/7 2003
37<=P<75	5	1.3	7	-	0.4		1/1 2004	1/1 2007		1/1 2004
18<=P<37	5.5	1.5	8	-	0.8		1/1 2001	1/1 2007		1/1 2002
Stage IIIA										
130<=P<560	3.5	-	-	4	0.2	2004/26	1/1 2006	1/1 2011	2005/13	1/1 2006
75<=P<130	5	-	-	4	0.3		1/1 2007	1/1 2011		1/1 2007
37<=P<75	5	-	-	4.7	0.4		1/1 2008	1/1 2012		1/1 2008
19<=P<37	5.5	-	-	7.5	0.6		1/1 2007	1/1 2011		1/1 2007
Stage IIIB										
130<=P<560	3.5	0.19	2	-	0.025	2004/26	1/1 2011	-	2005/13	1/1 2011
75<=P<130	5	0.19	3.3	-	0.025		1/1 2012	-		1/1 2012
56<=P<75	5	0.19	3.3	-	0.025		1/1 2012	-		1/1 2012
37<=P<56	5	-	-	4.7	0.025		1/1 2013	-		1/1 2013
Stage IV										
130<=P<560	3.5	0.19	0.4	-	0.025	2004/26	1/1 2014		2005/13	1/1 2014
56<=P<130	5	0.19	0.4	-	0.025		1/10 2014			1/10 2014

Table 3.3.11 Overview of the EU Emission Directive 2002/88 for gasoline fuelled non-road machinery.

	Category	Engine size [ccm]	CO [g pr kWh]	HC [g pr kWh]	NO_X [g pr kWh]	HC+NO_X [g pr kWh]	Implementation date
	Stage I						
Hand held	SH1	S<20	805	295	5.36	-	1/2 2005
	SH2	20=<S<50	805	241	5.36	-	1/2 2005
	SH3	50=<S	603	161	5.36	-	1/2 2005
Not hand held	SN3	100=<S<225	519	-	-	16.1	1/2 2005
	SN4	225=<S	519	-	-	13.4	1/2 2005
	Stage II						
Hand held	SH1	S<20	805	-	-	50	1/2 2008
	SH2	20=<S<50	805	-	-	50	1/2 2008
	SH3	50=<S	603	-	-	72	1/2 2009
Not hand held	SN1	S<66	610	-	-	50	1/2 2005
	SN2	66=<S<100	610	-	-	40	1/2 2005
	SN3	100=<S<225	610	-	-	16.1	1/2 2008
	SN4	225=<S	610	-	-	12.1	1/2 2007

For recreational craft, Directive 2003/44 comprises the emission legislation limits for diesel engines, and for 2-stroke and 4-stroke gasoline engines, respectively. The CO and VOC emission limits depend on engine size (kW) and the inserted parameters presented in the calculation formulas in Table 3.3.12. For NO_X, a constant limit value is given for each of the three engine types. For TSP, the constant emission limit regards diesel engines only.

Table 3.3.12 Overview of the EU Emission Directive 2003/44 for recreational craft.

Engine type	Impl. date	CO=A+B/P^n			HC=A+B/P^n			NO_X	TSP
		A	B	n	A	B	n		
2-stroke gasoline	1/1 2007	150.0	600.0	1.0	30.0	100.0	0.75	10.0	-
4-stroke gasoline	1/1 2006	150.0	600.0	1.0	6.0	50.0	0.75	15.0	-
Diesel	1/1 2006	5.0	0.0	0	1.5	2.0	0.5	9.8	1.0

Table 3.2.13 Overview of the EU Emission Directive 2004/26 for railway locomotives and motorcars.

	Engine size [kW]		CO [g pr kWh]	HC [g pr kWh]	NO_x [g pr kWh]	HC+NOX [g pr kWh]	PM [g pr kWh]	Implement. date
Locomotives	Stage IIIA							
	130<=P<560	RL A	3.5	-	-	4	0.2	1/1 2007
	560<P	RH A	3.5	0.5	6	-	0.2	1/1 2009
	2000<=P and piston displacement >= 5 l/cyl.	RH A	3.5	0.4	7.4	-	0.2	1/1 2009
	Stage IIIB	RB	3.5	-	-	4	0.025	1/1 2012
Motor cars	Stage IIIA							
	130<P	RC A	3.5	-	-	4	0.2	1/1 2006
	Stage IIIB							
	130<P	RC B	3.5	0.19	2	-	0.025	1/1 2012

Aircraft engine emissions of NO_x, CO, VOC and smoke are regulated by ICAO (International Civil Aviation Organization). The engine emission certification standards are contained in Annex 16 — Environmental Protection, Volume II — Aircraft Engine Emissions to the Convention on International Civil Aviation (ICAO Annex 16, 1993). The emission standards relate to the total emissions (in grams) from the so-called LTO

(Landing and Take Off) cycle divided by the rated engine thrust (kN). The ICAO LTO cycle contains the idealised aircraft movements below 3000 ft (915 m) during approach, landing, airport taxiing, take off and climb out.

For smoke all aircraft engines manufactured from 1 January 1983 have to meet the emission limits agreed by ICAO. For NO_x, CO, VOC The emission legislation is relevant for aircraft engines with a rated engine thrust larger than 26.7 kN. In the case of CO and VOC, the ICAO regulations apply for engines manufactured from from 1 January 1983.

For NO_x, the emission regulations fall in four categories

a) For engines of a type or model for which the date of manufacture of the first individual production model is on or before 31 December 1995, and for which the production date of the individual engine is on or before 31 December 1999.
b) For engines of a type or model for which the date of manufacture of the first individual production model is after 31 December 1995, or for individual engines with a production date after 31 December 1999.
c) For engines of a type or model for which the date of manufacture of the first individual production model is after 31 December 2003.
d) For engines of a type or model for which the date of manufacture of the first individual production model is after 31 December 2007.

The regulations published by ICAO are given in the form of the total quantity of pollutants (D_p) emitted in the LTO cycle divided by the maximum sea level thrust (F_{oo}) and plotted against engine pressure ratio at maximum sea level thrust.

The limit values for NO_x are given by the formular in Table 3.3.14.

Table 3.3.14 Current certification limits for NO_x for turbo jet and turbo fan engines.

	Engines first produced before 31.12.1995 & for engines manufactured up to 31.12.1999	Engines first produced after 31.12.1995 & for engines manufactured after 31.12.1999	Engines for which the date of manufacture of the first individual production model was after 31 December 2003	Engines for which the date of manufacture of the first individual production model was after 31 December 2007
Applies to engines >26.7 kN	$Dp/F_{oo} = 40 + 2\pi_{oo}$	$Dp/F_{oo} = 32 + 1.6\pi_{oo}$		
Engines of pressure ratio less than 30				
Thrust more than 89 kN			$Dp/F_{oo} = 19 + 1.6\pi_{oo}$	$Dp/F_{oo} = 16.72 + 1.4080\pi_{oo}$
Thrust between 26.7 kN and not more than 89 kN			$Dp/F_{oo} = 37.572 + 1.6\pi_{oo} - 0.208F_{oo}$	$Dp/F_{oo} = 38.54862 + (1.6823\pi_{oo}) - (0.2453F_{oo}) - (0.00308\pi_{oo}F_{oo})$
Engines of pressure ratio more than 30 and less than 62.5				
Thrust more than 89 kN			$Dp/F_{oo} = 7+2.0\pi_{oo}$	$Dp/F_{oo} = -1.04+ (2.0*\pi_{oo})$
Thrust between 26.7 kN and not more than 89 kN			$Dp/F_{oo} = 42.71 +1.4286\pi_{oo} -0.4013F_{oo} +0.00642\pi_{oo}F_{oo}$	$Dp/F_{oo} = 46.1600 + (1.4286\pi_{oo}) - (0.5303F_{oo}) - (0.00642\pi_{oo}F_{oo})$
Engines with pressure ratio 82.6 or more			$Dp/F_{oo} = 32+1.6\pi_{oo}$	$Dp/F_{oo} = 32+1.6\pi_{oo}$

Source: International Standards and Recommended Practices, Environmental Protection, ICAO Annex 16 Volume II Part III Paragraph 2.3.2, 2nd edition July 1993, plus amendments: Amendment 3 (20 March 1997),Amendment 4 (4 November 1999),Amendment 5 (24 November 2005).

where:

D_p = the sum of emissions in the LTO cycle in g

F_{oo} = thrust at sea level take-off (100 %)

π_{oo} = pressure ratio at sea level take-off thrust point (100 %)

The equivalent limits for HC and CO are D_p/F_{oo} = 19.6 for HC and D_p/F_{oo} = 118 for CO (ICAO Annex 16 Vol. II paragraph 2.2.2). Smoke is limited to a regulatory smoke number = 83 $(F_{oo})^{-0.274}$ or a value of 50, whichever is the lower.

A further description of the technical definitions in relation to engine certification as well as actual engine exhaust emission measurement data can be found in the ICAO Engine Exhaust Emission Database. The latter database is accessible from http://www.caa.co.uk, hosted by the UK Civil Aviation Authority.

For seagoing vessels, NO_x emissions are regulated as explained in Marpol 73/78 Annex VI, formulated by IMO (International Maritime Organisation). The legislation is relevant for diesel engines with a power output higher than 130 kW, which are installed on a ship constructed on or after 1 January 2000 and diesel engines with a power output higher than 130 kW which undergo major conversion on or after 1 January 2000.

The NO_x emission limits for ship engines in relation to their rated engine speed (n) given in RPM (Revolutions Per Minute) are the following:

- 17 g pr kWh, n < 130 RPM.
- 45 x n-0.2 g pr kWh, 130 ≤ n < 2000 RPM.
- 9,8 g pr kWh, n ≥ 2000 RPM.

Further, the Marine Environment Protection Committee (MEPC) of IMO has approved proposed amendments to MARPOL Annex VI to be agreed by IMO in October 2008 in order to strengthen the emission standards for NO_x and the sulphur contents of heavy fuel oil used by ship engines.

For NO_x emission regulations, a three tiered approach is considered, which comprises the following:

- Tier I: Diesel engines (> 130 kW) installed on a ship constructed on or after 1 January 2000 and prior to 1 January 2011.
- Tier II: Diesel engines (> 130 kW) installed on a ship constructed on or after 1 January 2011.
- Tier III[28]: Diesel engines (> 130 kW) installed on a ship constructed on or after 1 January 2016.

As for the existing NO_x emission limits, the new Tier I-III NO_x legislation values rely on the rated engine speeds. The emission limit equations are shown in Table 3.3.15.

Table 3.3.15 Tier I-III NOx emission limits for ship engines (amendments to MARPOL Annex VI).

	NO_x limit	RPM (n)
Tier I	17 g pr kWh	n < 130
	45 x n-0.2 g pr kWh	130 ≤ n < 2000
	9,8 g pr kWh	n ≥ 2000
Tier II	14.4 g pr kWh	n < 130
	44 x n-0.23 g pr kWh	130 ≤ n < 2000
	7.7 g pr kWh	n ≥ 2000
Tier III	3.4 g pr kWh	n < 130
	9 x n-0.2 g pr kWh	130 ≤ n < 2000
	2 g pr kWh	n ≥ 2000

The Tier I emission limits are identical with the existing emission limits from MARPOL Annex VI.

Also to be agreed by IMO in October 2008, the NO_x Tier I limits are to be applied for existing engines with a power output higher than 5000 kW and a displacement pr cylinder at or above 90 litres, installed on a ship constructed on or after 1 January 1990 but prior to 1 January 2000.

In relation to the sulphur content in heavy fuel and marine gas oil used by ship engines, Table 3.3.16 shows the current legislation in force, and the amendment of MARPOL Annex VI to be agreed by IMO in October 2008.

[28] For ships operating in a designated Emission Control Area. Outside a designated Emission Control Area, Tier II limits apply.

Table 3.3.16 Current legislation in relation to marine fuel quality.

Legislation		Heavy fuel oil		Gas oil	
		S- %	Impl. date (day/month/year)	S- %	Impl. date
EU-directive 93/12		None		0.2[1]	1.10.1994
EU-directive 1999/32		None		0.2	1.1.2000
EU-directive 2005/33[2]	SECA - Baltic sea	1.5	11.08.2006	0.1	1.1.2008
	SECA - North sea	1.5	11.08.2007	0.1	1.1.2008
	Outside SECA's	None		0.1	1.1.2008
MARPOL Annex VI	SECA – Baltic sea	1.5	19.05.2006		
	SECA – North sea	1.5	21.11.2007		
	Outside SECA	4.5	19.05.2006		
MARPOL Annex VI amendments	SECA's	1	01.03.2010		
	SECA's	0.1	01.01.2015		
	Outside SECA's	3.5	01.01.2012		
	Outside SECA's	0.5	01.01.2020[3]		

[1] Sulphur content limit for fuel sold inside EU.

[2] From 1.1.2010 fuel with a sulphur content higher than 0.1 % must not be used in EU ports for ships at berth exceeding two hours

[3] Subject to a feasibility review to be completed no later than 2018. If the conclusion of such a review becomes negative the effective date would default 1 January 2025.

For non road machinery, the EU directive 2003/17/EC gives a limit value of 50 ppm sulphur in diesel (from 2005).

Emission factors

The CO_2 emission factors are country-specific and come from the DEA. The N_2O emission factors are taken from the EMEP/EEA guidebook (EMEP/EEA, 2009).

For military ground material, aggregated CH_4 emission factors for gasoline and diesel are derived from the road traffic emission simulations. The CH_4 emission factors for railways are derived from specific Danish VOC measurements from the Danish State Railways (Delvig, 2010) and a NMVOC/CH_4 split, based on own judgement.

For agriculture, forestry, industry, household gardening and inland waterways, the VOC emission factors are derived from various European measurement programmes and the current EU emission legislation; see IFEU (2004) and Winther et al. (2006). The NMVOC/CH_4 split is taken from USEPA (2004). The baseline emission factors are shown in Annex 3.B.9.

For national sea transport and fisheries, the VOC emission factors come from Trafikministeriet (2000), for the ferries used by Mols Linjen, however, new VOC emission factors are provided by Kristensen (2008). The latter data originate from measurement results by Hansen et al. (2004), Wismann (1999) and PHP (1996).

For ship engines VOC/CH_4 splits are taken from EMEP/EEA (2009), and all emission factors are shown in Annex 3.B.12.

The CH_4 emission factors for domestic aviation come from the EMEP/EEA (2009).

For all sectors, emission factors for the years 1990 and 2009 are given in CollectER format in Annex 3.B.14.

Table 3.3.17 shows the aggregated emission factors for CO_2, CH_4 and N_2O in 2009 used to calculate the emissions from other mobile sources in Denmark.

Table 3.3.17 Fuel-specific emission factors for CO_2, CH_4 and N_2O for other mobile sources in Denmark.

SNAP ID	CRF ID	Category		Fuel type	Emission factors[29] CH_4 g pr GJ	CO_2 g pr GJ	N_2O g pr GJ
080100	1A5	Military		AvGas	21.90	73.00	2.00
080100	1A5	Military		Diesel	2.05	74.00	2.73
080100	1A5	Military		Gasoline	7.54	73.00	1.75
080100	1A5	Military		Jet fuel	2.65	72.00	2.30
080200	1A3c	Railways		Diesel	2.15	74.00	2.04
080300	1A3d	Inland waterways		Diesel	2.64	74.00	2.97
080300	1A3d	Inland waterways		Gasoline	61.52	73.00	1.41
080402	1A3d	National sea traffic		Diesel	1.51	74.00	4.68
080402	1A3d	National sea traffic		Residual oil	1.93	78.00	4.89
080403	1A4c	Fishing		Diesel	1.77	74.00	4.68
080403	1A4c	Fishing		LPG	20.26	65.00	0.00
080404	Memo item	International sea traffic		Diesel	1.75	74.00	4.68
080404	Memo item	International sea traffic		Residual oil	1.92	78.00	4.89
080501	1A3a	Air traffic, Dom. < 3000 ft.	Other airports	AvGas	21.90	73.00	2.00
080501	1A3a	Air traffic, Dom. < 3000 ft.	Other airports	Jet fuel	7.59	72.00	10.85
080502	Memo item	Air traffic, Int. < 3000 ft.	Other airports	AvGas	21.90	73.00	2.00
080502	Memo item	Air traffic, Int. < 3000 ft.	Other airports	Jet fuel	2.45	72.00	7.90
080503	1A3a	Air traffic, Dom. > 3000 ft.	Other airports	Jet fuel	2.06	72.00	2.30
080504	Memo item	Air traffic, Int. > 3000 ft.	Other airports	Jet fuel	0.76	72.00	2.30
080600	1A4c	Agriculture		Diesel	1.00	74.00	3.17
080600	1A4c	Agriculture		Gasoline	160.47	73.00	1.72
080700	1A4c	Forestry		Diesel	0.54	74.00	3.21
080700	1A4c	Forestry		Gasoline	49.79	73.00	0.44
080800	1A2f	Industry		Diesel	1.07	74.00	3.09
080800	1A2f	Industry		Gasoline	108.68	73.00	1.48
080800	1A2f	Industry		LPG	7.69	65.00	3.50
080900	1A4b	Household and gardening		Gasoline	76.04	73.00	1.25
081100	1A4a	Commercial and institutional		Gasoline	70.04	73.00	1.11
080501	1A3a	Air traffic, Dom. < 3000 ft.	Copenhagen	AvGas	21.90	73.00	2.00
080501	1A3a	Air traffic, Dom. < 3000 ft.	Copenhagen	Jet fuel	11.53	72.00	6.46
080502	Memo item	Air traffic, Int. < 3000 ft.	Copenhagen	AvGas	21.90	73.00	2.00
080502	Memo item	Air traffic, Int. < 3000 ft.	Copenhagen	Jet fuel	7.70	72.00	3.87
080503	1A3a	Air traffic, Dom. > 3000 ft.	Copenhagen	Jet fuel	1.92	72.00	2.30
080504	Memo item	Air traffic, Int. > 3000 ft.	Copenhagen	Jet fuel	1.16	72.00	2.30

Factors for deterioration, transient loads and gasoline evaporation for non road machinery

The emission effects of engine wear are taken into account for diesel and gasoline engines by using the so-called deterioration factors. For diesel engines alone, transient factors are used in the calculations, to account

[29] References. CO_2: Country-specific. N_2O: EMEP/CORINAIR. CH_4: Railways: DSB/NERI; Agriculture/Forestry/Industry/Household-Gardening: IFEU/USEPA; National sea traffic/Fishing/International sea traffic: Trafikministeriet/EMEP-CORINAIR; domestic and international aviation: EMEP/CORINAIR.

for the emission changes caused by varying engine loads. The evaporative emissions of NMVOC are estimated for gasoline fuelling and tank evaporation. The factors for deterioration, transient loads and gasoline evaporation are taken from IFEU (2004), and are shown in Annex 3.B.9. For more details regarding the use of these factors, please refer to paragraph 3.1.4 or Winther et al. (2006).

3.3.4 Calculation method

Air traffic

For aviation, the domestic and international estimates are made separately for landing and take-off (LTOs < 3000 ft), and cruising (> 3000 ft).

The fuel consumption for one LTO cycle is calculated according to the following sum formula:

$$FC_{LTO}^{a} = \sum_{m=1}^{4} t_m \cdot ff_{a,m} \quad (13)$$

Where FC = fuel consumption (kg), m = LTO mode (approach/landing, taxiing, take off, climb out), t = times in mode (s), ff = fuel flow (kg pr s), a = representative aircraft type.

The emissions for one LTO cycle are estimated as follows:

$$E_{LTO}^{a} = \sum_{m=1}^{4} FC_{a,m} \cdot EI_{a,m} \quad (14)$$

Due to lack of specific airport data, for approach/descent, take off and climb out, standardised times-in-modes of 4, 0.7 and 2.2 mins are used as defined by ICAO (ICAO, 1995), whereas for taxiing the appropriate time interval is 13 mins in Copenhagen Airport and 5 mins in other airports present in the Danish inventory.

To estimate cruise results, fuel consumption and emissions for standard flying distances from EMEP/EEA (2009) are interpolated or extrapolated – in each case determined by the great circle distance between the origin and the destination airports.

If the great circle distance, y, is smaller than the maximum distance for which fuel consumption and emission data are given in the EMEP/EEA data bank the fuel consumption or emission E (y) becomes:

$$E(y) = E_{x_i} + \frac{(y - x_i)}{x_{i+1} - x_i} \cdot (E_{x_{i+1}} - E_{x_i}) \quad y<x_{max},\ i = 0,1,2\ldots max-1 \quad (15)$$

In (5.3) x_i and x_{max} denominate the separate distances and the maximum distance, respectively, with known fuel use and emissions. If the flight distance y exceeds x_{max} the maximum figures for fuel use and emissions must be extrapolated and the equation then becomes:

$$E(y) = E_{x_{max}} + \frac{(y - x_{max})}{x_{max} - x_{max-1}} \cdot (E_{x_{max}} - E_{x_{max-1}}) \quad y>x_{max} \quad (16)$$

Total results are summed up and categorised according to each flight's airport and country codes.

The overall fuel precision in the model is around 0.8, derived as the fuel ratio between model estimates and statistical sales. The fuel difference is accounted for by adjusting cruising fuel use and emissions in the model according to domestic and international cruising fuel shares.

Prior to 2001, the calculation procedure was first to estimate each year's fuel use and emissions for LTO. Secondly, total cruising fuel use was found year by year as the statistical fuel use total minus the calculated fuel use for LTO. Lastly, the cruising fuel use was split into a domestic and international part by using the results from a Danish city-pair emission inventory in 1998 (Winther, 2001a). For more details of this latter fuel allocation procedure, see Winther (2001b).

Non-road working machinery and recreational craft

Prior to adjustments for deterioration effects and transient engine operations, the fuel use and emissions in year X, for a given machinery type, engine size and engine age, are calculated as:

$$E_{Basis}(X)_{i,j,k} = N_{i,j,k} \cdot HRS_{i,j,k} \cdot P \cdot LF_i \cdot EF_{y,z} \quad (17)$$

where E_{Basis} = fuel use/emissions in the basic situation, N = number of engines, HRS = annual working hours, P = average rated engine size in kW, LF = load factor, EF = fuel use/emission factor in g pr kWh, i = machinery type, j = engine size, k = engine age, y = engine-size class and z = emission level. The basic fuel use and emission factors are shown in Annex 2.B.9.

The deterioration factor for a given machinery type, engine size and engine age in year X depends on the engine-size class (only for gasoline), y, and the emission level, z. The deterioration factors for diesel and gasoline 2-stroke engines are found from:

$$DF_{i,j,k}(X) = \frac{K_{i,j,k}}{LT_i} \cdot DF_{y,z} \quad (18)$$

where DF = deterioration factor, K = engine age, LT = lifetime, i = machinery type, j = engine size, k = engine age, y = engine-size class and z = emission level.

For gasoline 4-stroke engines the deterioration factors are calculated as:

$$DF_{i,j,k}(X) = \sqrt{\frac{K_{i,j,k}}{LT_i}} \cdot DF_{y,z} \quad (19)$$

The deterioration factors inserted in (18) and (19) are shown in Annex 2.B.9. No deterioration is assumed for fuel use (all fuel types) or for LPG engine emissions and, hence, DF = 1 in these situations.

The transient factor for a given machinery type, engine size and engine age in year X, relies only on emission level and load factor, and is denominated as:

$$TF_{i,j,k}(X) = TF_z \quad (20)$$

Where i = machinery type, j = engine size, k = engine age and z = emission level.

The transient factors inserted in (20) are shown in Annex 2.B.9. No transient corrections are made for gasoline and LPG engines and, hence, TF_z = 1 for these fuel types.

The final calculation of fuel use and emissions in year X for a given machinery type, engine size and engine age, is the product of the expressions 17-20:

$$E(X)_{i,j,k} = E_{Basis}(X)_{i,j,k} \cdot TF(X)_{i,j,k} \cdot (1 + DF(X)_{i,j,k}) \quad (21)$$

The evaporative hydrocarbon emissions from fuelling are calculated as:

$$E_{Evap,fueling,i} = FC_i \cdot EF_{Evap,fueling} \quad (22)$$

Where $E_{Evap,fueling}$, = hydrocarbon emissions from fuelling, i = machinery type, FC = fuel consumption in kg, $EF_{Evap,fueling}$ = emission factor in g NMVOC pr kg fuel.

For tank evaporation, the hydrocarbon emissions are found from:

$$E_{Evap,\tan k,i} = N_i \cdot EF_{Evap,\tan k,i} \quad (23)$$

Where $E_{Evap,tank,i}$ = hydrocarbon emissions from tank evaporation, N = number of engines, i = machinery type and $EF_{Evap,fueling}$ = emission factor in g NMVOC pr year.

Ferries, other national sea transport and fisheries

The fuel use and emissions in year X, for regional ferries are calculated as:

$$E(X) = \sum_i N_i \cdot T_i \cdot S_{i,j} \cdot P_i \cdot LF_j \cdot EF_{k,l,y} \quad (24)$$

Where E = fuel use/emissions, N = number of round trips, T = sailing time pr round trip in hours, S = ferry share of ferry service round trips, P = engine size in kW, LF = engine load factor, EF = fuel use/emission factor in g pr kWh, i = ferry service, j = ferry, k = fuel type, l = engine type, y = engine year.

For the remaining navigation categories, the emissions are calculated using a simplified approach:

$$E(X) = \sum_i EC_{i,k} EF_{k,l,y} \quad (25)$$

Where E = fuel use/emissions, EC = energy consumption, EF = fuel use/emission factor in g pr kg fuel, i = category (local ferries, other national sea, fishery, international sea), k = fuel type, l = engine type, y = average engine year.

The emission factor inserted in (25) is found as an average of the emission factors representing the engine ages which are comprised by the average lifetime in a given calculation year, X:

$$EF_{k,l,y} = \frac{\sum_{year=X}^{year=X-LT} EF_{k,l}}{LT_{k,l}} \quad (26)$$

Other sectors

For military and railways, the emissions are estimated with the simple method using fuel-related emission factors and fuel use from the DEA:

$$E = FC \cdot EF \quad (27)$$

where E = emission, FC = fuel consumption and EF = emission factor. The calculated emissions for other mobile sources are shown in CollectER format in Annex 3.B.14 for the years 1990 and 2007 and as time-series 1990-2007 in Annex 3.B.15 (CRF format).

Energy balance: DEA statistics and NERI estimates

Following convention rules, the DEA statistical fuel sales figures are behind the full Danish inventory. However, in some cases for mobile sources the DEA statistical sectors do not fully match the inventory sectors. This is the case for non road machinery, where relevant DEA statistical sectors also include fuel consumed by stationary sources.

In other situations, fuel consumption figures estimated by NERI from specific bottom-up calculations are regarded as more reliable than DEA reported sales. This is the case for national sea transport.

In the following the transferral of fuel consumption data from DEA statistics into inventory relevant categories is explained for national sea transport and fisheries, non road machinery and recreational craft, and road transport. A full list of all fuel consumption data, DEA figures as well as intermediate fuel consumption data, and final inventory input figures is shown in Annex 3.B.13.

National sea transport and fisheries

For national sea transport in Denmark, the fuel consumption estimates obtained by NERI (see 1.1.3 Activity data – national sea transport) are regarded as much more accurate than the DEA fuel sales data, since the large fluctuations in reported fuel sales cannot be explained by the actual development in the traffic between different national ports. As a consequence, the new bottom-up estimates replace the previous fuel based figures for national sea transport.

There are different potential reasons for the differences between estimated fuel consumption and reported sales for national sea transport in Denmark. According to the DEA, the latter fuel differences are most likely explained by inaccurate costumer specifications made by the oil suppliers. This inaccuracy can be caused by a sector misallocation in the sales statistics between national sea transport and fisheries for gas oil, and between national sea transport and industry for heavy fuel oil (Peter Dal, DEA, personal communication, 2007). Further, fuel sold for vessels sailing between Denmark and Greenland/Faroe Islands are reported as international in the DEA statistics, and this fuel categorisation is different from the IPCC guideline definitions (see following paragraph "Bunkers").

Following this, for fisheries and industry the updated fuel consumption time-series for national sea transport lead, in turn, to changes in the fuel activity data for fisheries (gas oil), industry (heavy fuel oil) and international sea transport, so the national energy balance can remain unchanged.

For fisheries, fuel investigations made prior to the initiation of the work made by Winther (2008a) have actually pointed out a certain area of inaccuracy in the DEA statistics. No engines installed in fishing vessels use heavy fuel oil, even though a certain amount of heavy fuel oil is listed in the DEA numbers for some statistical years (H. Amdissen, Danish Fishermen's Association, personal communication, 2006). Hence, for fisheries small amounts of fuel oil are transferred to national sea transport, and in addition small amounts of gasoline and diesel are transferred to recreational craft.

Non road machinery and recreational craft

For diesel and LPG, the non-road fuel consumption estimated by NERI is partly covered by the fuel consumption amounts in the following DEA sectors: agriculture and forestry, market gardening, and building and construction. The remaining quantity of non-road diesel and LPG is taken from the DEA industry sector.

For gasoline, the DEA residential sector, together with the DEA sectors mentioned for diesel and LPG, contribute to the non-road fuel consumption total. In addition, a certain amount of fuel from road transport is needed to reach the fuel consumption goal.

The amount of diesel and LPG in DEA industry not being used by non-road machinery is included in the sectors, "Combustion in manufacturing industry" (0301) and "Non-industrial combustion plants" (0203) in the Danish emission inventory.

For recreational craft, the calculated fuel consumption totals for diesel and gasoline are subsequently subtracted from the DEA fishery sector. For gasoline, the DEA reported fuel consumption for fisheries is far too small to fill the fuel gap, and hence the missing fuel amount is taken from the DEA road transport sector.

Bunkers

The distinction between domestic and international emissions from aviation and navigation should be in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. For the national emission inventory, this, in principle, means that fuel sold (and associated emissions) for flights/sea transportation starting from a seaport/airport in the Kingdom of Denmark, with destinations inside or outside the Kingdom of Denmark, are regarded as domestic or international, respectively.

Aviation

For aviation, the emissions associated with flights inside the Kingdom of Denmark are counted as domestic. The flights from Denmark to Greenland and the Faroe Islands are classified as domestic flights in the inventory background data. In Greenland and in the Faroe Islands, the jet fuel sold is treated as domestic. This decision becomes reasonable when considering that almost no fuel is bunkered in Greenland/the Faroe Islands by flights other than those going to Denmark.

Navigation

In DEA statistics, the domestic fuel total consists of fuel sold to Danish ferries and other ships sailing between two Danish ports. The DEA international fuel total consists of the fuel sold in Denmark to international ferries, international warships, other ships with foreign destinations, transport to Greenland and the Faroe Islands, tank vessels and foreign fishing boats.

In order to follow the IPCC guidelines the bottom-up fuel estimates for the ferry routes between Denmark and the Faroe Islands, and freight transport between Denmark and Greenland/Faroe Islands are being subtracted from the fuel sales figures for international sea transport prior to inventory fuel input.

In Greenland, all marine fuel sales are treated as domestic. In the Faroe Islands, fuel sold in Faroese ports for Faroese fishing vessels and other Faroese ships is treated as domestic. The fuel sold to Faroese ships bunkering outside Faroese waters and the fuel sold to foreign ships in Faroese ports or outside Faroese waters is classified as international (Lastein and Winther, 2003).

Conclusively, the domestic/international fuel split (and associated emissions) for navigation is not determined with the same precision as for aviation. It is considered, however, that the potential of incorrectly allocated fuel quantities is only a small part of the total fuel sold for navigational purposes in the Kingdom of Denmark.

3.3.5 Uncertainties and time-series consistency

Uncertainty estimates for greenhouse gases on Tier 1 and Tier 2 levels, are made for road transport and other mobile sources using the guidelines formulated in the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC, 2000). For road transport, railways and fisheries, these guidelines provide uncertainty factors for activity data that are used in the Danish situation. For other sectors, the factors reflect specific national knowledge (Winther et al., 2006 and Winther, 2008a). These sectors are (SNAP categories): Inland Waterways (a part of 1A3d: Navigation), Agriculture and Forestry (parts of 1A4c: Agriculture-/forestry/fisheries), Industry (mobile part of (1A2f: Industry-other), Residential (1A4b) and National sea transport (a part of 1A3d: Navigation).

The activity data uncertainty factor for civil aviation is based on own judgement.

The calculations for Tier 1 are shown in Annex 3.B.16 for all emission components. Please refer to Chapter 1.7 for further information regarding the calculation procedure for Tier 2 uncertainty calculations.

Table 3.3.18 Tier 1 Uncertainties for activity data, emission factors and total emissions in 2009 and as a trend.

Category	Activity data %	CO_2 %	CH_4 %	N_2O %
Road transport	2	5	40	50
Military	2	5	100	1000
Railways	2	5	100	1000
Navigation (small boats)	41	5	100	1000
Navigation (large vessels)	11	5	100	1000
Fisheries	2	5	100	1000
Agriculture	24	5	100	1000
Forestry	30	5	100	1000
Industry (mobile)	41	5	100	1000
Residential	35	5	100	1000
Commercial/Institutional	35	5	100	1000
Civil aviation	10	5	100	1000
Overall uncertainty in 2009		5.0	27.4	145.8
Trend uncertainty		5.4	4.9	50.7

Table 3.3.19 Tier 2 Uncertainty factors for activity data and emission factors in 2009.

Category	Activity data %	CO_2 %	CH_4 %	N_2O %
Road transport	2	5	40	500
Military	2	5	100	1000
Railways	2	5	100	1000
Pleasure craft	41	5	100	1000
Regional ferries	20	5	100	1000
Local ferries	20	5	100	1000
Fisheries	2	5	100	1000
Greenland & Faroe Islands	20	5	100	1000
Other national sea transport	20	5	100	1000
Civil aviation	10	5	100	1000
Agriculture	24	5	100	1000
Forestry	30	5	100	1000
Industry	41	5	100	1000
Household and gardening	35	5	100	1000
Commercial and institutional	35	5	100	1000

Table 3.3.20 Tier 2 Uncertainty estimates for CO_2, CH_4, N_2O and CO_2-eq. in 2009.

		1990			2009			1990-2009		
		Median	Uncertainty (%)		Median	Uncertainty (%)		Median	Uncertainty (%)	
		Emission	Lower (-)	Upper (+)	Emission	Lower (-)	Upper (+)	Emission	Lower (-)	Upper (+)
CO_2	ktonnes	13625	5	5	16210	5	5	19	7	6
CH_4	tonnes	2966	29	40	1200	26	36	-59	34	48
N_2O	Tonnes	704	45	199	771	42	171	10	150	360
CO_2-eq.	Ktonnes	13934	5	6	16502	5	5	18	7	7

As regards time-series consistency, background flight data cannot be made available on a city-pair level prior to 2000. However, aided by LTO/aircraft statistics for these years and the use of proper assumptions, a sound level of consistency is, in any case, obtained for this part of the transport inventory.

The time-series of emissions for mobile machinery in the agriculture, forestry, industry, household and gardening (residential) and inland waterways (part of navigation) sectors are less certain than time-series for other sectors, since DEA statistical figures do not explicitly provide fuel consumption information for working equipment and machinery.

3.3.6 Quality assurance/quality control (QA/QC)

The intention is to publish every second year a sector report for road transport and other mobile sources. The last sector report prepared concerned the 2006 inventory (Winther, 2008).

The QA/QC descriptions of the Danish emission inventories for transport follow the general QA/QC description for NERI in Section 1.6, based on the prescriptions given in the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC, 2000).

An overview diagram of the Danish emission inventory system is presented in Figure 1.2 (Data storage and processing levels), and the exact definitions of Critical Control Points (CCP) and Points of Measurements (PM) are given in Section 1.6. The status for the PMs relevant for the mobile sector are given in the following text and the result of this investigation indicates a need for future QA/QC activities in order to fulfil the QA/QC requirements from the IPCC GPG.

Data storage level 1

Data Storage level 1	3.Completeness	DS.1.3.1	Documentation showing that all possible national data sources are included by setting down the reasoning behind the selection of datasets.

The following external data sources are used in the mobile part of the Danish emission inventories for activity data and supplementary information:

- Danish Energy Authority: Official Danish energy statistics.
- National sea transport (Royal Arctic Line, Eim Skip): Annual fuel consumption data.

- DTU Transport: Road traffic vehicle fleet and mileage data.
- Civil Aviation Agency of Denmark: Flight statistics.
- Non-road machinery: Information from statistical sources, research organisations, different professional organisations and machinery manufacturers.
- Ferries (Statistics Denmark): Data for annual return trips for Danish ferry routes.
- Ferries (Danish Ferry Historical Society): Detailed technical and operational data for specific ferries.
- Ferries (Mols Linjen, Bornholmstrafikken, Langelandstrafikken, Smyril Line): Detailed technical and operational data for specific ferries.
- Danish Meteorological Institute (DMI): Temperature data.
- The National Motorcycle Association: 2-wheeler data.

The emission factors come from various sources:
- Danish Energy Authority: CO_2 emission factors and lower heating values (all fuel types).
- COPERT IV: Road transport (all exhaust components, except CO_2, SO_2).
- Danish State Railways: Diesel locomotives (NO_X, VOC, CO and TSP).
- EMEP/EEA guidebook: Civil aviation and supplementary.
- Non road machinery: References given in NERI reports.
- National sea transport and fisheries: TEMA2000 (NO_X, VOC, CO and TSP) and MAN Diesel (sfc, NO_X).

Table 3.3.21 to follow contains Id, File/Directory/Report name, Description, Reference and Contacts. As regards File/Directory/Report name, this field refers to a file name for Id when all external data (time-series for the existing inventory) are stored in one file. In other cases, a computer directory name is given when the external data used are stored in several files, e.g. each file contains one inventory year's external data or each file contains time-series of external data for sub-categories of machinery. A third situation occurs when the external data are published in publicly available reports; here the aim is to obtain electronic copies for internal archiving.

Table 3.3.21 Overview table of external data for transport.

Id no	File/-Directory/-Report name	Description	Activity data or emission factor	Reference	Contacts	Data agreement
T1	Transport energy[1]	Dataset for all transport energy use	Activity data	The Danish Energy Authority (DEA)	Peter Dal	Yes
T2	Fleet and mileage data[1]	Road transport fleet and mileage data	Activity data	DTU Transport	Thomas Jensen	Yes
T3	Flight statistics[2]	Data records for all flights	Activity data	Civil Aviation Agency of Denmark	Jess Nørgaard	Yes
T4	Non road machinery[2]	Stock and operational data for non-road machinery	Activity data	Non road Documentation report	Morten Winther	No
T5	Emissions from ships[3]	Data for ferry traffic	Activity data	Statistics Denmark	Sonja Merkelsen	No
T6	Emissions from ships[3]	Technical and operational data for Danish ferries	Activity data	Navigation emission documentation report	Hans Otto Kristensen	No
T7	Temperature data[3]	Monthly avg of daily max/min temperatures	Other data	Danish Meteorological Institute	Danish Meteorological Institute	No
T8	Fleet and mileage data[1]	Stock data for mopeds and motorcycles	Activity data	The National Motorcycle Association	Henrik Markamp	No
T9	CO_2 emission factors[1]	DEA CO_2 emission factors (all fuel types)	Emission factor	The Danish Energy Authority (DEA)	Peter Dal	No
T10	COPERT IV emission factors[3]	Road transport emission factors	Emission factor	Laboratory of applied thermodynamics Aristotle University Thessaloniki	Leonidas Ntziachristos	No
T11	Railways emission factors[1]	Emission factors for diesel locomotives	Emission factor	Danish State Railways	Per Delvig	Yes
T12	EMEP/EEA guidebook[3]	Emission factors for navigation, civil aviation and supplementary	Emission factor	European Environment Agency	European Environment Agency	No
T13	Non road emission factors[3]	Emission factors for agriculture, forestry, industry and household/gardening	Emission factor	Non road Documentation report	Morten Winther	No
T14	Emissions from ships[3]	Emission factors for national sea transport and fisheries	Emission factor	Navigation emission documentation report	Morten Winther	No

1) File name; 2) Directory in the NERI data library structure; 3) Reports available on the internet.

Danish Energy Authority (energy statistics)

The official Danish energy statistics are provided by the Danish Energy Authority (DEA) and are regarded as complete on a national level. For most transport sectors, the DEA subsector classifications fit the SNAP classifications used by NERI.

For non-road machinery, this is however not the case, since DEA do not distinguish between mobile and stationary fuel consumption in the subsectors relevant for non-road mobile fuel consumption.

Here, NERI calculates a bottom-up non-road fuel consumption estimate and for diesel (land based machinery only) and LPG, the residual fuel quantities are allocated to stationary consumption. For gasoline (land-based machinery) the relevant fuel consumption quantities for the DEA are smaller than the NERI estimates, and the amount of fuel consumption missing is subtracted from the DEA road transport total to account for all fuel sold. For recreational craft, no specific DEA category exists and, in this case, the gasoline and diesel fuel consumption is taken from road transport and fisheries, respectively.

In the case of Danish national sea transport, fuel consumption estimates are obtained by NERI (Winther, 2008a), since they are regarded as much more accurate than the DEA fuel sales data. For the latter source, the large fluctuations in reported fuel sales cannot be explained by the actual development in the traffic between different national ports.

In order to maintain the national energy balance, the updated fuel consumption time-series for national sea transport lead, in turn, to changes in the fuel activity data for fisheries (gas oil) and industry (heavy fuel oil).

The NERI fuel modifications, thus, give DEA-SNAP differences for road transport, national sea transport and fisheries.

A special note must be made for the DEA civil aviation statistical figures. The domestic/international fuel consumption division derives from bottom-up fuel consumption calculations made by NERI.

DTU Transport

Figures for fleet numbers and mileage data are provided by DTU Transport on behalf of the Danish Ministry of Transport. Following the data deliverance contract between NERI and the Danish Ministry of Transport, it is a basic task for DTU Transport to possess comprehensive information on Danish road traffic. The fleet figures are based on data from the Car Register, kept by Statistics Denmark and are, therefore, regarded as very precise. Annual mileage information comes from the Danish Vehicle Inspection and Maintenance Programme.

Civil Aviation Agency of Denmark

The Civil Aviation Agency of Denmark (CAA-DK) monitors all aircraft movements in Danish airspace and, in this connection, possesses data records for all take-offs and landings at Danish airports. The dataset from 2001 onwards, among others consisting of aircraft type and origin and destination airports for all flights leaving major Danish airports, are, therefore, regarded as very complete. For inventory years before 2001, the most accurate data contain CAA-DK total movements from major Danish airports and detailed aircraft type distributions for aircraft using Copenhagen Airport, provided by the airport itself.

Non-road machinery (stock and operational data)

A great deal of new stock and operational data for non road machinery was obtained in a research project carried out by Winther et al. (2006) for the 2004 inventory. The source for the agricultural machinery stock of tractors and harvesters is Statistics Denmark. Sales figures for tractors, harvesters and construction machinery, together with operational data and supplementary information, are obtained from The Association of Danish Agricultural Machinery Dealers. IFAG (The Association of Producers and Distributors of Fork Lifts in Denmark) provides fork-lift sale figures, whereas total stock numbers for gasoline equipment are obtained from machinery manufacturers with large Danish market shares, with figures validated through discussions with KVL. Stock information disaggregated into vessel types for recreational craft was obtained from the Danish Sailing Association. A certain part of the operational data comes from previous Danish non-road research projects (Dansk Teknologisk Institut, 1992 and 1993; Bak et al., 2003).

No statistical register exists for non-road machinery types and this affects the accuracy of stock and operational data. For tractors and harvesters, Statistics Denmark provide total stock data based on information from questionnaires and the registers of crop subsidy applications kept by the Ministry of Food, Agriculture and Fishery. In combination with new sales figures pr engine size from The Association of Danish Agricultural Machinery Dealers, the best available stock data are obtained. In addition, using the sources for construction machinery and fork lift sale figures are regarded as the only realistic approach for consolidated stock information for these machinery types. Use of this source-type also applies in the case of machinery types (gasoline equipment, recreational craft) where data is even scarcer.

To support the 2008 inventory, new 2008 stock data for tractors, harvesters, fork lifts and construction machinery was obtained from the same sources as in Winther et al. (2006). For non-road machinery in general, it is, however, uncertain if data in such a level can be provided annually in the future.

Ferries (Statistics Denmark)

Statistics Denmark provides information of annual return trips for all Danish ferry routes from 1990 onwards. The data are based on monthly reports from passenger and ferry shipping companies in terms of transported vehicles passengers and goods. Thus, the data from Statistics Denmark are regarded as complete. Most likely the data can be provided annually in the future.

Ferries (Danish Ferry Historical Society, DFS)

No central registration of technical and operational data for Danish ferries and ferry routes is available from official statistics. However, one valuable reference to obtain data and facts about construction and operation of Danish ferries, especially in the recent 20 - 30 years is the archives of Danish Ferry Historical Society. Pure technical data has not only been obtained from this society´s archives, but some of the knowledge has been obtained through the personal insight about ferries from some of the members of the society, which have been directly involved in the ferry business for example consultants, naval architects, marine engineers, captains and superintendents. However, until recently no documentation of the detailed DFS knowledge was established in terms of written reports or a central database system.

To make use of all the ferry specific data for the Danish inventories, DSF made a data documentation for the years 1990-2005 as a specific task of the research project carried out by Winther (2008a).

Ferries (Mols Linjen, Bornholmstrafikken, Langelandstrafikken, Smyril Line)

For the years 2006+, the major Danish ferry companies are contacted each year in order to obtain ferry technical data, relating to specific ferries in service, annual share of total round trips and other technical information. The relevant annual information is given as personal communication, a method which can be repeated in the future.

National sea transport (Royal Arctic Line, Eim Skip)

For the years 2006+, the major shipping companies with frequent sailing activities between Denmark and Greenland/Faroe Islands are contacted each year in order to obtain data for fuel sold in Denmark used for these vessel activities. The relevant annual information is given as personal communication, a method which can be repeated in the future.

Danish Meteorological Institute

The monthly average max/min temperature for Denmark comes from DMI. This source is self explanatory in terms of meteorological data. Data are publicly available for each year on the internet.

The National Motorcycle Association

Road transport: 2-wheeler stock information (The National Motorcycle Association). Given that no consistent national data are available for mopeds in terms of fleet numbers and distributions according to new sales pr year, The National Motorcycle Association is considered to be the professional organisation, where most expert knowledge is available. The relevant annual information is given as personal communication, a method which can be repeated in the future.

Danish Energy Authority (CO_2 emission factors and lower heating values)

The CO_2 emission factors and lower heating values (LHV) are fuel-specific constants. The country-specific values from the DEA are used for all inventory years.

COPERT IV

COPERT IV provides factors for fuel consumption and for all exhaust emission components which are included in the national inventory. For several reasons, COPERT IV is regarded as the most appropriate source of road traffic fuel consumption and emission factors. First of all, very few Danish emission measurements exist, so data are too scarce to support emission calculations on a national level. Secondly, most of the fuel consumption and emission information behind the COPERT model are derived from different large European research activities, and the formulation of fuel consumption and emission factors for all single vehicle categories has been made by a group of road traffic emission experts. A large degree of internal consistency is, therefore, achieved. Finally, the COPERT model is regularly updated with new experimental findings from European research programmes and, apart from updated fuel consumption and emission factors, the use of COPERT IV by many European countries ensures a large degree of cross-national consistency in reported emission results.

Danish State Railways

Aggregated emission factors of NO_x, VOC, CO and TSP for diesel locomotives are provided annually by the Danish State Railways. Taking into account available time resources for subsector emission calculations, the use of data from Danish State Railways is sensible. This operator accounts for around 90 % of all diesel fuel consumed by railway locomotives in Denmark and the remaining diesel fuel is used by various private railways companies. Setting up contacts with the private transport operators is considered to be a rather time consuming experience taking time away from inventory work in areas of greater emission importance.

EMEP/EEA guidebook

Fuel consumption and emission data from the EMEP/EEA guidebook is the prime and basic source for the aviation and navigation part of the Danish emission inventories. For aviation, the guidebook contains the most comprehensive list of representative aircraft types available for city-pair fuel consumption and emission calculations. The data have been evaluated specifically for detailed national inventory use by a group of experts representing civil aviation administration, air traffic management, emission modellers and inventory workers.

In addition, the EMEP/EEA guidebook is the source of non-exhaust TSP, PM_{10} and $PM_{2.5}$ emission factors for road transport, and the primary source of emission factors for some emission components – typically N_2O, NH_3 and PAH – for other mobile sources.

Non-road machinery (fuel consumption and emission factors)

The references for non-road machinery fuel consumption and emission factors are listed in Winther et al. (2006). The fuel consumption and emission data is regarded as the most comprehensive data collection on a European level, having been thoroughly evaluated by German emission measurement and non-road experts within the framework of a German non-road inventory project.

National sea transport and fisheries

Emission factors for NO_X, VOC, CO and TSP are taken from the TEMA2000 model developed for the Ministry of Transport. To a large extent the emission factors originate from the exhaust emission measurement programme carried out by Lloyd's (1995). For NO_X, additional information of emission factors in a time-series going back to 1949, and PM_{10} and $PM_{2.5}$ fractions of total TSP was provided by the engine manufacturer MAN Diesel.

Specifically for the ferries used by Mols Linjen new NO_x , VO and CO emission factors are provided by Kristensen (2008), originating from measurement results by Hansen et al. (2004), Wismann (1999) and PHP (1996).

The experimental work by Lloyd's is still regarded as the most comprehensive measurement campaign with results publicly available. The additional NO_X and $PM_{10}/PM_{2.5}$ information comes from the world's largest ship engine manufacturer and data from this source is consistent with data from Lloyd's. Consequently the data used in the Danish inventories for national sea transport is regarded as the best available for emission calculations.

Data Storage level 1	1. Accuracy	DS.1.1.1	General level of uncertainty for every dataset, including the reasoning for the specific values

The uncertainty involved in the DEA fuel consumption information (except civil aviation) and the CAA-DK flight statistics is negligible, as such, and this is also true for DMI temperature data. For civil aviation, some uncertainty prevails, since the domestic fuel consumption figures originate from a division of total jet-fuel sales figures into domestic and international fuel quantities, derived from bottom-up calculations. A part of the fuel consumption uncertainties for non-road machines is due to the varying levels of stock and operational data uncertainties, as explained in DS 1.3.1. The road transport fleet totals from DTU Transport and The National Motorcycle Association in the main vehicle categories are accurate. Uncertainties, however, are introduced when the stock data are split into vehicle subcategories. The mileage figures from DTU Transport are generally less certain and uncertainties tend to increase for disaggregated mileage figures on subcategory levels.

As regards emission factors, the CO_2 factors (and LHVs) from the DEA are considered to be very precise, since they relate only to fuel. For the remaining emission factor sources, the SO_2 (based on fuel sulphur content), NO_X, NMVOC, CH_4, CO, TSP, PM_{10} and $PM_{2.5}$ emission factors are less accurate. Though many measurements have been made, the experimental data rely on the individual measurement and combustion conditions. The uncertainties for N_2O and NH_3 emission factors increase even further due to the small number of measurements available. For heavy metals and PAH, experimental data are so scarce that uncertainty becomes very high.

A special note, however, must be made for energy. The uncertainties due to the subsequent treatment of DEA data for road transport, national sea transport, fisheries and the non-road relevant sectors, explained in DS 1.3.1, trigger some uncertainties in the fuel consumption figures for these sectors. This point is, though, more relevant for QA/QC description for data processing, Level 1.

Data Storage level 1	1. Accuracy	DS.1.1.2	Quantification of the uncertainty level of every single data value including the reasoning for the specific values.

The general uncertainties of the DEA fuel consumption information, DMI temperature data, road transport stock totals and the CAA-DK flight statistics are zero. For domestic aviation fuel consumption, the uncertainty is based on own judgement. For road transport, military and railways the fuel consumption uncertainties are taken from the IPCC Good Practice Guidance manual. It is noted that for road transport, it is not possible to quantify in-depth the uncertainties (1) of stock distribution into COPERT IV-relevant vehicle subsectors and (2) of the national mileage figures, as such.

For non-road machinery stock and operational data, the uncertainty figures are given in Winther et al. (2006). For navigation, the uncertainty figures are given in Winther (2008b).

For emission factors, the uncertainties for mobile sources are determined as suggested in the IPCC and UNECE guidelines. The uncertainty figures are listed in Paragraph 1.1.5 for greenhouse gases, and in Nielsen et al. (2009), Winther et al. (2006) and Winther (2008b) for the remaining emission components.

Data Storage level 1	2.Comparability	DS.1.2.1	Comparability of the data values with similar data from other countries, which are comparable with Denmark, and evaluation of discrepancy.

Work has been carried out to compare Danish figures with corresponding data from other countries in order to evaluate discrepancies. The comparisons have been made on a CRF level, mostly for implied emission factors (Fauser et al., 2007).

Data Storage level 1	4.Consistency	DS.1.4.1	The origin of external data has to be preserved whenever possible without explicit arguments (referring to other PMs)

It is ensured that the original files from external data sources are archived internally at NERI. Subsequent raw data processing is carried out either in the NERI database models or in spreadsheets (data processing level 1).

Data Storage level 1	6.Robustness	DS.1.6.1	Explicit agreements between the external institution holding the data and NERI about the condition of delivery

For transport, NERI has made formal agreements with regard to external data deliverance with (Table 3.3.21 external data source Id's in brackets): DEA (T1), CAA-DK (T3), Danish State Railways (T9) and DTU Transport (T2).

Data Storage level 1	7.Transparency	DS.1.7.1	Summary of each dataset, including the reasoning for selecting the specific dataset

Please refer to DS 1.1.1. In this measurement point, the reason for external data selections in different inventory areas is given.

Data Storage level 1	7.Transparency	DS.1.7.3	References for citation for any external dataset have to be available for any single value in any dataset.

The references for external datasets are provided in the present report.

Data Storage level 1	7.Transparency	DS.1.7.4	Listing of external contacts for every dataset

The following list shows the external data source (source Id in brackets), the responsible person and contact information for each area where formal data deliverance agreements have been made.

- Danish Energy Authority (T1): Peter Dal (pd@ens.dk)
- DTU Transport (T2): Thomas Jensen (tcj@vd.dk)
- Civil Aviation Agency of Denmark (T3): Jess Nørgaard (jeno@slv.dk)

- Danish State Railways (T9): Per Delvig (pede@dsb.dk)

Data Processing Level 1

Data Processing level 1	1. Accuracy	DP.1.1.1	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to type of variability. (Distribution as: normal, log normal or other type of variability)

In the mobile part of the Danish emission inventories, uncertainty assessments are made at Data Processing Level 1 for non-road machinery, recreational craft and national sea transport. For these types of mobile machinery, the stock and operational data variations are assumed to be normally distributed (Winther et al., 2006; Winther, 2008a). Tier 1 uncertainty calculations produce final fuel consumption uncertainties ready for Data Storage Level 2 (SNAP level 2: Inland waterways, agriculture, forestry, industry and household-gardening).

Data Processing level 1	1. Accuracy	DP.1.1.2	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to scale of variability (size of variation intervals)

For non-road machinery, recreational craft and national sea transport, uncertainty assessments are made by Winther et al. (2006) and Winther (2008a), and the sizes of the variation intervals are given for activity data and emission factors.

Data Processing level 1	1. Accuracy	DP.1.1.3	Evaluation of the methodological approach using international guidelines

An evaluation of the methodological inventory approach has been made, which proves that the emission inventories for transport are made according to the international guidelines (Winther, 2005: Kyoto notat, in Danish). This paper will be translated into English and the conclusions will be implemented in the future national inventory reports.

Data Processing level 1	1. Accuracy	DP.1.1.4	Verification of calculation results using guideline values

It has been checked that the greenhouse gas emission factors used in the Danish inventory are within margin of the IPCC guideline values.

Data Processing level 1	2.Comparability	DP.1.2.1	The inventory calculation has to follow the international guidelines suggested by UNFCCC and IPCC.

See DP 1.1.3.

Data Processing level 1	3.Completeness	DP.1.3.1	Assessment of the most important quantitative knowledge which is lacking.

Data Processing level 1	3.Completeness	DP.1.3.2	Assessment of the most important cases where access is lacking with regard to critical data sources that could improve quantitative knowledge.

No important areas can be identified.

Data Processing level 1	4.Consistency	DP.1.4.1	In order to keep consistency at a high level, an explicit description of the activities needs to accompany any change in the calculation procedure.

Se DP 1.7.5.

Data Processing level 1	5.Correctness	DP.1.5.1	Show at least once, by independent calculation, the correctness of every data manipulation.

During model development it has been checked that all mathematical model relations give exactly the same results as independent calculations.

Data Processing level 1	5.Correctness	DP.1.5.2	Verification of calculation results using time-series

Data Processing level 1	5.Correctness	DP.1.5.3	Verification of calculation results using other measures

When NERI transport model changes are made relating to fuel consumption, it is checked that the calculated fuel consumption sums correspond to the expected fuel consumption levels in the time-series. The fuel consumption check also includes a time-series comparison with fuel consumption totals calculated in the previous model version. The checks are performed on a SNAP level and, if appropriate, detailed checks are made for vehicle/machinery technology splits.

As regards model changes in relation to derived emission factors (and calculated emissions), the time-series of emission factors (and emissions) are compared to previous model figures. A part of this evaluation includes an assessment, if the development corresponds to the underlying assumptions given by detailed input parameters. Among other things, the latter parameters depend on emission legislation, new technology phase-in, deterioration factors, engine operational conditions/driving modes, gasoline evaporation (hydrocarbons) and cold starts. For methodological issues, please refer to Section 3.3.2.

Data Processing level 1	5.Correctness	DP.1.5.4	Show one-to-one correctness between external data sources and the data bases at Data Storage level 2

For road transport, aviation and non-road machinery, whether all external data are correctly put into the NERI transport models is checked. This is facilitated by the use of sum queries which sum up stock data (and mileages for road transport) to input aggregation levels. However, spreadsheet or database manipulations of external data are, in some cases, included in a step prior to this check.

This is carried out in order to produce homogenous input tables for the NERI transport models (road, civil aviation, non-road machinery/recreational craft, navigation/fisheries). The sub-routines perform operations, such as the aggregation/disaggregation of data into first sales year (Examples: Fleet numbers and mileage for road transport, stock numbers for tractors, harvesters and fork lifts) or simple lists of total stock pr year (per machinery type for e.g. household equipment and for recreational craft). For civil aviation, additional databases control the allocation of representative aircraft to real aircraft types and the cruise distance between airports. A more formal description of the sub-routines will be made.

Regarding fuel data, it is checked for road transport and civil aviation that DEA totals (modified for road) match the input values in the NERI models. For the transport modes military and railways, the DEA fuel consumption figures go directly into Data Storage Level 2. This is also the case for the railway emission factors obtained from Danish State Railways and, generally, for the emission factors which are kept constant over the years.

The NERI model simulations of fuel consumption and emission factors for road transport, civil aviation and non-road machinery refer to Data Processing Level 1.

Data Processing level 1	7.Transparency	DP.1.7.1	The calculation principle and equations used must be described
Data Processing level 1	7.Transparency	DP.1.7.2	The theoretical reasoning for all methods must be described
Data Processing level 1	7.Transparency	DP.1.7.3	Explicit listing of assumptions behind all methods

The NERI model calculation principles and basic equations are thoroughly described in the present report, together with the theoretical model reasoning and assumptions. Documentation is also given e.g. in Nielsen et al. (2009), Winther (2001, 2007, 2008) and Winther et al. (2006). Further formal descriptions of NERI model sub routines are given in internal notes, and flow maps show the interrelations between tables and calculation queries in the models.

Data Processing level 1	7.Transparency	DP.1.7.4	Clear reference to dataset at Data Storage level 1.

In the different documentation reports for transport in the Danish emission inventories, there are explicit references for the different external data used.

Data Processing level 1	7.Transparency	DP.1.7.5	A manual log to collect information about recalculations

Recalculation changes in the emission inventories are described in the NIR and ECE reports as a standard. These descriptions take into account changes in emission factors, activity data and calculation methods.

Data Storage Level 2

Data Storage level 2	5.Correctness	DS.2.5.1	Documentation of a correct connection between all data types at level 2 to data at level 1

In the various documentation reports behind the transport part of the Danish emission inventories there is a thorough documentation of the

SNAP aggregated fuel consumption figures and emission factors, based on the original external data derived from external sources.

Data Storage level 2	5.Correctness	DS.2.5.2	Check if a correct data import to level 2 has been made.

At present, a NERI software programme imports data from prepared input data tables (SNAP fuel consumption figures and emission factors) into the CollectER database.

Tables for CollectER fuel consumption and emission results are prepared by a special NERI database (NERIrep.mdb). The results relevant for mobile sources are copied into a database containing all the official inventory results for mobile sources (Data2008 NIR-UNECE.mdb). By the use of database queries, the results from this latter database are aggregated into the same formats as being used by the relevant NERI transport models in their results calculation part. The final comparison between CollectER and NERI transport model results are set up in a spreadsheet.

Suggested QA/QC plan for mobile sources

The following points make up the list of QA/QC tasks to be carried out directly in relation to the mobile part of the Danish emission inventories. The time plan for the individual tasks has not yet been prepared.

Data storage level 1

- An elaboration of the PAH part of the inventory for mobile sources. Review of existing emission factors and inclusion of new sources.

3.3.7 Recalculations and improvements

The following recalculations and improvements of the emission inventories have been made since the emission reporting in 2009.

Road transport

The total mileage per vehicle category from 2005-2008 have been updated based on new data prepared by DTU Transport. More accurate fleet and mileage figures are provided by the latter institution, split into the different vehicle layers of the emission model. An important change is the categorisation of fleet data for heavy duty trucks and buses into the numerous weight classes covered by the COPERT IV model.

The minimum and maximum percentage difference and year of numeric maximum differences (min %, max %, year of max %) for the different emission components are: CO_2 (-0.081%, 0.082 %, 1993), CH_4 (-1.3 %, -17.9 %, 2008) and N_2O (-4.6 %, 3.7 %, 1991).

National sea transport

Fuel consumption by vessels sailing between Denmark and Greenland/Faroe Islands, and between Denmark and the North Sea off shore installations has been added to this category. Previously this fuel consumption was reported under international sea transport. The corresponding minimum and maximum percentage difference and year of numeric maximum differences (min %, max %, year of max %) for the different emission components are: CO_2 (9.2 %, 30.8 %, 2008), CH_4 (4.6 %, 10.7 %, 2008) and N_2O (9.6 %, 34.0 %, 2008).

Fisheries

Due to the changes made in national sea transport, and the fuel transferral between national sea transport and fisheries made as an integral part of the Danish inventories, significant fuel consumption and emission changes have been made for the fishery sector accordingly, for 2001 onwards. The corresponding minimum and maximum percentage difference and year of numeric maximum differences (min %, max %, year of max %) are (27 %, 39 %, 2006), for all emission components.

Agriculture

The stock of harvesters have been updated for the years 2001-2008, based on discussions with the Danish Knowledge Centre for Agriculture. For gasoline fuelled ATV's the stock has been updated for 2007 and 2008. The changes in fuel consumption and emissions are between 0 and 2 % for CO_2 and N_2O, whereas for CH_4 the emission changes are 12 % and 21 %, in 2007 and 2008 respectively.

Agriculture/forestry/fisheries

The total consequences for agriculture/forestry/fisheries, expressed as minimum and maximum percentage difference and year of numeric maximum differences (min %, max %, year of max %) for the different emission components are: CO_2 (9.6 %, 12.1 %, 2006), CH_4 (4.0 %, 21.7 %, 2008) and N_2O (12.4 %, 15.5 %, 2008).

Military

Emission factors derived from the new road transport simulations have caused some emission changes from 1985-2008. The minimum and maximum emission differences (min %, max %) for the different emission components are: CH_4 (-1 %, -16 %) and N_2O (-4 %, 1 %).

Residential

A split in activity codes has been made. In this way the majority of the fuel consumption and emissions previously reported under residential (SNAP code 0809; NFR code 1A4b) are now reported under commercial/institutional (SNAP code 0811; NFR code 1A4a ii).

No changes have been made in the estimated fuel consumption and emissions for Residential and Commercial/institutional as a sum.

Commercial/institutional

A split in activity codes has been made. The majority of the fuel consumption and emissions previously reported under residential (SNAP code 0809; NFR code 1A4b) are now reported under commercial/institutional (SNAP code 0811; NFR code 1A4a ii).

No changes have been made in the estimated fuel consumption and emissions for Residential and Commercial/institutional as a sum.

Industrial non road machinery

The annual working hours for fork lifts in 2008 have been adjusted with a factor of 0.95 due to the decrease in activities caused by the global financial crisis. The total fuel consumption and emission changes in 2008 for industrial non road machinery are approximately -1 %.

Railways
No changes have been made.

Aviation
Very small emission changes between -2 % and 1 % occur for the years 2001-2008, due to inclusion of new aircraft types assigned to the representative aircraft types.

3.3.8 Planned improvements

The ongoing aspiration is to fulfil the requirements from UNECE and UNFCCC for good practice in inventory preparation for transport. A study has been completed for transport, reviewing the different issues of choices relating to methods (methods used, emission factors, activity data, completeness, time-series consistency, uncertainty assessment) reporting and documentation, and inventory quality assurance/quality control. This work and the overall priorities of NERI, taking into account emission source importance (from the Danish 2009 key source analysis), background data available and time resources, lay down the following list of improvements to be made in future.

Emission factors
Fuel consumption factors for road transport vehicles will be updated by the time when new data becomes available from COPERT model updates.

QA/QC
Future improvements regarding this issue are dealt with in Section 3.1.4.

References for Chapter 3.3

Cappelen, J. 2010: The Climate of Denmark 2009, with Thorshavn, Faroe Islands and Nuuk, Greenland - with English translations, Technical report No 10-01, pp. 66, Danish Meteorological Institute.

Dávastovu, Jógvan í (2010): Unpublished data material from Smyril Line.

Danish Energy Authority, 2010: The Danish energy statistics, Available at http://www.ens.dk/en-US/Info/FactsAndFigures/Energy_statistics_and_indicators/Annual%20Statistics/Sider/Forside.aspx (02-02-2011).

Delvig, P. 2010: Unpublished data material from the Danish State Railways.

Ekman, B. 2005: Unpublished data material from the Danish Road Directorate.

EMEP/EEA, 2009: Air Pollutant Emission Inventory Guidebook, prepared by the UNECE/EMEP Task Force on Emissions Inventories and Projections (TFEIP). Available at http://www.eea.europa.eu/publications/emep-eea-emission-inventory-guidebook-2009 (02-02-2011).

Fauser, P., Thomsen, M., Nielsen, O.K., Winther, M., Gyldenkærne, S., Hoffmann, L., Lyck, E. & Illerup, J.B. 2007: Verification of the Danish emission inventory data by national and international data comparisons. National Environmental Research Institute, University of Aarhus. - NERI Technical Report 627: 53 pp. (electronic). Available at: http://www2.dmu.dk/Pub/FR627_Final.pdf.

Hansen, K.F., Jensen, M.G. 2004: MÅLING AF EMISSIONER FRA FREMDRIVNINGSANLÆG PÅ MADS MOLS. Ruston 20RK270, Sagsnr.: 1076868, Documentation note, 5 pages (in Danish).

Hjortberg, Frank Krohn 2010: Unpublished data material from Bornholmstrafikken.

ICAO Annex 16: "International standards and recommended practices", Volume II "Aircraft Engine Emissions", 2th ed. (1993), plus amendments: Amendment 3 20th March 1997 and amendment 4 4 November 1999.

IFEU, 2004: Entwicklung eines Modells zur Berechnung der Luftschadstoffemissionen und des Kraftstoffverbrauchs von Verbrennungsmotoren in mobilen Geräten und Maschinen - Endbericht, UFOPLAN Nr. 299 45 113, pp. 122, Heidelberg.

IPCC, 2000: Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. Available at: http://www.ipcc-nggip.iges.or.jp/public/gp/english/ (15-04-2007).

Jensen, T.C., Kveiborg, O. 2009: Dokumentation af konvertering af trafiktal til emissionsopgørelser, arbejdsnotat, 9 pp. DTU Transport, 2010.

Kristensen, Flemming 2010: Unpublished data material from Mols-Linjen.

Lastein, L. & Winther, M. 2003: Emission of greenhouse gases and long-range transboundary air pollutants in the Faroe Islands 1990-2001. National Environmental Research Institute. - NERI Technical Report 477: 62 pp. (electronic). Available at: http://www.dmu.dk/1_viden/2_Publikationer/3_fagrapporter/FR477.PDF

Markamp, 2010: Personal communication, Henrik Markamp, The National Motorcycle Association.

Marpol 73/78 Annex VI: Regulations for the prevention of air pollution from ships, technical and operational implications, DNV, 21 February 2005.

Ministry of Transport, 2000: TEMA2000 - et værktøj til at beregne transporters energiforbrug og emissioner i Danmark (TEMA2000 - a calculation tool for transport related fuel use and emissions in Denmark). Technical report. Available at: http://www.trm.dk/sw664.asp

Ntziachristos, L. & Samaras, Z. 2000: COPERT III Computer Programme to Calculate Emissions from Road Transport - Methodology and Emission Factors (Version 2.1). Technical report No 49. European Environment Agency, November 2000, Copenhagen. Available at: http://re-ports.eea.eu.int/Technical_report_No_49/en (June 13, 2003).

Nørgaard, T., Hansen, K.F. 2004: Chiptuning af køretøjer - miljømæssig effekt, Miljøprojekt nr. 888, Miljøstyrelsen.

Nielsen, O.-K., Winther, M., Mikkelsen, M.H., Hoffmann, L. Nielsen, M., Gyldenkærne, S., Fauser, P., Plejdrup, M.S., Albrektsen, R, & Hjelgaard, K. 2010: Denmark's National Inventory Report 2010. Emission Inventories 1990-2008 - Submitted under the United Nations Framework Convention on Climate Change. National Environmental Research Institute, University of Aarhus. 1178 pp. – NERI Technical Report no. 784. Available at: http://www.dmu.dk/Pub/FR784.pdf

PHP, 1996: Research Report – Emission tests at Alpha, Mols 2 and Mols 4, 9L25MC mk6 engines #35031 and #35033, 22-23/10 1995 and 16/1 1996, DOK, PHP Basic Research, October 1996, 20 pages.

Pulles, T., Aardenne J.v., Tooly, L. & Rypdal, K. 2001: Good Practice Guidance for CLRTAP Emission Inventories, Draft chapter for the UNECE CORINAIR Guidebook, 7 November 2001, 42pp.

Rasmussen, Henrik 2010: Unpublished data material from Royal Arctic Line.

Statistics Denmark, 2010: Data from Statbank Denmark. Available at: www.statbank.dk/statbank5a/default.asp?w=1280

Sørensen, P.B., Illerup, J.B., Nielsen, M., Lyck, E., Bruun, H.G., Winther, M., Mikkelsen, M.H. & Gyldenkærne, S. 2005: Quality manual for the green house gas inventory. Version 1. National Environmental Research Institute. - Research Notes from NERI 224: 25 pp. (electronic). Available at: http://www2.dmu.dk/1_viden/2_Publikationer/3_arbrapporter/AR224.pdf

USEPA, 2004: Conversion Factors for Hydrocarbon Emission Components. EPA420-P-04-001, US Environmental Protection Agency, 5 pp.

Thorarson, Baldvin, 2010: Unpublished data material from Eim Skip.

Winther, M. 2001a: 1998 Fuel Use and Emissions for Danish IFR Flights. Environmental Project no. 628, 2001. 112 p. Danish EPA. Prepared by the National Environmental Research Institute, Denmark. Available at: http://www.mst.dk/udgiv/Publications/2001/87-7944-661-2/html/.

Winther, M. 2001b: Improving fuel statistics for Danish aviation. National Environmental Research Institute, Denmark. 56 p. – NERI Technical Report No. 387.

Winther, M. 2005: Kyoto notat - Transport. Internal NERI note (unpublished). 4 p. (in Danish).

Winther, M. & Nielsen, O.K. 2006: Fuel use and emissions from non-road machinery in Denmark from 1985–2004 – and projections from 2005-2030. The Danish Environmental Protection Agency. - Environmental Project 1092: 238 pp. Available at:
http://www.dmu.dk/Udgivelser/-Arbejdsrapporter/Nr.+200-249/

Winther, M. 2007: Danish emission inventories for road transport and other mobile sources. Inventories until year 2004. National Environmental Research Institute. - Research Notes from NERI 236: 244 pp. (electronic). Available at:
http://www2.dmu.dk/1_viden/2_Publikationer/3_arbrapporter/rapporter/AR201.pdf

Winther, M. 2008a: Fuel consumption and emissions from navigation in Denmark from 1990-2005 - and projections from 2006-2030. Technical Report from NERI no. 650. 109 pp. Available at:
http://www2.dm-u.dk/Pub/FR650.pdf

Winther, M. 2008b: Danish emission inventories for road transport and other mobile sources. Inventories until year 2006. National Environmental Research Institute, University of Aarhus. 219 pp. – NERI Technical Report No. 686. Available at: http://www.dmu.dk/Pub/FR686.pdf.

Wismann, T. 1999: MOLS-LINIEN, Mai Mols - Måling af emissioner fra fra hovedturbiner, dk-RAPPORT 14.901, 9 pages (in Danish).

Wismann, T. 2001: Energiforbrug og emissioner fra skibe i farvandene omkring Danmark 1995/1996 og 1999/2000 (Fuel consumption and emissions from ships in Danish coastal waters 1995/1996 and 1999/2000). The Danish Environmental Protection Agency. - Environmental Project 597: 88 pp. Available at:
http://www2.mst.dk/common/Udgivramme/Frame.asp?pg=http://www2.mst.dk/Udgiv/publikationer/2001/87-7944-505-5/html/default.htm.

Wismann, T. 2007: Energiforbrug for skibe i fart mellem danske havne (Fuel consumption by ships sailing between Danish ports), Internal note, September 2007, 3 pp.

3.4 Additional information (CRF sector 1A Fuel combustion)

3.4.1 Reference approach, feedstocks and non-energy use of fuels

In addition to the sector-specific CO_2 emission inventories (the national approach), the CO_2 emission is also estimated using the reference approach described in the IPCC Reference Manual (IPCC, 1997). The reference approach is based on data for fuel production, import, export and stock change. The CO_2 emission inventory based on the reference approach is reported to the Climate Convention and used for verification of the official data in the national approach.

Data for import, export and stock change used in the reference approach originate from the annual "basic data" table prepared by the Danish Energy Agency and published on their home page (Danish Energy Agency, 2010b). The fraction of carbon oxidised has been assumed to be 1.00. The carbon emission factors are default factors originating from the IPCC Reference Manual (IPCC, 1997). The country-specific emission factors are not used in the reference approach, the approach being for the purposes of verification.

The Climate Convention reporting tables include a comparison of the national approach and the reference approach estimates. To make results comparable, the CO_2 emission from incineration of the plastic content of municipal waste is added in the reference approach while the fuel consumption is subtracted.

Three fuels are used for non-energy purposes: lube oil, bitumen and white spirit. The total consumption for non-energy purposes is relatively low – 10.6 PJ in 2009.

In 2009 the fuel consumption rates in the two approaches differ by -1.93 % and the CO_2 emission differs by -1.28%. In the period 1990-2009 both the fuel consumption and the CO_2 emission differ by less than 2.0%. The differences are below 1 % for all years except 1998 and 2009. According to IPCC Good Practice Guidance (IPCC 2000) the difference should be within 2 %. A comparison of the national approach and the reference approach is illustrated in Figure 3.4.1.

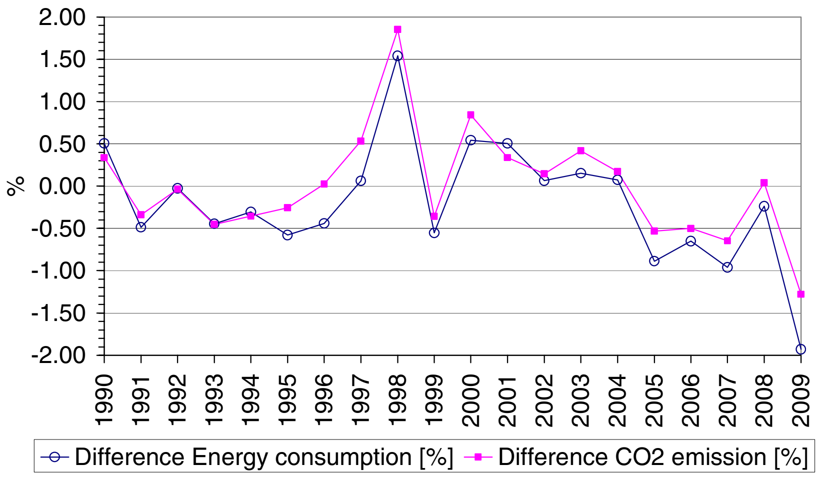


Figure 3.4.1 Comparison of the reference approach and the national approach.

The differences in certain years, e.g. 1998 and 2009 are due to high statistical differences in the official energy statistics in these years. This is illustrated in Figure 3.4.2. The Danish Energy Agency is aware of the unusually high statistical difference for 2009 and are working on improvements for a specific data delivery and thus the statistical difference for 2009 is expected to be lower in the next energy statistics.

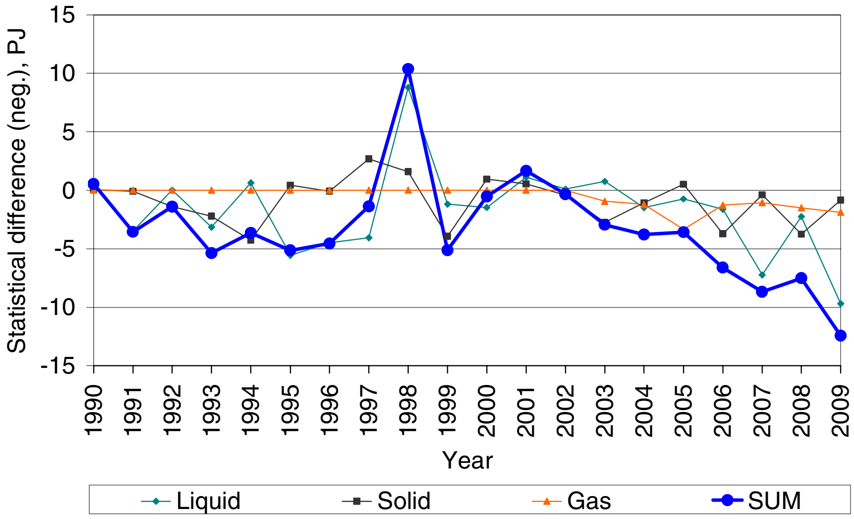


Figure 3.4.2 Statistical difference in the Danish energy statistics (DEA, 2010b).

3.5 Fugitive emissions (CRF sector 1B)

This chapter includes fugitive emissions in the CRF sector 1B.

3.5.1 Source category description

According to the IPCC sector definitions the category *fugitive emissions* is a sub-category under the main-category Energy (Sector 1). The category *fugitive emissions* (Sector 1B) is segmented into sub-categories covering emissions from solid fuels (coal mining and handling (1B1a), solid fuel transformation (1B1b), other (1B1c)) and from oil and natural gas (oil (1B2a), natural gas (1B2b), venting and flaring (1B2c) and other (1B2d)). The sub-sectors relevant for the Danish emission inventory are shortly described below according to Danish conditions:

- 1B1c: Fugitive emission from solid fuels: Emissions from solid fuels are only relevant for the Danish national emission inventories in the case of particulate emissions from storage and handling of coal. Other components are not occurring, as these emissions should be included in the inventory for the nation housing the coalmines.
- 1B2a: Fugitive emissions from oil include emissions from offshore activities and refineries.
- 1B2b: Fugitive emissions from natural gas include emissions from transmission and distribution of natural gas. Emissions from gas storage are included in the transmission.
- 1B2c: Venting and flaring include activities onshore and offshore. Flaring occur both offshore and onshore in gas treatment and storage plants and in refineries. Venting occurs in gas storage plants. Venting of gas is assumed to be negligible in extraction and in refineries as controlled venting enters the gas flare system.

Activity data, emission factors and emissions are stored in the Danish emission database on SNAP sector categories (Selected Nomenclature for Air Pollution). In Table 3.5.1 the corresponding SNAP codes and IPCC sectors relevant to fugitive emissions are shown. Further, the table holds the SNAP names for the SNAP codes and the overall activity (e.g. oil and natural gas).

Table 3.5.1 List of the IPCC sectors and corresponding SNAP codes for the categories included in the Danish emission inventory model.

IPCC sectors	SNAP code	SNAP name	Activity
	04	Production processes	
1 B 2 a 4	040101	Petroleum products processing	Oil
1 B 2 a 4	040103	Other	Oil
	05	Extraction and distribution of fossil fuels and geothermal energy	
1 B 1 a	050103 *	Storage of solid fuel	Coal mining and handling
1 B 2 a 2	050201	Land-based activities	Oil
1 B 2 a 2	050202 **	Off-shore activities	Oil
1 B 2 a 5	050503	Service stations (including refuelling of cars)	Oil
1 B 2 b / 1 B 2 b 3	050601	Pipelines	Natural gas / Transmission
1 B 2 b / 1 B 2 b 4	050602	Distribution networks	Natural gas / Distribution
	09	Waste treatment and disposal	
1 B 2 c 2 1	090203	Flaring in oil refinery	Venting and flaring
1 B 2 c 2 2	050699	Venting in gas storage	Venting and flaring
1 B 2 c 2 2	090206	Flaring in oil and gas extraction	Venting and flaring

*Only relevant for emissions of particulate matter from storage and handling of coal.

**In the Danish inventory emissions from extraction of gas are united under "Extraction, 1st treatment and loading of liquid fossil fuels/off-shore activities" (IPCC 1B2a / SNAP 050202).

Table 3.5.2 summarizes the Danish fugitive emissions in 2009. The methodologies, activity data and emission factors used for calculation are described in the following chapters.

Table 3.5.2 Summary of the Danish fugitive emissions 2009. P refers to point source and A to area source.

IPCC code	SNAP code	Source	Pollutant	Emission	Unit
1B2a i	050201	A	NMVOC	3818	Mg
1B2a i	050201	A	CH_4	1386	Mg
1B2a i	050202	A	NMVOC	2018	Mg
1B2a i	050202	A	CH_4	1775	Mg
1B2a iv	040101	P	SO_2	0 *	Mg
1B2a iv	040101	P	NMVOC	3994	Mg
1B2a iv	040101	P	CH_4	2137	Mg
1B2a iv	040103	P	SO_2	375	Mg
1B2a v	050503	A	NMVOC	1171	Mg
1B2b	050601	A	NMVOC	2	Mg
1B2b	050601	A	CH_4	9	Mg
1B2b	050603	A	NMVOC	32	Mg
1B2b	050603	A	CH_4	135	Mg
1B2c	050699	P	NMVOC	17	Mg
1B2c	050699	P	CH_4	53	Mg
1B2c	090203	P	SO_2	453	Mg
1B2c	090203	P	NO_x	17	Mg
1B2c	090203	P	NMVOC	23	Mg
1B2c	090203	P	CH_4	5	Mg
1B2c	090203	P	CO	53	Mg
1B2c	090203	P	CO_2	17	Gg
1B2c	090203	P	N_2O	0	Mg
1B2c	090206	A	SO_2	1	Mg
1B2c	090206	A	NO_x	105	Mg
1B2c	090206	A	NMVOC	9	Mg
1B2c	090206	A	CH_4	18	Mg
1B2c	090206	A	CO	85	Mg
1B2c	090206	A	CO_2	238	Gg
1B2c	090206	A	N_2O	2	Mg
1B2c	090206	P	SO_2	<0.1	Mg
1B2c	090206	P	NOx	6	Mg
1B2c	090206	P	NMVOC	14	Mg
1B2c	090206	P	CH_4	36	Mg
1B2c	090206	P	CO	1	Mg
1B2c	090206	P	CO_2	3	Gg
1B2c	090206	P	N_2O	<0.1	Mg

* From 2001 SO_2 emissions from oil refining are included in stationary combustion.

3.5.2 Methodological issues

The following chapters give descriptions on the methods of calculation used in the Danish emission inventory. Further, the activity data and emission factors that form the basis for the calculations are described according to data source and values.

Use of EU ETS data

Reporting to the European Emission Trading Scheme are available in the annual EU ETS reports for refineries, offshore oil and gas extraction facilities and the natural gas treatment plant, concerning fugitive emissions. EU ETS data are only included in the national emission inventory if higher tier methodologies are applied. EU ETS data adequate the requirements in the IPCC good practice guidance and are considered the best data source on CO_2 emission factors due to the legal obligation for the relevant companies to make the accounting following the specified EU decisions. The EU ETS data are thereby a source of consistent data with low uncertainties. For further information on EU ETS please refer to chapter 1.4.10. Unfortunately, corresponding data does not exist before the commencement of EU ETS in 2006 and therefore it is not possible to set up time-series based on EU ETS.

Refineries:

Activity data is measured with flow meters and amounts are reported with high accuracy and the oxidation factor is set to 1. CO2 emission factors are calculated according to the relevant Tier given in the EU Commission Decision of 18 July 2007. For combustion of fuel gas Tier 2b methodology based on yearly density and calorific values is applied, while the activity specific Tier 3 methodology is applied for diesel. CO2 emissions factors for flaring are found using Tier 3 methodology due to the analysed C contents of flare gas.

Offshore installations

Activity data is measured with flow meters and amounts are reported with high accuracy (± 1.5 % for combustion and ± 7.5 – ± 17.5 % for flare). The oxidation factor is set to 1. CO2 emission factors are calculated according to the relevant Tier given in the EU Commission Decision of 18 July 2007. For combustion of fuel gas Tier 3 methodology, which is activity specific, is applied, while the country specific Tier 2a methodology is applied for diesel. CO2 emissions factors for flaring are found using Tier 3 methodology due to the analysed C contents of flare gas.

Fugitive emissions from oil (1B2a)

The emissions from oil derive from offshore activities, service stations and refineries. Emissions from offshore activities include emissions from extraction, onshore oil tanks and onshore and offshore loading of ships. In the case of service stations emissions from reloading of tankers and refuelling of vehicles are included. The emissions from refineries derive from petroleum products processing (oil refining). Emissions from flaring in refineries are included in the chapters concerning flaring.

Offshore activities

Fugitive emissions from oil include emissions from extraction, from onshore oil tanks and from onshore and offshore loading of ships.

The total emission can be expressed as:

$$E_{total} = E_{extraction} + E_{ship} + E_{oil\ tanks} \quad \text{(Eq. 3.5.1)}$$

Fugitive emissions from extraction

According to the EMEP/EEA Guidebook (EMEP/EEA, 2009) the total fugitive emissions of volatile organic components (VOC) from extraction of oil and gas can be estimated by means of equation 3.5.2.

$$E_{extraction,VOC} = 40.2 \cdot N_P + 1.1 \cdot 10^{-2} P_{gas} + 8.5 \cdot 10^{-6} \cdot P_{oil} \quad \text{(Eq. 3.5.2)}$$

where $E_{extraction,VOC}$ is the emission of VOC in Mg pr year, N_P is the number of platforms, P_{gas} is the production of gas, 10^6 Nm^3 and P_{oil} is the production of oil, 10^6 tonnes.

It is assumed that the VOC contains 75 % methane (CH_4) and 25 % NMVOC and in consequence the total emission of CH_4 and NMVOC for extraction of oil and gas can be calculated as:

$$E_{extraction,CH_4} = 0.75 \cdot E_{extraction,VOC} \quad \text{(Eq. 3.5.3)}$$

$$E_{extraction,NMVOC} = 0.25 \cdot E_{extraction,VOC} \quad \text{(Eq. 3.5.4)}$$

Loading of ships

Fugitive emissions of CH_4 and NMVOC from loading of ships include the transfer of oil from storage tanks or directly from the well into ships. The activity also includes losses during transport. When oil is loaded hydrocarbon vapour will be displaced by oil and new vapour will be formed, both leading to emissions. The emissions from ships are calculated by equation 3.5.5.

$$E_{ships} = EMF_{ships,onshore} \cdot L_{oil,onshore} + EMF_{ships,offshore} \cdot L_{oil,ofshore} \quad \text{(Eq. 3.5.5)}$$

where EMF_{ships} is the emission factor for loading of ships off-shore and on-shore and L_{oil} is the amount of oil loaded.

Oil tanks

The CH_4 and NMVOC emissions from storage of oil are given in the environmental reports from DONG Energy for 2009 (DONG Energy, 2010a). An implied emission factor is calculated for use in the reporting template on the basis of the amount of oil transported in pipelines according to equation 3.5.6.

$$IEF_{tanks} = \frac{E_{tanks}}{T_{oil}} \quad \text{(Eq. 3.5.6)}$$

where IMF_{tanks} is the implied emission factor for storage of raw oil in tanks, E_{tanks} is the emission and T_{oil} is the amount of oil transported in pipelines.

Service stations

NMVOC emissions from service stations are estimated as outlined in equation 3.5.7.

$$E_{service\ stations} = \left(EMF_{reloading} \cdot T_{fuel}\right) + \left(EMF_{refuelling} \cdot T_{fuel}\right) \quad \text{(Eq.3.5.7)}$$

where $EMF_{reloading}$ is the emission factor for reloading of tankers to underground storage tanks at the service stations, $EMF_{refuelling}$ is the emission factor for refuelling of vehicles and T_{fuel} is the amount of gasoline used for road transport.

Oil refining

When oil is processed in the refineries, part of the volatile organic components (VOC) is emitted to the atmosphere. The VOC emissions from the petroleum refinery process include non-combustion emissions from handling and storage of feedstock (raw oil), from the petroleum product processing and from handling and storage of products. Emissions from flaring in refineries are included under "Flaring". Emissions related to process furnaces in refineries are included in stationary combustion with the relevant emission factors. In cases where only the total VOC emission is given by the refinery the emission of CH_4 and NMVOC is estimated due to the assumption that 1 % of VOC is CH_4 and the remaining 99 % is NMVOC.

Both the non-combustion processes including product processing and sulphur recovery plants emit SO_2. The SO_2 emissions are calculated by the refineries and implemented in the emission inventory without further calculation.

Fugitive emissions from gas (1B2b)

Transmission and distribution of gas

The fugitive emission from transmission, storage and distribution is based on information from the gas companies. The transmission and distribution companies give data on the transported amount and length and material of the pipeline systems. The fugitive losses from pipelines are only given for some companies, here among the transmission company. The available distribution data are used for the remaining companies too. From the fugitive losses from transmission and distribution pipelines the emissions of CH_4 and NMVOC are calculated due to the gas quality measured by Energinet.dk.

Flaring

Emissions from flaring are estimated from the amount of gas flared offshore, in gas treatment/storage plants and in refineries and from the corresponding emission factors. From 2006 data on offshore flaring (flared amounts, calorific values and CO_2 emission factors) is given in the reports for the European Union Greenhouse Gas Emission Trading System (EU ETS) and thereby flaring can be split to the individual production units. Before 2006 only the summarized flared amount are available.

3.5.3 Activity data

Extraction of oil and gas and loading of ships

Activity data used in the calculations of the emissions from oil and gas production and loading of ships are shown in Table 3.5.3. Data are based on information from the Danish Energy Agency (2010a) and from the environmental reports from DONG Energy (DONG Energy, 2010a).

Table 3.5.3 Activity data for 2009.

Activity	Symbols	Amounts	Data source
Number of platforms	N_p	54	Danish Energy Agency, 2010a
Produced gas, 10^6 Nm^3	P_{gas}	8 559	Danish Energy Agency, 2010a
Produced oil, 10^3 m^3	$P_{oil,vol}$	15 169	Danish Energy Agency, 2010a
Produced oil, 10^3 tonnes	P_{oil}	13 045	Danish Energy Agency, 2010a
Oil loaded, 10^3 m^3	$L_{oil\ off\text{-}shore}$	1 687	Danish Energy Agency, 2010a
Oil loaded, 10^3 tonnes	$L_{oil\ off\text{-}shore}$	1 451	Danish Energy Agency, 2010a
Oil loaded, 10^3 m^3	$L_{oil\ on\text{-}shore}$	10 000	DONG Energy, 2010a
Oil loaded, 10^3 tonnes	$L_{oil\ on\text{-}shore}$	8 600	DONG Energy, 2010a

Mass weight raw oil = 0.86 tonnes pr m^3

As seen in Figure 3.5.1 the production of oil and gas in the North Sea has generally increased in the years 1990-2004. Since 2004 the production has decreased. The number of platforms is yet still increasing (Figure 3.5.2). Five major platforms were completed in 1997-1999 which is the main reason for the great increase in the oil production in the years 1998-2000.

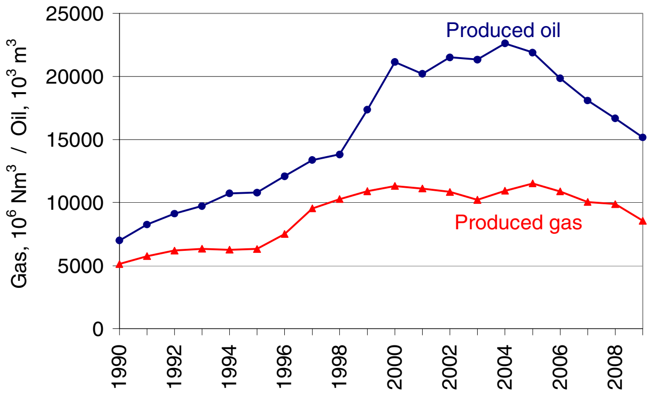


Figure 3.5.1 Production of oil and gas in the Danish part of the North Sea.

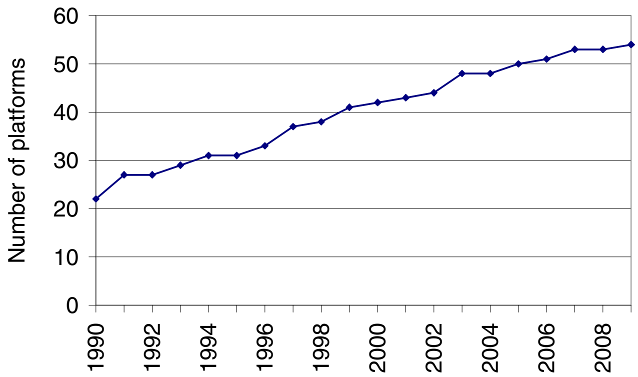


Figure 3.5.2. The number of platforms in the Danish part of the North Sea.

The amounts of oil loaded offshore on ships roughly follow the trend of the oil and gas production (Figure 3.5.3). In case of onshore loading of ships the trend is more smoothed.

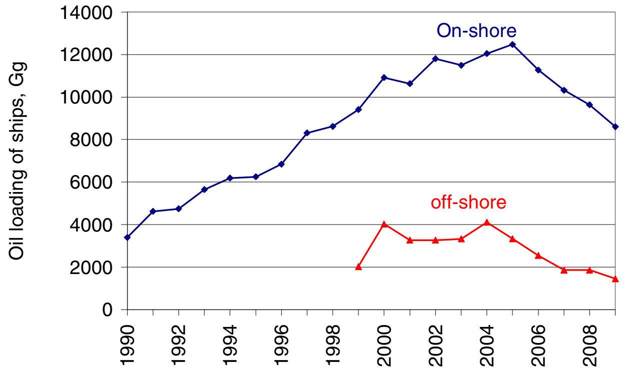


Figure 3.5.3 Onshore and offshore loading of ships.

Oil refining

Data on the amount of crude oil processed in the two Danish refineries are given by the refineries in their annual environmental report (A/S Dansk Shell, 2010; Statoil A/S, 2010a). Data are shown in Table 3.5.4. In the last years the amount of crude oil being processed has been slightly decreasing to 7 978 Gg in 2009.

Table 3.5.4 Oil refineries. Processed crude oil in the two Danish refineries.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Crude oil, 1000 Mg	7 263	7 798	8 324	8 356	8 910	9 802	10 522	7 910	7 906	8 252
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Crude oil, 1000 Mg	8 508	8 284	8 045	8 350	8 264	8 033	8 179	7 963	7 933	7 978

Service stations

The Danish Energy statistics holds data on the sale of gasoline that is the basis for estimating emissions of NMVOC from service stations. The gasoline sales show an increase from 1990-1998 and a slightly decreasing trend from 1999-2008 as shown in Figure 3.5.4. In 2009 the gasoline sale was 1 665 317 Mg.

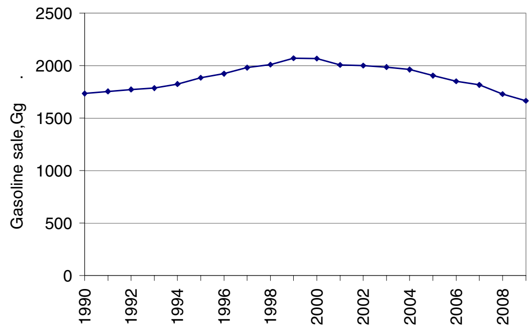


Figure 3.5.4 Gasoline sales in Denmark 1990-2009.

Transmission, storage and distribution of gas

The activity data used in the calculation of the emissions from natural gas is shown in Table 3.5.5. Transmissions rates for 1990-1997 refer to the Danish energy statistics and to the annual environmental report of DONG Energy for 1998. The distribution rates for 1990-1998 are estimated according to the transmission rates. Transmissions and distribution rates for 1999-2006 refers to Dong Energy, Danish Gas Technology Centre and the Danish gas distribution companies. In 2007-2009 the transmission rate stems from the annual environmental report by Energinet.dk (2010b). The distribution rates for 2007-2009 are given by the distribution companies, either in their annual reports or through personal communication.

Table 3.5.5 Activity data on transmission and distribution of gas. Town gas is included in distribution.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Transmission, Mm^3 *	2 739	3 496	3 616	3 992	4 321	4 689	5 705	6 956	6 641	6 795
Distribution, Mm^3 **	1 905	2 145	2 252	2 516	2 693	3 089	3 585	3 607	3 734	3 627
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Transmission, Mm^3 *	7 079	7 289	7 287	7 275	7 384	7 600	7 600	6 400	7 565	6 500
Distribution, Mm^3 **	3 511	4 005	3 749	3 749	3 579	3 297	3 460	3 160	3 135	2 890

* In 1990-1997 transmission rates refer to Danish energy statistics, in 1998 the transmission rate refers to the annual environmental report of DONG Energy, in 1999-2006 emissions refer to DONG/Danish Gas Technology Centre (Karll 2003, Karll 2005, Oertenblad 2006, Oertenblad 2007). Since 2007 transmission data refer to the annual environmental report by Energinet.dk.

**) In 1990-98 distribution rates are estimated from the Danish energy statistics. Distribution rates are assumed to equal total Danish consumption rate minus the consumption rates of sectors that receive the gas at high pressure. The following consumers are assumed to receive high pressure gas: town gas production companies, production platforms and power plants. In 1999-2006 distribution rates refer to DONG Energy / Danish Gas Technology Centre / Danish gas distribution companies (Karll 2003, Karll 2005, Oertenblad 2006, Oertenblad 2007). Since 2007 the distribution rates are given by the companies. The distribution of town gas is based on the available data from the Danish town gas distribution companies of which more are closed down today.

In 2009 the gas transmission was 6 500 Mm_n^3 and the distribution rate is 2 890 Mm_n^3, hereof 20 Mm_n^3 town gas (Figure 3.5.5). The variations of the transmission rates mainly owe to variations in production amounts and the gas amounts used for injection at the exploration sites.

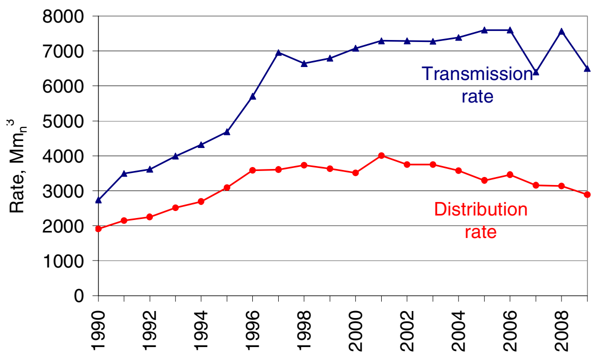


Figure 3.5.5 Rates for transmission and distribution of gas. Distribution cower both natural gas and town gas.

Data on the transmission pipelines excluding offshore pipelines and on the distribution network are given by Energinet.dk (2010b), DGC and the distribution companies concerning length and material. In 2009 the length of the transmission pipelines was 860 km. Because the distribution system in Denmark is relatively new most of the distribution network is made of PE. In 2009 the length of the distribution network was 23 402 km. The major part is made of plastic (MDPE) (approximately 90 %) and the remaining part is made of steel. For this reason the fugitive emission is negligible under normal circumstances as the MDPE distribution system is basically tight with only minimal fugitive losses. However, the MDPE pipes are vulnerable and therefore most of the fugitive emissions from the pipes are caused by losses due to excavation damages and construction and maintenance activities performed by the gas companies. These losses are either measured or estimated by calculation in each case by the gas companies. About 5 % of the distribution network is used for town gas distribution. This part of the network is older and the fugitive losses are greater. The fugitive losses from the town gas network are associated with more uncertainty as the losses are estimated as a percentage (15 %) of the meter differential. This assumption is based on expert judgement from one of the town gas companies. It must be noted that more town gas distribution companies are now closed (one in 2004 and another in 2006), and therefore the data availability is scarce.

In Denmark there are two natural gas storage facilities. Both are obligated to make an environmental report on annual basis. Data on gas input and withdrawal are included and were 793 Mm^3 and 743 Mm^3 in 2009, respectively. Until 2000 emissions from storage of gas were included in transmission in the inventories.

Venting and flaring

Activity data for venting in gas storage facilities are given in the environmental reports (DONG Energy, 2010b; Energinet.dk, 2010a).

Offshore flaring amounts are given in Denmark's oil and gas production (Danish Energy Agency, 2010a) while flaring in treatment/storage plants are given in DONG Energy's environmental reports (Dong Energy, 2010b). Flaring rates for the two Danish refineries are given in their environmental reports and additional data. From 2006 flaring amounts are given in the EU ETS reporting.

The flaring rates are shown in figure 3.5.6 and figure 3.5.7. Flaring rates in gas treatment and gas storage plants are not available until 1995. The mean value for the following ten years (1995 to 2004) has been adopted as basis for the emission calculation for the years 1990-1994.

The amount of flared gas is high in 2007 because of larger maintenance work at the gas treatment plant. In 2008 there has also been one situation with flaring of a larger amount of gas. No situations with flaring of of larger amounts of natural gas are mentioned in the 2009 environmental reports.

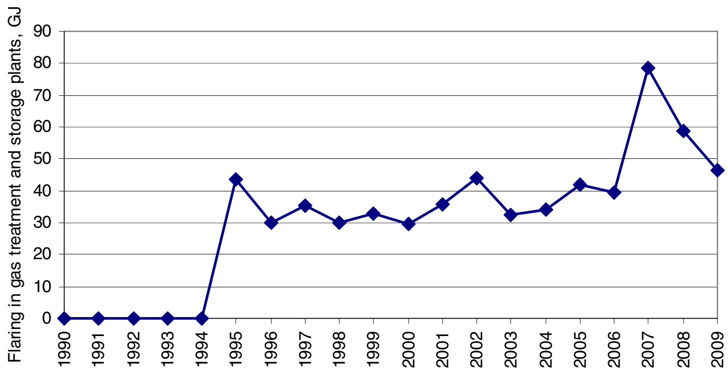


Figure 3.5.6 Amount flared in gas treatment and storage plants (DONG Energy, 2010b).

The offshore flaring amounts have been decreasing over the last five years in accordance with the decrease in production as seen in Figure 3.5.7. Further, there is focus on reduction of the amount being flared for environmental reasons.

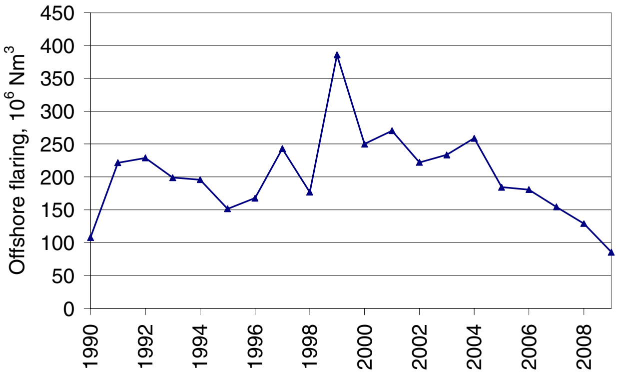


Figure 3.5.7 Amounts of gas flared offshore at exploration facilities (Danish Energy Agency, 2010b).

3.5.4 Emission factors

Loading of ships

In the EMEP/EEA Guidebook standard emission factors for different countries are given. In the Danish emission inventory the Norwegian emission factors are used for estimation of fugitive emissions from loading of ships onshore and offshore (EMEP/EEA, 2009). The emission factors are listed in Table 3.5.6.

Table 3.5.6 Emission factors for loading of ships onshore and offshore.

	NMVOC, fraction of loaded	CH_4, fraction of loaded	Reference
Ships off-shore	0.001	0.00005	EMEP/EEA, 2009
Ships on-shore	0.0002	0.00001	EMEP/EEA, 2009

Oil refining

The refineries deliver information on consumption of fuel gas and fuel oil. The calorific values are given by the refineries in the reporting for EU ETS from 2006. Before 2006 the calorific values given by the refineries were used when available. When not available standard calorific values given in the basic data tables from the Danish Energy Agency combined with the conversion factor between fuel gas and fuel oil given by the refinery were used for calculation. The emissions are given by the refineries for SO_2, NO_x and VOC. Only one of the two refineries has made a split between NMVOC and CH_4. For the other refinery it is assumed that 1 % of the VOC emission is CH_4 and the remaining 99 % is NMVOC.

Service stations

NMVOC from service stations is calculated by use of different emission factors for the time-series as shown in Table 3.5.7. In 1994 the emission factors for NMVOC from service stations were investigated by Fenhann and Kilde (1994) for the years 1990 1991 and 1992, individually. The emission factors reported for reloading and refuelling for 1990 were used for the years 1985-1990, while the emission factors for 1991 was used for that year only. For the years 1992-1995 only emission factor for refuelling reported by Fenhann and Kilde (1994) was used in the Danish emission inventory. For reloading of tankers the British emission factor - as given in the UK Emission Factor Database - was adopted for the years 1992-2000. From 2008 the emission factors from the EMEP/EEA guidebook (2009) are used for reloading and refuelling. For the years 2001-2007 and 1996-2007 the emission factors for reloading and refuelling, respectively, are estimated by using interpolation.

Table 3.5.7 Emission factors used for estimating NMVOC from service stations.

Year	Reloading of tankers, kg NMVOC pr tonnes gasoline	Refuelling of vehicles, kg NMVOC pr tonnes gasoline	Sum of reloading and refuelling, kg NMVOC pr tonnes gasoline	Source
1985-1990	1.28	1.52	2.80	Fenhann & Kilde,1994
1991	0.64	1.52	2.16	Fenhann & Kilde,1994
1992-1995	0.08	1.52	1.60	UK emf. database / Fenhann & Kilde,1994
1996	0.08	1.45	1.53	UK emf. database / interpolation 1995-2008
1997	0.08	1.39	1.47	UK emf. database / interpolation 1995-2008
1998	0.08	1.32	1.40	UK emf. database / interpolation 1995-2008
1999	0.08	1.25	1.33	UK emf. database / interpolation 1995-2008
2000	0.08	1.19	1.27	UK emf. database / interpolation 1995-2008
2001	0.077	1.12	1.20	Interpolation 2000-2008 / 1995-2008
2002	0.073	1.05	1.13	Interpolation 2000-2008 / 1995-2008
2003	0.070	0.99	1.05	Interpolation 2000-2008 / 1995-2008
2004	0.067	0.92	0.98	Interpolation 2000-2008 / 1995-2008
2005	0.063	0.85	0.91	Interpolation 2000-2008 / 1995-2008
2006	0.060	0.78	0.84	Interpolation 2000-2008 / 1995-2008
2007	0.056	0.72	0.77	Interpolation 2000-2008 / 1995-2008
2008	0.053	0.65	0.70	EMEP/EEA 2009
2009	0.053	0.65	0.70	EMEP/EEA 2009

Transmission, storage and distribution of gas

The fugitive emissions from transmission, storage and distribution of natural gas are based on data on gas losses from the companies and on the average yearly natural gas composition given by Energinet.dk.

Venting and flaring

Venting

Emissions from venting are given in the environmental reports for the gas storage facilities and no emission factors are applied in the inventory.

Flaring in refineries

The composition of fuel gas is given for 2008 by one of the two refineries. As the composition for fuel gas is marked different than the composition of natural gas, which has been used in earlier year's calculations, the new composition data are adopted in the calculations. The same fuel gas composition is used in calculations for the other Danish refinery. The new emission factors for CH_4 and NMVOC have been included in the inventory for all years (1990-2008) as the 2008 fuel gas composition is assumed to be more accurate for the emission calculation than the yearly composition for natural gas being distributed in Denmark used in previous emission inventories. The CO_2 emission factor is based on the refineries reporting to the EU ETS for the years 2006-2008. Before 2006 corresponding data are not available and the CO_2 emission factors are calculated from the yearly natural gas composition given by Energinet.dk. For NO_x and CO the emission factors from the EMEP/EEA guidebook 2009 are used. The emission factor applied for N_2O is based on the EMEP/EEA guidebook 2007 for flaring in oil and gas extraction as no value are given for flaring in refineries. The emission factors are listed in table 3.5.8.

Table 3.5.8 Emission factors for flaring in refineries.

Pollutant	Emission factor	Unit
NO_x *	32.2	g pr GJ
NMVOC	76.5	g pr GJ
CH_4	18.5	g pr GJ
CO	177	g pr GJ
CO_2 **	56.74 / 57.08	kg pr GJ
N_2O	0.47	g pr GJ

*The emission of NO_x is given for one refinery why the emission factor is used for one refinery only.

** The CO_2 emission is based on the refineries reports for ETS and is source specific.

Flaring offshore

The emission factors for offshore flaring are shown in Table 3.5.9. Since 2006 the CO_2 emission factor is calculated according to the reporting for EU ETS. Corresponding data are not available for earlier years and therefore the CO_2 emission factor is assumed to follow the same time-series as for natural gas combusted in stationary combustion plants.

The NO_x emission factor is based on the conclusion in a Danish study of NO_x emissions from offshore flaring carried out by the Danish Environmental Protection Agency (2008). The recommended NO_x emission factor (31 008 g pr GJ or 0.0015 tonnes NO_x pr tonnes gas) corresponds well with the emission factors used to estimate NO_x emission in other countries with oil production in the North Sea (Netherlands: approximately 0.0014 tonnes NO_x pr tonnes gas and United Kingdom: approximately 0.0013 tonnes NO_x pr tonnes gas).

Emission factors for CH_4 and N_2O are based on the EMEP/EEA Guidebook 2007 and emission factors for NMVOC and CO are based on the EMEP/EEA Guidebook 2009. For trace metals, dioxin and PAHs the emission factors given in the guidebook (EMEP/EEA, 2009) for stationary combustion Tier 1 are adopted for flaring in refineries.

Emissions from flaring in gas treatment and storage plants are calculated from the same emission factors which are used for offshore flaring. Only difference is the CO_2 emission factor for the years from 2006. The emission factor used for the plants are based on the same data source, the reporting for EU ETS, but the values are different than for offshore flaring. The gas that are flared in the treatment and storage plants are natural gas with the same composition as natural gas distributed in Denmark. Therefore, the emission factors in the EU ETS reports are the same as the one calculated on basis of the gas composition given by Energinet.dk (56.69 g pr GJ in 2009).

Table 3.5.9 Emission factors for offshore flaring.

Pollutant	Emission factor	Unit
SO_2	0.014	g pr Nm3
NO_x	1.227	g pr Nm3
NMVOC	0.100	g pr Nm3
CH_4	0.190	g pr Nm3
CO	1.000	g pr Nm3
CO_2	2.790	kg pr Nm3
N_2O	0.019	g pr Nm3

3.5.5 Emissions

Extraction of oil and gas and loading of ships

From the activity data in Table 3.5.3, equation 3.5.3 and equation 3.5.4 the fugitive emissions of CH_4 and NMVOC from extraction are calculated. Corresponding emissions from loading of ships can be estimated by Table 3.5.3, Table 3.5.6 and equation 3.5.5. The emissions are listed in Table 3.5.10 along with the emissions from storage of oil given in the environmental reports from DONG Energy (2010a).

Table 3.5.10 CH_4 and NMVOC emissions for 2009.

	CH_4, Mg	NMVOC, Mg
Onshore loading of ships	86	1 720
Oil tanks	1 300	2 098
Fugitive emissions from extraction	1 703	568
Offshore loading of ships	73	1 451
Total	3 161	5 836

The emissions from extraction of oil and gas are aggregated in two sources; emissions related to onshore and offshore activities, respectively. The time-series for onshore and offshore activities related to extraction of oil and natural gas are shown in table 3.5.11 and table 3.5.12.

Tabel 3.5.11 CH_4 and NMVOC from onshore activities related to extraction of oil and natural gas (onshore loading of ships and oil tanks).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
NMVOC, Mg	2 404	2 961	3 199	3 520	3 876	3 913	4 304	4 918	5 078	5 582
CH_4, Mg	817	970	1 069	1 142	1 259	1 271	1 400	1 560	1 608	1 794
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
NMVOC, Mg	6 183	6 126	6 761	6 698	6 908	6 994	6 403	5 981	5 551	3 818
CH_4, Mg	1 809	2 006	2 118	2 115	2 220	2 225	2 013	1 883	1 744	1386

The major increase for NMVOC emission from offshore activities in 1999 owe to offshore loading as there were no offshore loading in the years 1990-1998. A similar increase is not seen for CH_4 as emissions from extraction is the dominating source.

Tabel 3.5.12 CH_4 and NMVOC from offshore activities related to extraction of oil and natural gas (offshore loading of ships and extraction).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
NMVOC, Mg	236	288	289	310	330	330	353	400	412	2 465
CH_4, Mg	708	864	868	930	989	990	1 060	1 199	1 235	1 432
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
NMVOC, Mg	4 476	3 726	3 742	3 836	4 620	3 873	3 087	2 442	2 437	2 018
CH_4, Mg	1 566	1 556	1 584	1 702	1 748	1 775	1 759	1 839	1 837	1 775

Oil refining

In Table 3.5.13 the activity data and emissions of CH_4 and NMVOC from the Danish refineries are listed for the years 1990-2009. Further, the emissions of SO_2 from oil refining and sulphur recovery in refineries are shown. In cases where only VOC emissions are given, 1 % of the VOC emission is assumed to be CH_4 and 99 % NMVOC. The emission of SO_2 has shown a pronounced decrease since 1990 because of technical improvements at the refineries. Note that SO_2 from refining and recovery prior to 1994 was summarized and reported as an area source in the IPCC category 1B2a vi. Note also that SO_2 from oil refining from 2001 are included in stationary combustion.

Table 3.5.13 Oil Refineries. Emissions of NMVOC and SO_2 from oil refining and SO_2 from sulphur recovery.

<table>
<tr><th></th><th>1990[1]</th><th>1991[1]</th><th>1992[1]</th><th>1993[1]</th><th>1994</th><th>1995</th><th>1996</th><th>1997</th><th>1998</th><th>1999</th></tr>
<tr><td>NMVOC, Mg</td><td>3 667</td><td>3 937</td><td>4 203</td><td>4 219</td><td>5 855</td><td>4 546</td><td>5 875</td><td>4 547</td><td>4 558</td><td>4 558</td></tr>
<tr><td>SO_2, oil refining, Mg</td><td rowspan="2">3 335</td><td rowspan="2">2 713</td><td rowspan="2">3 147</td><td rowspan="2">2 526</td><td>934</td><td>585</td><td>167</td><td>216</td><td>253</td><td>234</td></tr>
<tr><td>SO_2, sulphur recovery, Mg</td><td>3 332</td><td>2 437</td><td>2 447</td><td>1 766</td><td>1 188</td><td>1 125</td></tr>
<tr><td>Continued</td><td>2000</td><td>2001[2]</td><td>2002[2]</td><td>2003[2]</td><td>2004[2]</td><td>2005[2]</td><td>2006[2]</td><td>2007[2]</td><td>2008[2]</td><td>2009[2]</td></tr>
<tr><td>NMVOC, Mg</td><td>4 983</td><td>4 338</td><td>4 302</td><td>3 708</td><td>3 732</td><td>3 550</td><td>3 837</td><td>3 761</td><td>3 784</td><td>3 994</td></tr>
<tr><td>SO_2, oil refining Mg</td><td>178</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>SO_2, sulphur recovery Mg</td><td>803</td><td>672</td><td>332</td><td>246</td><td>119</td><td>255</td><td>679</td><td>610</td><td>794</td><td>375</td></tr>
</table>

1) Prior to 1994 SO_2 emissions from oil refining and sulphur recovery are reported as area sources in category 1B2a vi.

2) From 2001 SO_2 emissions from oil refining are included in stationary combustion.

Service stations

Emissions from service stations are calculated using the emission factors in Table 3.5.7 and the sold amounts of gasoline given by the Danish Energy statistics (Danish Energy Agency, 2010b). The NMVOC emissions are listed in Table 3.5.14.

Table 3.5.14 Emissions of NMVOC from service stations 1990-2009.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
NMVOC, Mg	4 856	3 792	2 832	2 854	2 916	3 016	2 949	2 906	2 813	2 760
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
NMVOC, Mg	2 616	2 399	2 252	2 094	1 933	1 742	1 563	1 405	1 216	1 171

Transmission, storage and distribution of gas

The gas transmission company gives emissions of CH_4. The CH_4 emissions for transmission are estimated on the basis of registered loss in the transmission grid and the emission from the natural gas consumption in the pressure regulating stations (Oertenblad, 2007). The distribution companies give data on fugitive losses, and the CH_4 emissions are estimated due to the gas quality given by Energinet.dk.

The emissions of NMVOC are calculated on the basis of the CH_4 emission according to the gas quality measured by Energinet.dk (equation 3.5.8).

$$E_{NMVOC} = E_{CH_4} \times \left(w_{NMVOC} / w_{CH_4} \right) \text{(Eq.3.5.8)}$$

where w_{NMVOC} is the weight-% NMVOC and w_{CH_4} is the weight-% CH_4 according to the gas quality of the current year.

Emissions of CH_4 and NMVOC from transmission, storage and distribution of gas are shown in table 3.5.15 and table 3.5.16, respectively. For the years before 2000 emissions from transmission and venting in gas storage plants have not been estimated separately and both sources are included in the transmission category. As the pipelines in Denmark are relatively new, most emissions are due to construction and maintenance. The decrease in emission from transmission in 2007 is caused by the completion of a greater construction work and rerouting of a major pipeline. There have been no significant construction or renovation work in 2007 and therefore a low emission. The increase in 2008 owe to a minor increase in these work activities.

The increased emission from distribution in 2004 owes to venting of the distribution network. The reason for the increase in 2007 is not explained by the given company.

Table 3.5.15 CH_4 emission from transmission and distribution.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Transmission Mg*	170	310	93	186	151	536	205	235	156	191
Distribution Mg**	254	278	279	278	280	298	302	225	228	243
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Transmission Mg*	170	157	78	88	85	141	152	7	16	9
Distribution Mg**	231	246	227	211	294	239	260	269	156	135

*In 1991-95 CH_4 emissions are based on the annual environmental report from DONG for the year 1995.
In 1996-99 the CH_4 emission refers to the annual environmental reports from DONG for the years 1996-99.
In 2000-2006 the CH_4 emission refers to DONG/Danish Gas Technology Centre (Karll 2003, Karll 2005, Oertenblad 2006, Oertenblad 2007).
From 2007 the CH_4 emission refers to the annual environmental reports from Energinet.dk.
**Danish Gas Technology Centre/DONG/Danish gas distribution companies (Karll 2003, Karll 2005, Oertenblad 2006, Oertenblad 2007.
1) Data from Naturgas Fyn not included until 2007 as data has not been available.
2) Assumed same emission as in 2002.
3) Distribution data are extrapolated from 2006 according to change in transmission data.

Table 3.5.16 NMVOC emission from transmission and distribution. NMVOC emissions are estimated from the CH_4 emission according to the gas quality given by Energinet.dk.

NMVOC emission	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Transmission, Mg*	36	67	20	41	34	121	42	60	44	55
Distribution, Mg**	60	66	66	66	67	71	72	55	56	61
Continued	2000	2001	2002	2003[1]	2004	2005	2006	2007	2008	
Transmission, Mg*	52	45	23	25	23	36	37	2	4	2
Distribution, Mg**	59	62	57	53	75	59	63	65	38	32

*NMVOC emissions are estimated from the CH_4 emission according to the gas quality given by Energinet.dk.
**Danish Gas Technology Centre/DONG/Danish gas distribution companies (Karll 2003, Karll 2005, Oertenblad 2006, Oertenblad 2007.
1) Data from Naturgas Fyn not included until 2007 as data has not been available.
2) Assumed same emission as in 2002.
3) Distribution data are extrapolated from 2006 according to change in transmission data.

Venting and Flaring

As shown in Figure 3.5.8 there was a marked increase in the amount of offshore flaring in 1997 and especially in 1999. The increase in 1997 was due to the new Dan field and the completion of the Harald field. The increase in 1999 was due to the opening of the three new fields Halfdan, Siri and Syd Arne.

The time-series for the emission of CO_2 from offshore flaring fluctuates due to the fluctuations in the fuel rate and to a minor degree due to the CO_2 emission factor. The latter rests on gas quality measurements. From 2006 the calorific values for flaring are given at installation level in the EU ETS. This information is incorporated in the inventory for the years from 2006 onwards. This has lead to an increase of the CO_2 emission factor. The average of the emission factors for 2006-2008 is adopted for 1990-2005. Fuel rate and CO_2 emission are shown in Figure 3.5.8.

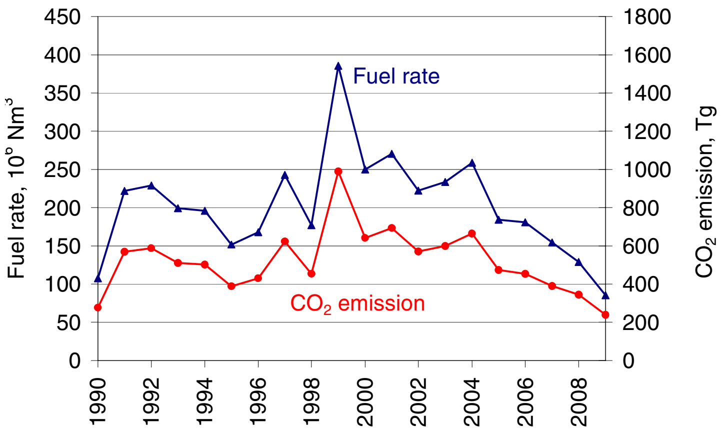


Figure 3.5.8 Fuel rate and CO_2 emission from offshore flaring of gas 1990-2009.

The emissions from offshore flaring are estimated from the same emission factors for all years and the variations reflect only the variations in the flared amounts. The only exception is CO_2 where the emission factors from the EU ETS reports are used for 2006-2008. Emissions of selected components are shown in table 3.5.17.

Table 3.5.17 Emissions from flaring offshore and in gas treatment/storage plants.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes
SO_2	2	3	3	3	3	2	2	3	2	5
NO_x	132	272	281	244	240	199	211	303	217	476
NMVOC	11	22	23	20	20	19	19	27	20	41
CO	108	222	229	199	196	160	174	250	183	392
CO_2	276	569	588	510	502	391	432	625	455	991
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes
SO_2	4	4	3	3	4	3	3	2	2	1
NO_x	310	336	277	291	322	231	226	197	165	111
NMVOC	28	30	26	26	29	21	21	22	19	23
CO	256	277	231	240	266	193	189	170	130	86
CO_2	643	696	572	601	666	475	455	394	348	241

Besides in the offshore sector flaring also takes place in refineries and gas treatment/storage plants. Flaring in refineries is a significant fugitive emission source for SO_2. In 1990-1993 emissions from petroleum product processing were included in emissions from flaring in refineries (1B2c). From 1994 the data delivery format was changed, which made it possible to split the emissions into contributions from flaring and processing, respectively. Emissions from processing are from 1994 included in 1B2a iv.

The decreasing emissions of SO_2 from 1995 to 1998 are due to technical improvements of the sulphur recovery system at one of the two Danish refineries (Table 3.5.18). The increase in SO_2 from flaring in refineries in 2005 and 2007 was due to planned shutdowns due to inspection and maintenance at one of the two refineries. Further, in 2007-2009 the same refinery has had problems with the ATS system leading to an increased SO_2 emission from flaring.

Table 3.5.18 Emissions from flaring in refineries.

	1990*	1991*	1992*	1993*	1994	1995	1996	1997	1998	1999
	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes
SO_2 *	943	926	935	1 190	520	203	218	138	70	50
NO_x	41	41	41	41	230	21	36	18	25	31
NMVOC	34	34	34	34	32	32	32	20	26	25
CO	5	5	5	5	49	49	49	47	60	57
CO_2	24	24	24	24	29	24	24	15	19	18
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes
SO_2	51	46	68	96	53	296	257	526	380	453
NO_x	32	21	39	23	30	26	22	24	30	17
NMVOC	26	17	31	19	24	32	31	33	38	23
CO	60	39	72	44	56	73	73	77	88	53
CO_2	19	13	23	14	18	24	23	25	28	17

*In 1990-1993 emissions from petroleum product processing were included in flaring in refineries due to the data delivery form. From 1994 emissions from petroleum product processing were given in 1B2a iv.

3.5.6 Uncertainties and time-series consistency

Two set of uncertainty estimates are made for the Danish emission inventory for greenhouse gases based on Tier 1 and Tier 2 methodology, respectively. The uncertainty models follow the methodology in IPCC

Good Practise Guidance (IPCC, 2000). Tier 1 is based on the simplified uncertainty analysis and Tier 2 is based on Monte Carlo simulations.

Uncertainty estimates are made for total emissions in the base year (only Tier 2), in the latest inventory year and for the emission trend for the corresponding time-series. Uncertainty estimates are made for the GHGs separately and summarized.

Input data
The Tier 1 uncertainty model is based on emission data, uncertainty levels for activity data and uncertainty levels for emission factors for base year and latest inventory year. The Tier 2 model is based on activity data and emission factors for the same years and the same uncertainty levels as in Tier 1. Emission data, activity data and emission factors are described in chapter 3.5.3, 3.5.4 and 3.5.5.

The uncertainty levels used in the uncertainty models are based on different sources, e.g. IPCC Good Practice Guidance, EMEP/EEA Guidebook and reports for the EU ETS. Further, a number of the uncertainty levels are given as NERI assumptions in Table 3.5.19 and 3.5.21. NERI assumptions are based on source and/or plant specific uncertainty levels for part of the SNAP category and assumptions for the remaining sources and/or plants in the category.

Input data are aggregated on SNAP level. Estimates are made for the greenhouse gases CO_2, CH_4 and N_2O both separately and summarized (GHG). Uncertainty levels for activity data and emission factors are listed in table 3.5.19. Uncertainty levels are given in percentage related to the 95 % confidence interval assuming a normal distribution.

Table 3.5.19 Uncertainty levels for activity rates and emission factors.

Pollutant	Source	Activity data uncertainty level, %		Emission factor uncertainty level, %	
CO_2	Flaring in refineries	11	N, H	5	N, H
CO_2	Flaring offshore	8	I	5	S
CH_4	Petroleum product processing	1	I	125	N
CH_4	Landbased activities	2	I	40	G
CH_4	Offshore activities	2	N	30	N
CH_4	Gas transmission	15	N	5	N
CH_4	Gas distribution	25	N	10	E
CH_4	Venting in gas storage plants	15	N	5	N
CH_4	Flaring in refineries	11	N, H	15	G
CH_4	Flaring offshore	8	E	5	G
N_2O	Flaring in refineries	11	N, H	1 000	I
N_2O	Flaring offshore	8	E	1 000	I

N: NERI assumption.

I: IPCC Good Practice Guidance (default value).

S: Statistisk Sentralbyrå, Statistics Norway, 2008.

E: EU Emission Trading Scheme (EU ETS).

G: EMEP/EEA Guidebook, 2009.

H: Holst, 2009 and Statoil A/S, 2010b

The CO_2 emission factors are the most accurate as they are calculated on basis of gas quality analysis. Detailed CO_2 emission factors are available for flaring offshore and in refineries in the reports for EU ETS. For the remaining sources the gas quality for the distributed natural gas in Denmark are used. The IPCC Good Practice Guidance (IPCC, 2000) suggests that the accuracy for gas composition is usually ±5 %, which is adopted in the Danish emission inventories.

The EMEP/CORINAIR Guidebook (2007) suggests an error of 65 % for the standard equation used to estimate fugitive emissions of VOC from extraction noting that the error could be much higher when the equation is used for other fields than the ones in USA, which it has been based on. It is expected in the EMEP/EEA Guidebook (2009) that it seems to be in reasonable agreement with estimates for Norway and UK. Data from the Danish operators (one year only) indicate that the VOC emissions in the Danish inventory have an uncertainty around 30 %.

The uncertainty level for the emission factor for fugitive CH_4 from refineries is dominated by a large uncertainty for one refinery. Further, measurements of fugitive emissions from the refineries are only available for one and two years, respectively, and these measurements indicate larger emissions than earlier estimates. As more measurements become available the uncertainty level is expected to decrease significantly.

According to IPCC (2000) the emission factor for N_2O is the least reliable. An uncertainty level of 1 000 % is adopted in the Danish uncertainty model.

The Tier 2 uncertainty model is based on Monte Carlo simulations and the input uncertainty levels are given for the 95 % confidence interval assuming a log-normal distribution. The input uncertainty levels are the same as those used in the Tier 1 uncertainty model (table 3.5.19).

Results

The results of the Tier 1 uncertainty model for 2009 are shown in table 3.5.20. In 2009 N_2O has the largest uncertainty for the total emission followed by CH_4 and CO_2. Due to the emission trend CH_4 has the largest uncertainty followed by N_2O and CO_2. The estimated uncertainty for the total GHG emission is 17 % and the GHG emission trend is 9 % ± 18 %-point.

Table 3.5.20 Uncertainty estimates for total emissions and emission trends from the Tier 1 uncertainty model.

	Emission, Gg CO_2-eqv	Uncertainty, % Lower and upper (±)	Trend, %	Uncertainty, % Lower and upper (±)
CO_2	258	9	-14	9
CH_4	117	50	168	124
N_2O	1	466	-27	43
GHG	375	17	9	18

Table 3.5.21 show the results from the Tier 2 uncertainty model for 1990 and 2009. The overall emission uncertainty in 2009 is -11/+25 %. The Tier 2 trend estimate is 10 % -21/+30 %-point.

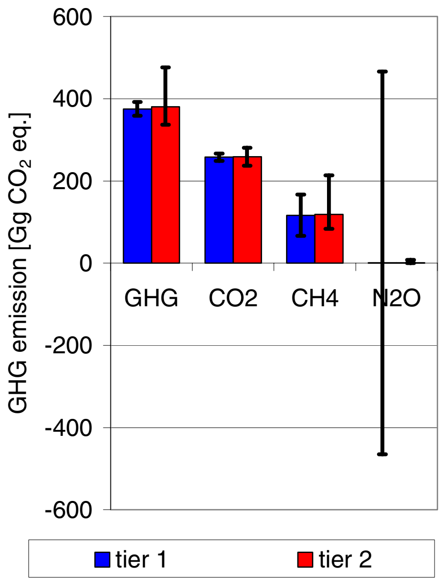
Table 3.5.21 Uncertainty estimates for total emissions in 1990 and 2009 and for the emission trends from the Tier 2 uncertainty model.

	1990			2009			1990-2009		
	Median emission Gg CO_2-eqv	Uncertainty, %		Median emission Gg CO_2-eqv	Uncertainty, %		Median trend, %	Uncertainty, %	
		Lower (-)	Upper (+)		Lower (-)	Upper (+)		Lower (-)	Upper (+)
CO_2	300	15	18	258	7	7	-95	128	117
CH_4	44	17	22	119	30	78	25	12	32
N_2O	1	93	1 009	1	94	1 139	-31	226	29
GHG	346	14	16	380	11	25	10	21	30

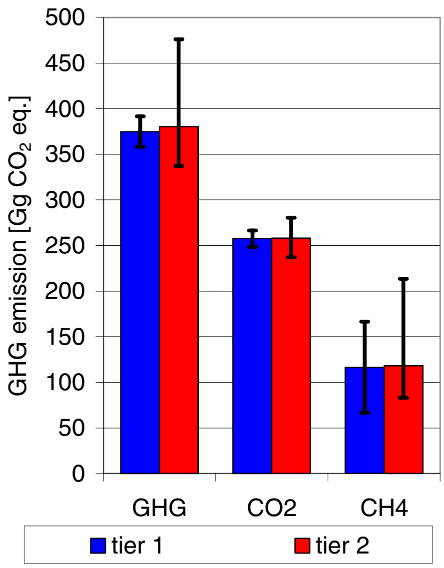
Tier 1 and Tier 2 emissions and uncertainties are shown together in Figure 3.5.9. The figures show that the emissions and median emissions from Tier 2 are very similar. Further, the uncertainty estimates are in the same range for Tier 1 and Tier 2. The N_2O uncertainty is leaved out in Figure 3.5.9 b as the N_2O uncertainties are much higher than for CO_2 and CH_4. It must be noted that the uncertainty models, especially the Tier 1 model, are not suitable for very large uncertainty levels and therefore the uncertainty estimates for N_2O may only be seen as an indicator for a large uncertainties while the values are less accurate. The Tier 2 model has been developed further according to the last submission to be more suitable for very large uncertainties, as it is possible to apply truncation for uncertainties. This has been included in the uncertainty calculation for fugitive emissions in case of N_2O, as the uncertainty level for the emission factors is 1 000 %. A truncation of 2 000 % has been applied to ensure that the emission factor interval is order of magnitude as given in IPCC Good Practice Guidance.

Figure 3.5.9 Emissions and uncertainty estimates from the Tier 1 and Tier 2 models; a) GHG, CH_4, CO_2 and N_2O, b) as figure a, but without N_2O.

a)



b)



3.5.7 Source specific QA/QC and verification

The elaboration of a formal QA/QC plan started in 2004 and the first version is available (Sørensen et al., 2005). The plan describes the concepts of quality work and definitions of sufficient quality, critical control points and a list of Points of Measuring, PM (Figure 3.5.9). Please refer to the general chapter on QA/QC.

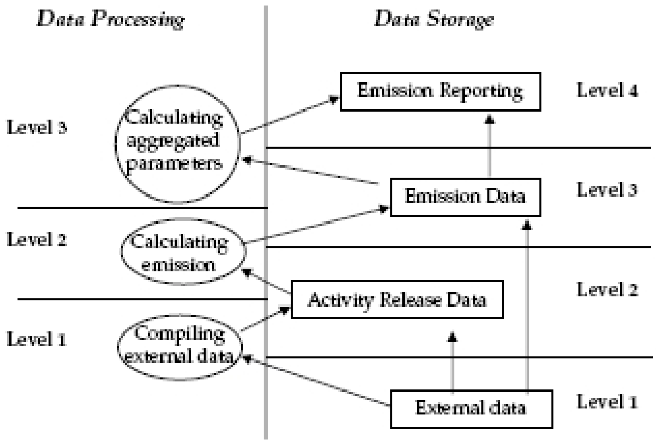


Figure 3.5.9 The general data structure for the Danish emission inventory (Sørensen et al., 2005).

Data storage level 1

Data storage level 1 refers to the data collected by NERI before any processing or preparing. Table 3.5.21 lists the external data deliveries used for the inventory of fugitive emissions. Further the table holds information on the contacts at the data delivery companies.

Table 3.5.23 List of external data sources.

Source	Data description	Activity data, emission factors or emissions	Reference	Contact(s)	Data agreement/ Comment
Offshore extraction	Gas and oil production. Dataset for production of oil, gas and number of platforms. CRF 1B2a	Activity data	The Danish Energy Agency (DEA)	Jan H. Andersen	No formal data agreement.
Offshore flaring	Flaring offshore in oil and gas extraction	Activity data	The Danish Energy Agency	Peter Dal	Data agreement
Service stations	Data on gasoline sales from the Danish energy statistics.	Activity data	The Danish Energy Agency (DEA)	Peter Dal	Data agreement
Gas transmission	Natural gas from the transmission company, sales and losses (meter differences)	Activity data	Energinet.dk	Christian Friberg B. Nielsen	Not necessary due to obligation by law
Environmental report from DONG Energy	Environmental report from DONG Energy. Oil and gas production. The amount of oil loaded onshore and emissions from raw oil tanks. CRF 1B2a	Activity data and emission data	DONG Energy		Not necessary due to obligation by law
Gas distribution	Natural gas from the distribution company, sales and losses (meter differences)	Activity data	Naturgas Fyn, DONG Energy, HNG and MN	Gert Nielsen, Ida Pernille Schou	No formal data agreement.
Air emissions from refinery	Fuel consumption and emission data. CRF 1B2a.	Activity data and emission data	Statoil A/S, A/S Danish Shell	Anette Holst, Lis Rønnow Rasmussen	No formal data agreement.
Storage and treatment of gas	Environmental reports from plants defined as large point sources (Lille Torup, Stenlille, Nybro)	Activity data	Various plants		Not necessary due to obligation by law
CO_2 emission factors for different sources	Reports according to the CO_2 emission trading scheme (ETS)	Activity data	Various plants		Not necessary due to obligation by law
Emission factors	Emission factors origin from a large number of sources	Emission factors	See chapter regarding emission factors		

Data Storage level 1	1. Accuracy	DS.1.1.1	General level of uncertainty for every dataset including the reasoning for the specific values.

The DEA is responsible for the official Danish energy statistics as well as reporting to the IEA. NERI regards the data as being complete and in accordance with the official Danish energy statistics and IEA reporting. The uncertainties connected with estimating fuel consumption do not, therefore, influence the accordance between IEA data, the energy statistics and the dataset on SNAP level utilised by NERI. For the remaining datasets, it is assumed that the level of uncertainty is relatively small, except for the emissions from refineries. For further comments regarding uncertainties, see Chapter 3.5.6.

Data Storage level 1	1. Accuracy	DS.1.1.2	Quantification of the uncertainty level of every single data value including the reasoning for the specific values.

The uncertainty for external data is not quantified. The uncertainties of activity data and emission factors are quantified see Chapter 3.5.6.

Data Storage level 1	2.Comparability	DS.1.2.1	Comparability of the data values with similar data from other countries, which are comparable with Denmark, and evaluation of discrepancy.

Systematic inter-country comparison has only been made on Data Storage Level 4. Refer to DS 4.3.2.

Data Storage level 1	3.Completeness	DS.1.3.1	Documentation showing that all possible national data sources are included, by setting down the reasoning behind the selection of datasets.

External data sources are the Danish Energy Authority and annual environmental reports from plants which are obligated to publish environmental reports. Further, annual reports from the gas companies are used. Some environmental reports and annual reports are supplemented with data and information from the given companies.

Energy statistics
The Danish Energy Authority reports fuel consumption statistics on the SNAP level based on a correspondence table developed in co-operation with NERI. Both traded and non-traded fuels are included in the Danish energy statistics. Data on offshore extraction, offshore flaring and gasoline sales are used for estimation of fugitive emissions.

Environmental reports
A large number of plants are obligated by law to publish an environmental report annually with information on fuel consumption and emissions, among other things. NERI compares data with those from previous years and discrepancies are checked.

Annual reports
The gas distribution companies are not obligated to publish environmental reports. Instead the annual reports and additional data and information are used when available. All information is compared with previous years.

Reports for the European Union Greenhouse Gas Emission Trading System (EU ETS)
CO_2 emission factors for flaring offshore and in refineries are taken from the EU ETS reports since 2006 when the EU ETS reports became available. EU ETS reports are available for the individual Danish oil/gas production fields and for the refineries.

Emission factors from a wide range of sources
For specific references, see chapter regarding emission factors.

Data Storage level 1	4.Consistency	DS.1.4.1	The origin of external data has to be preserved whenever possible without explicit arguments (referring to other PMs)

All external data are stored in the inventory file system and are accessible for all inventory staff members. Data processing is carried out in other spreadsheets or databases so that the data are always available in the original form. Refer to Section 1.3.

Data Storage level 1	6.Robustness	DS.1.6.1	Explicit agreements between the external institution holding the data and NERI about the condition of delivery

Formal agreements are made with the Danish Energy Authority. Most of the other external data sources are available due to legal requirements in this regard. See Table. 3.5.23

Data Storage level 1	7.Transparency	DS.1.7.1	Summary of each dataset including the reasoning for selecting the specific dataset

See DS 1.3.1

Data Storage level 1	7.Transparency	DS.1.7.3	References for citation for any external data set have to be available for any single value in any dataset.

Refer to Table 3.5.23 for general references. The references are available in the inventory file system. Refer to Section 1.3.

Data Storage level 1	7.Transparency	DS.1.7.4	Listing of external contacts for every dataset.

Refer to Table 3.5.23

Data Processing Level 1

Data Processing level 1	1. Accuracy	DP.1.1.1	Uncertainty assessment for every data source as input to Data Storage Level 2 in relation to type of variability (distribution as: normal, log normal or other type of variability)

Refer to Section 1.7 in the Danish NIR and the QA/QC Section 3.5.7.

Data Processing level 1	1. Accuracy	DP.1.1.2	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to scale of variability (size of variation intervals)

The uncertainty assessment of activity data and emission factors are discussed in Section 1.7 concerning uncertainties.

Data Processing level 1	1. Accuracy	DP.1.1.3	Evaluation of the methodological approach using international guidelines

The methodological approach is consistent with international guidelines and described in Section 3.5.2.

Data Processing level 1	1. Accuracy	DP.1.1.4	Verification of calculation results using guideline values.

This PM has only been carried out for some of the sources, but will be completed for the key categories.

Data Processing level 1	2.Comparability	DP.1.2.1	The inventory calculation has to follow the international guidelines suggested by UNFCCC and IPCC.

The calculations follow the principles in international guidelines.

Data Processing level 1	3.Completeness	DP.1.3.1	Assessment of the most important quantitative knowledge which is lacking.

Regarding the emissions from refineries and gas distribution, more detailed data material would be preferred. Further, more detailed data on emissions from exploration of oil and gas would be preferred.

Data Processing level 1	3.Completeness	DP.1.3.2	Assessment of the most important cases where access is lacking with regard to critical data sources that could improve quantitative knowledge.

No accessibility to critical data sources is lacking.

Data Processing level 1	4.Consistency	DP.1.4.1	In order to keep consistency at a high level, an explicit description of the activities needs to accompany any change in the calculation procedure.

A change in calculating procedure would entail that an updated description would be elaborated.

Data Processing level 1	5.Correctness	DP.1.5.1	Show at least once, by independent calculation, the correctness of every data manipulation.

During data processing it is checked that calculations are performed correctly. Documentation needs to be elaborated, however.

Data Processing level 1	5.Correctness	DP.1.5.2	Verification of calculation results using time-series.

A time-series for activity data on SNAP level as well as emission factors is used to identify possible errors in the calculation procedure.

Data Processing level 1	5.Correctness	DP.1.5.3	Verification of calculation results using other measures.

This PM has only been carried out for some of the sources.

Data Processing level 1	5.Correctness	DP.1.5.4	Shows one-to-one correctness between external data sources and the databases at Data Storage level 2.

There is a direct line between the external datasets, the calculation process and the input data used on Data Storage level 2. During the calculation process, numerous controls are in place to ensure correctness, e.g. sum checks of the various stages in the calculation procedure.

Data Processing level 1	7.Transparency	DP.1.7.1	The calculation principle and equations used must be described.
Data Processing level 1	7.Transparency	DP.1.7.2	The theoretical reasoning for all methods must be described.
Data Processing level 1	7.Transparency	DP.1.7.3	Explicit listing of assumptions behind all methods.

Where appropriate this is included in the NIR in chapter 3.5.

Data Processing level 1	7.Transparency	DP.1.7.4	Clear reference to data set at Data Storage level 1.

References to external data sets are in most cases incorporated in the data storage and calculation systems. References will be worked out for the remaining sources.

Data Processing level 1	7.Transparency	DP.1.7.5	A manual log to collect information on recalculations.

At present, a manual log table is not in place on this level. However, this feature will be implemented in the future. A manual log table is incorporated in the national emissions database, Data Storage level 2.

Data storage level 2

Data Storage level 2	5.Correctness	DS.2.5.1	Documentation of a correct connection between all data types at level 2 to data at level 1

To ensure a correct connection between data on level 2 to data on level 1, different controls are in place, e.g. control of sums and random tests.

Data Storage level 2	5.Correctness	DS.2.5.2	Check if a correct data import to level 2 has been made.

Data import is checked by use of sum control and random testing. The same procedure is applied every year in order to minimise the risk of data import errors.

Other QC procedures

A list of QA/QC tasks are performed directly in relation to the fugitive emission part of the Danish emission inventories. The following procedures are carried out to ensure the data quality:

- Checking of time-series in the IPCC and SNAP source categories. Considerable changes are controlled and explained.
- Comparison with the inventory of the previous year. Any major changes are verified.
- Total emission, when aggregated to IPCC and LRTAP reporting tables, is compared with totals based on SNAP source categories (control of data transfer).
- A manual log table in the emission databases is applied to collect information about recalculations.

- The emission from the large point sources (refineries, gas treatment and storage plants) are compared with the emission reported the previous year.
- Some automated checks have been prepared for the emission databases:
  - Check of units for fuel rate, emission factor and plant-specific emissions.
  - Check of emission factors for large point sources. Emission factors for pollutants that are not plant-specific should be the same as those defined for area sources.
  - Additional checks on database consistency.
- Most emission factor references are now incorporated in the emission database, itself.
- Most data sources are implemented in the fugitive emission model.
- Annual environmental reports are kept for subsequent control of plant-specific emission data.

The QC work will continue in future years.

3.5.8 Recalculations

In the emission inventory for 2009 there have been some recalculations as listed below.

Service stations: The amounts of gasoline sales used for calculation of fugitive emissions from service stations (SNAP 050503) have been updated according to the Energy Statistics for 2009 1990-2008. The NMVOC emission in 2008 has thereby increased by 6 Mg corresponding to 0.5 %.

Extraction of oil and gas: fugitive emissions from extraction are calculated from the standard formula in the EMEP/EEA Guidebook (EMEP/EEA, 2009) based on the number of platforms. In 2009 the number of platforms has been corrected for 2007 and 2008. The NMVOC emission in 2008 has decreased by 20 Mg according to this correction corresponding to 1 %.

Gas distribution: distribution amounts have been updated for one of three natural gas distribution companies for the years 2006-2008 due to new data availability. The NMVOC emission has decreased by 4 Mg in 2008 due to this corresponding to 10 %. Emissions from venting in gas storage have previously been included in gas transmission, but are now included in the venting and flaring category (1B2c). The emissions have not been changed for the time-series during the IPCC category shift.

Venting and flaring in oil and gas extraction: The NMVOC emission in 2008 from flaring in the gas treatment plant has been updated for 2008 according to the environmental report leading to an increase of 2 Mg NMVOC. The increase corresponds to 12 % of the NMVOC emission from flaring in oil and gas extraction including offshore flaring. Emissions from venting in gas storage have previously been included in gas transmission, but are now included in the venting and flaring category (1B2c). The emissions have not been changed for the time-series during the IPCC category shift. Minor corrections of the emission factors for offshore flaring have been applied due to a correction of conversion between Sm^3 and Nm^3.

3.5.9 Source-specific planned improvements

The following future improvements are suggested.

- **Emissions from storage of fuels in tank facilities:** The recent edition of the Danish emission inventory holds emissions from extraction of fuels, combustion of fuels and from service stations. To make the inventory complete emissions from storage of fuels in tank facilities should be included in the future if data is available. Work is going on to locate greater tank facilities in Denmark and collect the available data. In cases where no emission estimates or measurements are available a set of emission factors have to be set up.
- **Emissions from offshore extraction of oil and gas:** The fugitive emissions from extraction of oil and gas are based on a standard formula. If better estimates become available those will be implemented.

References for Chapter 3.5

Danish Energy Agency, 2010a: Oil and Gas Production in Denmark 2007. Available at: http://www.ens.dk/Documents/Netboghandel%20-%20publikationer/2010/Denmarks_oil_and_gas_production.pdf (11-01-2011).

Danish Energy Agency, 2010b: The Danish energy statistics (Energistatistik) (in Danish). Available at: http://www.ens.dk/en-US/Info/FactsAndFigures/Energy_statistics_and_indicators/Annual%20Statistics/Sider/Forside.aspx (11-01-2011).

Danish Environmental Protection Agency, 2008: Emissionsfaktorer for NO_x-emissioner fra flaring fra platforme i Nordsøen (in Danish). Not published.

DONG Energy, 2010a: Annually environmental reports from DONG Energy for Fredericia Oil terminal (in Danish).

DONG Energy, 2010b: Annually environmental reports from DONG Energy for Nybro gas treatment plant and Stenlille gas storage plant (in Danish). Available at: http://www.dongenergy.com/da/ansvarlighed/rapportering/pages/gronne_regnskaber.aspx (11-01-2011).

EMEP/CORINAIR, 2007: Emission Inventory Guidebook, prepared by the UNECE/EMEP Task Force on Emissions Inventories and Projections, 2007 update. Available at: http://www.eea.europa.eu/publications/EMEPCORINAIR5/page002.html (11-01-2011).

EMEP/EEA, 2009: air emission inventory guidebook, prepared by the UNECE/EMEP Task Force on Emission Inventories and Projections, 2009 update. Available at: http://www.eea.europa.eu/publications/emep-eea-emission-inventory-guidebook-2009 (11-01-2011).

Energinet.dk, 2010a: Annually environmental reports for Lille Torup Natural gas storage (in Danish). Available at: http://www.e-pages.dk/energinet/190/ (11-01-2011)

Energinet.dk, 2010b: Environmental Report 2010. Available at: http://energinet.dk/SiteCollectionDocuments/Engelske%20dokumenter/Klima%20og%20miljø/Environmental%20report%202010.pdf (11-01-2011)

Fenhann, J. & Kilde, N.A. 1994: Inventory of Emissions to the Air from Danish Sources 1972-1992. Risø National Laboratory, Roskilde, Denmark.

Holst, A. 2009: Personal communication, e-mail 18-11-2009.

IPCC, 2000: Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. Available at: http://www.ipcc-nggip.iges.or.jp/public/gp/english/ (11-01-2011).

Karll, B. 2003: Personal communication, e-mail 17-11-2003, Danish Gas Technology Centre.

Karll, B. 2005: Personal communication, e-mail 09-11-2005, Danish Gas Technology Centre.

Oertenblad, M. 2006: personal communication, e-mail 2006, Danish Gas Technology Centre.

Oertenblad, M. 2007: personal communication, e-mail 2007, Danish Gas Technology Centre.

A/S Dansk Shell 2010: Annual environmental report 2008.

Statistisk Sentralbyrå, Statistics Norway, 2008: The Norwegian Emission Inventory 2008. Documentation of methodologies for estimating emissions of greenhouse gases and long-range transboundary air pollutants. 252 pp. Reports 2008/48. Available at: http://www.ssb.no/english/subjects/01/sa_nrm/nrm2008/sa109.pdf (11-01-2011).

Statoil A/S 2010a: Annual environmental report 2008. Available at: http://www.statoil.dk/file_archive/resultater/Groentregnskab_2009_raffinaderiet.pdf (11-01-2011)

Statoil A/S, 2010b: Ubestemtheden på massestrømmen ved blændemåling og ultralyd. Report in Danish.

Sørensen, P.B., Illerup, J.B., Nielsen, M., Lyck, E., Bruun, H.G., Winther, M., Mikkelsen, M.H. & Gyldenkærne, S. 2005: Quality manual for the greenhouse gas inventory. Version 1. National Environmental Research Institute, Denmark. 25 pp. Research Notes from NERI no. 224. Available at: http://www2.dmu.dk/1_viden/2_Publikationer/3_arbrapporter/rapporter/AR224.pdf (11-01-2011).

4 Industrial processes (CRF sector 2)

4.1 Overview of the sector

The aim of this chapter is to present industrial emissions of greenhouse gases, not related to generation of energy. An overview of the sources identified is presented in Table 4.1 with an indication of the contribution to the industrial part of the emission of greenhouse gases in 2009. The emissions are extracted from the CRF tables.

Table 4.1 Overview of industrial greenhouse gas sources (2009).

Process	IPCC Code	Substance	Emission ktonne CO_2-eq.	%
Cement	2A		764	43.3
Refrigeration	2F	HFCs+PFCs	691	39.1
Foam blowing	2F	HFCs	95.7	5.42
Lime	2A		43.2	2.45
Limestone and dolomite use	2A		37.9	2.15
Other (lubricants)	2G		31.2	1.77
Other (laboratories, double glaze windows)	2F	SF_6	22.1	1.25
Aerosols / Metered dose inhalers	2F	HFCs	17.7	1.00
Other (yellow bricks)	2A		16.5	0.93
Electrical equipment	2F	SF_6	14.6	0.82
Other (container glass, glass wool)	2A		10.8	0.61
Other (fibre optics)	2F	HFCs+PFCs	9.06	0.51
Other (expanded clay products)	2A		6.48	0.37
Catalysts / fertilisers	2B		2.13	0.12
Food and Drink	2D		1.92	0.11
Road paving	2A		1.64	0.093
Asphalt roofing	2A		0.016	0.0009
Metal production	2C		0	0
Nitric acid	2B	N_2O	0	0
Total			1 766	100

The subsectors *Mineral products* (2A) constitutes 50 %, *Chemical industry* (2B) constitutes below 1 %, *Metal production* (2C) constitutes 0 %, *Consumption of halocarbons and SF_6* (2F) constitutes 48 %, *Other, Food and Drink* (2D) constitutes below 1 %, and *Other, Lubricants* (2G) constitutes 1.8 % of the industrial emission of greenhouse gases. The total emission of greenhouse gases (excl. LUCF) in Denmark is estimated to 61.0 Mt CO_2-eq., of which industrial processes contribute with 1.77 Mt CO_2-eq. (2.9 %). The emission of greenhouse gases from industrial processes from 1990-2009 are presented in Figure 4.1.

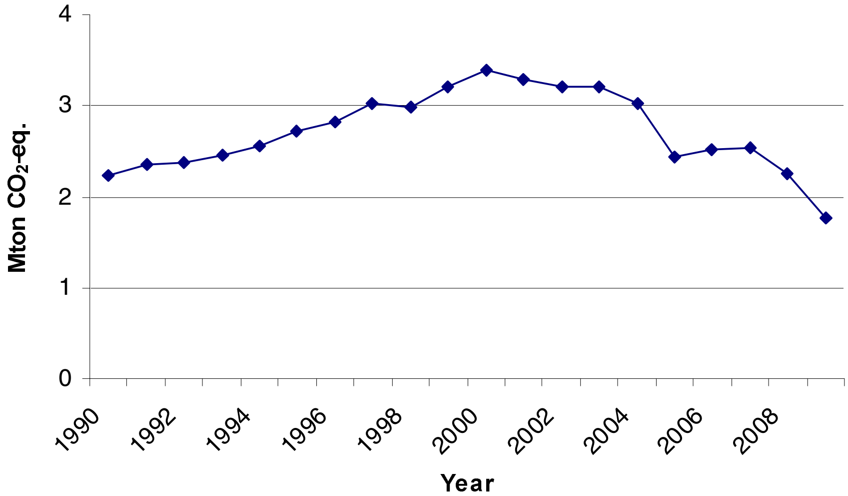


Figure 4.1 Emission of greenhouse gases from industrial processes (CRF Sector 2) from 1990-2009.

The key categories in the industrial sector constitute 1.3 and 1.1 % of the total emission of greenhouse gases. The trends in greenhouse gases from the industrial sector/subsectors are presented in Table 4.2 and they will be discussed subsector by subsector below. The emissions are extracted from the CRF tables.

Table 4.2 Emission of greenhouse gases from industrial processes in different subsectors from 1990-2009.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CO_2 (kt CO_2)										
A. Mineral Products	1 068	1 246	1 366	1 383	1 406	1 405	1 513	1 681	1 615	1 595
B. Chemical Industry	0.80	0.80	0.80	0.80	0.80	0.80	1.45	0.87	0.56	0.58
C. Metal Production	28.4	28.4	28.4	31.0	33.5	38.6	35.2	35.0	42.2	43.0
D. Food and Drink	4.45	4.49	4.14	4.26	4.36	3.91	3.80	4.29	4.90	4.71
G. Other	49.7	48.9	48.1	47.6	46.9	48.8	48.9	47.1	44.9	42.7
Total	1 151	1 329	1 447	1 467	1 492	1 497	1 603	1 768	1 707	1 686
CH_4										
N_2O (kt N_2O)										
B. Chemical Industry	3.36	3.08	2.72	2.56	2.60	2.92	2.69	2.74	2.60	3.07
HFCs (kt CO_2 eq.)										
F. Consumption of Halocarbons and SF_6	-	-	3.44	93.9	135	218	329	324	411	504
PFCs (kt CO_2 eq.)										
F. Consumption of Halocarbons and SF_6	-	-	-	-	0.053	0.50	1.66	4.12	9.10	12.5
SF_6 (kt CO_2 eq.)										
F. Consumption of Halocarbons and SF_6	44.5	63.5	89.2	101	122	107	61.0	73.1	59.4	65.4
Continued *Year*	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CO_2 (kt CO_2)										
A. Mineral Products	1 616	1 612	1 656	1 527	1 644	1 544	1 607	1 606	1 320	881
B. Chemical Industry	0.65	0.83	0.55	1.05	3.01	3.01	2.18	2.16	2.40	2.13
C. Metal Production	40.7	46.7	NA,NO	NA,NO	NA,NO	15.6	NA,NO	NA,NO	NA,NO	NA,NO
D. Food and Drink	3.90	4.95	4.47	4.49	3.97	4.46	2.17	1.72	2.67	1.92
G. Other	39.7	38.5	39.9	37.0	37.7	37.6	37.5	37.9	34.0	31.2
Total	1 701	1 703	1 701	1 569	1 688	1 604	1 649	1 647	1 360	916
CH_4										
N_2O (kt N_2O)										
B. Chemical Industry	3.24	2.86	2.50	2.89	1.71	NO	NO	NO	NO	NO
HFCs (kt CO_2 eq.)										
F. Consumption of Halocarbons and SF_6	607	650	676	701	755	802	823	850	853	799
PFCs (kt CO_2 eq.)										
F. Consumption of Halocarbons and SF_6	17.9	22.1	22.2	19.3	15.9	13.9	15.7	15.4	12.8	14.2
SF_6 (kt CO_2 eq.)										
F. Consumption of Halocarbons and SF_6	59.2	30.4	25.0	31.4	33.1	21.8	36.0	30.3	31.6	36.7

A number of improvements have been planned and are implemented continuously.

4.2 Mineral products (2A)

4.2.1 Source category description

The subsector *Mineral products* (2A) cover the following processes:

- Production of cement.
- Production of lime (and quicklime).
- Production of bricks, tiles and expanded clay products.
- Limestone and dolomite use.
- Roof covering with asphalt materials.
- Road paving with asphalt.
- Production of container glass/glass wool.

Production of cement is identified as a key category; see *Annex 1: Key Category Analyses*.

The time-series for the emission of CO_2 from *Mineral products* (2A) are presented in Table 4.3. The emissions are extracted from the CRF tables and the values are rounded.

Table 4.3 Time-series for emission of CO_2 (kt) from Mineral products (2A).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1. Production of Cement	882	1 088	1 192	1 206	1 192	1 204	1 282	1 441	1 390	1 355
2. Production of Lime	115	82.7	95.0	93.7	96.4	87.9	82.0	87.4	74.4	78.9
3. Limestone and dolomite use	13.7	23.2	25.2	32.6	53.1	53.7	85.5	85.3	86.3	94.5
5. Asphalt roofing	0.019	0.021	0.017	0.018	0.021	0.020	0.024	0.019	0.026	0.026
6. Road paving	1.76	1.76	1.79	1.81	1.75	1.77	1.77	1.77	1.70	1.75
7. Other										
Glass and Glass wool	17.4	15.6	14.5	14.1	14.9	14.1	13.9	14.0	15.0	18.1
Yellow Bricks	23.0	23.0	24.0	22.0	30.8	28.8	31.4	33.1	33.0	32.0
Expanded Clay	14.9	12.1	12.7	13.0	17.3	15.3	16.6	18.3	14.6	14.8
Total	1 068	1 246	1 366	1 383	1 406	1 405	1 513	1 681	1 615	1 595
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1. Production of Cement	1 385	1 388	1 416	1 330	1 459	1 363	1 395	1 407	1 155	764
2. Production of Lime	76.7	80.7	103	75.1	67.9	63.5	69.2	66.9	65.6	43.2
3. Limestone and dolomite use	89.7	87.2	80.9	70.0	60.2	56.2	71.7	49.6	38.7	37.9
5. Asphalt roofing	0.032	0.025	0.017	0.018	0.020	0.024	0.024	0.025	0.025	0.016
6. Road paving	1.72	1.66	1.66	1.67	1.85	1.84	1.84	2.00	1.92	1.64
7. Other										
Glass and Glass wool	15.9	16.0	16.3	13.5	13.3	12.6	13.5	15.0	15.1	10.8
Yellow Bricks	32.6	27.8	27.4	27.0	28.9	32.2	34.8	38.0	28.4	16.5
Expanded Clay	14.2	10.5	10.8	9.53	12.7	14.0	20.9	26.9	16.1	6.48
Total	1 616	1 612	1 656	1 527	1 644	1 544	1 607	1 606	1 320	881

The increase in CO_2 emission is most significant for the production of cement. From 1990 to 2009, the CO_2 emission decreased from 882 to 764 kt CO_2, i.e. by 13 %. The maximum emission occurred in 2004 and constituted 1 459 kt CO_2; see Figure 4.2.

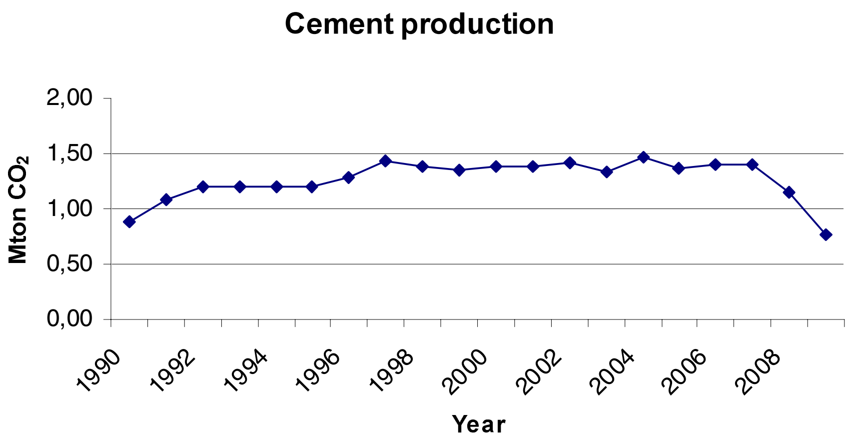


Figure 4.2 Emission of CO_2 from cement production.

The increase can be explained by the increase in the annual cement production. The emission factor has only changed slightly as the distribution between types of cement especially grey/white cement has been almost constant from 1990-1997.

4.2.2 Methodological issues

General

The CO_2 emission from the production of cement has been estimated by the company (Aalborg Portland, 2010a; 2010b; 2011). The emission factor has been estimated from the loss of ignition determined for the different kinds of clinkers produced, combined with the volumes of grey and white cements produced. Determination of loss of ignition takes into account all the potential raw materials leading to release of CO_2 and omits the Ca-sources leading to generation of CaO in cement clinker without CO_2 release. The applied methodology is in accordance with EU guidelines on calculation of CO_2 emissions (Aalborg Portland, 2008).

However, from the year 2005 the CO_2 emission determined by Aalborg Portland for EU-ETS is used in the inventory (Aalborg Portland, 2010a). The reporting to EU-ETS also provides detailed information of alternative fuels used in the production of clinker; see Table 4.4.

Table 4.4 Alternative fuels used in production of cement clinker (Aalborg Portland 2010a).

Fuel type	Biomass fraction %
Cemmiljø fuel	30-56
Paper residues	79
Dry wastewater sludge	100
Meat and bone meal	100
Tyre residues	15
Textile residues from tyres	100
Wood waste	100
Garden waste	100
Glycerine	100

Activity data and emission factors for cement production are presented in Table 4.5.

Table 4.5 Activity data, emission factors, and CO_2 emission for cement production.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Tonnes TCE	1 619 976	1 998 674	2 214 104	2 244 329	2 242 409	2 273 775	2 418 988	2 718 923	2 754 405	2 559 575
Tonnes clinker	NI	NI	NI	NI	NI	NI	NI	NI	2 462 249	2 387 282
Tonnes clinker + white cement[1]	1 406 212	1 811 958	2 089 393	2 117 895	2 192 402	2 353 123	2 481 792	2 486 475	-	-
EF tonnes CO_2 pr tonnes TCE[2]	0.545	0.544	0.539	0.537	0.532	0.529	0.530	0.530	0.505	-
EF tonnes CO_2 pr tonnes TCE[3]	-	-	-	-	-	-	-	-	0.505	0.529
EF tonnes CO_2 pr tonnes TCE[4]	-	-	-	-	-	-	-	-	-	-
EF tonnes CO_2 pr tonnes clinker[5]	*0.628*	*0.600*	*0.571*	*0.569*	*0.544*	*0.512*	*0.517*	*0.580*	0.564	0.568
Tonnes CO_2	882 402	1 087 816	1 192 336	1 206 093	1 192 196	1 203 777	1 282 064	1 441 029	1 390 975	1 354 015

Continued Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Tonnes TCE	2 612 721	2 660 972	2 698 459	2 546 295	2 861 471	2 706 371	2 842 282	2 946 294	2 551 346	1 575 211
Tonnes clinker	2 452 394	2 486 146	2 508 415	2 363 610	2 611 617	2 520 788	2 632 112	2 706 048	2 269 687	1 493 230
Tonnes clinker + white cement[1]	-	-	-	-	-	-	-	-	-	-
EF tonnes CO_2 pr tonnes TCE[2]	-	-	-	-	-	-	-	-	-	-
EF tonnes CO_2 pr tonnes TCE[3]	0.530	0.517	0.529	0.532	0.510	-	-	-	-	-
EF tonnes CO_2 pr tonnes TCE[4]	-	-	-	-	-	0.504	0.491	0.478	-	-
EF tonnes CO_2 pr tonnes clinker[5]	0.565	0.553	0.569	0.573	0.559	0.541	0.530	0.520	0.509	0.512
Tonnes CO_2	1 384 742	1 375 723	1 427 485	1 354 629	1 459 350	1 363 000	1 395 466	1 408 329	1 154 749	764 407

1. 1990-1997: Amount of clinker produced has not been measured as from 1998-2008. Therefore, the amount of GLK-, FHK-, SKL-/RKL-clinker and white cement is used as estimate of total clinker production.
2. 1990-1997: EF based on information provided by Aalborg Portland.
3. 1998-2004: EF based on information provided by Aalborg Portland (Aalborg Portland, 2008c).
4. 2005-2009: EF based on emissions reported to EU-ETS (Aalborg Portland, 2010a).
5. 1998-2009: EF based on clinker production statistics provided by Aalborg Portland (Aalborg Portland, 2011).

NI No information.

The EF depends on the ratio: white/grey cement and the ratio between three types of clinker for grey cement: GKL-clinker/FHK-clinker/SKL-RKL-clinker. The ratio white/grey cement is known from 1990-1997 with maximum in 1990 and thereafter decreasing. The ratio: GKL-clinker/FHK-clinker/SKL-RKL-clinker is known from 1990-1997. The individual EF for the different clinker types are respectively: 0.477, 0.459, and 0.610 ton CO_2 pr ton. The production of SKL/RKL-clinker peaks in 1991 and decreases hereafter. FKH-clinker is introduced in 1992 and increase to 35% in 1997.

When estimating the activity for 1990-1997 the amount of white cement is summed with the amount of clinker for grey cement as an estimate for total clinker production. Information on the total production of clinker from 1998-2009 has been provided by the company recently (Aalborg Portland 2008c, 2011).

The company has at the same time stated that data until 1997 can not be improved as they are not available anymore.

The CO_2 emission from the production of burnt lime (quicklime) as well as hydrated lime (slaked lime) has been estimated from the annual production figures, registered by Statistics Denmark – see Table 4.6 and emission factors.

Table 4.6 Statistics for production of lime and slaked lime (tonnes) (Statistics Denmark, 2010).

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Lime	127 978	86 222	104 526	106 587	112 480	100 789	95 028	102 587	88 922	95 177
Slaked lime	27 686	27 561	23 821	17 559	14 233	15 804	13 600	12 542	8 445	7 654
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Lime	92 002	96 486	122 641	87 549	77 844	71 239	78 652	75 504	74 981	46 202
Slaked lime	8 159	9 012	12 006	11 721	12 532	13 839	13 731	14 028	12 326	12 842

The emission factors applied are 0.785 kg CO_2 pr kg CaO as recommended by IPCC (IPCC, 1997, vol. 3, p. 2.8) and 0.541 kg CO_2 pr kg hydrated lime (calculated from company information on composition of hydrated lime (Faxe Kalk, 2003)).

The CO_2 emission from the production of bricks and tiles has been estimated from information on annual production registered by Statistics Denmark, corrected for amount of yellow bricks and tiles. This amount is unknown and, therefore, is assumed to be 50 %; see Table 4.7.

Table 4.7 Statistics for production of yellow bricks and expanded clay products (tonnes) (Statistics Denmark, 2010).

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Bricks (1000 pcs.)	291 348	291 497	303 629	278 534	389 803	362 711	377 652	419 431	423 254	405 241
Yellow bricks[1]	291 348	291 497	303 629	278 534	389 803	362 711	377 652	419 431	423 254	405 241
Expanded clay products	331 760	268 871	282 920	288 310	383 768	340 881	368 080	406 716	324 413	329 393
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Bricks (1000 pcs.)	414 791	351 955	342 179	341 981	365 388	407 940	465 504	348 928	322 137	226 363
Yellow bricks[1]	414 791	351 955	342 179	341 981	365 388	407 940	465 504	348 928	322 137	226 363
Expanded clay products	316 174	232 289	239 664	211 794	281 828	310 901	411 869	504 925	303 948	140 915

1. Assumptions: Brick weight: 2 kg/brick, 50 % yellow bricks.

The content of $CaCO_3$ and a number of other factors determine the colour of bricks and tiles and, in the present estimate, the average content of $CaCO_3$ in clay has been assumed to be 18 %. The emission factor lime (0.44 kg CO_2 pr kg $CaCO_3$) has been used to calculate the emission factor for yellow bricks: 0.079 tonne CO_2 pr tonne yellow bricks. For verification of this approach see Figure 4.3.

For 2006-2009 emission factors have been derived from CO_2 emissions reported by the brickworks to EU-ETS (confidential reports from approximately 20 brickworks) and production statistics (Statistics Denmark, 2010). The emission factors are calculated to 0.0728-0.1089 tonne CO_2 pr tonne yellow bricks.

The CO_2 emission from the production of container glass/glass wool has been estimated from production statistics published in environmental reports from the producers (Rexam Glass Holmegaard, 2007; Ardagh Glass Holmegaard, 2010; Saint-Gobain Isover, 2010) and emission factors based on release of CO_2 from specific raw materials (stoichiometric determination).

The CO_2 emission from consumption of limestone for flue gas cleaning has been estimated from statistics on generation of gypsum (wet flue gas cleaning processes) and the stoichiometric relations between gypsum and release of CO_2:

$$SO_2\ (g) + ½O_2\ (g) + CaCO_3\ (s) + 2H_2O \rightarrow CaSO_4{,}2H_2O\ (s) + CO_2\ (g)$$

and the emission factor is: 0.2325 tonnes CO_2 pr tonne gypsum.

Statistics on the generation of gypsum from power plants are compiled by Energinet.dk (2008). However, for 2006 - 2009 information on consumption of $CaCO_3$ at the relevant power plants has been compiled (from environmental reports) and used in the calculation of CO_2-emission from flue gas cleaning.

Information on the generation of gypsum at waste incineration plants does not explicitly appear in the Danish waste statistics (Miljøstyrelsen, 2010). However, the total amount of waste products generated can be found in the statistics. The amount of gypsum is calculated by using information on flue gas cleaning systems at Danish waste incineration plants (Illerup et al., 1999; Nielsen & Illerup, 2002) and waste generation from the different flue gas cleaning systems (Hjelmar & Hansen, 2002).

The CO_2 emission from the production of expanded clay products has been estimated from production statistics compiled by Statistics Denmark and an emission factor of 0.045 tonne CO_2 pr tonne product. For 2006-2009 emission factors have been derived from CO_2 emissions reported to EU-ETS (Damolin, 2010; Maxit, 2010) and production statistics (Statistics Denmark, 2010). The emission factors are calculated to 0.0507 and 0.0529 tonne CO_2 pr tonne product.

The indirect emission of CO_2 from asphalt roofing and road paving has been estimated from production statistics compiled by Statistics Denmark and default emission factors presented by IPCC (1997) and EMEP/CORINAIR (2004). The default emission factors, together with the calculated emission factor for CO_2, are presented in Table 4.8.

Table 4.8 Default emission factors for application of asphalt products.

		Road paving with asphalt	Use of cutback asphalt	Asphalt roofing
CH_4	g pr tonnes	5	0	0
CO	g pr tonnes	75	0	10
NMVOC	g pr tonnes	15	64 935	80
Carbon content fraction of NMVOC	%	0.667	0.667	0.8
Indirect CO_2	Kg pr tonnes	0.168	159	0.250

EU-ETS (EU Emission Trading Scheme)

Guidelines for calculating company specific CO_2 emissions are developed by EU (EU, 2007). The guidelines present standard methods for minor companies and methods for developing individual plans for major companies. The standard methods include default emission factors similar to the default emission factors presented by IPCC (e.g. for limestone), whereas, the major companies has to use individual methods to determine the actual composition of raw materials (e.g. purity of limestone or

Ca pr Mg ratio in dolomite) or the actual CO_2 emission from the specific process.

4.2.3 Uncertainties and time-series consistency

The time-series are presented in Table 4.5. The methodology applied for the years 1990-2009 is considered to be consistent as the emission factor has been determined by the same approach for all years. The emission factor has only changed slightly as the distribution between types of cement, especially grey/white cement, has been almost constant from 1990-1997. Furthermore, the activity data originates from the same company for all years.

For the production of lime and bricks, as well as container glass and glass wool, the same methodology has also been applied for all years. The emission factors are based either on stoichiometric relations or on a standard assumption of $CaCO_3$-content of clay used for bricks. The source for the activity data is, for all years, Statistics Denmark.

The source-specific uncertainties for mineral products are presented in Chapter 4.9. The overall uncertainty estimate is presented in Chapter 1.7.

4.2.4 Verification

The estimation of CO_2 release from the production of bricks based on an assumption of 50 % yellow bricks has been verified by comparing the estimate with actual information on emission of CO_2 from calcination of lime compiled by the Danish Energy Authority (DEA) (DEA, 2004). The information from the companies (tile-/brickworks; based on measurements of $CaCO_3$ content of raw material) has been compiled by DEA in order to allocate a CO_2 quota to Danish companies with the purpose of future reductions. The result of the comparison is presented in Figure 4.3.

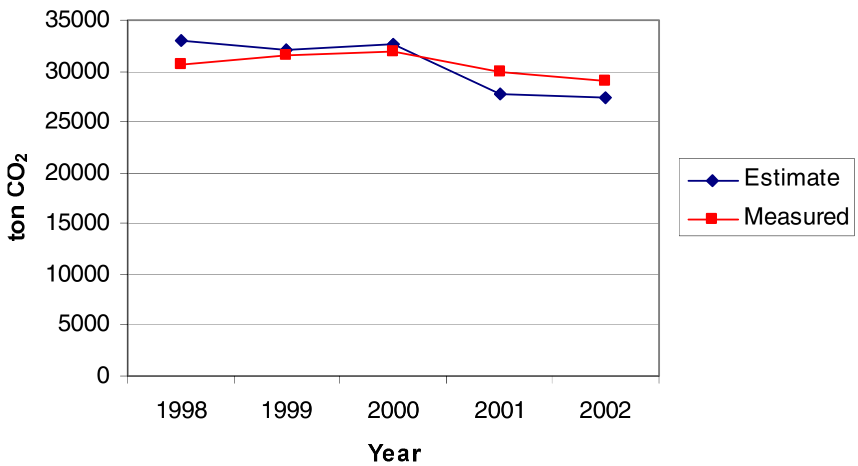


Figure 4.3 Estimated and “measured” CO_2 emission from tile-/brickworks; “measured” means information provided to the Danish Energy Authority by the individual companies (DEA, 2004).

Figure 4.3 shows a reasonable correlation between the estimated and measured CO_2 emission.

The ERT has recommended Denmark to develop a national EF based on the IEF for the years 2006-2009 i.e. emissions based on company reports to EU-ETS. Figure 4.4 presents three scenarios for yellow bricks and expanded clay products:

1. Applied methodology from 1990-2005. The EF is based on the assumption that clay for yellow bricks contains 18% $CaCO_3$.

2. CO_2 emission based on company reporting to EU ETS for the years 2006-2009.

3. Methodology recommended by UNFCCC ERT. The national EF is based on an average of IEF from the years 2006-2009.

Expanded clay products are also a mix of different products with different $CaCO_3$ addition or content. The actual mix is unknown.

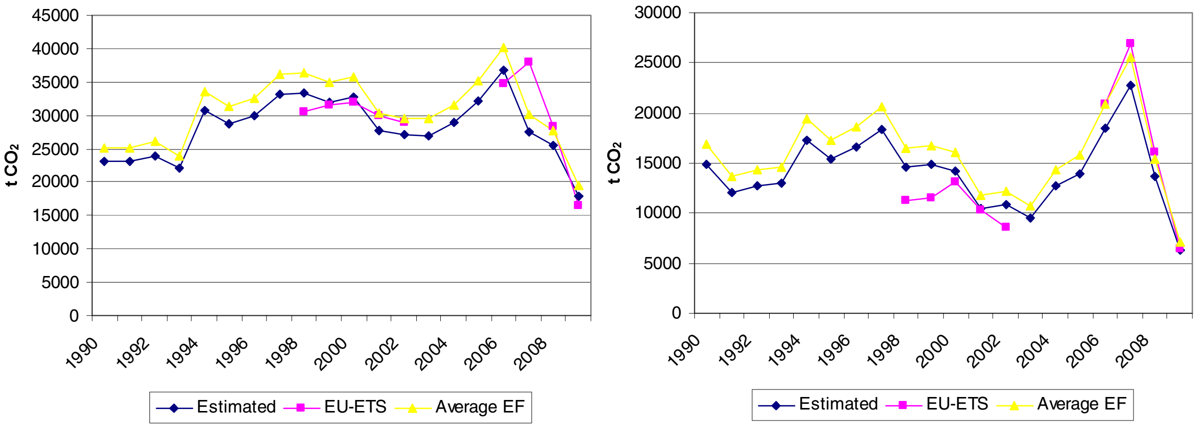


Figure 4.4 CO_2 emission from production of yellow bricks and expanded clay products. The scenarios present the applied methodology (Estimated), available EU-ETS data, and emissions based on a national EF (Average EF) as recommended by the UNFCCC ERT.

The recommended methodologies have weaknesses as the (average) EFs are based on actual reported emissions from brickworks and an assumed amount of yellow bricks as well as actual reported emissions from producers of expanded clay products and an assumed product mix. The reliability of the EFs therefore depends on non verifiable assumptions.

Changes in the methodologies do not change/improve the base year estimates and the best and most precise estimate for the resent years is considered to be the estimates made by the companies for EU-ETS.

4.2.5 Recalculations

No source-specific recalculations have been performed regarding emissions from mineral products.

4.2.6 Source-specific planned improvements

Production statistics for glass and glass wool as well as information on consumption of raw materials will be completed for 1990-1995.

4.3 Chemical industry (2B)

4.3.1 Source category description

The subsector *Chemical industry* (2B) covers the following processes:

- Production of nitric acid/fertiliser.
- Production of catalysts/fertilisers.

Production of nitric acid is identified as a key category.

The time-series for emission of CO_2 and N_2O from *Chemical industry* (2B) are presented in Table 4.9.

Table 4.9 Time-series for emission of greenhouse gasses from Chemical industry (2B).

2B	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
2. Nitric acid production (kt N_2O)	3.36	3.08	2.72	2.56	2.60	2.92	2.69	2.74	2.60	3.07
2. Nitric acid production (kt CO_2 eq.)	1 043	955	844	795	807	904	834	848	807	950
5. Other (kt CO_2)	0.80	0.80	0.80	0.80	0.80	0.80	1.45	0.87	0.56	0.58
Total (kt CO_2 eq.)	1 044	956	844	796	807	905	836	849	807	951
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
2. Nitric acid production (kt N_2O)	3.24	2.86	2.50	2.89	1.71	0	0	0	0	0
2. Nitric acid production (kt CO_2 eq.)	1 004	885	774	895	531	0	0	0	0	0
5. Other (kt CO_2)	0.65	0.83	0.55	1.05	3.01	3.01	2.18	2.16	2.40	2.13
Total (kt CO_2 eq.)	1 004	886	775	896	534	3.01	2.18	2.16	2.40	2.13

The emissions are extracted from the CRF tables and the values are rounded.

The emission of N_2O from nitric acid production is the most considerable source of GHG from the chemical industry. The trend for N_2O from 1990 to 2003 shows a decrease from 3.36 to 2.89 kt, i.e. -14 %, and a 40 % decrease from 2003 to 2004. However, the activity and the corresponding emission show considerable fluctuations in the period considered and the decrease from 2003 to 2004 can be explained by the closing of the plant in the middle of 2004.

From 1990 to 2009, the emission of CO_2 from the production of catalysts/fertilisers has increased from 0.80 to 2.13 kt with maximum in 2004-5, due to an increase in the activity as well as changes in raw material consumption.

4.3.2 Methodological issues

The N_2O emission from the production of nitric acid/fertiliser is based on measurement for 2002. For the previous years, the N_2O emission has been estimated from annual production statistics from the company and an emission factor of 7.5 kg N_2O pr tonne nitric acid, based on the 2002 emission measured (Kemira Growhow, 2004). The production of nitric acid ceased in the middle of 2004.

The CO_2 emission from the production of catalysts/fertilisers is based on information in an environmental report from the company (Haldor Topsøe, 2010), combined with personal contacts. In the environmental report, the company has estimated the amount of CO_2 from the process and the amount from energy conversion. Based on information from the company, the emission of CO_2 has been calculated from the composition of raw materials used in the production (for the years 1990 and 1996-2004) and for 2006 to 2009 assumed to be the same as in 2004 based on the same activity (produced amount). For the years 1991-1995, the production, as well as the CO_2 emission, has been assumed to remain the same as in 1990.

4.3.3 Uncertainties and time-series consistency

The time-series are presented in Table 4.9. The applied methodology regarding N_2O is considered to be consistent. The activity data is based on information from the specific company. The emission factor applied has been constant from 1990 to 2001 and is based on measurements in 2002. The production equipment has not been changed during the period.

The estimated CO_2 emissions are considered to be consistent as they are based on stoichiometric relations combined with company assumptions for the years 1991-1995.

The source-specific uncertainties for the chemical industry are presented in Section 4.9. The overall uncertainty estimate is presented in Chapter 1.7.

4.3.4 Recalculations

No source-specific recalculations have been performed regarding emissions from the chemical industry.

4.3.5 Source-specific planned improvements

No improvements are planned for this sector.

4.4 Metal production (2C)

4.4.1 Source category description

The subsector *Metal production* (2C) covers the following process:

- Steelwork

The time-series for emission of CO_2 from *Metal production* (2C) is presented in Table 4.10. The emissions are extracted from the CRF tables and the values presented are rounded.

Table 4.10 Time-series for emission of CO_2 (kt) from Metal production (2C).

2C	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1. Iron and steel production	28.4	28.4	28.4	31.0	33.5	38.6	35.2	35.0	42.2	43.0
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1. Iron and steel production	40.7	46.7	NE,NO	NE,NO	NE,NO	15.6	NE,NO	NE,NO	NE,NO	NE,NO

From 1990 to 2001, the CO_2 emission from the electro-steelwork has increased from 28 to 47 kt, i.e. by 68 %. The increase in CO_2 emission is similar to the increase in the activity as the consumption of metallurgical coke pr amount of steel sheets and bars produced has almost been constant during the period. The electro-steelwork reopened and closed down again in 2005.

4.4.2 Methodological issues

The CO_2 emission from the consumption of metallurgical coke at steelworks has been estimated from the annual production of steel sheets and steel bars combined with the consumption of metallurgical coke pr produced amount (Stålvalseværket, 2002). The carbon source is assumed to be coke and all the carbon is assumed to be converted to CO_2 as the carbon content in the products is assumed to be the same as in the iron scrap. The emission factor (3.6 tonnes CO_2 pr tonne metallurgical coke) is based on values in the IPCC-guidelines (IPCC (1997), vol. 3, p. 2.26). Emissions of CO_2 for 1990-1991 and for 1993 have been determined with extrapolation and interpolation, respectively.

4.4.3 Uncertainties and time-series consistency

The time-series (see Table 4.10) is considered to be consistent as the same methodology has been applied for the whole period. The activity, i.e. amount of steel sheets and bars produced as well as consumption of metallurgical coke, has been published in environmental reports. The emission factor (consumption of metallurgical coke pr tonnes of product) has been almost constant from 1994 to 2001. For the remaining years, the same emission factor has been applied. In 2002, production stopped. For 2005 the production has been assumed to be one third the production in 2001 as the steelwork was operating between 4 and 6 months in 2005.

The source-specific uncertainties for the metal production are presented in Section 4.9. The overall uncertainty estimate is presented in Chapter 1.7.

4.4.4 Recalculations

No source-specific recalculations have been performed regarding emissions from the metal production.

4.4.5 Source-specific planned improvements

The emission of CO_2 from consumption of metallurgical carbon in iron foundries is not included at the moment. However, this source will be investigated and included.

4.5 Other production (2D)

4.5.1 Source category description

The subsector *Other production*, Food and Drink (2D2) cover the following process:

- Production of sugar

The time-series for emission of CO_2 from *Other production, Food and Drink* (2D) is presented in Table 4.11.

Table 4.11 Time-series for emission of CO_2 (kt) from Other production, Food and Drink (2D).

2D	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
2. Food and Drink	4.45	4.49	4.14	4.26	4.36	3.91	3.80	4.29	4.90	4.71
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
2. Food and Drink	3.90	4.95	4.47	4.49	3.97	4.46	2.17	1.72	2.67	1.92

The emissions are extracted from The CRF tables and the values are rounded.

4.5.2 Methodological issues

The CO_2 emission from the refining of sugar is estimated from production statistics for sugar and a number of assumptions: consumption of 0.02 tonne $CaCO_3$ per tonne sugar and precipitation of 90 % CaO resulting in an emission factor at 0.0088 tonne CO_2 per tonne sugar. However, from the year 2006-2009 the CO_2 emission compiled by the company for EU-ETS is used in the inventory (Danisco, 2010).

4.5.3 Uncertainties and time-series consistency

The time-series is presented in Table 4.11. The same methodology has been applied for 1990-2005. From 2006-2009 data from EU-ETS has been available and therefore included in the inventory.

4.5.4 Recalculations

No source-specific recalculations have been performed for the sector *Food and Drink*.

4.5.5 Source-specific planned improvements

No improvements are planned for this sector.

4.6 Production of Halocarbons and SF_6 (2E)

There is no production of Halocarbons or SF_6 in Denmark.

4.7 Metal production (2C) and consumption of Halocarbons and SF_6 (2F)

4.7.1 Source category description

The sub-sector *Consumption of halocarbons and* SF_6 (2F) includes the following source categories and the following F-gases of relevance for Danish emissions:

- 2C4: SF_6 used in Magnesium Foundries: SF_6; see Table 4.12.
- 2F1: Refrigeration: HFC32, 125, 134a, 152a, 143a, PFC (C_3F_8); see Table 4.13.
- 2F2: Foam blowing: HFC134a, 152a; see Table 4.14.

- 2F4: Aerosols/Metered dose inhalers: HFC134a; see Table 4.15.
- 2F8: Production of electrical equipment: SF_6; see Table 4.16.
- 2F9: Other processes (laboratories, double glaze windows, fibre optics): SF_6, HFC23, CF_4, C_3F_8, C_4F_8; see Table 4.17.

A quantitative overview is given below for each of these source categories and each F-gas, showing their emissions in tonnes through the times-series. The data is extracted from the CRF tables that form part of this submission and the data presented is rounded values. It must be noticed that the inventories for the years 1990-1993 (1994) might not cover emissions of these gases in full. The choice of base-year for these gases is 1995 for Denmark.

Table 4.12 SF_6 used in magnesium foundries (t).

2C4	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
SF_6 used in magnesium foundries	1.30	1.30	1.30	1.50	1.90	1.50	0.40	0.60	0.70	0.70
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
SF_6 used in magnesium foundries	0.89	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 4.13 Consumption of HFCs and PFC in refrigeration and air condition systems (t).

2F1 Refrigeration	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
HFC32	NE	NE	NE	NA	NA	0.11	0.84	1.77	2.72	3.77
HFC125	NE	NE	NE	NA	0.23	2.58	9.46	15.8	21.8	31.7
HFC134a	NE	NE	0.32	2.63	10.3	14.3	16.3	34.2	45.9	94.3
HFC152a	NE	NE	NE	NA	NA	NA	NA	0.05	0.36	0.49
HFC143a	NE	NE	NE	NA	0.22	2.43	8.65	13.7	19.3	29.1
PFC (C_3F_8)	NE	NE	NE	NA	0.0075	0.072	0.24	0.59	1.30	1.78
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
HFC32	5.75	7.33	8.44	10.1	12.0	13.7	14.5	15.4	16.8	17.6
HFC125	43.1	45.1	48.5	54.9	59.9	67.7	70.6	73.6	75.3	74.7
HFC134a	112	128	151	162	169	181	188	198	198	167
HFC152a	0.58	0.58	0.51	0.41	0.33	0.26	0.21	0.17	0.14	0.11
HFC143a	39.6	40.1	43.2	49.0	52.8	60.3	63.0	65.6	66.0	64.6
PFC (C_3F_8)	2.29	2.64	2.67	2.51	2.27	1.99	1.76	1.51	1.29	1.13

Table 4.14 Consumption of HFCs in foam blowing (t).

2F2 Foam blowing	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
HFC32	NE	NE	NE	NA	NA	NA	NA	NA	NA	NA
HFC125	NE	NE	NE	NA	NA	NA	NA	NA	NA	NA
HFC134a	NE	NE	2.00	66.4	87.1	136	187	138	164	125
HFC152a	NE	NE	3.00	30.0	46.0	43.4	32.2	15.2	9.30	37.7
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
HFC32	NA	3.72	NA	NA	NA	NO	NO	NO	NO	NO
HFC125	NA	3.72	NA	NA	NA	NO	NO	NO	NO	NO
HFC134a	127	132	122	98.8	110	91.2	81.8	78.9	78.6	73.2
HFC152a	16.2	12.8	12.5	1.63	5.81	1.49	2.56	2.82	3.39	3.61

Table 4.15 Consumption of HFC in aerosols/metered dose inhalers (t).

2F4 Aerosols	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
HFC134a	NE	NE	NE	NA	NA	NA	NA	NA	0.61	8.91
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
HFC134a	14.5	11.7	10.8	11.4	11.5	16.1	18.8	16.0	14.3	13.6

Table 4.16 Consumption of SF_6 in electrical equipment (t).

2F8 Electrical equipment	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
SF_6	0.060	0.11	0.11	0.12	0.14	0.16	0.18	0.38	0.27	0.48
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
SF_6	0.47	0.53	0.37	0.40	0.43	0.52	0.54	0.63	0.68	0.61

Table 4.17 Consumption of SF_6, HFCs, and PFCs in other processes (t).

2F9 Other	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
SF_6	0.50	1.25	2.32	2.61	3.07	2.83	1.97	2.08	1.52	1.55
HFC23	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CF_4	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
C_3F_8	NE,NO	NE,NO	NE,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
C_4F_8	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
SF_6	1.12	0.75	0.68	0.91	0.96	0.39	0.96	0.64	0.65	0.93
HFC23	NO	NO	NO	NO	NO	NA,NO	0.08	0.24	0.12	0.24
CF_4	NO	NO	NO	NO	NO	NA,NO	0.25	0.14	0.11	0.36
C_3F_8	0.27	0.52	0.50	0.25	NA,NO	NO	NO	NO	NO	NO
C_4F_8	NO	NO	NO	NO	NO	NA,NO	0.20	0.45	0.35	0.45

The emission of SF_6 has been decreasing in recent years due to the fact that activities under Magnesium Foundry no longer exist and due to a decrease in the use of electric equipment. Also, a decrease in "other" occurs, which for SF_6 is used in window plate production use, laboratories and in the production of running shoes.

The emission of HFCs increased rapidly in the 1990s and, thereafter, increased more modestly due to a modest increase in the use of HFCs as a refrigerant and a decrease in foam blowing. The F-gases have been regulated in two ways since 1 March 2001. For some types of use there is a ban on use of the gases in new installations and for other types of use, taxation is in place. These regulations seem to have influenced emissions so that they now only increase modestly.

The phase out of F-gasses has in particular been effective within the foam blowing sector and refrigeration installations. According to foam blowing, there was a stepwise phase-out of HFC-134a used for foam blowing in hard and soft foam production, during the period 2001-2004. In 2006, all foam productions in DK have substituted HFC. Especially the phase-out of HFCs in soft foam is significant for the GWP emission in this period.

With respect to HFC refrigeration, it is not possible to determine a stabile decreasing trend yet. Since the introduction of taxes on HFC's in 2001, the consumption decreased in 2002-2003, but then the consumption of HFCs for refrigeration purposes increased again. Especially HFC-404a and HFC-134a increased. This increase is explained with another regulatory initiatives in Danish legislation, where new refrigeration systems containing HCFC-22 (ODP) was banned from 2001. It coursed a boom in HFC refrigeration systems during 2002-2004, because the HFC technology was cheap and well proven. Thus, the consumption of HFC for refrigeration has changed after 1 January 2007, where new larger HFC installations with stocks exceeding 10 kg are banned. Alternative refrigeration technologies based on CO_2, propan/buthan and ammonia is now introduced and available for customers.

Table 4.18 and Figure 4.5 quantify an overview of the emissions of the gases in CO_2-eq. The reference is the trend table as included in the CRF table for year 2009.

Table 4.18 Time-series for emission of HFCs, PFCs and SF_6 (kt CO_2-eq.).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
HFCs	-	-	3.44	93.9	135	218	329	324	411	504
PFCs	-	-	-	-	0.05	0.50	1.66	4.12	9.10	12.5
SF_6	44.5	63.5	89.2	101	122	107	61.0	73.1	59.4	65.4
Total	44.5	63.5	92.6	195	257	326	392	401	480	582
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
HFCs	607	650	676	701	755	802	823	850	853	799
PFCs	17.9	22.1	22.2	19.3	15.9	13.9	15.7	15.4	12.8	14.2
SF_6	59.2	30.4	25.0	31.4	33.1	21.8	36.0	30.3	31.6	36.7
Total	684	703	723	751	804	838	875	896	897	850

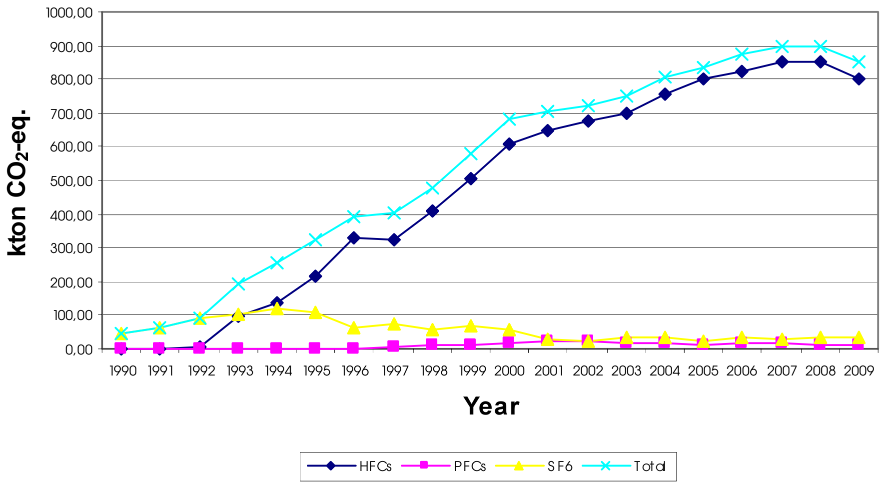


Figure 4.5 Time-series for emission of HFCs, PFCs and SF_6 (kt CO_2-eq.).

The decrease in the SF_6 emission has brought its emissions in CO_2-eq. down to the level of PFC. Overall, and for all uses, the most dominant group by far is HFCs. In this grouping, HFCs constitute a key category, both with regard to the key category level and trend analysis.

4.7.2 Methodological issues

The data for emissions of HFCs, PFCs, and SF_6 has been obtained in continuation on work on inventories for previous years. The determination includes the quantification and determination of any import and export of HFCs, PFCs, and SF_6 contained in products and substances in stock form. This is in accordance with the IPCC guidelines (IPCC (1997), vol. 3,

p. 2.43ff), as well as the relevant decision trees from the IPCC Good Practice Guidance (IPCC, 2000) p. 3.53ff).

For the Danish inventories of F-gases, a Tier 2 bottom-up approach is basically used. As for verification using import/export data, a Tier 2 top-down approach is applied. In an annex to the F-gas inventory report 2009 (DEPA, 2011), there is a specification of the approach applied for each sub-source category.

The following sources of information have been used:

- Importers, agency enterprises, wholesalers and suppliers.
- Consuming enterprises, and trade and industry associations.
- Recycling enterprises and chemical waste recycling plants.
- Statistics Denmark.
- Danish Refrigeration Installers' Environmental Scheme (KMO).
- Previous evaluations of HFCs, PFCs and $SF_{6.}$

Suppliers and/or producers provide consumption data of F-gases. Emission factors are primarily defaults from the GPG, which are assessed to be applicable in a national context. In case of commercial refrigerants and Mobile Air Condition (MAC), information from Danish suppliers has been used. The actual amount of F-gas used for refilling is used as an estimate on the actual emission.

Import/export data for sub-source categories where import/export is relevant (MAC, fridge/freezers for household) are quantified on estimates from import/export statistics of products + default values of the amount of gas in the product. The estimates are transparent and described in the annex to the report referred to above.

The Tier 2 bottom-up analysis used for determination of emissions from HFCs, PFCs, and SF_6 covers the following activities:

- Screening of the market for products in which F-gases are used.
- Determination of averages for the content of F-gases pr product unit.
- Determination of emissions during the lifetime of products and disposal.
- Identification of technological development trends that have significance for the emission of F-gases.
- Calculation of import and export on the basis of defined key figures, and information from Statistics Denmark on foreign trade and industry information.

The determination of emissions of F-gases is based on a calculation of the actual emission. The actual emission is the emission in the evaluation year, accounting for the time lapse between consumption and emission. The actual emission includes Danish emissions from production, from products during their lifetimes and from waste products.

Consumption and emissions of F-gases are, whenever possible, determined for individual substances, even though the consumption of certain HFCs has been very limited. This has been carried out to ensure transparency of evaluation in the determination of GWP values. However, the continued use of a category for *Other HFCs* has been necessary since not all importers and suppliers have specified records of sales for individual substances.

The potential emissions have been calculated as follows:

Potential emission = import + production - export - destruction/treatment.

Table 4.19 Content (w/w%) of "pure" HFC in HFC-mixtures, used as trade names.

HFC mixtures	HFC-32 %	HFC-125 %	HFC-134a %	HFC-143a %	HFC-152a %	HFC-227ea %
HFC-365						8
HFC-401a					13	
HFC-402a		60				
HFC-404a		44	4	52		
HFC-407a	23	25	52			
HFC-410a	50	50				
HFC-507a		50		50		

The substances have been accounted for in the survey according to their trade names, which are mixtures of HFCs used in the CRF, etc. In the transfer to the "pure" substances used in the CRF reporting schemes, the following ratios have been used; see Table 4.19.

The national inventories for F-gases are provided and documented in a yearly report (DEPA, 2011). Furthermore, detailed data and calculations are available and archived in an electronic version. The report contains summaries of methods used and information on sources as well as further details on methodologies.

Activity data is described in a spreadsheet for the current year.

4.7.3 Uncertainties and time-series consistency

The time-series for emission of Halocarbons and SF_6 are presented in Section 4.7.1. The time-series are consistent as regards methodology. No potential emission estimates are included as emissions in the time-series and the same emission factors are used for all years.

No appropriate measures of uncertainties have been established and no uncertainty estimates following the GPG procedures have been developed for the F-gas calculations, to date.

In general, uncertainty in inventories will arise through at least three different processes:

1. Uncertainties from definitions (e.g. incomplete, unclear, or faulty definition of an emission or uptake);
2. Uncertainties from natural variability of the process that produces an emission or uptake;
3. Uncertainties resulting from the assessment of the process or quantity depending on the method used: (i) uncertainties from measuring; (ii) uncertainties from sampling; (iii) uncertainties from reference data that may be incompletely described, and (iv) uncertainties from expert judgement.

Uncertainties due to poor definitions are not expected to be an issue in the F-gas inventory. The definitions of chemicals, the factors, sub-source categories in industries etc. are well defined.

Uncertainties from natural variability are likely to occur over the short-term while estimating emissions in individual years. But over a longer time period, 10-15 years, these variabilities level out in the total emission. This is due to that input data (consumption of F-gases) is known and is valid data, and has no natural variability due to the chemicals stabile nature.

Uncertainties that arise due to imperfect measurement and assessment are probably an issue for the:

- Emission from MAC (HFC-134a).
- Emission from commercial refrigerants (HFC-134a).

Due to the limited knowledge for these sources, the expert assessment of consumption of F-gases can lead to inexact values of the specific consumption of F-gases.

The uncertainty varies from substance to substance. Uncertainty is greatest for HFC-134a due to its widespread application in products that are imported and exported. The greatest uncertainty in application is expected to arise from consumption of HFC-404a and HFC-134a in commercial refrigerators and mobile refrigerators. The uncertainty involved in year-to-year data is influenced by the uncertainty associated with the rates at which the substances are released. This results in significant differences in the emission determinations in the short-term (approx. five years); differences that balance in the long-term.

The source-specific uncertainties for consumption of halocarbons and SF_6 are presented in Chapter 4.9. The overall uncertainty estimate is presented in Chapter 1.7.

4.7.4 QA/QC and verification

Comparison of emissions estimates using different approaches

Inventory agencies should use the Tier 1 potential emissions method for a check on the Tier 2 actual emission estimates. Inventory agencies may consider developing accounting models that can reconcile potential and actual emission estimates and which may improve the determination of emission factors over time.

This comparison was carried out in 1995-1997 and, for all three years, it shows a difference of approx. factor 3 higher emission by using potential emission estimates.

Inventory agencies should compare bottom-up estimates with the top-down Tier 2 approach, since bottom-up emission factors have the highest associated uncertainty. This technique will also minimise the possibility that certain end-uses are not accounted for in the bottom-up approach.

This comparison has not been developed.

National activity data check

For the Tier 2a (bottom-up) method, inventory agencies should evaluate the QA/QC procedures associated with estimating equipment and product inventories to ensure that they meet the general procedures outlined in the QA/QC plan and that representative sampling procedures are used. This is particularly important for the ODS (Ozone Depleting Substances)-substitute subsectors because of the large populations of equipment and products.

The spreadsheets containing activity data have incorporated several data-control mechanisms, which ensure that data estimates do not contain calculation failures. A very comprehensive QC procedure on the data in the model for the whole time-series has been carried for the present submission in connection with the process which provided, (1) data for the CRF background tables 2(II).F. for the years (1993)-2009 and (2) data for potential emissions in CRF tables 2(I). This procedure consisted of a check of the input data for the model for each substance. As regards the HFCs, this checking was carried out in relation to their trade names. Conversion was made to the HFC substances used in the CRF tables, etc. A QC was that emission of the substances could be calculated and checked comparing results from the substances as trade names and as the "no-mixture" substances used in the CRF.

Emission factors check

Emission factors used for the Tier 2a (bottom-up) method should be based on country-specific studies. Inventory agencies should compare these factors with the default values. They should determine if the country-specific values are reasonable, given similarities or differences between the national source category and the source represented by the defaults. Any differences between country-specific factors and default factors should be explained and documented.

Country-specific emission factors are explained and documented for MAC and commercial refrigerants and SF_6 in electric equipment. Separate studies have been carried out and reported. For other sub-source categories, the country-specific emission factors are assessed to be the same as the IPCC default emission factors.

Emission check

As the F-gas inventory is developed and made available in full in spreadsheets, where HFCs data relate to trade names, special procedures are performed to check the full possible correctness of the transformation to the CRF-format through Access databases.

Recalculations

No source-specific recalculations have been performed for the sector *Consumption of Halocarbons and* SF_6.

4.7.5 Planned improvements

It is planned to improve uncertainty estimates as well as the information on the choice of EFs and the specific approaches applied.

4.8 Other (2G)

4.8.1 Source category description

The subsector *Other* (2G) covers the following process:

- Consumption of lubricant oil.

The time-series for emission of CO_2 from *Other* (2G) is presented in Table 4.20.

Table 4.20 Time-series for emission of CO_2 (kt) from Other (2G).

2G	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1. Consumption of lubricant oil	49.7	48.9	48.1	47.6	46.9	48.8	48.9	47.1	44.9	42.7
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1. Consumption of lubricant oil	39.7	38.5	39.9	37.0	37.7	37.6	37.5	37.9	34.0	31.2

The emissions are extracted from The CRF tables and the values are rounded.

The emission of CO_2 from consumption of lubricants is decreasing from 49.7 kt in 1990 to 31.2 kt in 2009.

4.8.2 Methodological issues

The emission of CO_2 from consumption of lubricant oil is calculated according to the following formula:

$$E_{CO2} = LC \bullet CC_{\mathrm{lub}\,ricant} \bullet ODU_{\mathrm{lub}\,ricant} \bullet 44/12$$

where:

E_{CO2} = emission of CO_2

LC = consumption of lubricants

CC = carbon content of lubricant

ODU = amount of lubricant oxidised during use

In the calculation the following default values have been applied: CC = 20.1 kg C pr kg lubricant and ODU = 0.2. The activity data applied is presented in Table 4.21.

Table 4.21 Consumption of lubricant oil (TJ) (Danish Energy Authority).

2G	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1. Consumption of lubricant oil	3 372	3 315	3 265	3 226	3 185	3 314	3 317	3 199	3 043	2 898
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1. Consumption of lubricant oil	2 693	2 611	2 704	2 512	2 560	2 550	2 544	2 574	2 307	2 116

4.8.3 Uncertainties and time-series consistency

The time-series is presented in Table 4.20. The applied methodology has been the same during all the years and is therefore considered to be consistent. The activity data is based on information from Danish Energy

Authority. The same emission factor has been used for all the years from 1990 to 2009.

4.8.4 Recalculations

No source-specific recalculations have been performed regarding emissions from the consumption of lubricants.

4.8.5 Source-specific planned improvements

No improvements are planned for this sector.

4.9 Uncertainty

4.9.1 Tier 1 uncertainty

The source-specific uncertainties for industrial processes are presented in Table 4.22. The uncertainties are based on IPCC guidelines combined with assessment of the individual processes.

The producer has delivered the activity data for production of cement as well as calculated the emission factor based on quality measurements. The uncertainties on activity data and emission factors are assumed to be 1 % and 2 %, respectively.

The activity data for production of lime and bricks are based on information compiled by Statistics Denmark. Due to the many producers and the variety of products, the uncertainty is assumed to be 5 %. The emission factor is partly based on stoichiometric relations and partly on an assumption of the number of yellow bricks. The last assumption has been verified (see Table 4.22). The combined uncertainty is assumed to be 5 %.

The producers of glass and glass wool have registered the consumption of - raw materials containing carbonate. The uncertainty is assumed to be 5 %. The emission factors are based on stoichiometric relations and, therefore, uncertainty is assumed to be 2 %.

The producers have registered the production of nitric acid during many years and, therefore, the uncertainty is assumed to be 2 %. The measurement of N_2O is problematic and is only carried out for one year. Therefore, uncertainty is assumed to be 25 %.

The uncertainty for the activity data as well as for the emission factor is assumed to be 5 % for production of catalysts/fertilisers and iron and steel production.

The emission of F-gases is dominated by emissions from refrigeration equipment and, therefore, the uncertainties assumed for this sector will be used for all the F-gases. The IPCC propose an uncertainty at 30-40 % for regional estimates. However, Danish statistics have been developed over many years and, therefore the uncertainty on activity data is assumed to be 10 %. The uncertainty on the emission factor is, on the other hand, assumed to be 50 %. The base year for F-gases for Denmark is 1995.

Table 4.22 Uncertainties on activity data and emission factors as well as overall trend uncertainties for the different greenhouse gases.

	Activity data uncertainty	Emission factor uncertainty				
		CO_2	N_2O	HFCs[3]	PFCs[3]	SF_6[3]
Greenhouse gases	%	%	%	%	%	%
2A1. Production of Cement	1	2				
2A2. Production of Lime and Bricks	5	5				
2A3. Limestone and dolomite use	5	5				
2A5. Asphalt roofing	5	25				
2A6. Road paving with asphalt	5	25				
2A7. Other[1]	5	2				
2B2. Nitric acid production	2		25			
2B5. Other[2]	5	5				
2C1. Iron and Steel production	5	5				
2D. Food and Drink	5	5				
2F. Consumption of HFC	10			50		
2F. Consumption of PFC	10				50	
2F. Consumption of SF_6	10					50
2G. Other: Lubricants	2	5				
Overall uncertainty in 2009		1.914	25.08[4]	50.99	50.99	50.99
Trend uncertainty		1.033	1.439[4]	51.89	399.2	4.833

1) Production of yellow bricks, expanded clay products, container glass and glass wool.

2) Production of catalysts/fertilisers.

3) The base year for F-gases is for Denmark 1995.

4) 2004. The production closed down in the middle of 2004.

4.9.2 Tier 2 uncertainty

The tier 2 uncertainty for CO_2 emission from industrial processes and consumption of F-gases is presented in Table 4.23 and Table 4.24. The uncertainty estimates are based on the same individual uncertainties as applied for the tier 1 uncertainty estimate.

Table 4.23 Tier 2 uncertainty for industrial processes (kt CO_2).

		1990			2009			1990-2009		
		Median	Uncertainty (%)		Median	Uncertainty (%)		Median	Uncertainty (%)	
		Emission	Lower (-)	Upper (+)	Emission	Lower (-)	Upper (+)	Emission	Lower (-)	Upper (+)
CO_2	ktons	1 151	2	2	916	2	2	228	2	2

Table 4.24 Tier 2 uncertainty for consumption of F-gases (kt CO_2-eq.).

		1995			2009			1995-2009		
		Median	Uncertainty (%)		Median	Uncertainty (%)		Median	Uncertainty (%)	
		Emission	Lower (-)	Upper (+)	Emission	Lower (-)	Upper (+)	Emission	Lower (-)	Upper (+)
CO_2-eq.	ktons	292	22	33	862	28	43	-512	-52	-29

4.10 Quality assurance/quality control (QA/QC)

4.10.1 Internal QA/QC

The approach used for quality assurance/quality control (QA/QC) is presented in Chapter 1.6. The present chapter presents QA/QC considerations for industrial processes based on a series of Points of Measuring (PMs); see Chapter 1.6.

Data Storage level 1	1. Accuracy	DS.1.1.1	General level of uncertainty for every dataset including the reasoning for the specific values.

The uncertainty assessment has been performed on Tier 1 and Tier 2 level by using default and country specific uncertainty factors. The applied uncertainty factors are presented in Table 4.19.

Data Storage level 1	1. Accuracy	DS.1.1.2	Quantification of the uncertainty level of every single data value including the reasoning for the specific values.

See DS.1.1.1. As Tier 1 and default uncertainty factors are applied, the individual datasets have not been assessed.

Data Storage level 1	2.Comparability	DS.1.2.1	Comparability of the data values with similar data from other countries, which are comparable with Denmark, and evaluation of discrepancy.

Comparability of the data has not been performed at "Data Storage level 1". However, investigation of comparability at CRF level is in progress.

The applied data sets are presented in Table 4.25.

Data Storage level 1	3.Completeness	DS.1.3.1	Documentation showing that all possible national data sources are included setting down the reasoning behind the selection of datasets.

Table 4.25 Applied data sets.

File or folder name	Description	AD or E	Reference	Contact(s)	Comment
Ardagh Glass Holmegaard gr2009.pdf		E	www.ardaghglass.com		
Nordic Sugar Nakskov gr2009-2010.pdf		AD	www.nordicsugar.com		AD used for estimation of production at three different locations 1990-1995.
Nordic Sugar Nykøbing gr2009-2010.pdf		AD	www.nordicsugar.com		AD used for estimation of production at three different locations 1990-1995.
Faxe_Kalk-brandt_kalk.pdf	Chemical composition of product.		www.faxekalk.dk		
Faxe_Kalk-hydratkalk_191103.pdf	Chemical composition of product.		www.faxekalk.dk		
Haldor Topsoe gr2009.pdf		AD, E	www.topsoe.dk		
Haldor Topsoe 1990.xls		E	Haldor Topsøe	Allan Willumsen	
Haldor Topsoe – emissioner 1996 – 2004.xls		E	Haldor Topsøe	Allan Willumsen	
Kemira GR2003.pdf		AD, E	www.kemira-growhow.com		
Rockwool gr2009.pdf		AD	www.rockwool.dk		
Saint Gobain gr2009.pdf		AD,E	Saint-Gobain Isover www.isover.dk	Anette Åkesson	
Stålvalseværket (2002) – paper version.		AD, E	Stålvalseværket		
Aalborg Portland miljoredegorelse_2009.pdf		AD, E	www.aalborg-portland.dk		
Aalborg Portland energy 2000-2004 answer.xls		AD	Aalborg Portland	Henrik Møller Thomsen, Torben Ahlmann-Laursen	
_animal residues.xls		AD	Danmarks Statistik; www.statistikbanken.dk		
_bread.xls		AD	Danmarks Statistik; www.statistikbanken.dk		
_beverage.xls		AD	Danmarks Statistik; www.statistikbanken.dk		

The data sources - in general - can be grouped as follows:

- Company specific environmental reports.
- Personal communication with individual companies.
- Company specific information compiled by Danish Energy Agency in relation to the EU-ETS.
- Industrial organisations.
- Statistics Denmark.
- Secondary literature.
- IPCC guidelines.

The environmental reports contribute with company-specific emission factors, technical information and, in some cases, activity data. The environmental reports are primarily used for large companies and, for some companies, are supplemented with information from personal contacts, especially for completion of the time-series for the years before the legal requirement to prepare environmental reports (i.e. prior to 1996).

Statistics Denmark is used as source for activity data as they are able to provide consistent data for the period 1990-2009. In the cases where the statistics do not contain transparent data, statistics from industrial organisations are used to generate to required activity data.

For many of the processes, the default emission factors are based on chemical equations and are, therefore, the best choice. In some cases, the default EF has been modified in order to reflect local conditions.

Secondary literature may be used in the interpretation or in disaggregation of the public statistics.

Data Storage level 1	4.Consistency	DS.1.4.1	The origin of external data has to be preserved whenever possible without explicit arguments (referring to other PMs).

See DS.1.4.1. Consistency is secured by application of the same data source over the period in question, e.g. activity data from Statistics Denmark, or by using personal contacts in the individual companies to obtain activity data for the period when environmental reports were not mandatory. For some activities, statistics compiled by industrial organisations were applied.

Data Storage level 1	6.Robustness	DS.1.6.1	Explicit agreements between the external institution holding the data and NERI about the condition of delivery.

An agreement regarding inclusion of information - compiled by Danish Energy Authority for EU-ETS - in the Danish GHG-inventory has been signed. The implementation of this information has been introduced for production of cement as well as sugar refining.

Data Storage level 1	7.Transparency	DS.1.7.1	Summary of each dataset including the reasoning for selecting the specific dataset.

The datasets applied are presented in Table 4.25. For the reasoning behind their selection, see DS.1.3.1.

Data Storage level 1	7.Transparency	DS.1.7.3	References for citation for any external dataset have to be available for any single value in any dataset.

The data applied, including references for citation, are presented in Table 4.25.

Data Storage level 1	7.Transparency	DS.1.7.4	Listing of external contacts for every dataset.

The applied data including external contacts are presented in Table 4.25.

Data Processing level 1	1. Accuracy	DP.1.1.1	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to type of variability (distribution as: normal, log normal or other type of variability).

The uncertainty assessment has been performed on Tier 1 level, assuming a normal distribution of activity data as well as emission data, by application of default uncertainty factors. Therefore, no considerations regarding distribution or type of variability have been performed.

Data Processing level 1	1. Accuracy	DP.1.1.2	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to scale of variability (size of variation intervals).

See DP.1.1.2.

Data Processing level 1	1. Accuracy	DP.1.1.3	Evaluation of the methodological approach using international guidelines.

The applied methodologies are in line with the international guidelines issued by the IPCC combined with national adjustments. The degree of fulfilment of the required methodology has been documented in an internal note (Kyoto note).

Data Processing level 1	1. Accuracy	DP.1.1.4	Verification of calculation results using guideline values.

The emission factors applied are mostly based on chemical equations and are, therefore, in accordance with the default EFs. E.g. for production of nitric acid, where the emission factor is dependent on process conditions, a comparison has been made to the default EF listed in the guideline. E.g. for the deviation of the emission factor for calcination in the cement process, an explanation has been developed in cooperation with the company.

Data Processing level 1	2.Comparability	DP.1.2.1	The inventory calculation has to follow the international guidelines suggested by UNFCCC and IPCC.

See DP.1.1.3

Data Processing level 1	3.Completeness	DP.1.3.1	Assessment of the most important quantitative knowledge which is which is lacking.

This issue will be investigated further.

Data Processing level 1	3.Completeness	DP.1.3.2	Assessment of the most important cases where access is lacking with regard to critical data sources that could improve quantitative knowledge.

Accessibility to critical company-specific information will be established as a consequence of the formal agreement with the Danish Energy Authority concerning data compiled in relation to the EU-ETS.

Data Processing level 1	4.Consistency	DP.1.4.1	In order to keep consistency at a high level, an explicit description of the activities needs to accompany any change in the calculation procedure.

Recalculations are described in the NIR. A manual log is included in the tool used for data processing at Data Processing level 2. This log also includes changes on Data Processing level 1.

Data Processing level 1	5.Correctness	DP.1.5.1	Show at least once, by independent calculation, the correctness of every data manipulation.

The sector report for industry (in prep.) presents an independent example of the calculations to ensure the correctness of every data manipulation.

Data Processing level 1	5.Correctness	DP.1.5.2	Verification of calculation results using time-series.

The calculations are verified by checking the time-series.

Data Processing level 1	5.Correctness	DP.1.5.3	Verification of calculation results using other measures.

A methodology to verify calculation of results using other measures will be developed.

Data Processing level 1	5.Correctness	DP.1.5.4	Shows one-to-one correctness between external data sources and the databases at Data Storage level 2.

A methodology to check the correctness between external data sources and the databases at storage level 2 will be developed.

Data Processing level 1	7.Transparency	DP.1.7.1	The calculation principle and equations used must be described.

The calculation principles and equations are based on the methodology presented by the IPCC. A detailed description can be found in the sector report for industry (in prep.).

Data Processing level 1	7.Transparency	DP.1.7.2	The theoretical reasoning for all methods must be described.

The theoretical reasoning for choice or development of methods is described in detail in the sector report for industry (in prep.).

Data Processing level 1	7.Transparency	DP.1.7.3	Explicit listing of assumptions behind all methods.

The assumptions used in the different methods are described in the sector report for industry (in prep.) and also included in the present report. An explicit list of assumptions will be developed in the coming sector report.

Data Processing level 1	7.Transparency	DP.1.7.4	Clear reference to data set at Data Storage level 1.

Explicit references from the data processing to each dataset can be found in the sector report for industry (in prep.).

Data Processing level 1	7.Transparency	DP.1.7.5	A manual log to collect information about recalculations.

A manual log is included in the tool used for data processing at data level 2. This log also includes changes on Data Processing level 2. A detailed log will be developed in the sector report for industry (in prep.).

Data Processing level 2	5.Correctness	DS.2.5.1	Documentation of a correct connection between all data types at level 2 to data at level 1.

The sector report for industry (in prep.) presents the connection between the datasets on Data Storage level 1 and Data Processing level 2. Individual calculations are used to check the output of the data processing tool used at Data Processing level 2.

Data Processing level 2	5.Correctness	DS.2.5.2	Check if a correct data import to level 2 has been made.

See DS.2.5.2.

4.10.2 External QA/QC

External QA/QC is described for one source: cement production.

Cement production

Aalborg Portland has an environmental management system that meets the requirements in DS/ISO 14001, EMAS etc. (Aalborg Portland, 2010b). The environmental management system is part of an integrated process management system. The system is certified according to the standards by the accredited body: Danish Standards. Information on raw material consumption as well as internal recycling is compiled in an environmental database. Some pollutants (NO_x, SO_2, CO and TSP) are measured continuously. Emission of CO_2 is calculated based on (fuel and) raw material consumption and raw material flow according to an approved CO_2 emission plan (EU-ETS). The CO_2 emission plan has to fulfil the requirements in the guidelines developed by EU (EU, 2007).

References

Ardagh Glass Holmegaard, 2010: Grønt regnskab for Ardagh Glass Holmegaard A/S 2009, CVR nr. 18445042 incl. 2007-8 (in Danish).

Damolin, 2010: CO_2-opgørelse og afrapportering 2009. Damolin Fur A/S og Damolin Mors A/S. (In Danish) Confidential.

Danish Energy Authority (DEA), 2004: Anders Baunehøj Hansen, personal communication, 15 December 2004.

Danish Energy Authority (DEA), 2010: The Danish energy statistics, Available at:
http://www.ens.dk/en-US/Info/FactsAndFigures/Energy_statistics_and_indicators/Annual%20Statistics/Sider/Forside.aspx/BasicData2009.xls.

Danish Environmental Protection Agency (DEPA), 2011: The greenhouse gases HFCs, PFCs and SF_6. Danish consumption and emissions, 2009. Environmental Project No xx. In prep.

EMEP/CORINAIR, 2004: Emission Inventory Guidebook 3rd edition, prepared by the UNECE/EMEP Task Force on Emissions Inventories and Projections, 2004 update. Available at: http://reports.eea.eu.int/EMEPCORINAIR4/en (15-04-2007).

Energinet.dk, 2007: Baggrundsrapport til Miljøberetning 2006 (in Danish).

EU, 2007: Commission decission of 18 July 2007 establishing guidelines for monittoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council. Available at: http://eur-lex.europa.eu/

Faxe Kalk, 2003: Diverse produktblade (in Danish).

Haldor Topsøe, 2010: Miljøredegørelse for katalysatorfabrikken 2009 (14. regnskabsår); incl. 1996-2008 (in Danish).

Hjelmar, O. & Hansen, J.B., 2002: Restprodukter fra røggasrensning på affaldsforbrændingsanlæg. Nyttiggørelse eller deponering? DHI - Institut for Vand & Miljø. Kursusmateriale fra kurset Røggasrensning 2002. IDA, Brændsels- og Energiteknisk Selskab (in Danish).

Illerup, J.B., Geertinger A.M., Hoffmann, L. & Christiansen, K., 1999: Emissionsfaktorer for tungmetaller 1990-1996. Faglig rapport fra DMU, nr. 301. Miljø- og Energiministeriet, Danmarks Miljøundersøgelse (in Danish).

IPCC, 1997: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. Available at: http://www.ipcc-nggip.iges.or.jp/public/gl/invs6.htm (15-04-2007).

IPCC, 2000: Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. Available at: http://www.ipcc-nggip.iges.or.jp/public/gp/english/ (15-04-2007).

Kemira GrowHow, 2004: Miljø & arbejdsmiljø. Grønt regnskab 2003; incl. 1996-2002 (in Danish).

Maxit, 2010: CO_2-opgørelse og afrapportering 2009. Maxit a.s. Hinge og Maxit a.s. Ølst. (In Danish) Confidential.

Miljøstyrelsen, 2011: Affaldsstatistik 2010. Orientering fra Miljøstyrelsen (In Danish; to be published).

Nielsen, M. & Illerup, J.B., 2003: Emissionsfaktorer og emissionsopgørelse for decentral kraftvarme. Eltra PSO projekt 3141. Kortlægning af emissioner fra decentrale kraftvarmeværker. Delrapport 6. Danmarks Miljøundersøgelser. 116 s. Faglig rapport fra DMU nr. 442. Available at: http://www-.dmu.dk/udgivelser/ (in Danish).

Nordic Sugar, 2010: CO_2-opgørelse og afrapportering 2009. Nordic Sugar. Fremstilling af sukker. (In Danish) Confidential.

Rexam Glass Holmegaard, 2007: Grønt regnskab for Rexam Glass Holmegaard A/S 2006, CVR nr. 18445042; incl. 1996/97-2006 (in Danish).

Rockwool, 2010: Miljøredegørelse 2009 for fabrikkerne i Hedehusene, Vamdrup og Øster Doense; incl. 1996-2008 (in Danish).

Saint-Gobain Isover, 2010: Miljø- og energiredegørelse 2009; incl. 1996-2008 (in Danish).

Statistics Denmark, 2010: Statbank Denmark. Available at: www.statbank.dk

Stålvalseværket, 2002: Grønt regnskab og miljøredegørelse 2001. Det Danske Stålvalseværk A/S; incl. 1992, 1994-2000 (in Danish).

Aalborg Portland, 2008: Henrik Møller Thomsen, Personal communication 17 September 2008.

Aalborg Portland, 2010a: CO_2-opgørelse og afrapportering 2009. Aalborg Portland A/S. Fremstilling af klinker (cement); including 2005-2008. Confidential.

Aalborg Portland, 2010b: Environmental report 2009; including 1996-2008.

Aalborg Portland, 2011: Torben Ahlmann-Laursen, Personal communication 3 January 2011.

5 Solvents and Other Product Use (CRF sector 3)

5.1 Overview of the sector

This section presents the Danish methodology used for calculating CO_2, N_2O and NMVOC emissions from solvents and other product use in industrial processes and households that are related the source categories Paint application (CRF sector 3A), Degreasing and dry cleaning (CRF sector 3B), Chemical products, manufacture and processing (CRF sector 3C) and Other (CRF sector 3D). NMVOCs are not considered direct greenhouse gases but once emitted in the atmosphere they will over a period of time oxidise to CO_2.

Solvents are chemical compounds that are used on a global scale in industrial processes and as constituents in final products to dissolve e.g. paint, cosmetics, adhesives, ink, rubber, plastic, pesticides, aerosols or are used for cleaning purposes, i.e. degreasing. NMVOCs are main components in solvents - and solvent use in industries and households is typically the dominant source of anthropogenic NMVOC emissions (UNFCCC, 2008; Pärt, 2005; Karjalainen, 2005). In industrial processes where solvents are produced or used NMVOC emissions to air and as liquid can be recaptured and either used or destroyed. Solvent containing products are used indoor and outdoor and the majority of solvent sooner or later evaporate. A small fraction of the solvent ends up in waste or as emissions to water and may finally also contribute to air pollution by evaporation from these compartments. Emission inventories for solvents are based on model estimates, as direct and continuous emissions are only measured from a limited number of pollutants and sources, e.g. SO_2 and NOx from central power plants.

In this section the methodology for the Danish NMVOC emission inventory for solvent use is presented and the results for the period 1995 – 2009 are summarised. The method is based on the detailed approach described in EMEP/CORINAIR (2004) and emissions are calculated for industrial sectors, households in the NFR sectors mentioned above, as well as for individual chemicals.

5.2 Source category emissions

Table 5.1 and Figure 5.1 show the emissions of chemicals from 1985 to 2009, where the used amounts of single chemicals have been assigned to specific products and NFR sectors. The methodological approach for finding emissions in the period 1995 - 2009 is described in the following section. A linear extrapolation is made for the period 1985 – 1994. A general decrease is seen throughout the sectors. Table 5.2 shows the used amounts of chemicals for the same period. Table 5.1 is derived from Table 5.2 by applying emission factors relevant to individual chemicals and production or use activities. Table 5.3 showing the used amount of products is derived from Table 5.2, by assessing the amount of chemicals that is comprised within products belonging to each of the four source categories. The CO_2 conversion factor for each chemical is shown in Table 5.4.

In Table 5.4 the emission for 2009 is split into individual chemicals. The most abundantly used solvents are ethanol, turpentine, or white spirit defined as a mixture of stoddard solvent and solvent naphtha and propylalcohol. Ethanol is used as solvent in the chemical industry and as windscreen washing agent. Turpentine is used as thinner for paints, lacquers and adhesives. Propylalcohol is used in cleaning agents in the manufacture of electrical equipment, flux agents for soldering, as solvent and thinner and as windscreen washing agent. Household emissions are dominated by propane and butane, which are used as aerosols in spray cans, primarily in cosmetics. For some chemicals the emission factors are precise but for others they are rough estimates. Emission factors are divided into four categories: 1) chemical industry (lowest EF), 2) other industry, 3) non-industrial activities, 4) domestic and other diffuse use (highest EF). This implies that high emission factors are applicable for use of solvent containing products and lower emission factors are applicable for use in industrial processes.

Table 5.1 Emission of chemicals in Gg pr year.

Total emissions Gg pr year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Paint application (3A)	11.6	11.3	11.0	10.6	10.3	9.93	9.59	9.24	8.90	8.56
Degreasing and dry cleaning (3B)	1.04E-04	9.98E-05	9.55E-05	9.13E-05	8.7E-05	8.28E-05	7.85E-05	7.42E-05	7E-05	6.57E-05
Chemical products, manufacturing and processing (3C)	11.2	11.0	10.7	10.4	10.1	9.83	9.55	9.26	8.98	8.70
Other (3D)	40.4	39.4	38.4	37.3	36.3	35.3	34.3	33.3	32.3	31.3
Total NMVOC	63.3	61.6	59.98794	58.3543	56.7	55.1	53.5	51.8	50.2	48.6
Total CO_2	156	151	148	143	139	135	131	127	122	119

Continued	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Paint application (3A)	6.89	8.46	7.16	6.99	7.55	7.44	6.08	6.08	5.95	5.40
Degreasing and dry cleaning (3B)	7.67E-05	7.38E-05	4.46E-05	5.48E-05	3.45E-05	2.93E-05	1.25E-05	2.98E-05	2.89E-05	2.4E-05
Chemical products, manufacturing and processing (3C)	9.11	9.20	7.82	7.45	7.07	6.74	6.10	6.39	4.76	5.90
Other (3D)	28.7	31.2	29.3	26.6	25.6	26.5	23.7	23.3	21.3	20.5
Total NMVOC	44.7	48.8	44.2	41.0	40.2	40.6	35.9	35.7	32.0	31.8
Total CO_2	107	119	107	99.8	98.8	98.8	86.9	87.1	78.9	77.0

Continued	2005	2006	2007	2008	2009
Paint application (3A)	4.89	4.07	3.39	3.66	3.32
Degreasing and dry cleaning (3B)	1.83E-05	1.46E-05	2.17E-05	1.5E-05	1.31E-05
Chemical products, manufacturing and processing (3C)	6.12	5.94	6.07	5.84	4.90
Other (3D)	19.9	20.2	17.6	17.9	19.1

Table 5.2 Used amounts of chemicals in Gg pr year.

Used amounts of chemical Gg pr year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	
Paint application (3A)	24.8	24.1	23.5	22.8	22.1	21.5	20.8	20.2	19.5	18.9	15.3	18.5	
Degreasing and dry cleaning (3B)	1.04	1.00	0.959	0.917	0.874	0.832	0.789	0.746	0.704	0.661	0.767	0.738	
Chemical products, manufacturing and processing (3C)	53.4	57.2	60.9	64.6	68.4	72.1	75.9	79.6	83.3	87.1	101	105	
Other (3D)	63.0	61.6	60.3	58.9	57.6	56.2	54.9	53.6	52.2	50.9	47.8	50.0	
Total NMVOC	142	144	146	147	149	151	152	154	156	157	165	174	
Continued	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Paint application (3A)	16.0	16.2	16.8	17.3	14.2	14.3	13.4	12.8	12.1	10.2	8.76	9.10	8.04
Degreasing and dry cleaning (3B)	0.446	0.548	0.345	0.293	0.125	0.298	0.289	0.240	0.183	0.146	0.217	0.150	0.131
Chemical products, manufacturing and processing (3C)	104	106	97.7	114	110	108	103	127	148	150	163	155	137
Other (3D)	48.0	45.1	43.4	44.4	39.8	42.3	35.5	35.2	39.7	35.1	31.8	32.9	35.0
Total NMVOC	168	167	158	175	165	165	152	175	200	196	204	197	180

Table 5.3 Used amounts of products in Gg pr year.

Used amounts of products Gg pr year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	
Paint application (3A)	165	161	156	152	148	143	139	135	130	126	102	123	
Degreasing and dry cleaning (3B)	2.09	2.00	1.92	1.83	1.75	1.66	1.58	1.49	1.41	1.32	1.53	1.48	
Chemical products, manufacturing and processing (3C)	267	286	305	323	342	361	379	398	417	435	505	524	
Other (3D)	315	308	301	295	288	281	274	268	261	254	239	250	
Total products	749	757	764	772	779	787	794	802	809	817	848	898	
Continued	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Paint application (3A)	107	108	112	115	94.7	95.4	89.5	85.2	80.9	67.7	58.4	60.6	53.6
Degreasing and dry cleaning (3B)	0.892	1.10	0.690	0.586	0.251	0.597	0.578	0.481	0.366	0.292	0.433	0.299	0.263
Chemical products, manufacturing and processing (3C)	519	528	488	568	552	541	514	635	742	751	816	773	683
Other (3D)	240	225	217	222	199	211	178	176	199	176	159	165	175
Total products	867	863	818	905	846	848	781	896	1021	995	1034	999	912

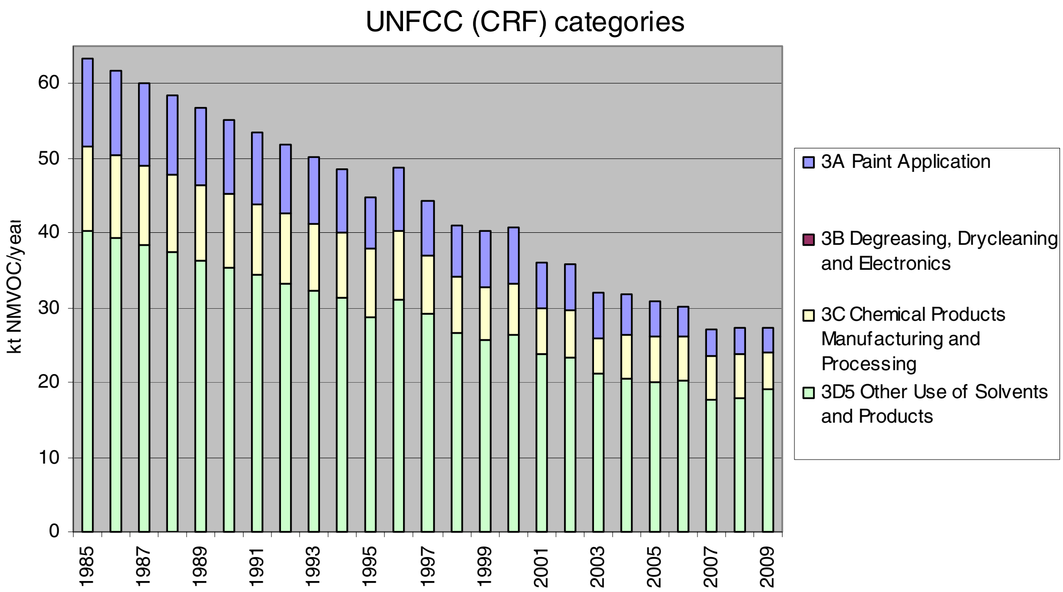


Figure 5.1 Emissions of chemicals in ktonnes pr year (equal to Gg pr year). The methodological approach for finding emissions in the period 1995 – 2009 is described in the text, and a linear extrapolation is made for 1985 – 1994. Figures can be seen in Table 5.1.

Table 5.4 Chemicals with highest emissions 2009, and CO_2 conversion factors assuming that all carbon molecules in the NMVOC molecule are converted to CO_2.

Chemical	CAS no	Emissions 2009 (tonnes)	CO_2-conversion factor (g CO_2 pr g NMVOC)
ethanol	64-17-5	8047	1.91
turpentine (white spirit: stoddard solvent and solvent naphtha)	64742-88-7 8052-41-3	6525	2.79
propylalcohol	67-63-0	3253	2.20
cyanates	79-10-7	1974	1.83
pentane	109-66-0	1472	3.06
acetone	67-64-1	892	2.28
methanol	67-56-1	839	1.38
propylenglycol	57-55-6	833	1.74
xylene	1330-20-7 95-47-6 108-38-3 106-42-3	736	3.32
propane	74-98-6	654	2.86
butane	106-97-8	654	2.93
butanone	78-93-3	533	2.45
phenol	108-95-2	361	2.81
ethylenglycol	107-21-1	212	1.42
formaldehyde	50-00-0	196	1.47
toluene	108-88-3	157	3.35
cyclohexanones	108-94-1	149	2.69
glycolethers	110-80-5 107-98-2 108-65-6 34590-94-8 112-34-5 and others	141	1.95
1-butanol	71-36-3	114	2.38
acyclic aldehydes	78-84-2 111-30-8 and others	109	2.31
methyl methacrylate	80-62-6	103	2.20
ethylacetate	141-78-6	47.1	2.00
butanoles	78-92-2 2517-43-3 and others	38.9	2.24
styrene	100-42-5	33.9	3.39
butylacetate	123-86-4	16.6	2.28
naphthalene	91-20-3	16.2	3.44
tetrachloroethylene	127-18-4	2.16	0.531
Total 2007		27351	

5.3 Other use (N_2O)

Five companies sell N_2O in Denmark and only one company produces N_2O. N_2O is primarily used in anaesthesia by dentists, veterinarians and in hospitals and in minor use as propellant in spray cans and in the production of electronics. Due to confidentiality no data on produced amount are available and thus the emissions related to N_2O production are unknown. An emission factor of 1 is assumed for all uses, which equals the sold amount to the emitted amount. Sold amounts are obtained from the respective companies and the produced amount is estimated from communication with the company.

Total sold and estimated produced NO_2 for sale in Denmark, which equals the emissions, is shown in Table 5.5.

Table 5.5 N_2O emissions. EF = 1, i.e. sale in Denmark equals emissions.

	2005	2006	2007	2008	2009
N_2O sale = emissions, (Gg)	0.0453	0.122	0.119	0.0881	0.109

5.4 Methodology

Until 2002 the Danish solvent emission inventory was based on questionnaires, which were sent to selected industries and sectors requiring information on solvent use. In 2003 it was decided to implement a method that is more complete, accurate and transparent with respect to including the total amount of used solvent, attributing emissions to industrial sectors and households and establishing a reliable model that is readily updated on a yearly basis.

Emission modelling of solvents can basically be done in two ways: 1) By estimating the amount of (pure) solvents consumed, or 2) By estimating the amount of solvent containing products consumed, taking account of their solvent content (EMEP/CORINAIR, 2004).

In 1) all relevant solvents must be estimated, or at least those together representing more than 90 % of the total NMVOC emission, and in 2) all relevant source categories must be inventoried or at least those together contributing more than 90 % of the total NMVOC emission. A simple approach is to use a pr capita emission for each category, whereas a detailed approach is to get all relevant consumption data (EMEP/CORINAIR, 2004).

The detailed method 1) is used in the Danish emission inventory for solvent use, thus representing a chemicals approach, where each chemical (NMVOC) is estimated separately. The sum of emissions of all estimated NMVOCs used as solvents equals the NMVOC emission from solvent use. See Figure 1 for methodological overview.

5.4.1 Chemical list

Some of the chemical compounds that are stated for reporting to the Climate and CLRTAP Conventions are not relevant for use of solvents. NMVOC is the most important chemical group especially in relation to the CLRTAP. There is also some use of N_2O and due to the high greenhouse warming potential (GWP) of N_2O, yielding a CO_2-equivalent of 1 g N_2O = 310 g CO_2 (IPCC 2000), N_2O is important in relation to the Climate Convention. Only NMVOC, N_2O and CO_2 are considered in the present reporting to the Climate Convention, CLRTAP and the NEC Directive. However, minor emissions may apply to use of other chemicals and e.g. mercury, PAHs, dioxins and PCBs will be assessed in coming inventories.

The definitions of solvents and VOC that are used in the Danish inventory (Nielsen et al., 2009) are as defined in the solvent directive (Directive 1999/13/EC) of the EU legislation: "Organic solvent shall mean any VOC which is used alone or in combination with other agents, and without undergoing a chemical change, to dissolve raw materials, products or waste materials, or is used as a cleaning agent to dissolve contaminants, or as a dissolver, or as a dispersion medium, or as a viscosity adjuster, or as a surface tension adjuster, or a plasticiser, or as a preservative". VOCs are defined as follows: "Volatile organic compound shall mean any organic compound having at 293,15 K a vapour pressure of 0,01 kPa or more, or having a corresponding volatility under the particular condition of use".

This implies that some chemicals, e.g. ethylenglycol, that have vapour pressures just around 0.01 kPa at 20 ^{o}C, may only be defined as VOCs at use conditions with higher temperature. However, use conditions under elevated temperature are typically found in industrial processes. Here the capture of solvent fumes is often efficient, thus resulting in small emissions (communication with industries).

The Danish list of chemicals comprises 33 chemicals or chemical groups representing more than 95 % of the total NMVOC emission from solvent use of the known NMVOCs, cf. Table 6. CO_2 conversion factors, where all C-molecules in a NMVOC molecule are converted to CO_2, are also listed in Table 6.

5.4.2 Activity data

For each chemical a mass balance is formulated:

$$\text{Consumption} = (\text{production} + \text{import}) - (\text{export} + \text{destruction/disposal} + \text{hold-up}) \quad \text{(Eq. 1)}$$

Data concerning production, import and export amounts of solvents and solvent containing products are collected from StatBank DK (2008), which contains detailed statistical information on the Danish society. Manufacturing and trading industries are committed to reporting production and trade figures to the Danish Customs & Tax Authorities in accordance with the Combined Nomenclature. Import and export figures are available on a monthly basis from 1995 to present and contain trade information from 272 countries world-wide. Production figures are reported quarterly as "industrial commodity statistics by commodity group and unit" from 1995 to present.

Destruction and disposal of solvents lower the NMVOC emissions. In principle this amount must be estimated for each NMVOC in all industrial activity and for all uses of NMVOC containing products. At present the solvent inventory only considers destruction and disposal for a limited number of NMVOCs. For some NMVOCs it is inherent in the emission factor, and for others the reduction is specifically calculated from information obtained from the industry or literature.

Hold-up is the difference in the amount in stock in the beginning and at the end of the year of the inventory. No information on solvents in stock has been obtained from industries. Furthermore, the inventory spans over several years so there will be an offset in the use and production, import and export balance over time.

In some industries the solvents are consumed in the process, e.g. in the graphics and plastic industry, whereas in the production of paints and lacquers the solvents are still present in the final product. These products can either be exported or used in the country. In order not to double count consumption amounts of NMVOCs it is important to keep track of total solvent use, solvents not used in products and use of solvent containing products. Furthermore some chemicals may be represented as individual chemicals and also in chemical groups, e.g. "o-xylene", "mixture of xylenes" and "xylene". Some chemicals are better inventoried as a group of NMVOCs rather than individual NMVOCs, due to missing information on use or emission for the individual NMVOCs. The Danish inventory considers single NMVOCs, with a few exceptions.

Activity data for chemicals are thus primarily calculated from Equation 1 with input from StatBank DK (2008). When StatBank (2008) holds no information on production, import and export or when more reliable information is available from industries, scientific reports or expert judgements the data can be adjusted or even replaced.

5.4.3 Emission factors

For each chemical the emission is calculated by multiplying the consumption with the fraction emitted (emission factor), according to:

Emission = consumption * emission factor

The present Danish method uses emission factors that represent specific industrial activities, such as processing of polystyrene, dry cleaning etc. or that represent use categories, such as paints and detergents. Some chemicals have been assigned emission factors according to their water solubility. Higher hydrophobicity yields higher emission factors, since a lower amount ends in waste water, e.g. ethanol (hydrophilic) and turpentine (hydrophobic).

Emission factors are categorised in four groups in ascending order: (1) Lowest emission factors in the chemical industry, e.g. lacquer and paint manufacturing, due to emission reducing abatement techniques and destruction of solvent containing waste, (2) Other industrial processes, e.g. graphic industry, have higher emission factors, (3) Non-industrial use, e.g. auto repair and construction, have even higher emission factors, (4) Diffuse use of solvent containing products, e.g. painting, where practically all the NMVOC present in the products will be released during or after use.

For a given chemical the consumed amount can thus be attributed with two or more emission factors; one emission factor representing the emissions occurring at a production or processing plant and one emission factor representing the emissions during use of a solvent containing product. If the chemical is used in more processes and/or is present in several products more emission factors are assigned to the respective chemical amounts.

Emission factors can be defined from surveys of specific industrial activities or as aggregated factors from industrial branches or sectors. Furthermore, emission factors may be characteristic for the use pattern of certain products. The emission factors used in the Danish inventory also rely on the work done in the joint Nordic project (Fauser et al. 2009).

5.4.4 Source allocation

The Danish Working Environment Authority (WEA) is administrating the registrations of chemicals and products to the Danish product register. All manufacturers and importers of products for occupational and commercial use are obliged to register. The following products are comprised in the registration agreement:

- Chemicals and materials that are classified as dangerous according to the regulations set up by the Danish Environmental Protection Agency (EPA).
- Chemicals and materials that are listed with a limit value on the WEA "limit value list".
- Materials, containing 1 % or more of a chemical, which is listed on the WEA "limit value list".
- Materials, containing 1 % or more of a chemical, which are classified as hazardous to humans or the environment according to the EPA rules on classification.

There are the following important exceptions for products, which do not need to be registered:

- Products exclusively for private use.
- Pharmaceuticals ready for use.
- Cosmetic products.

The Danish product register does therefore not comprise a complete account of used chemicals. Source allocations of exceptions from the duty of declaration are done based on information from trade organisations, industries, scientific reports and information from the internet.

Outputs from the inventory are

- a list where the 34 most predominant NMVOCs are ranked according to emissions to air,
- specification of emissions from industrial sectors and from households,
- contribution from each NMVOC to emissions from industrial sectors and households,
- yearly trend in NMVOC emissions, expressed as total NMVOC and single chemical, and specified in industrial sectors and households.

5.5 Uncertainties and time-series consistency

Uncertainties are expressed as ± 95%-confidence interval limits in percentage relative to the calculated mean 2009 emission.

Table 5.6 Tier 1 and Tier 2 uncertainty estimates, expressed as 95 %-confidence intervals relative to the mean emissions for 1990 and 2009, respectively. Input uncertainties follow normal distribution in 1990 and log-normal distribution in 2009.

Table 5.6 Tier 1 and Tier 2 level and trend uncertainties for solvent and other product use sector.

	Tier 1		Tier 2		
	2009	Trend 1990-2009	1990	2009	Trend 1990-2009
excl N_2O	11 %	3.4 %	-13%; +16%	-14%; +17%	-1.2%; +5.0%
incl N_2O	7.5 %	-	-	-9.2%; +11%	-

- No N_2O data for 1990

Important uncertainty issues related to the mass-balance approach are:

(i) Identification of chemicals that qualify as NMVOCs. Although a tentative list of 650 chemicals from NAEI (2000) has been used, it is possible that relevant chemicals are not included, e.g. chemicals that are not listed with their name in Statistics Denmark (StatBank DK, 2008) but as a product.

(ii) Collection of data for quantifying production, import and export of single chemicals and products where the chemicals are comprised. For some chemicals no data are available in StatBank DK (2008). This can be due to confidentiality or that the amount of chemicals must be derived from products wherein they are comprised. For other chemicals the amount is the sum of the single chemicals *and* product(s) where they are included. The data available in StatBank DK (2008) is obtained from Danish Customs & Tax Authorities and they have not been verified in this assessment.

(iii) Distribution of chemicals on products, activities, sectors and households. The present approach is based on amounts of single chemicals. To differentiate the amounts into industrial sectors it is necessary to identify and quantify the associated products and activities and assign these to the industrial sectors and households. No direct link is available between the amounts of chemicals and products or activities. From the Nordic SPIN database it is possible to make a relative quantification of products and activities used in industry, and combined with estimates and expert judgement these products and activities are differentiated into sectors. The contribution from households is also based on estimates. If the household contribution is set too low, the emission from industrial sectors will be too high and vice versa. This is due to the fact that the total amount of chemical is constant. A change in distribution of chemicals between industrial sectors and households will, however, affect the total emissions, as different emission factors are applied in industry and households, respectively.

A number of activities are assigned as "other", i.e. activities that can not be related to the comprised source categories. This assignment is based on expert judgement but it is possible that the assigned amount of chemicals may more correctly be included in other sectors. More detailed information from the industrial sectors is continuously being implemented.

(iv) Rough estimates and assumed emission factors are used for some chemicals. For some chemicals more reliable information has been obtained from the literature and from communication with industrial sectors. In some cases it is more appropriate to define emission factors for sector specific activities rather than for the individual chemicals.

A quantitative measure of the uncertainty has not been assessed. Single values have been used for emission factors and activity distribution ratios etc. A Tier 2 Monte Carlo assessment is currently being implemented in the Danish inventory.

5.6 QA/QC and verification

Please refer to the Danish National Inventory Report reported to the UNFCCC (Nielsen et al., 2009).

5.7 Recalculations

Improvements and additions are continuously being implemented due to the comprehensiveness and complexity of the use and application of solvents in industries and households. The main improvements in the 2009 reporting include the following:

- Further improvement of source allocation model, which combines information on Use Categories and NACE Industrial Use Categories from SPIN and use amounts from Statistics DK.
- Implementation of correct 2008 import amounts for xylene, which has been verified by Statistics Denmark.
- Inclusion of Firework in Other Product Use.

5.8 Planned improvements

- N_2O emissions from fire extinguishers will be implemented in the coming inventory.
- Chemicals that are listed as products in Statistics Denmark, e.g. cosmetics, will be assessed.
- Extrapolation of emissions in the period 1985-1994 will be re-assessed.

5.9 Fireworks

The consumption of fireworks is in general limited to a short period around New Years Eve. This section contains calculations of the annual aggregated emissions.

In general fireworks consist of a container of papers and polymers, a propeller in form of black powder and for fireworks like e.g. rockets there is a content of different compounds for colours and effects. Black powder consists of about 75 % oxidizer, most commonly potassium nitrate. The remaining components in black powder are a fuel (carbon), and an accelerant. The combustion of black powder commonly produces carbon dioxide, potassium sulfide and nitrogen (Vecchi et al. 2008, Paster P. 2009).

5.9.1 Methodology

In November 2004, a terrible accident occurred in a residential area in Denmark, resulting in the explosive burning of vast amounts of fireworks. It was estimated that the explosion involved around 284 Mg net explosive mass (NEM). This episode led to a wide evaluation of the laws on use and storage of fireworks. (Report Seest).

Since November 2005 the use of fireworks has only been legal in the period December 1st to January 5th or with special permission by the local municipality (Police, 2005). Only persons over the age of 18 are allowed to buy fireworks with the exception of smaller devices such as party poppers, crackers and sparklers which are also allowed all year (Police 2007). Regarding storage, The Danish Safety Technology Authority states that it is illegal to store more than 5 kg NEM.

All fireworks that are imported to Denmark must comply with DS/EN 15947-5.

Emissions from fireworks are calculated by multiplying the activity data with selected emission factors. Emissions are calculated for the compounds CH4, CO2 and N2O.

5.9.2 Activity data

The cross-border shopping and use of illegal fireworks are assumed negligible.

Activity data for the years 1990-2009 are collected from Statistics Denmark, these data are based on information on import and export.

The production of fireworks in Denmark is presumed negligible (Danish Pyrotechnical Association). It is also assumed that the effect from irregular stock control is negligible.

Figure 5.2 and Table 5.7 show the national trend of import minus export of fireworks. 1990-2003 shows an increasing trend with only 1999 as an outlier, the strong increase in consumed fireworks in 1999 were caused by the celebration of the new century. As mentioned above, 2004 were the year of a terrible accident where around 284 Mg NEM corresponding to a gross weight of about 1,500 Mg exploded (Report Seest), this of course contributed greatly to the consumption of fireworks in 2004. In 2005 much awareness and new restrictions dominated the subject of fireworks causing the national consumption to drop. Since 2005 the trend has once again been increasing.

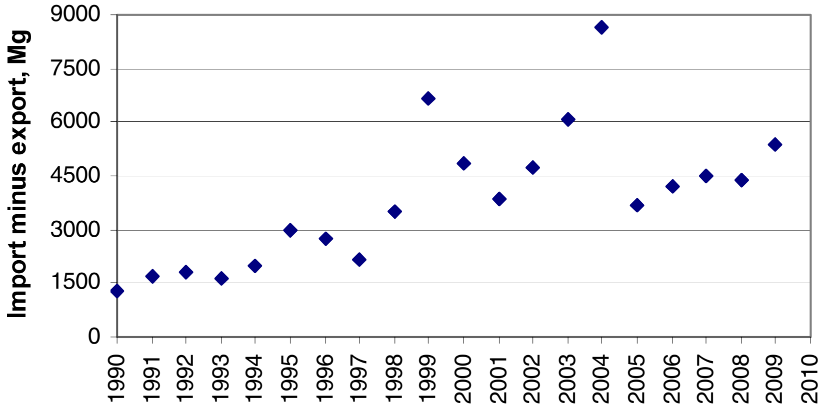


Figure 5.2 Trend of activity data for fireworks 1990-2010 (Statistics Denmark).

Table 5.7 Activity data for the national use of fireworks (Statistics Denmark).

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Fireworks	Gg	1.28	1.69	1.83	1.62	1.96	3.00	2.75	2.16	3.52	6.67
Continued											
		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Fireworks	Gg	4.85	3.83	4.74	6.05	8.64	3.68	4.21	4.47	4.37	5.38

5.9.3 Emission factors

In the evaluation of suitable emission factors many sources have been researched. Letting off fireworks (2008), which is based on Brouwer et al. (1995), is chosen as the source for CH_4, CO_2 and N_2O emission factors. No other sources were found to provide emission factors for these compounds.

Table 5.8 Emission factors for use of fireworks.

	Unit	Emission factor	Source
CO_2	Mg/Mg	0.043	Letting off fireworks (2008)
CH_4	kg/Mg	0.825	Letting off fireworks (2008)
N_2O	kg/Mg	1.935	Letting off fireworks (2008)

5.9.4 Emissions

Table 5.9 shows the national emissions from fireworks for the years 1990-2009. In general, the national consumption of fireworks has been increasing over the last two decades, but the trend is quite easily influenced by certain events.

Table 5.9 Overall emission of greenhouse gasses from fireworks.

	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CO_2-equivalents	Gg	0.84	1.12	1.21	1.07	1.30	1.98	1.82	1.43	2.33	4.41
CO_2	Gg	0.06	0.07	0.08	0.07	0.08	0.13	0.12	0.09	0.15	0.29
CH_4	Mg	1.06	1.40	1.51	1.33	1.62	2.47	2.27	1.79	2.91	5.51
N_2O	Mg	2.47	3.28	3.54	3.13	3.80	5.80	5.32	4.19	6.82	12.91
Continued	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CO_2-equivalents	Gg	3.21	2.53	3.13	4.00	5.71	2.43	2.78	2.95	2.89	3.55
CO_2	Gg	0.21	0.17	0.20	0.26	0.37	0.16	0.18	0.19	0.19	0.23
CH_4	Mg	4.01	3.16	3.91	4.99	7.13	3.04	3.47	3.69	3.60	4.44
N_2O	Mg	9.39	7.41	9.17	11.71	16.72	7.13	8.15	8.66	8.45	10.41

5.9.5 Uncertainties and time-series consistency

Table 5.10 lists the 95 % confidence interval uncertainties for use of fireworks. The uncertainties are assumed valid for all years 1990-2009.

The uncertainty of the activity data for import and export of fireworks provided by Statistics Denmark is small, but it is difficult to identify the uncertainty of the assumed negligible parts of the activity (Danish production and import of illegal fireworks). The overall uncertainty for the activity data for use of fireworks is estimated to 8 %. The uncertainty of the source Letting off fireworks (2008) is estimated to 300 %.

Table 5.10 Estimated uncertainty rates for use of fireworks, %

Pollutant	Activity data	Emission factor
CO_2	8	300
CH_4	8	300
N_2O	8	300

Tier 1 uncertainty results

The tier 1 uncertainty estimates for the consumption of fireworks are calculated from 95 % confidence interval uncertainties, the tier 1 uncertainties for the activity data and emission factors used in this inventory, and at the present level of available information, are shown in Table 5.11

The uncertainty interval for GHG is estimated to be ±273.4 % and the trend in GHG emission is 320.8 % ±43.4 %-age points. The main sources of uncertainty for GHG emission are accidental fires, in particular accidental building fires. The main source of trend uncertainty for GHG emission is by far compost production.

Table 5.11 National tier 1 uncertainty estimates for waste other

Pollutant	Total emission uncertainty, %	Trend 1990-2009, %	Trend Uncertainty %-age points
GHG	273.4	320.8	43.4
CO_2	300.1	320.8	47.6
CH_4	300.1	320.8	47.6
N_2O	300.1	320.8	47.6

GHG emissions are calculated in CO_2-equivalents.

Tier 2 uncertainty results

The tier 2 uncertainty estimates for use of fireworks are calculated from 50 % confidence interval uncertainties, results are shown in Table 5.12. The estimates were based on a Monte Carlo approach as described in this NIR section 1.7.

Table 5.12 National tier 2 uncertainty estimates consumption of fireworks

Category 3D3	1990 Total emission Uncertainty interval	2009 Total emission Uncertainty interval	2009 Trend Uncertainty
GHG	0.87 Gg (-67 %, +272 %)	3.64 Gg (-67 %. +272 %)	2.78 Gg (-67 %, +272 %)
CO_2	55.91 Mg (-75 %, +285 %)	235.23 Mg (-75 %, +285 %)	179,37 Mg (-75 %, +286 %)
CH_4	1.05 Mg (-74 %, +293 %)	4.43 Mg (-74 %, +293 %)	3.38 Mg (-74 %, +294 %)
N_2O	2.47 Mg (-74 %, +288 %)	10.40 Mg (-74 %, +288 %)	7.93 Mg (-74 %, +289 %)

GHG emissions are calculated in CO_2-equivalents.

The medians for the national emissions from source category 3D3 calculated with the tier 2 method, are in very similar to those shown in Table 5.9.

Tier 1 uncertainties are the same for 1990 and 2009 because the uncertainty input data are the same for all years. The only input data that vary over time are the activity data, and for tier 2 results will vary slightly due to the calculation method.

5.9.6 QA/QC and verification

QA/QC-procedure

The methodology for estimating emissions from consumption of fireworks was introduced for the first time in this year's inventory submission. Data in this methodology currently involves activity data for 1990-2009 as presented in the preceding sections.

In general terms, for this part of the inventory, the Data Storage (DS) Level 1 and 2 and the Data Processing (DP) Level 1 can be described as follows:

Data Storage Level 1

The external data level refers to the placement of original data for the import and export of fireworks.

Table 5.13 Overview of yearly stored external data sources at DS level1.

http, file or folder name	Description	AD or EF	Reference	Contact	Data agreement/ Comment
http://www.statistikbanken.dk/SITC5R3Y http://www.statistikbanken.dk/SITC5R4Y	Import, export statistics of fireworks	AD	Statistics Denmark	Katja Hjelgaard kahj@dmu.dk	Public access

Data Processing Level 1

This level, for consumption of fireworks, comprises a stage where the external data are treated internally. Adjusting the emission factors to match the activity data of total consumed fireworks including 20 % net explosive mass.

Data Storage Level 2

Data Storage Level 2 is the placement of selected output data from the multiplication of activity data and emission factors as inventory data on SNAP levels in the Access (CollectER) database.

Points of measurement

The present stage of QA/QC for the Danish emission inventories for consumption of fireworks is described below for DS and DP level 1 Points of Measurement (PMs). This is to be seen in connection with the general QA/QC description in Section 1.6 and, especially, 1.6.10 on specific description of PMs common to all sectors, general to QA/QC.

Data Storage level 1	1. Accuracy	DS.1.1.1	General level of uncertainty for every dataset including the reasoning for the specific values

Tier 1 and tier 2 uncertainty calculations have been performed. The level of uncertainty is generally low for activity data but higher for emission factors. The general level of uncertainty for consumption of fireworks could be improved if better emission factors were available.

Data Storage Level 1	1. Accuracy	DS.1.1.2	Quantification of the uncertainty level of every single data value including the reasoning for the specific values.

There are no available uncertainties from the IPCC GL or the sources used to calculate the emission inventories for consumption of fireworks. All uncertainties are achieved by expert judgements.

Data Storage level 1	2.Comparability	DS.1.2.1	Comparability of the data values with similar data from other countries, which are comparable with Denmark, and evaluation of discrepancy.

Some comparison of Danish data values with data sources from other countries has been carried out for activity data and emission factors.

Data Storage level 1	3.Completeness	DS.1.3.1	Documentation showing that all possible national data sources are included by setting down the reasoning behind the selection of datasets.

The following external data sources are used for the inventory on product use other (refer also to the table above):

- Tables from Statistics Denmark.
- Direct contact with the Danish Pyrotechnical Association.
- Emission factors from literature.

Information from the Danish Statistics Denmark is based on import and export data. Data is available for the complete time-series.

Data Storage level 1	4.Consistency	DS.1.4.1	The origin of external data has to be preserved whenever possible without explicit arguments (referring to other PMs).

The origin of external activity data has been preserved as much as possible. Files are saved for each year of reporting, in this way changes to previously received data and calculations is reflected and explanations are given.

Data Storage level 1	6.Robustness	DS.1.6.1	Explicit agreements between the external institution holding the data and NERI about the conditions of delivery.

No explicit agreement has been made. The collecting of data for the emission inventories of waste incineration is unproblematic.

Data Storage level 1	7.Transparency	DS.1.7.1	Summary of each dataset including the reasoning for selecting the specific dataset

A summary of the data set can be seen in section 5.9.2. For the reasoning behind the selection of the specific dataset, refer to DS 1.3.1.

Data Storage level 1	7.Transparency	DS.1.7.3	References for citation for any external dataset have to be available for any single value in any dataset.

These references exist in the description given in the report sections above.

Data Storage level 1	7.Transparency	DS.1.7.4	Listing of external contacts for every dataset

There are no contact-persons related to the delivery of data for consumption of fireworks.

Data Processing level 1	1. Accuracy	DP.1.1.1	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to type of variability. (Distribution as: normal, log normal or other type of variability)

Tier 1 and Tier 2 uncertainty calculations are made. The use of the Tier 1 methodology presumes a normal distribution of activity data and emission factor variability. Uncertainties are reported in section 5.9.5.

Data Processing level 1	1. Accuracy	DP.1.1.2	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to scale of variability (size of variation intervals)

The uncertainty assessment has been given in Section 5.9.5.

Data Processing level 1	1. Accuracy	DP.1.1.3	Evaluation of the methodological approach using international guidelines

There is no available information in the international guidelines for the emission inventories of consumption of fireworks.

Data Processing level 1	1. Accuracy	DP.1.1.4	Verification of calculation results using guideline values

There are no useful guideline values.

Data Processing level 1	2.Comparability	DP.1.2.1	The inventory calculation has to follow the international guidelines suggested by the UNFCCC and IPCC.

The inventory calculations are a simple multiplication of activity data and emission factors

Data Processing level 1	3.Completeness	DP.1.3.1	Assessment of the most important quantitative knowledge which is lacking.

Emission factors are gathered from literature studies. There is no Danish literature or measurements available on greenhouse gas emissions from use of fireworks

Data Processing level 1	3.Completeness	DP.1.3.2	Assessment of the most important cases where access is lacking with regard to critical data sources that could improve quantitative knowledge.

There is no direct data to elucidate the points mentioned under DP.1.3.1.

Data Processing level 1	4.Consistency	DP.1.4.1	In order to keep consistency at a high level, an explicit description of the activities needs to accompany any change in the calculation procedure.

There is no change in calculation procedure during the time-series and the activity data is, as far as possible, kept consistent for the calculation of the time-series.

Data Processing level 1	5.Correctness	DP.1.5.1	Show at least once, by independent calculation, the correctness of every data manipulation.

No data manipulation has been performed.

Data Processing level 1	5.Correctness	DP.1.5.2	Verification of calculation results using time-series

The time-series of activities and emissions in the output, in the SNAP source categories and in the CRF format have been prepared. The time-series are examined and significant changes are checked and explained.

Data Processing level 1	5.Correctness	DP.1.5.3	Verification of calculation results using other measures

The correct interpretation in the calculation of the methodology has been checked

Data Processing level 1	5.Correctness	DP.1.5.4	Shows one-to-one correctness between external data sources and the databases at Data Storage level 2

Data transfer control is made from the external data source and to the SNAP source categories at level 2. This control is carried on further to the aggregated CRF source categories.

Data Processing level 1	7.Transparency	DP.1.7.1	The calculation principle and equations used must be described

The calculation principle and equations are described in Section 5.9.1.

Data Processing level 1	7.Transparency	DP.1.7.2	The theoretical reasoning for all methods must be described

The calculation principle and equations are described in Section 5.9.1.

Data Processing level 1	7.Transparency	DP.1.7.3	Explicit listing of assumptions behind all methods

For the emission calculation for use of fireworks it is assumed that:

- cross-border shopping and use of illegal fireworks can be counted as negligible
- that the effect from irregular stock control is negligible

Data Processing level 1	7.Transparency	DP.1.7.4	Clear reference to dataset at Data Storage level 1

Refer to the Table 5.13 and DS.1.1.1 above.

Data Processing level 1	7.Transparency	DP.1.7.5	A manual log to collect information about recalculations

Recalculation changes in the emission inventories are described in the NIR. The logging of the changes takes place in the yearly model file.

Data Storage level 2	5.Correctness	DS.2.5.1	Documentation of a correct connection between all data types at level 2 to data at level 1

The full documentation for the correct connection exists through the yearly model file, its output and report files made by the CollectER database system.

Data Storage level 2	5.Correctness	DS.2.5.2	Check if a correct data import to level 2 has been made

This check is performed, comparing model output and report files made by the CollectER database system, refer to DS.2.5.1.

5.9.7 Source-specific recalculations

There are no recalculations

5.9.8 Source-specific planned improvements

National emissions from tobacco smoking and barbeques are under development.

5.9.9 Source-specific performed improvements

Calculations on the emissions from use of fireworks are new in this year's inventory.

5.10 References

Brancheforeningen fortsætter kampen mod ulovlige kemikalier, Fyrværkeribrancheforeningen, Danish Pyrotechnical Association. Available at: http://fyrvaerkeribrancheforeningen.dk/data/images/hcb%20-%20tekst%20til%20hjemmeside.doc (Danish) (15/9-2010).

Brouwer J.G.H., Hulskotte J.H.J., Annema J.A., Afsteken van Vuurwerk, Wesp, 1995: Werkgroep Emissies Servicebedrijven en Produktgebruik, RIVM Report No. 772414005. Available at: http://rivm.openrepository.com/rivm/bitstream/10029/10517/1/772414005.pdf (Dutch) (25/8-2010).

Danish Pyrotechnical Association, Fyrværkeribrancheforeningen, personal contact with Karsten Nielsen (29/9-2010).

Directive 1999/13/EC of 11 March 1999 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations, Brüssel, 1999.

Directive 2001/81/EC Of The European Parliament And Of The Council of 23 October 2001 - on national emission ceilings for certain atmospheric pollutants. Official Journal of the European Communities.

Directive 2004/42/EC of the European Parliament and Council on the Limitation of Emissions of Volatile Organic Compounds due to the Use of Organic Solvents in Certain Paints and Varnishes and Vehicle Refinishing Products and Amending Directive 1999/13/EC 30.04.2004, L 143/87.

EMEP/CORINAIR, 2004: Emission Inventory Guidebook 3rd edition, prepared by the UNECE/EMEP Task Force on Emissions Inventories and Projections, 2004 update. Available at: http://reports.eea.eu.int/EMEPCORINAIR4/en (15-04-2007).

Emission estimates for diffuse sources, Netherlands Emission Inventory, Letting off fireworks, Version dated June 2008, Netherlands National Water Board – Water Unit in cooperation with Deltares and TNO.

Eurostat on the internet. Available at: http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database

Fauser, P., Saarinen, K., Harðardóttir, K., Kittilsen, M.O., Holmengen, N. & Skårman, T. 2009: Improvement of Nordic Emission Models for Solvent Use in Selected Sectors. TemaNord 2009:556. Nordic Council Of Ministers, Copenhagen.

Fyrverkeriers miljöpåverkan: Kemisk Analys av Fyrverkeripjäser, Fyrverkeriers miljöpåverkan - En undersökning av metaller i konsumentfyrverkerier, Miljö Göteborg, Hansson Pyrotech PM 1999:1, ISSN 1401-243X, ISRN GBG-M-PM- -99/1- -SE (Swedish).

Fyrværkeri og miljø, Fyrværkeribrancheforeningen, Danish Pyrotechnical Association, December 8 2009. Available at: http://fyrvaerkeribrancheforeningen.dk/data/images/pdf/fyrv%C3%

A6rkeri%20og%20milj%C3%B8%2008december%202009.pdf (Danish) (15/9-2010).

IPCC, 2000: Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. Available at: http://www.ipcc-nggip.iges.or.jp/public/gp/english/ (15-04-2007).

Karjalainen, T. 2005: Commission research in Action: tackling the hormone disrupting chemicals issue, EUR report 21941.

Klimont Z., Cofala J., Bertok I., Amann M., Heyes C., and Gyarfas F., Modellierung von Feinstaubemissionen in Europa. Entwicklung eines Technologie- und Kosten-Moduls für Staubemissionen im Rahmen des Integrated Assessment Modelling zur Unterstützung europäischer Luftreinhaltestrategien, Umweltforschungsplan des Bundesministers für Umwelt, Naturschutz und Reaktorsicherheit, Forschungsbericht 299 43 249, Juni 2002. Available at: http://www.umweltdaten.de/publikationen/fpdf-l/2279.pdf (German) (14/9-2010).

Myatt, S., Health and Safety Laboratory, United Kingdom, CHAF Workpackage 4 Report, Deliverable D4-4, The Effect of Fireworks on Health and the Environment, Literature review, June 2003, Workpackage leader: A. von Oertzen, Bundesanstalt für Materialforschung und –prüfung, Germany. Available at: http://www.pyrobin.com/files/european%20firework%20testing%20reports,%20bam%20etc.pdf (15/9-2010).

NAEI, 2007: The British National Atmospheric Emission Inventory. Available at: http://www.naei.org.uk/emissions/selection.php (9/4-2010).

NAEI, 2000: British National Atmospheric Inventory performed by the National Environmental Technology Centre, June 2000, available at http://www.aeat.co.uk/netcen/airqual/naei/annreport/annrep99/app1_28.html (05-05-2006).

Nielsen, O.-K., Lyck, E., Mikkelsen, M.H., Hoffmann, L., Gyldenkærne, S., Winther, M., Nielsen, M., Fauser, P., Thomsen, M., Albrektsen, R., Hjelgaard, K., Vesterdal, L., Møller, I.S. & Baunbæk, L. 2009: Denmark's National Inventory Report 2009. Emission Inventories 1990-2007 - Submitted under the United Nations Framework Convention on Climate Change.National Environmental Research Institute, Aarhus University, 2009. 826 s. (NERI Technical Report; 724). IPCC, 1997. Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. Available at http://www.ipcc-nggip.iges.or.jp/public/g-l/invs6.htm (15-04-2007).

Passant N., Stewart R., Woodfield M., 2003, Characterisation of Emissions Of New Persistent Organic Pollutants, Department for Environment, Food and Rural Affairs, AEAT/ENV/R/1421 Issue 1, Appendix 1 Fireworks briefing note, p 14-26.

http://www.airquality.co.uk/reports/cat08/0407081206_DByr1_summary_report_issue1.pdf (25/8-2010).

Paster P., Fireworks: Ungreen Or A Necessary Part Of Ringing In The New Year?, San Francisco, 31/12 2009. Available at: http://www.treehugger.com/files/2009/12/fireworks-ungreeen-or-necessary.php

Pedersen, T. 1992: Atmosfærekemi – En Introduktion. Kemisk Institut, Københavns Universitet. ISBN 87-87438-28-3.

Politi 141105: News from the Danish Police 14/11-2005. Available at: http://www.politi.dk/da/aktuelt/nyheder/2005/fyrvaerkeri_141105.htm (Danish) (25/08-2010).

Politi 031207: News from the Danish Police 03/12-2007. Available at: http://www.politi.dk/da/aktuelt/nyheder/2007/nytaarsfyrvaerkeri_03122007.htm (Danish) (25/08-2010).

Pärt, P. (main author) 2005: Environment and health, EEA Report No 10/2005, Copenhagen.

Report Seest: Rapport vedrørende fyrværkeriulykken i Seest den 3. november 2004, Udarbejdet af en uafhængig ekspertgruppe nedsat den 26. august 2005. Prepared by the Ministry of Economic and Business Affairs Denmark and the Ministry of Defence Denmark. Available at: http://www.oem.dk/graphics/oem/nyheder/Pressemeddelelser%202006/RapportSeest.pdf (25th Aug. 2005) (Danish).

SPIN on the Internet. Substances in Preparations in Nordic Countries. Availble at: http://www.spin2000.net/spin.html

Statistics Denmark, 2010: Statistics Denmark, StatBank Denmark. Available at: http://www.statistikbanken.dk/statbank5a/default.asp?w=1024 (Danish/English). (25/8-2010).

The Danish Safety Technology Authority, 20/07-2010. Available at: https://www.borger.dk/Emner/forbrug-penge-forsikring/forbrug-koeb-og-salg/saerlige-varegrupper/Sider/fyrvaerkeri.aspx?#RichHtmlField2Bookmark1 (Danish) (25/08-2010).

UNFCCC, 2008: Available at: http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/3929.php

Vecchi R., Bernardoni V., Cricchio D., D'Alessandro A., Fermo P., Lucarelli F., Nava S., Piazzalunga A., Valli G., The impact of fireworks on airbourne particles, Atmospheric Environment 42 (2008) p 1121-1132, Elsevier. Available at: http://www.sciencedirect.com/science?_ob=MImg&_imagekey=B6VH3-4R1KVWY-2-H&_cdi=6055&_user=6461277&_pii=S1352231007009685&_orig=search&_coverDate=02/29/2008&_sk=999579993&view=c&wchp=dGLbVtb-zSkWA&md5=c7797fe87330b819a13720f23229830a&ie=/sdarticle.pdf

6 Agriculture (CRF sector 4)

The emission of greenhouse gases from agricultural activities includes:

- CH_4 emission from enteric fermentation and manure management.
- N_2O emission from manure management and agricultural soils.
- NMVOC emission from agricultural soils.
- Emission of CH_4, N_2O, NMVOC, CO and NO_x from burning of straw on field.

The emissions are reported in CRF Tables 4.A, 4.B(a), 4.B(b), 4.D and 4.F. Furthermore, the emission of NMVOC, CO and NO_x from field burning is given in CRF Table 4s2. CO_2 emissions from agricultural soils are included in the LULUCF sector.

Emission from rice production and burning of savannas does not occur in Denmark and the CRF Tables 4.C and 4E have, consequently, not been completed.

6.1 Overview of the sector

In CO_2 equivalents, the agricultural sector contributes with 16 % of the overall greenhouse gas emission (GHG) in 2009. Next to the energy sector, the agricultural sector is the largest source of GHG emission in Denmark. The main part of the emissions covers N_2O and CH_4, which contributes in 2009 with 91 % and 70 % respectivily of the total emissions of N_2O and CH_4. The remaining emissions of NMVOC, CO and NOx contribute less than 1% of the total emission.

From 1990 to 2009, the emissions decreased from 12.4 million tonnes eqv. to 9.6 million tonnes CO_2 eqv., which corresponds to a 22 % reduction (Table 6.1). The N_2O emission is the largest contributor to the overall agricultural emission, which in 2009 corresponds to 57 % given in CO_2 equivalents. The decrease in the agricultural emission is caused by a fall in N_2O emission, while the CH_4 emission is nearly unaltered.

Since the previous reporting, there have been changes, which have reduced the emissions for all years 1990 to 2008 by 4% - 10%. The most important explanation for the lower emission is due to changes in the calculation of N_2O emission from leaching. Available data from NOVANA – the National Monitoring program of the Water Environment and Nature, has given the opportunity to calculate the emission in three separate sources; groundwater, rivers and estuaries as given in IPCC guidelines. These studies include measurements from 223 monitoring stations in all parts of Denmark and have been going on from the early 1990'ies (Wiberg-Larsen et al., 2010). Description of other changes – refer to Chapter 6.9.

Table 6.1 Emission of GHG in the agricultural sector in Denmark 1990 – 2009

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CH_4, Gg CO_2-eqv.	4 226	4 242	4 229	4 308	4 199	4 186	4 186	4 080	4 115	3 975
N_2O, Gg CO_2-eqv.	8 181	7 987	7 767	7 620	7 594	7 275	6 730	6 702	6 935	6 634
Total, Gg CO_2-eqv.	12 407	12 229	11 996	11 928	11 793	11 461	10 917	10 782	11 050	10 609
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CH_4, Gg CO_2-eqv.	3 982	4 104	4 050	4 015	3 946	3 907	3 883	4 028	4 017	4 090
N_2O, Gg CO_2-eqv.	6 358	6 175	6 093	5 679	5 876	5 804	5 650	5 741	5 811	5 547
Total, Gg CO_2-eqv.	10 340	10 279	10 143	9 695	9 822	9 711	9 533	9 769	9 828	9 637

The major part of the emission is related to livestock production, which in Denmark is dominated by the production of cattle and pigs.

Figure 6.1 shows the distribution of the greenhouse gas emission across the main agricultural sources. The total N_2O emission from 1990-2009 has decreased by 33 %. The decrease in national emissions can largely be attributed to the decrease in N_2O emissions from agricultural soils. This reduction is due to a proactive national environmental policy over the last twenty years to prevent loss of nitrogen from agricultural soil to the aquatic environment. These measures includes among other things a ban on manure application during autumn and winter, increasing area with winter-green fields to catch nitrogen, a maximum number of animals pr hectare (ha) and maximum nitrogen application rates for agricultural crops. A combination of these increasing environmental requirements and the efforts to obtain economic advantage, the farmers has been forced to improve the utilisation of nitrogen in manure. An improvement of feed efficiency has been one of the most important drivers to reach the objectives. This has lead to a halving of nitrogen use in synthetic fertiliser and a decrease of emission per produced kg meat, which all has reduced the overall GHG emission.

The CH_4 emissions from 1990 to 2009 shown in Figure 6.1 indicate a decrease in emission from enteric fermentation, which is mainly due to a decrease in the number of cattle. A contrasting development has taken place in emission from manure management. Structural changes in the sector have led to a move towards the use of slurry-based housing systems, which have a higher emission factor than systems with solid manure. By coincidence, the decrease and the increase almost balance each other out and the total CH_4 emission from 1990 to 2009 has decreased by 3 %.

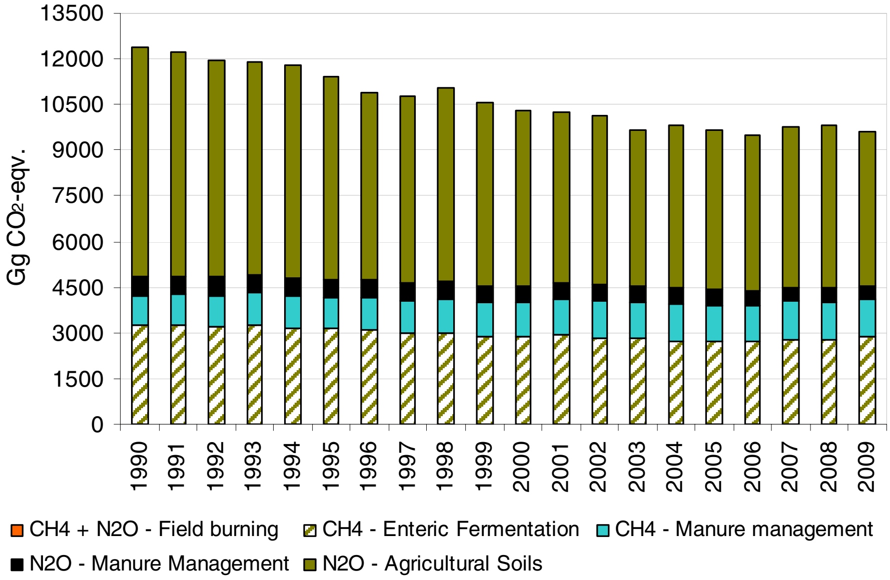


Figure 6.1 Danish greenhouse gas emissions 1990 – 2009.

6.1.1 References – sources of information

The calculations of the emissions are based on methods described in the IPCC Reference Manual (IPCC, 1997) and the Good Practice Guidance (IPCC, 2000).

Activity data and emission factors are collected and discussed in cooperation with specialists and researchers in various institutes, such as the Faculty of Agricultural Sciences – Aarhus University, Statistics Denmark, the Danish Agricultural Advisory Service, the Danish Plant Directorate and the Danish Environmental Protection Agency. In this way, both data and methods will be evaluated continually, according to the latest knowledge and information. National Environmental Research Institute has established data agreements with the institutes and organisations to assure that the necessary data is available to prepare the emission inventory on time.

Table 6.2 List of institutes involved in the emission inventory for the agricultural sector.

References	Link	Abbreviation	Data/information
National Environmental Research Institute, University of Aarhus	www.dmu.dk	NERI	- data collecting - emission calculations - responsible for QA/QC - reporting
Statistics Denmark – Agricultural Statistics	www.dst.dk	DSt	- livestock production - milk yield - slaughtering data - export of live animal - poultry - land use - crop production - crop yield
Faculty of Agricultural Sciences, University of Aarhus	www.agrsci.dk	DJF	- N-excretion - feeding situation - animal growth - N-fixed crops - crop residue - N-leaching/runoff - NH_3 emissions factor
The Danish Agricultural Advisory Service	www.lr.dk	DAAS	- housing type (until 2004) - grazing situation - manure application time and methods - estimation of extent of field burning of agricultural residue
Danish Environmental Protection Agency	www.mst.dk	EPA	- sewage sludge used as fertiliser - industrial waste used as fertiliser
The Danish Plant Directorate	www.pdir.dk	PD	- synthetic fertiliser (consumption and type) - housing type (from 2005) - sewage sludge used as fertiliser (from 2005 based on The Register for fertilization)
The Danish Energy Authority	www.ens.dk	DEA	- manure used in biogas plants

The emissions from the agricultural sector are calculated in a comprehensive agricultural model complex called IDA (Integrated Database model for Agricultural emissions). The model complex is designed in a relational database system (MS Access). Input data are stored in tables in one database called IDA_Backend and the calculations are carried out as queries in another linked database called IDA. This model complex, as shown in Figure 6.2, is implemented in great detail and is used to cover emissions of NH_3, particulate matter and greenhouse gases. Thus, there is a direct coherence between the NH_3 emission and the emission of N_2O.

IDA - Integrated Database model for Agricultural emissions

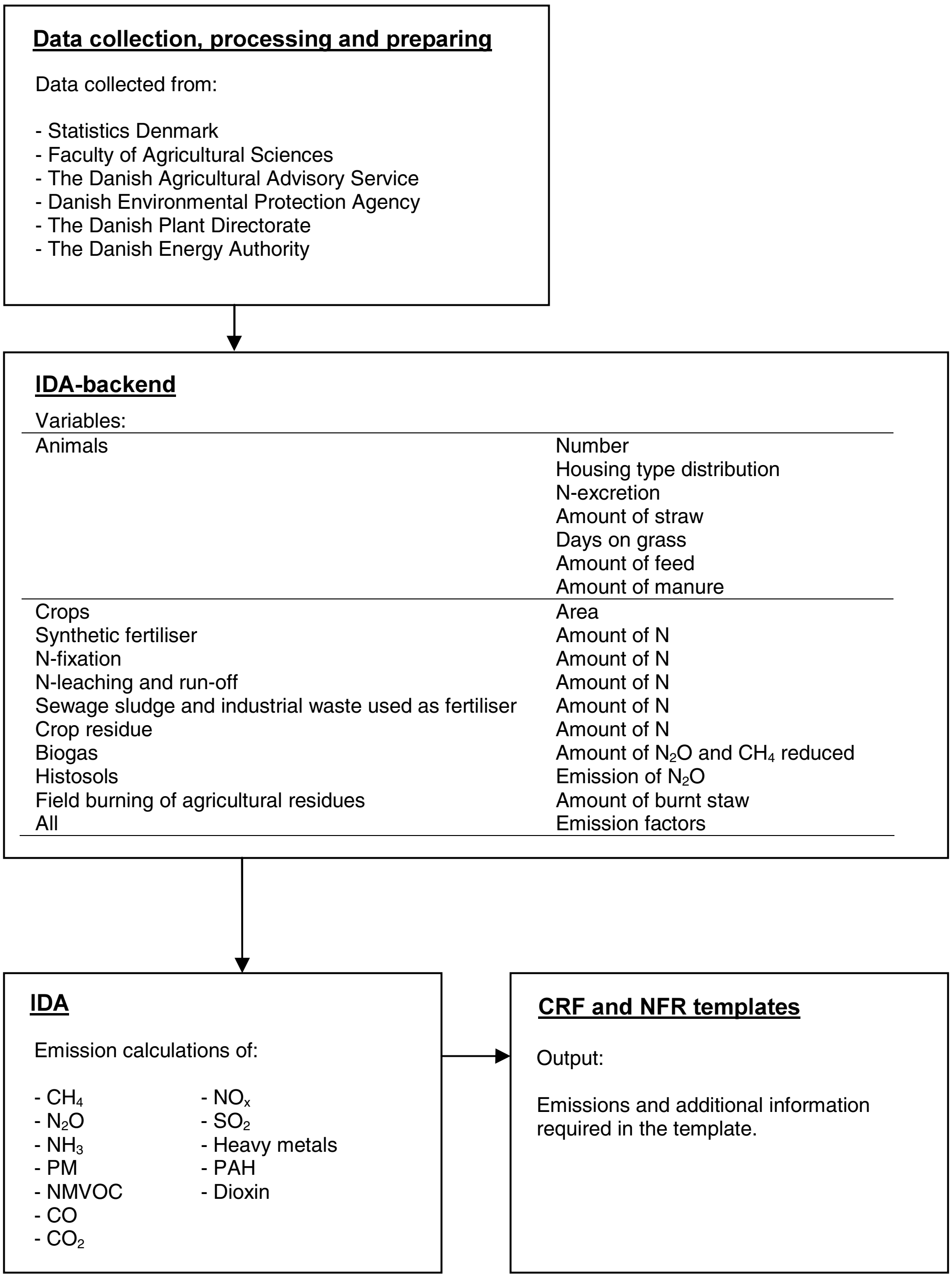


Figure 6.2 IDA - Integrated Database model for Agricultural emissions

Most emissions relate to livestock production, which basically is based on information on the number of animals, the distribution of animals according to housing type and, finally, information on feed consumption and excretion.

IDA operates with 38 different livestock categories, according to livestock category, weight class and age. These categories are subdivided into housing type and manure type, which results in around 200 different combinations of livestock subcategories and housing types (see Annex 3E Table 1). For each of these combinations, information on e.g. feed intake, digestibility, excretion and methane conversion factors is attached. The emission is calculated from each of these subcategories and then aggregated in accordance with the IPCC livestock categories given in the CRF.

Table 6.3 Livestock categories and subcategories.

CRF 4B	Aggregated livestock categories as given in IPCC	Includes	No. of subcategories in IDA, animal type/housing system
4B 1a	Dairy Cattle[1]	Dairy Cattle	28
4B 1b	Non-dairy Cattle[1]	Calves (<½ yr), heifers, bulls, suckling cattle	96
4B 3	Sheep	Including lambs	1
4B 4	Goats	Including kids (meet, dairy and mohair)	3
4B 6	Horses	<300 kg, 300 - 500 kg, 500 - 700 kg, >700 kg	4
4B 8	Swine	Sows, Weaners, fattening pigs	26
4B 9	Poultry	Hens, pullet, broilers, turkey, geese, ducks	24
4B 13	Other	Fur farming, deer, ostrich, pheasant	10

1) For all subcategories, large breed and jersey cattle are distinguished from each other.

It is important to point out that changes over the years, both to the national emission and the implied emission factor, are not only a result of changes in the numbers of animals, but also depend on changes in the allocation of subcategories, changes in feed consumption and changes in housing type.

Number of animals: Livestock production is primarily based on the agricultural census from Statistics Denmark (DSt). The emission from fattening pigs and poultry is based on slaughter data. Approximate numbers of horses, goats and sheep on small farms are added to the number in DSt, in agreement with the Danish Agricultural Advisory Service (DAAS) because Statistics Denmark does not include farms less than 5 ha. Statistics Denmark is the source for the database kept by FAO (Food and Agriculture Organization of the United Nations). This explains why the number of sheep, goats and horses in FAO and the Danish emission inventory disagree. The largest difference is found for horses. In the agricultural census, for 2009 the number of horses is estimated to be 58 000. Including horses on small farms and riding schools, however, the number of horses rises to approximately 177 500. As recommended by the ERT improvements to the documentation of the number of sheep and goats on small farms are made. Data on the number of sheep and goats is based on the Central House-animal farm Register (CHR) which is the central register of farms and animal of the Ministry of Food, Agriculture and Fisheries.

Information of number of deer, ostriches and pheasants are not included in Statistics Denmark and the number of deer and ostriches are based on information delivered from CHR. The number of pheasants is based on expert judgement from NERI and the pheasant breeding association.

In Annex 3E Table 2 is provided number of animal allocated on all livestock subcategories for all years 1990-2009.

Housing type: From 2005, all farmers have to report to the Danish Plant Directorate information concerning the use of housing type. Annex 3E Table 1 shows the housing type for each livestock category 1990 – 2009.

Before 2005 there exist no official statistics concerning the distribution of animals according to housing type. The distribution is, therefore, based on an expert judgement from the Danish Agricultural Advisory Service

(DAAS) and Faculty of Agricultural Sciences (DJF). Approximately 90-95 % of Danish farmers are members of DAAS, which regularly collects statistical data from the farmers on different issues, as well as making recommendations with regard to farm buildings. Hence, DAAS have a very good feeling of which housing types are currently in use.

Feed consumption and excretion: The Faculty of Agricultural Sciences (DJF) provide Danish standards related to feed consumption, excreted volumes, nutrient content of nitrogen, phosphor and potassium, dry matter in manure, contribution of different manure type. These standards are all a part of the "Danish Normative System", which is used for fertilizer planning and control by the Danish farmers and authorities (Poulsen et al., 2010). The complexity and dynamics of the system has increased during the years to secure the development of accurate values. Furthermore the normative system includes emission factors for NH_3 which is based on a combination of measurements and model calculations. Emission factors for NH_3 from the housing unit and storage are given in Annex 3E Table 3 and 4.

The Danish normative standards are based on practical farming and thus reflect the actual Danish agricultural production conditions. DJF receive data from the Danish Agricultural Advisory Service (DAAS), which is the central office for all Danish agricultural advisory services. DAAS carries out a considerable amount of research itself, as well as collecting efficacy reports from the Danish farmers for dairy production, meat production, pig production, etc., to optimise productivity in Danish agriculture. Feeding plans are used to provide values to the Danish Normative System and for dairy cows the values are based on approximately 800 feeding plans. In total the normative standards covers feed plans from 15-18 % of the Danish dairy production, 25-30 % of the pig production, 80-90 % of the poultry production and approximately 100 % of the fur production are collected. A very higher fraction of the pig production is represented, which is caused by the intensive focus on the possibilities to optimize the feed intake to increase the feed efficiency. The values covering the cattle production can be considered as reliable, even though there are not represented more than halved of the production. These values include mainly feeding plans from the farmers with a production efficiency corresponding to a middle level. The farmers with high productivity level are often not user of Danish Agricultural Advisory Service, which also is the case for farmers with a low productivity level.

Previously, the normative standards were updated and published every third or fourth year (Laursen, 1987; Laursen, 1994; Poulsen and Kristensen, 1997). From 2001 these standards are updated annually and available to download at the homepage of DJF:
http://www.agrsci.au.dk/ny_navigation/institutter/institut_for_husdyrbiologi_og_sundhed/husdyrernaering_og_miljoe/normtal (26.01.2011).

One of the reports concerning the normative data is published in English in Poulsen and Kristensen (1998) and are available at the homepage of DJF:http://web.agrsci.dk/djfpublikation/djfpdf/djfhd7.pdf
(24.02.2011).

6.1.2 National inventory system reviewed

A more detailed description of the methodology used to calculate the emissions and use of background data have been published in Mikkelsen et al. (2006) and recently updated in Mikkelsen et al. (2011). Both reports have been reviewed. The first one by the Statistics Sweden, responsible for the Swedish agricultural inventory and the second one by Nicholas J. Hutchings from the Faculty of Agricultural Sciences, Aarhus University and Johnny M. Andersen from the Faculty of Life Sciences, University of Copenhagen. None of the reviewers are involved in work concerning the annual emission inventory.

Many of the review comments were related to structural issues as e.g. standardisation of units, improvements in presentation of tables and equations, which are corrected and indeed improved both the reader-friendliness and the transparency. In several sections proposed by the reviewers the text is changed to obtain a more precise description or explanation – e.g. description of methane emission from manure management. Another critic point which could be mentioned is that several national variables are based on sciences with reference to Danish written documents or based on personal communication. DK will continue the efforts to encourage the respective institutions to publish the background knowledge in English.

6.1.3 Key category identification

In the key category analysis the agriculture emissions are divided into 14 categories, refer Annex 1. In the Tier 1 and Tier 2 KCA including LULUCF 12 of these categories are in 2009 key categories (Table 6.4). Tier 1 only gives key source identification based on the quantitative emission, while the Tier 2 analyse also include information on uncertainties estimates (refer to Chapter 1.5). In 1990 most of sources are key source except from N-fixing crops, crops residue and sewage sludge and industrial waste. In 2008, 6 of the sources are registered as key categories according to level and trend for both Tier 1 and Tier 2. Category "Pasture, range and paddock" are Tier 1 key source in level only but key source for both level and trend in Tier 2. For the remaining sources is seen a mix of key categories for trend and level.

The three most important agriculture key categories are CH_4 from enteric fermentation and N_2O emission from agricultural soils – nitrogen leaching and run-off and synthetic fertilisers.

Table 6.4 Key category identification Tie1 and Tier 2 from the agricultural sector 1990 and 2009.

CRF table	Compounds	Emission source	Key category identification	
2008			Tier 1	Tier 2
4.A	CH_4	Enteric fermentation	Level/trend	Level
4.B(a)	CH_4	Manure management	Level/trend	Level/trend
4.B(b)	N_2O	Manure management	Level/trend	Level/trend
4.D1.1	N_2O	Synthetic fertilisers	Level/trend	Level/trend
4.D1.2	N_2O	Animal manure applied to soils	Level/trend	Level/trend
4.D1.3	N_2O	N-fixing crops	Level	Level
4.D1.4	N_2O	Crop residue	Level	Level
4.D1.5	N_2O	Cultivation of histosols	-	Level
4.D1.6	N_2O	Sewage sludge and industrial waste	-	Trend
4.D2	N_2O	Pasture, range and paddock	Level	Level/trend
4.D3.1	N_2O	Atmospheric deposition	Level/trend	Level/trend
4.D3.2	N_2O	Nitrogen leaching and run-off	Level/trend	Level/trend
1990				
4.A	CH_4	Enteric fermentation	Level	Level
4.B(a)	CH_4	Manure management	Level	Level
4.B(b)	N_2O	Manure management	Level	Level
4.D1.1	N_2O	Synthetic fertilisers	Level	Level
4.D1.2	N_2O	Animal manure applied to soils	Level	Level
4.D1.3	N_2O	N-fixing crops	-	Level
4.D1.4	N_2O	Crop residue	Level	Level
4.D1.5	N_2O	Cultivation of histosols	-	Level
4.D1.6	N_2O	Sewage sludge and industrial waste	-	-
4.D2	N_2O	Pasture, range and paddock	Level	Level
4.D3.1	N_2O	Atmospheric deposition	Level	Level
4.D3.2	N_2O	Nitrogen leaching and run-off	Level	Level

6.2 CH_4 emission from enteric fermentation (CRF sector 4A)

6.2.1 Description

The major part of the agricultural CH_4 emission originates from digestive processes. In 2009, this source accounts for 30 % of the total GHG emission from agricultural activities. The emission is primarily related to ruminants and, in Denmark, particularly to cattle, which, in 2009, contributed with 86 % of the emission from enteric fermentation. The emission from pig production is the second largest source and covers 9 % of the national emission from enteric fermentation, followed by horses (3 %) and sheep, goats and deer (2 %).

6.2.2 Methodological issues

The methodology for estimating emission of enteric fermentation is based on IPCC guidelines 1996 and 2000. The implied emission factor for poultry, ostrich and pheasants are based on Tier 1, while the remaining animal categories are based on the Tier 2/Country Specific (CS) approach. CH_4 emission from enteric fermentation from fur farming is considered to be not applicable (NA) (Hansen, 2010). Feed consumption for all animal categories is based on the Danish normative figures. Default values for the methane conversion rate (Y_m) given by the IPCC are used for all livestock categories, except for dairy cattle and heifers, where a national Y_m is used for all years.

Tier 1

EF used for poultry, ostrich and pheasants is based on EF given by Wang & Huang (2005) (see Table 6.5). EF for broilers with a life cycle of 30-56 days is scaled in proportion to 42 days for broilers given by Wang & Huang (2005). Organic broilers with a life cycle of 81 days are scaled in proportion to the Taiwan country chicken with 91 days of life cycle and pullet with a life cycle of 112-119 days is scaled in proportion to the 140 days given for pullets by Wang & Huang (2005). EF for ducks, geese, turkeys, ostrich chickens and pheasant chickens is scaled by weight in proportion to a broiler with 40 days of life cycle. For laying hens EF for laying hens given by Wang & Huang (2005) is used and for ostrich hens and pheasant hens EF is scaled by weight in proportion to a laying hen.

Table 6.5 EF for poultry in mg CH_4 per head per lifecycle.

	EF
Broilers, 42 days	15.87
Taiwan country chicken, 91 days	84.82
Pullets, 140 days	3561
Laying hens, 365 days	10610

Source: Wang & Huang, 2005.

Tier 2

The Tier 2/CS equation for EF of enteric fermentation is given below. It is only dairy cattle and heifers which have sugar beets in the feed, therefore will the parts of the equation concerning sugar beet be left out for the remaining animal categories.

$$EF = EF_{winter} + EF_{summer}$$

$$EF_{winter} = FU \cdot ((\frac{GE_{FU\,winter}}{55.65}) \cdot Y_{m\,excl\,sugar\,beet} \cdot (1 - \frac{grazing\ days}{365} - \frac{days\ with\ sugar\ beet}{365}) + (\frac{GE_{FU\,winter}}{55.65}) \cdot Y_{m\,incl\,sugar\,beet} \cdot \frac{days\ with\ sugar\ beet}{365})$$

$$EF_{summer} = FU \cdot (\frac{GE_{FU\,summer}}{55.65}) \cdot Y_{m\,grazing} \cdot \frac{grazing\ days}{365}$$

Where:

FU = feeding units
GE_{FU} = gross energy pr feeding unit, MJ pr FE

The Tier2/CS for enteric fermentation differs mainly from the IPCC Tier 2 in the calculation of GE. A comparison between these two methods is shown in chapter 6.2.4.

Gross energy intake (GE)

GE_{FU} used in the calculation of EF is based on information of FU and the calculated GE:

$$GE_{FU} = \frac{GE}{FU}$$

The calculation of GE is shown in the equation below:

$$GE = (FU \cdot \frac{BFU_{winter}}{365} \cdot (365 - grazingdays) + FU \cdot \frac{BFU_{Summer}}{365} \cdot grazingdays)/365$$

Table 6.6: FU, GE and parameters used to calculate GE, 2009.

2009	FU[1]	BFU_{Winter}[2]	BFU_{summer}[2]	Grazing days	GE
	FU per year	MJ per FU	MJ per FU	Days per year	MJ per animal per day
Dairy cattle	6 845	18.3	18.3	18	343
Heifers	2 046	25.75	18.83	132	130
Fattening pigs	855	17.25	17.25	0	40

[1]From normative figures.

[2]Gross energy per feed unit. Calculated from feeding plans by DAAS.

The normative data are based on actual efficacy feeding controls or actual feeding plans at farm level, collected by DAAS or DJF. For cattle, approximately 20 % of the herd is included and for pigs, approximately 35 % are included. The data is given in Danish feed units or kg feedstuff and is converted to mega joule (MJ). A more detailed description is given in Mikkelsen et al. (2011). For grazing animals the energy content in the winter periods feed plan and the energy plan in grass are distinguished between. Annex 3E, Table 5, 6 and 7 provides additional information about FU, BFU and grazing days for each livestock category. In Annex 3E Table 8a, the annual average feed intake (GE) is shown, from 1990 to 2009, for each CRF livestock category and Annex Table 8b shows the GE for each subcategory for non-dairy cattle and swine.

Methane conversion rate (Y_m)

Investigations from DJF have shown a change in fodder practice from use of sugar beet to maize (whole cereal). Sugar beet feeding gives a higher methane production rate compared to grass and maize due to the high content of easily convertible sugar. The development in fodder practice reflects the change in the average Y_m for dairy cattle and heifer from 6.39 in 1990 to 5.94 in 2009.

The estimation of the national values of Y_m is based on model "Karoline" developed by DJF based on average feeding plan for 20 % of all dairy cows in Denmark obtained from the Danish Agricultural Advisory Service DAAS (Olesen et al.; 2005). DJF have estimated the CH_4 emission for a winter feeding plan for two years, 1991 (Y_m=6.7) and 2002 (Y_m=6.0). Y_m for the years between 1991 and 2002 are estimated by interpolation and for 1990 and 2003 to 2009 by extrapolation where the actual sugar beet area is taken into account. Data for actual sugar beet area are shown in Table 6.7. Sugar beet is only included in the winter feeding plan and the Y_m is therefore also adjusted for days on winter and summer feeding plan. It is assumed that winter feeding plan covers 200 days. The value of the estimated Y_m for 1991 and 2002 are, when adjusted for winter/summer, 6.35 and 5.96, respectively (see Table 6.8).

Table 6.7 Area grown with sugar beet and maize for feeding 1990-2009, ha.

Area	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Sugar beet for feeding	102 347	93 170	80 979	70 993	60 380	52 927	41 347	37 414	32 188	22 917
Maize for feeding	18 735	19 164	20 245	26 187	31 269	36 583	41 652	42 701	46 992	48 452
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Sugar beet for feeding	17 577	13 302	9 953	7 991	6 233	4 974	4 035	3 819	5 206	5 257
Maize for feeding	61 493	78 814	95 741	118 267	129 317	131 027	135 245	144 869	159 030	168 917

Table 6.8 Average CH_4 conversion rate (Y_m) – national factor used for dairy cattle and heifer > ½ year 1990 – 2009, %.

Dairy cattle + Heifer > ½ year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Ym - average	6.39	6.35	6.29	6.24	6.19	6.16	6.11	6.09	6.06	6.02
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Ym - average	6.00	5.98	5.96	5.95	5.95	5.94	5.93	5.93	5.94	5.94

Implied emission factor

Table 6.9 shows the implied emission factors for all IPCC livestock categories. The implied emission factor (IEF) vary across the years for dairy cattle, non-dairy cattle, swine and poultry due to changes for feed consumption, allocation of subcategories and number of grazing days. For goats new subcategories are introduced in 2007 and therefore the IEF differs from the other years. For sheep, horses, deer, ostrich and pheasants the IEF is constant. The emission from fur farming is considered to be not applicable (Hansen, 2010).

Table 6.9 Implied emission factor – Enteric Fermentation 1990 – 2009, kg CH_4 pr head pr yr.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1. Cattle										
a. Dairy	116.62	117.59	118.32	119.14	119.96	119.45	118.45	118.20	118.55	117.67
b. Non-Dairy	35.44	35.48	35.41	35.43	35.15	35.16	35.00	35.27	35.18	35.45
3. Sheep	17.17	17.17	17.17	17.17	17.17	17.17	17.17	17.17	17.17	17.17
4. Goats	13.15	13.15	13.15	13.15	13.15	13.15	13.15	13.15	13.15	13.15
6. Horses	21.81	21.81	21.81	21.81	21.81	21.81	21.81	21.81	21.81	21.81
8. Swine	0.99	1.00	1.00	0.99	1.02	1.00	1.02	1.00	1.00	1.05
9. Poultry	0.004	0.003	0.003	0.003	0.004	0.003	0.004	0.003	0.003	0.003
10. Other										
Fur farming	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Deer	11.30	11.30	11.30	11.30	11.30	11.30	11.30	11.30	11.30	11.30
Ostrich	NO	NO	NO	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Pheasant	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1. Cattle										
a. Dairy	117.16	119.33	121.46	124.08	126.20	128.12	129.24	130.46	130.47	133.76
b. Non-Dairy	35.53	35.83	35.85	35.99	35.58	36.94	38.73	40.17	40.46	43.10
3. Sheep	17.17	17.17	17.17	17.17	17.17	17.17	17.17	17.17	17.17	17.17
4. Goats	13.15	13.15	13.15	13.15	13.15	13.15	13.15	12.83	13.04	13.06
6. Horses	21.81	21.81	21.81	21.81	21.81	21.81	21.81	21.81	21.81	21.81
8. Swine	1.01	1.03	1.04	1.02	1.04	0.98	1.01	1.00	1.03	1.01
9. Poultry	0.003	0.003	0.003	0.004	0.004	0.004	0.003	0.003	0.004	0.003
10. Other										
Fur farming	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Deer	11.30	11.30	11.30	11.30	11.30	11.30	11.30	11.30	11.30	11.30
Ostrich	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Pheasant	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003

NO = Not occurring

NA = Not applicable

The increase in the IEF for dairy cattle from 1990-2009 is the result of increasing feed consumption due to rising milk yields. On average, the milk yield has increased from 6200 litre pr cow pr yr in 1990 to approximately 8400 litre pr cow pr year in 2009 (Statistics Denmark). A comparison with IPCC Tier 2 calculation in chapter 6.2.4 shows that the IEF used in the Danish inventory are lower. However, the national IEF can be considered as reasonable because this can be explained by the improvement in feed efficiency which has taken place in the Danish agriculture from 2000.

The category "Non-Dairy Cattle" includes calves, heifers, bulls and suckling cattle and the implied emission factor is a weighted average of these different subcategories. The development 1990 - 2004 in IEF shows a slight increase, which is due to changes in allocation of the subcategories. From 2005 to 2009 the IEF increases due to a higher feed consumption for heifers.

The Danish IEF for non-dairy cattle is lower compared with the Tier 1 default value given in the IPCC Reference Manual (IPCC, 1997). This is due to a combination of lower Y_m value for heifer and lower weight/lower feed intake (Table 6.10). In Chapter 6.2.4 the national IEF is compared with IPCC Tier 2 calculation and the result shows a good correlation which indicates the national estimate is reasonable.

Table 6.10 Subcategories for Non Dairy Cattle 2009 – enteric fermentation.

Non Dairy Cattle – subcategories (Based on an one year production)		Energy intake, MJ pr day	Methane conversion rate (Y_m), %	IEF, kg CH_4 pr head pr yr
Calves, bull (0-6 month)	200 kg	61.66	4.00	16.18
Calves, heifer (0-6 month)	150 kg	102.28	6.00	39.71
Bull (6 month to slaughter)	large breed: 440 kg sl. weight jersey: 330 kg sl. weight	116.21	4.00	30.49
Heifer (6 month to calving)	325 kg	130.34	5.94	50.82
Suckling cattle	Up to 800 kg	163.55	6.00	63.51
Average - Non-Dairy Cattle				43.10
IPCC – default value				48.00

The yearly changes for swine primarily reflect the changes in the allocation of the subcategories (sows, weaners and fattening pigs). The feed intake for sows and weaners has overall increased while the feed intake for fattening pigs has decreased as a result of improved fodder efficacy (Annex 3E Table 5 and 8b).

In Table 6.11 the IEF for swine subcategories is shown. The Danish IEF for swine is lower compared to the IPCC default values. This is probably due to the allocation of subcategories, because the share of weaners is high and these have a low IEF.

Table 6.11 Subcategories for Swine 2009 – enteric fermentation.

Swine – subcategories (Based on an one year production)	Energy intake, MJ pr day	Methane conversion rate (Y_m), %	IEF, kg CH_4 pr head pr yr
Sows (incl. piglets until 7.4 kg)	71.88	0.60	1.62
Weaners (7.4 – 32 kg)	14.28	0.60	0.56
Fattening pigs (32 – 107 kg)	40.41	0.60	1.59
Average - Swine			1.01
IPCC – default value	38	0.60	1.5

It is important to point out that the IEF for sheep and goats includes emission from lambs and kids, which corresponds to the Danish normative data. This explains why the Danish IEF is nearly twice as high as the IPCC default value. A comparison with IPCC Tier 2 calculation (see chapter 6.2.4) which includes lamb indicates that the national IEF are reasonable.

Activity data

In Table 6.12, the development in the number of animals from the agricultural statistics (Statistics Denmark), DAAS and CHR from 1990 to 2009 is presented (for subcategories see Annex 3E Table 2). The agricultural census does not include farms less than 5 ha. In the Danish emission inventory, the decision has been made to add number of sheep, goats and horses on small farms and deer, pheasants and ostriches based on information from DAAS and CHR (see chapter 6.1.1 – number of animals).

Since 1990, the number of swine and poultry has increased, in contrast to the number of cattle, which has decreased due to an increasing milk yield. Buffalo, camels and llamas, mules and donkeys are not relevant for Denmark.

Table 6.12 Number of animals from 1990 to 2009, 1000 head.

CRF Table 4.A, 4.B (a) and 4.B (b)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
IPCC livestock categories:										
Dairy Cattle	753	742	712	714	700	702	701	670	669	640
Non-Dairy Cattle	1 486	1 480	1 478	1 481	1 405	1 388	1 393	1 334	1 308	1 247
Sheep*	92	107	102	88	80	81	94	96	101	106
Goats*	7	7	7	7	7	7	7	7	8	8
Horses*	135	137	138	140	141	143	144	146	147	149
Swine	9 497	9 783	10 455	11 568	10 923	11 084	10 842	11 383	12 095	11 626
Poultry	16 249	15 933	19 041	19 898	19 852	19 619	19 888	18 994	18 674	21 010
Other;										
Fur farming	2 264	2 112	2 283	1 537	1 828	1 850	1 918	2 212	2 345	2 089
Pheasant**	1 063	1 063	1 063	1 063	1 063	1 063	1 063	1 063	1 063	1 063
Deer**	10	10	10	10	10	10	10	10	10	10
Ostrich**	NO	NO	NO	1	2	3	4	6	7	8
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
IPCC livestock categories:										
Dairy Cattle	636	623	610	596	563	564	550	545	558	563
Non-Dairy Cattle	1 232	1 284	1 187	1 128	1 082	1 006	984	1 021	1 006	977
Sheep*	112	119	117	121	124	126	128	124	117	116
Goats*	8	9	9	10	11	11	12	13	14	16
Horses*	150	155	160	165	170	175	180	185	190	178
Swine	11 922	12 608	12 732	12 949	13 233	13 534	13 361	13 723	12 738	12 369
Poultry	21 830	21 236	20 580	17 844	16 649	17 632	17 425	16 741	15 406	19 676
Other;										
Fur farming	2 199	2 304	2 422	2 361	2 471	2 552	2 708	2 837	2 747	2 677
Pheasant**	1 063	1 063	1 063	1 063	1 063	1 063	1 063	1 063	1 063	1 063
Deer**	10	11	10	10	10	10	10	10	10	9
Ostrich**	9	10	7	5	4	4	4	1	0.5	0.4

* Including animals on small farms (less than 5 ha), which are not covered by the Statistics Denmark.
** Not included in DSt
NO = Not occurring

6.2.3 Time-series consistency

The national emission from enteric fermentation is given in Table 6.13. From 1990 to 2009, the emission has decreased by 12 %, which is primarily related to a decrease in the number of dairy cattle from 753 000 in 1990 to 563 000 in 2009. The number of pigs has increased from 9.5 million in 1990 to 12.4 million in 2009, but this increase is only of minor importance in relation to the total CH_4 emission from enteric fermentation.

Table 6.13 Emission of CH_4 from Enteric Fermentation 1990 – 2009, Gg CH_4.

CRF 4.A	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy Cattle	87.83	87.21	84.24	85.08	83.92	83.91	82.99	79.23	79.32	75.33
Non-Dairy Cattle	52.66	52.51	52.34	52.48	49.40	48.80	48.74	47.05	46.03	44.20
Sheep	1.58	1.83	1.76	1.52	1.37	1.39	1.61	1.65	1.73	1.82
Goats	0.10	0.10	0.10	0.09	0.09	0.09	0.09	0.09	0.10	0.11
Horses	2.94	2.98	3.01	3.04	3.08	3.11	3.14	3.17	3.21	3.24
Swine	9.41	9.73	10.49	11.42	11.14	11.03	11.07	11.38	12.13	12.20
Poultry	0.06	0.05	0.06	0.06	0.08	0.07	0.07	0.06	0.06	0.06
Other;										
Fur farming	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Deer	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Ostrich	NO	NO	NO	NO	#	#	#	#	#	#
Pheasant	#	#	#	#	#	#	#	#	#	#
Total, Gg CH_4	154.69	154.52	152.10	153.80	149.19	148.51	147.83	142.75	142.69	137.06
Total, Gg CO_2 eqv.	3 249	3 245	3 194	3 230	3 133	3 119	3 104	2 998	2 996	2 878
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy Cattle	74.46	74.39	74.04	73.96	71.11	72.29	71.12	71.16	72.80	75.32
Non-Dairy Cattle	43.79	45.99	42.54	40.61	38.51	37.16	38.13	41.00	40.72	42.12
Sheep	1.92	2.04	2.02	2.08	2.13	2.17	2.19	2.13	2.02	1.98
Goats	0.11	0.12	0.12	0.13	0.14	0.15	0.16	0.16	0.18	0.20
Horses	3.27	3.38	3.49	3.60	3.71	3.82	3.93	4.03	4.14	3.87
Swine	12.08	12.95	13.29	13.24	13.75	13.32	13.47	13.69	13.12	12.47
Poultry	0.06	0.06	0.05	0.06	0.06	0.07	0.06	0.06	0.06	0.06
Other;										
Fur farming	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Deer	0.11	0.12	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Ostrich	#	#	#	#	#	#	#	#	#	#
Pheasant	#	#	#	#	#	#	#	#	#	#
Total, Gg CH_4	135.80	139.04	135.66	133.79	129.52	129.08	129.17	132.34	133.15	136.14
Total, Gg CO_2 eqv.	2 852	2 920	2 849	2 810	2 720	2 711	2 712	2 779	2 796	2 859

NO = Not occurring
NA = Not applicable
# - emission ≤ 0.0003

6.2.4 Tier 2/Country Specific compared to IPCC Tier 2 method

As recommended by ERT a comparison between IPCC Tier 2 and Denmark's Tier2/Country Specific (CS) calculation method for enteric fermentation is made. In IPCC default values are given for dairy cattle, non-dairy cattle and sheep therefore is a comparison made for these three groups. The data is based on 2008 values.

Calculations of IEF are made by IPCC Tier 2, with both default and national values for Y_m, and Denmark's Tier 2/CS method. A comparison between IEF (Table 6.14) shows that the Danish method gives a value for dairy cattle there is up to 7 % lower than the IPCC Tier 2 and for non-dairy cattle a value up to 5 % higher. To compare the IEF for sheep the calculation includes lamb. The Danish method gives a 7 % lower value than IPCC with default values for Y_m, but a 9 % higher value than IPCC with national values for Y_m.

Table 6.14 EF for enteric fermentation calculated by to methods, 2008.

IEF, kg CH_4 pr animal pr year	Tier 2 (IPCC Y_m)	Tier 2 (DK Y_m)	Tier 2/CS
Dairy Cattle	140.3	137.9	130.5
Non-Dairy Cattle	38.8	38.3	40.4
Sheep (incl. lambs)	18.4	15.8	17.2

The three different Tier 2 calculations for Non-dairy cattle all shows a IEF between 38-41 kg per head per year, which indicate that the Tier 2/CS used in the Danish inventor seems to be reasonable. However, these values are particularly higher compared to the Tier 1 default value at 48 kg per head per year given in the Reference manual (IPCC, 1997) (Table 4.-4) which properly can be explained by combination of lower Y_m for heifers and lower animal weight/lower feed intake.

The calculations of IEF for sheep indicate that the value used in the Danish inventor are reasonable. A Tier 2 calculation, where the productions of lamb are included, based on IPCC Y_m shows an IEF at the same level.

The lower value for IEF for dairy cattle is mainly due to a lower value for gross energy (GE) (Table 6.15). The Danish values for feed consumption is based on the Danish normative figures and the normative data are based on actual efficacy feeding controls or actual feeding plans at farm level, more info on GE calculations in chapter 6.2.2.

Table 6.15 Gross energy for dairy cattle calculated by to methods, 2008

GE, MJ pr animal pr day	Tier 2 (IPCC Y_m)	Tier 2/CS
Dairy cattle	356.4	335.3

In Statistic Denmark is given that in average dairy cattle produce 22.5 kg milk per animal per day in 2008. Table 6.16 shows the need of energy intake to produce this milk production calculated by two different methods. By using the Tier 2 calculation given in the Reference manual (IPCC, 1997) 15.8 MJ is needed to produce 22.5 kg milk/animal/day. National data for feed intake which reflect the actual Danish agricultural conditions shows a lower need of energy intake corresponding to 14.9 MJ. This is a result of improved feeding efficiency.

Table 6.16 MJ pr kg milk produced 2008

	Kg milk pr animal pr day	MJ pr kg milk Tier 2	MJ pr kg milk Tier 2/CS
Dairy cattle	22.5	15.8	14.9

In Figure 6.3 is shown the Danish trend of MJ per kg milk for dairy cattle. It is seen that the energy intake per kg milk have overall decreased from 1996 up till now. Around 1999 the Danish level of MJ per kg milk was at the same level as given in the IPCC Tier 2 method. Since then have feeding efficiency continued to rice due to the structural development – bigger farms and more intensive production. This can be an explanation of the lower IEF for dairy cattle used in the Danish inventory.

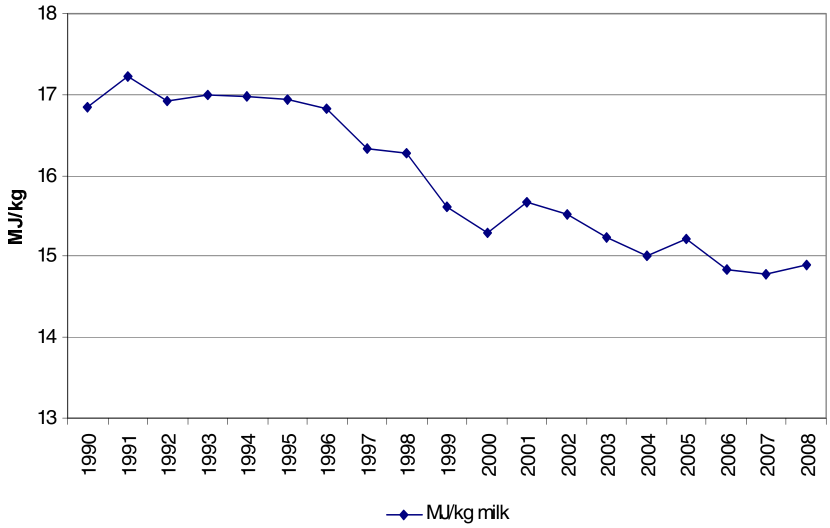


Figure 6.3 The Danish trend for MJ pr kg milk produced for dairy cattle, 1990-2008.

6.3 CH_4 and N_2O emission from manure management (CRF sector 4B)

6.3.1 Description

The emissions of CH_4 and N_2O from manure management are given in CRF Table 4.B (a) and 4.B (b). This source contributes with 17 % of the national emission from the agricultural sector in 2009 and the major part of the emission originates from the production of cattle (50 %) followed by swine production (37 %). The remaining part is mainly from poultry and fur farming (13 %).

6.3.2 Methodological issues

CH_4 emission

The IPCC Tier 2/CS methodology is used for the estimation of the CH_4 emission from manure management. The calculation is based on manure excretion instead of feed intake as described in IPCC Reference manual (IPCC, 1997). Default values for maximum methane producing capacity, B_0 and methane conversion factor, MCF given by the IPCC are used. Calculation of volatile solids, VS is based on national data.

Table 6.17 CH_4 – Manure management – use of national parameters and IPCC default values.

CH_4 – Manure management	National parameters	IPCC default value
Volatile solids, VS	Based on amount of manure (Annex 3E Table 9a and 9b)	
Maximum methane producing capacity, B_0		IPCC 1997
Methane conversion factor, MCF		IPCC 1997

The amount of manure is calculated for each combination of livestock subcategory and housing type and then aggregated to the IPCC livestock categories. In the calculation grazing days and use of straw in the housing is taken into account. Equation for CH_4 calculation:

$$CH_{4_{Manure}} = CH_4 \text{ housing} + CH_4 \text{ grazing}$$

$$CH_4 \text{ housing} = VS_{housing} \cdot MCF \cdot 0.67 \cdot B_0$$

$$CH_4 \text{ grazing} = VS_{grazing} \cdot MCF \cdot 0.67 \cdot B_0$$

VS is calculated from data concerning amount of manure, dry matter content, share of VS in dry matter, amount of bedding and grazing days. Except from grazing days, all these parameters are based on Danish Normative data.

MCF used for slurry

Default values provided in the IPCC guidelines for the methane production B_o and MCF are used. For liquid systems, the MCF of 10 % in the Reference Manual (IPCC, 1997) is used.

The revised 1996 IPCC guidelines use a default MCF of 10% for liquid/slurry, which is based on research of Hashimoto, A. and J. Steed (1993) and Woodbury, J.W. and A. Hashimoto (1993). This MCF value was changed to 39% in the revised guidelines IPCC 2000 - the Good Practice Guidance, without any scientific argumentation, documentation or specific references. It has to be remarked that the new IPCC 2006 guidelines return to a MCF value of 10 % for Danish conditions referred to Judgement of IPCC Expert Group in combination with Mangino et al. (2001) and Sommer et al. (2000).

The methane emission from liquid systems is very sensitive to temperature effects. Basically most of the manure is stored in Denmark under cold conditions (<5-10 degrees) .The CH_4 formation practically stops at 4°C and therefore there are no plausible arguments that 39% of total CH_4 capacity should be released under Danish conditions. Danish studies confirm this assumption (Husted, 1994 and Sommer et al., 2000). Furthermore, investigations based on measurements in Canada, which conditions are similar to Denmark, support this value (Massé et al., 2003). Support of this value is also found from a Swedish review (Dustan, 2002), taking both the cold climate and the fact that the slurry containers usually have a surface cover, in to account and which also argues for a liquid MCF at 10 %.

Considering the agricultural conditions in Denmark and the present scientific knowledge as described above a MCF of 10 % for liquid/slurry is more appropriate under the Danish conditions. The Danish decision of using a MCF of 10 % is as demonstrated above backed by several scientific papers as well as both the revised 1996 IPCC Guidelines and the IPCC 2006 Guidelines. Therefore Denmark intends to continue using a MCF value of 10 % until scientific knowledge become available

It has to be remarked that countries with comparable climate use a MCF for liquid/slurry at the same level as default recommended in the revised IPCC 1996 guidelines. Sweden, Finland and Germany use the same value as Denmark, which mean a MCF at 10 %, Belgium use 19 % and Norway and Netherland use a MCF below 10 %.

A lower CH_4 emission from biogas treated slurry

In 2009, approximately 2.4 million tonnes slurry were treated in biogas plants (DEA, 2010) and it is assumed that of the total amount of biogas treated slurry, cattle slurry makes up 45 % and pig slurry 55 % (Tafdrup, 2010). The amount of biogas treated slurry is equivalent to approximately 8 % of all animal manure.

Treated slurry in biogas plants has a lower emission of both CH_4 and N_2O. No description on how to include biogas treated slurry in the inventories is provided in the IPCC guidelines. Therefore, the Danish inventory uses data based on a Danish study (Sommer et al., 2001).

The lower CH_4 emission as a consequence of biogas treated slurry is calculated as the difference between non-treated slurry and treated slurry.

$$CH_{4,\text{lower}} = CH_{4,\text{non-treated slurry}} - CH_{4,\text{treated slurry}}$$

The calculation is based on the amount of volatile solids (VS) calculated as the VS percentage of dry matter (DM) which is 80 % for both cattle and pig slurry. The dry matter content is based on the Danish normative figures (Poulsen et al., 2001 and Poulsen, 2010).

The CH_4 emission from treated and non-treated slurry is calculated as:

$$CH_{4,\text{non-treated slurry}} = VS \cdot B_o \cdot MCF \cdot 0.67$$

$$CH_{4,\text{treated slurry}} = VS \cdot B_o \cdot MCF \cdot 0.67 \cdot E_{\text{lower}}$$

Where; $CH_{4,\text{non-treated slurry}}$ and $CH_{4,\text{treated slurry}}$ are the emission of non-biogas treated slurry and biogas treated slurry, respectively. VS express the total amount of volatile solid in biogas treated slurry, B_0 is the maximum methane forming capacity, MCF is the methane conversion factor and the factor 0.67 express the conversion from m^3 to kg. E_{lower} is the lower emission of biogas treated slurry compared to untreated slurry. It is assumed that treated cattle slurry is 0.77 compared with untreated slurry and 0.60 for pig slurry (Sommer et al., 2001).

All key model parameters for estimating the lower CH_4 emission in 2009 as a result of biogas plants are listed in Table 6.18. Data for 1990 to 2009 are shown in Annex 3E Table 10a.

Table 6.18 Key model parameters used to calculate the lower CH_4 emission due to biogas treated slurry.

2009	Slurry biogas treated	DM[a]	VS of DM[b]	VS in treated slurry	MCF	B_0	E_{lower}[d]	CH_4 emission in untreated slurry	CH_4 emission in biogas treated slurry	Lower the total CH_4 emission with
	1000 Gg	Pct	Pct.	10^6 kg VS	pct	m^3 CH_4 pr kg VS		Gg CH_4	Gg CH_4	Gg CH_4
Cattle slurry	1.08	10.3	80	88.62	10	0.24	0.77	1.43	1.09	0.33
Pig slurry	1.31	6.1	80	64.15	10	0.45	0.60	1.93	1.16	0.78
Lower emission										1.11

[a] Poulsen et al., 2001 and Poulsen, 2010.

[b] Møller, 2003.

[c] IPCC default.

[d] Sommer et al., 2001.

Due to biogas treated slurry, the national emission of CH_4 in 2009 is lowered by 1.11 Gg CH_4 (Table 6.18), which correspond a 2 % reduction of the total CH_4 emission from manure management in 2009. Calculations for the lower CH_4 emission for all years 1990 – 2009 are listed in Table 6.19.

The lower emission is subtracted in the emission related to manure management from dairy cattle and pigs for fattening, which are the main sources of the production of slurry.

Table 6.19 Lower CH_4 emissions as a result of biogas treated slurry 1990 – 2009.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Amount of treated slurry, Mt										
- cattle	0.09	0.14	0.18	0.21	0.24	0.29	0.31	0.37	0.45	0.47
- swine	0.10	0.18	0.21	0.25	0.30	0.35	0.38	0.46	0.56	0.57
VS total in treated slurry										
- cattle	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.04	0.04
- swine	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03
Total reduced emission, Gg CH_4	0.09	0.15	0.18	0.21	0.25	0.30	0.32	0.39	0.47	0.48
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Amount of treated slurry, Mt										
- cattle	0.52	0.57	0.65	0.79	0.85	0.87	0.96	0.97	0.99	1.08
- swine	0.64	0.69	0.79	0.97	1.03	1.06	1.18	1.18	1.20	1.31
VS total in treated slurry										
- cattle	0.04	0.05	0.05	0.07	0.07	0.07	0.08	0.08	0.08	0.09
- swine	0.03	0.03	0.04	0.05	0.05	0.05	0.06	0.06	0.06	0.06
Total reduced emission, Gg CH_4	0.54	0.59	0.67	0.82	0.87	0.90	0.99	1.00	1.02	1.11

CH_4–implied emission factor

Table 6.20 shows the development in the implied emission factors from 1990 to 2009. Variations between the years for dairy cattle, other cattle, poultry, swine and fur farming reflect changes in feed intake, allocation of subcategories, grazing situation and changes in housing type system.

The IEF for sheep and deer is unaltered because of very few changes in feed intake and grazing days. A more detailed division in subcategories for goats and horses is from 2007 and 2003, respectively, implemented and can explain the small change in IEF.

Table 6.20 Implied emission factor – Manure Management 1990 – 2009, kg CH_4 pr head pr yr.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1a. Dairy Cattle	20.68	21.02	21.37	21.71	22.06	22.42	22.76	23.15	23.55	23.55
1b. Non-Dairy Cattle	6.69	6.91	7.18	7.46	7.45	7.57	7.85	7.96	8.07	8.23
3. Sheep	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
4. Goats	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.44
6. Horses	2.96	2.96	2.96	2.96	2.96	2.96	2.96	2.96	2.96	2.96
8. Swine	1.96	1.97	2.01	1.97	2.08	2.03	2.07	2.03	2.03	2.12
9. Poultry	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
10. Other										
Fur farming	0.57	0.57	0.57	0.58	0.59	0.59	0.60	0.60	0.61	0.61
Deer	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Ostrich	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Pheasant	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1a. Dairy Cattle	25.93	26.59	28.12	30.29	31.81	31.80	31.80	32.75	32.67	33.66
1b. Non-Dairy Cattle	8.54	9.09	9.07	8.76	9.06	9.00	9.23	10.28	9.88	10.46
3. Sheep	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82	2.82
4. Goats	2.44	2.44	2.44	2.44	2.44	2.44	2.44	2.43	2.45	2.45
6. Horses	2.96	2.96	2.96	2.95	2.95	2.95	2.95	2.95	2.95	2.95
8. Swine	2.05	2.04	2.12	2.10	2.13	2.02	1.99	2.04	2.12	2.14
9. Poultry	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02
10. Other										
Fur farming	0.65	0.68	0.62	0.67	0.70	0.76	0.76	0.89	0.92	0.97
Deer	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Ostrich	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Pheasant	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

NE = Not estimated.

IEF for dairy cattle has increased as a result of an increasing milk yield, but also because of change in housing types. In Annex 3E Table 1 shows the changes in housing types from 1990 to 2009. Old-style tethering systems with solid manure have been replaced by loose-housing with slurry-based systems. The MCF for liquid manure is ten times higher than that for solid manure. For non-dairy cattle the same development in IEF is seen, but because an increasing proportion of bull-calves are raised in housings with deep litter, where the MCF is also high.

For pigs and fur farming, there has been a similar development as for dairy cattle with a move from solid manure to slurry-based systems.

The IEF for sheep and goats includes lambs and kids and the housing systems for these categories are defined as deep litter with a MCF at 10 %. This explains why the Danish IEF is considerable higher than the IPCC default value, which if given for sheep and goats housed in dry manure management systems.

The implied emission factor based on Tier 2/CS compared to IPCC default values shows some differences and can be explained by looking at the values for the most important parameters as volatile solids (VS), feed consumption and the part of animal placed on slurry based system.

As shown in Table 6.21 the national IEF for dairy cattle is particularly higher, which is mainly due to the fact that more cattle are housed on slurry based system than given in the IPCC assumptions. Furthermore VS used for Danish dairy cattle are higher due to higher milk yield.

For non dairy cattle the national VS value is nearly the same as the default, but a high proportion of the animals are housed in deep litter or liquid/slurry systems, 37 % and 32 % in 2009 respectively, which both have a MCF at 10 %.

Table 6.21 Cattle – important parameters for calculation of the average implied emission factor for manure management 2009.

	IPCC			DK - 2009		
	VS kg dm pr hd pr day	Liquid/slurry %	IEF kg CH_4 pr hd pr yr	VS kg dm pr hd pr day	Liquid/slurry %	IEF kg CH_4 pr hd pr yr
Dairy	5.1	40	14	6.2	88	33
Non-dairy (average)	2.7	50	6	2.8	32	10
Calves, bull				1.5	0	0
Calves, heifer				1.8	0	0
Bulls > ½ yr				4.0	35	17
Heifer > ½ yr				2.8	44	9
Suckling cattle				4.2	9	12

The category of swine operates with three subcategories. The IEF is lower compared with the IPCC default value due to particularly lower VS value. In Reference manual (IPCC, 1997) is used 38 MJ pr head pr day which is significantly higher than the average feed intake for Danish weaners and fattening pigs.

Table 6.22 Swine – important parameters for calculation of the average implied emission factor for manure management 2009.

	IPCC				DK – 2009			
	VS kg dm pr hd pr day	Feed intake MJ pr hd pr day	Pit > 1 month %	IEF Kg CH_4 pr hd pr yr	VS kg dm pr hd pr day	Feed intake MJ pr hd pr day	Liquid/slurry %	IEF kg CH_4 pr hd pr yr
Swine	0.5	38	73	3.0	0.2		96	2.0
Sows (incl. piglets until 7 kg)					0.3	72		4.0
Weaners (7-32 kg)					0.1	2		0.2
Fattening pigs (32-107 kg)					0.3	10		0.8

Table 6.23 Emission of CH_4 from Manure Management 1990 – 2009, Gg CH_4.

CRF 4.A	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy Cattle	15.57	15.59	15.21	15.50	15.44	15.75	15.95	15.52	15.76	15.07
Non-Dairy Cattle	9.95	10.22	10.61	11.05	10.47	10.50	10.93	10.61	10.56	10.26
Sheep	0.26	0.30	0.29	0.25	0.23	0.23	0.27	0.27	0.28	0.30
Goats	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Horses	0.40	0.40	0.41	0.41	0.42	0.42	0.43	0.43	0.43	0.44
Swine	18.60	19.32	21.04	22.80	22.69	22.49	22.49	23.12	24.60	24.67
Poultry	0.47	0.47	0.49	0.52	0.58	0.54	0.51	0.51	0.50	0.53
Other;										
Fur farming	1.29	1.21	1.31	0.89	1.07	1.09	1.14	1.33	1.42	1.27
Deer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ostrich	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Pheasant	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Total, Gg CH_4	46.56	47.54	49.38	51.44	50.92	51.04	51.74	51.81	53.58	52.57
Total, Gg CO_2 eqv.	978	998	1 037	1 080	1 069	1 072	1 086	1 088	1 125	1 104
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy Cattle	16.48	16.57	17.14	18.06	17.93	17.94	17.50	17.86	18.23	18.95
Non-Dairy Cattle	10.52	11.66	10.76	9.88	9.81	9.05	9.09	10.49	9.94	10.22
Sheep	0.31	0.33	0.33	0.34	0.35	0.36	0.36	0.35	0.33	0.33
Goats	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.04
Horses	0.44	0.46	0.47	0.49	0.50	0.52	0.53	0.55	0.56	0.52
Swine	24.49	25.68	26.99	27.16	28.22	27.31	26.53	28.04	26.96	26.43
Poultry	0.52	0.53	0.52	0.55	0.56	0.56	0.50	0.47	0.47	0.49
Other;										
Fur farming	1.44	1.58	1.49	1.58	1.73	1.95	2.07	2.53	2.52	2.60
Deer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ostrich	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Pheasant	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Total, Gg CH_4	54.23	56.84	57.73	58.09	59.12	57.72	56.60	60.33	59.05	59.58
Total, Gg CO_2 eqv.	1 139	1 194	1 212	1 220	1 242	1 212	1 189	1 267	1 240	1 251

NE = Not estimated.

N_2O emission

The N_2O emission from manure management is based on the amount of nitrogen in the manure in housings. The emission from manure deposits on grass is included in "Pasture, Range and Paddock Manure" (Section 6.4.2). The IPCC default emission values are applied, see Table 6.24.

Table 6.24 Emission factors for N_2O from manure management.

	Emission factor	
	Unit	IPCC – default values
Handling of manure:		
Solid manure, poultry	kg N_2O-N pr kg N	0.005
Solid manure, other	kg N_2O-N pr kg N	0.02
Slurry and urine	kg N_2O-N pr kg N	0.001
Deep litter	kg N_2O-N pr kg N	0.02
Deep litter, farmyard manure < 1 month[1]	kg N_2O-N pr kg N	0.005

[1] Farmyard manure, which is faeces and urine mixed with large amounts of bedding (usually straw) on the floors of cattle or pig housing.

The total amount of nitrogen in manure has decreased by 8 % from 1990 to 2009 (Table 6.25), despite the increasing production of pigs and poultry. This reduction is particularly due to an improvement in fodder efficiency, especially for fattening pigs. A decrease in total amount of nitrogen means also a decrease for the N_2O emission. Another reason for the decreased N_2O emission is the lower emission factor for liquid manure than for solid manure. The development from the previous more traditional tethering systems with solid manure to slurry based system leads to a reduction in the emission of N_2O.

It is important to point out that the N-excretion rates shown in Table 6.25 are values weighted for the subcategories (Table 6.3). N-excretion reflects nitrogen excreted per animal per year. The variations in N-excretion in the time-series reflect changes in feed intake, fodder efficiency and allocation of subcategories.

Table 6.25 Nitrogen excretion, annual average 1990 – 2009, kg N pr head pr yr.

CRF Table 4.B(b)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Livestock category										
Non-dairy	36.56	36.67	36.80	36.91	36.64	36.56	36.62	36.73	36.76	36.99
Dairy cattle	129.49	128.63	127.76	126.89	126.06	125.23	125.08	124.94	124.82	124.60
Sheep	21.18	21.33	21.47	21.61	21.76	21.90	20.11	18.32	16.53	14.75
Goats	21.18	21.33	21.47	21.61	21.76	21.90	20.11	18.32	16.53	14.75
Swine	11.85	11.52	11.18	10.47	10.49	9.73	9.93	9.69	9.64	9.99
Poultry	0.63	0.65	0.57	0.59	0.65	0.62	0.60	0.62	0.62	0.57
Horses	44.15	43.23	42.31	41.40	40.48	39.56	39.56	39.56	39.56	39.56
Fur farming	4.90	4.83	4.80	4.75	4.70	4.65	4.66	4.65	4.65	4.63
Deer	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
Ostrich	NO	NO	NO	15.61	15.61	15.61	15.61	15.60	15.60	15.60
Pheasant	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
N-excretion, total, Gg N pr yr	297	292	292	292	283	274	274	273	280	272
N-excretion, housing, Gg N pr yr	260	256	257	258	249	239	239	238	244	237
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Livestock category										
Non-dairy	37.15	37.65	37.54	37.44	38.39	40.79	43.05	44.89	45.01	47.82
Dairy cattle	125.31	125.31	127.16	129.79	131.56	133.30	134.66	137.58	137.77	138.12
Sheep	16.95	16.95	16.95	16.95	16.95	16.95	16.95	16.95	16.95	16.95
Goats	16.95	16.95	16.36	16.36	16.36	16.36	16.36	15.65	16.32	16.37
Swine	9.62	9.55	9.95	9.55	9.74	9.22	8.56	8.56	8.68	8.40
Poultry	0.55	0.57	0.59	0.69	0.79	0.79	0.70	0.63	0.70	0.53
Horses	39.56	39.56	39.56	39.56	39.56	39.56	39.56	39.56	39.56	39.56
Fur farming	4.62	4.62	4.61	4.61	5.09	5.38	5.18	5.18	5.30	5.52
Deer	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
Ostrich	15.60	15.60	15.60	15.60	15.60	15.60	15.60	15.60	15.60	15.60
Pheasant	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
N-excretion, total, Gg N pr yr	272	279	282	280	286	287	277	284	275	267
N-excretion, housing, Gg N pr yr	236	243	247	245	252	252	242	250	245	240

NO = Not occurring

A lower N_2O emission from biogas treated slurry

Investigation indicates a lower N_2O emission from biogas treated slurry compared to untreated slurry (Sommer et al., 2001 and Sommer et al., 2004). The lower emission is a result of displacement in allocation between the fraction of degradable and non-degradable VS. Biogas treated slurry increase the fraction of non-degradable VS, which promote the oxygen content in soil. These conditions will reduce the potential risk for N_2O emission, because N_2O emission takes place in environments without oxygen or with very low concentrations of oxygen (Sommer et al., 2001).

In practice this effect of a lower N_2O emission will takes place in the manure applied on soil. However, it is chosen, in the inventory, to incorporate the lower N_2O-emission as a subtracting from the manure management emission. The biogas treatment is accomplished before the slurry is applied to soil.

No description in IPCC Reference Manual or GPG refers how to provide this reduction, why this estimation is based on Danish studies (Sommer et al., 2001). The reduced N_2O emission is calculated as:

$$N_2O\text{-}N_{lower} = N_2O\text{-}N_{non\text{-}treated\ slurry} - N_2O\text{-}N_{treated\ slurry}$$

The N_2O emission from treated and non-treated slurry is calculated as:

$$N_2O\text{-}N_{non\text{-}treated} = N_{slurry\ non\text{-}treated} \cdot N_{content} \cdot EF_{N_2O}$$

$$N_2O\text{-}N_{treated} = N_{slurry\ treated} \cdot N_{content} \cdot E_{lower} \cdot EF_{N_2O}$$

Where; $N_2O_{non\text{-}treated}$ slurry and $N_2O_{treated}$ slurry are the emission of non-biogas treated slurry and biogas treated slurry, respectively. N_{slurry} is the total amounts of N in slurry, EF_{N2O} express the N_2O emission factor based on IPCC default (1.25 percent). E_{lower} is the lower emission of biogas treated slurry compared to untreated slurry. It is assumed that treated cattle slurry is 64 % compared with untreated slurry and 60% for pig slurry (Sommer et al., 2001).

Tabel 6.26 N content in slurry and lower fraction of N_2O emission for biogas treated slurry

	Total N in treated slurry, %[a]	E_{lower}[b]
Cattle	0.538	0.64
Swine	0.541	0.59

[a] Poulsen et al., 2001

[b] Sommer et al., 2001

Due to the biogas plants, the national emission of N_2O in 2009 is reduced by 0.06 Gg N_2O (Table 6.27) which correspond a 4 % reduction of the N_2O emission from manure management in 2009. Data for 1990 to 2009 are shown in Annex 3E Table 10b.

Table 6.27 Lower N_2O emissions as a result of biogas-treated slurry 1990 – 2009.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Amount of treated slurry, Mt										
- cattle	0.09	0.14	0.18	0.21	0.24	0.29	0.31	0.37	0.45	0.47
- swine	0.10	0.18	0.21	0.25	0.30	0.35	0.38	0.46	0.56	0.57
Total reduced emission, Gg N_2O	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Amount of treated slurry, Mt										
- cattle	0.52	0.57	0.65	0.79	0.85	0.87	0.96	0.97	0.99	1.08
- swine	0.64	0.69	0.79	0.97	1.03	1.06	1.18	1.18	1.20	1.31
Total reduced emission, Gg N_2O	0.03	0.03	0.04	0.05	0.05	0.05	0.06	0.06	0.06	0.06

6.3.3 Time-series consistency

In Table 6.28, the national emission from manure management from 1990 to 2009 is shown. The N_2O emission has decreased by 29 %. The national emission from manure management has, nevertheless, increased by 6 % in CO_2 equivalents due to the increase in the CH_4 emission.

Table 6.28 Emissions of N_2O and CH_4 from Manure Management 1990 – 2009.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
N_2O emission										
Liquid manure, Gg N_2O	0.31	0.30	0.30	0.30	0.28	0.27	0.27	0.26	0.26	0.26
Solid manure, Gg N_2O	1.01	0.97	0.94	0.90	0.85	0.81	0.79	0.79	0.80	0.77
Other manure, Gg N_2O	0.63	0.67	0.71	0.74	0.75	0.76	0.78	0.80	0.83	0.82
Total, Gg N_2O	1.95	1.93	1.94	1.94	1.89	1.83	1.84	1.85	1.89	1.85
Total, Gg CO_2 eqv.	604	599	603	602	584	569	569	574	586	573
CH_4 emission										
Total, Gg CH_4	46.56	47.54	49.38	51.44	50.92	51.04	51.74	51.81	53.58	52.57
Total, Gg CO_2 eqv.	978	998	1 037	1 080	1 069	1 072	1 086	1 088	1 125	1 104
Total Manure Management, Gg CO_2 eqv.*	1 582	1 597	1 640	1 682	1 654	1 640	1 655	1 662	1 711	1 677
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
N_2O emission										
Liquid manure, Gg N_2O	0.26	0.26	0.27	0.26	0.26	0.26	0.24	0.26	0.26	0.25
Solid manure, Gg N_2O	0.64	0.62	0.61	0.57	0.55	0.61	0.58	0.43	0.36	0.30
Other manure, Gg N_2O	0.85	0.89	0.87	0.86	0.90	0.87	0.83	0.84	0.83	0.83
Total, Gg N_2O	1.75	1.78	1.74	1.69	1.72	1.74	1.66	1.53	1.45	1.38
Total, Gg CO_2 eqv.	543	551	540	524	533	539	514	476	449	426
CH_4 emission										
Total, Gg CH_4	54.23	56.84	57.73	58.09	59.12	57.72	56.60	60.33	59.05	59.58
Total, Gg CO_2 eqv.	1 139	1 194	1 212	1 220	1 242	1 212	1 189	1 267	1 240	1 251
Total Manure Management, Gg CO_2 eqv.*	1 682	1 745	1 753	1 744	1 774	1 751	1 702	1 742	1 690	1 678

* Incl. the reduction from biogas treated slurry.

6.4 N_2O emission from agricultural soils (CRF sector 4D)

6.4.1 Description

The N_2O emissions from agricultural soils, CRF Table 4.D, contribute, in 2009 with 53 % of the national emission from the agricultural sector. Figure 6.4 shows the distribution and the development from 1990 to 2009 according to different sources. The emission has overall decreased 33 %. The increase from 2007 to 2008 was due to a rise in the use of fertiliser, which can mainly be explained by expectations of rising prices, in 2009 the emission have decreased again.

The main part of the emission originates as direct emission. The largest sources here are manure and fertiliser applied on agricultural soils. Another large source is the indirect N_2O emission, of which the emission from nitrogen leaching is an essential part.

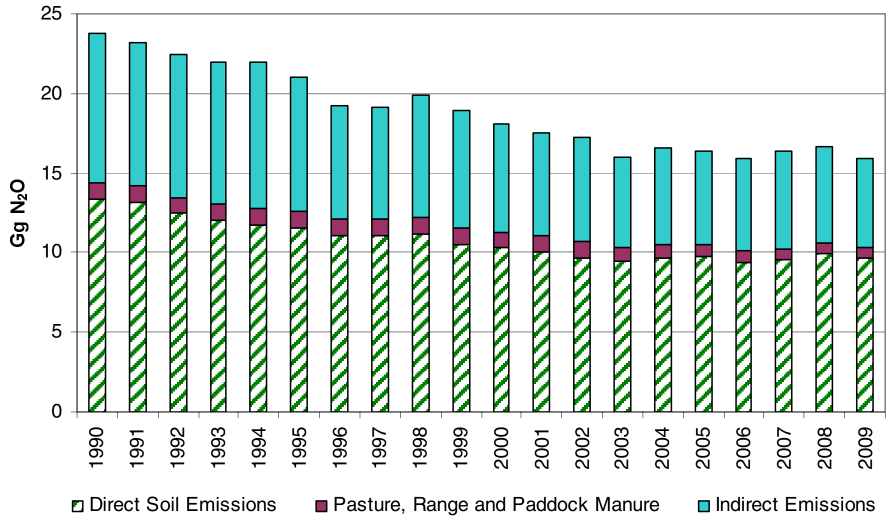


Figure 6.4 N_2O emissions from agricultural soils 1990 - 2009.

6.4.2 Methodological issues

To calculate the N_2O emission IPCC Tier 1b is used in combination with a country specific method (CS). Tier 1 b is use in calculation of emission from N-fixing crops, crop residue and atmospheric deposition.

Emissions of N_2O are closely related to the nitrogen balance and all data concerning the evaporation of NH_3 and data for manure condition is applied from the national NH_3 emission inventory. This is in more detailed described in Mikkelsen et al. (2011) and Denmark's annual inventory report, due to the UNECE-Convention on Longe-Range Transboundary Air Pollution (Nielsen et al., 2010) and are available on the internet. Specific for calculation of emission from nitrogen leaching and runoff a national model is used.

In connection to calculation of N_2O from agricultural soils the N_2O emission factors for all sources are based on the default values given in IPCC (2000). A NH_3 and N_2O emission factor survey is presented in Table 6.29. The estimated emissions from the different sub-sources are described in the text which follows.

Table 6.29 Emissions factor - N_2O emission from the Agricultural Soils 1990 – 2009.

Agricultural soils – emission sources CRF Table 4.D	NH_3 emission factor (national data)	N_2O emission factor (IPCC default value)
	Kg NH_3-N pr kg N	kg N_2O -N pr kg N
1. Direct Soil Emissions		
Synthetic Fertiliser Applied to Soils	0.02	0.0125
Animal Wastes Applied to Soils	0.31 – 0.25	0.0125
N-fixing Crops		0.0125
Crop Residue		0.0125
Cultivation of Histosols		8*
2. Animal Production	0.07	0.02
3. Indirect Soil Emissions		
Atmospheric Deposition		0.01
Nitrogen Leaching and Runoff		0.025**
4. Other		
Industrial Waste Used as Fertiliser		0.0125
Sewage Sludge Used as Fertiliser	0.02	0.0125

*Unit: kg N_2O-N pr ha

**Groundwater = 0.015, rivers = 0.0075 and estuaries = 0.0025

Direct emissions

Synthetic fertiliser

The amount of nitrogen (N) applied to soil via use of synthetic fertiliser is estimated from sales estimates from the Danish Plant Directorate, the source for the FAO database. Table 6.30 shows the consumption of each fertiliser type. Furthermore, the NH_3 emission factor for each fertiliser is given, based on the values given in EMEP/EEA (2009). The Danish value for the FracGASF is estimated at 0.02 and is considerably lower than the recommended default value in IPCC, i.e. 0.10. The NH_3 emission depends on fertiliser type and the major part of the Danish emission is related to the use of calcium ammonium nitrate and NPK fertiliser, where the emission factor is 0.01 kg NH_3-N pr kg N. The low Danish FracGASF is also due to the small consumption of urea (<1%), which has a high emission factor.

Table 6.30 Synthetic fertiliser consumption 2009 and the NH_3 emission factors.

Synthetic fertiliser year 2009	NH_3 Emission factor[1] kg NH_3-N pr kg N	Consumption[2] t N
Fertiliser type		
Calcium and boron calcium nitrate	0.01	0.2
Ammonium sulphate	0.02	3.8
Calcium ammonium nitrate and other nitrate types	0.01	121.5
Ammonium nitrate	0.01	9.7
Liquid ammonia	0.02	8.0
Urea	0.13	1.1
Other nitrogen fertiliser	0.06	18.8
Magnesium fertiliser	0.01	0.0
NPK-fertiliser	0.01	30.0
Diammonphosphate	0.01	0.5
Other NP fertiliser types	0.01	3.8
NK fertiliser	0.01	2.8
Total consumption of N in synthetic fertiliser		200.3
National emission of NH_3-N, M kg	4.00	
Average NH_3-N emission (FracGASF)	0.02	

[1]) EMEP/EEA (2009).

[2]) The Danish Plant Directorate.

The use of synthetic fertiliser includes fertiliser used in parks, golf courses and private gardens. 1 % of the synthetic fertiliser can be related to these uses outside the agricultural area.

As a result of increasing requirements for improved use of nitrogen in livestock manure and reduce the nitrogen loss to the environment, the consumption of nitrogen in synthetic fertiliser has more than halved from 1990 to 2009 (Table 6.31). From 2007 to 2008 the consumption is increased which is due to an expectation of rising prices and therefore the consumption is decreased again in 2009.

Table 6.31 Nitrogen applied as fertiliser to agricultural soils 1990 – 2009.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
N content in synthetic fertiliser, Gg N	400	395	370	333	326	316	291	288	283	263
NH_3-N emission, Gg NH_3-N	7	7	6	6	6	6	5	5	5	4
N in fertiliser applied on soil, Gg N	393	388	363	327	320	310	286	283	279	258
N_2O emission, Gg N_2O	7.72	7.62	7.13	6.42	6.28	6.09	5.61	5.56	5.47	5.08
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
N content in synthetic fertiliser, Gg N	251	234	211	201	207	206	192	195	220	200
NH_3-N emission, Gg NH_3-N	4	4	3	3	4	4	4	4	4	4
N in fertiliser applied on soil, Gg N	247	230	207	198	203	203	188	191	216	196
N_2O emission, Gg N_2O	4.86	4.51	4.07	3.89	3.99	3.98	3.70	3.75	4.25	3.86

Manure applied to soil

The amount of nitrogen applied to soil is estimated as the N-excretion in housings minus the NH_3 emission, which occur in housings, under storage and in relation to the application of manure. These values are based on national estimations and are calculated in the NH_3 emission inventory (Table 6.32). Emission factors for NH_3 from the housing unit and storage are given in Annex 3E Table 3 and 4. The total N-excretion in housings from 1990 to 2009 has decreased by 8 %. Despite this reduction in N-excretion, the amount of nitrogen applied to soil remains almost unaltered, due to the reduction in the NH_3 emission.

Table 6.32 Nitrogen applied as manure to agricultural soils 1990 – 2009.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
N-excretion, housing, Gg N	260	256	257	258	249	239	239	238	244	237
N ab Storage, Gg N	215	213	214	216	208	201	201	199	203	201
NH_3-N emission from application, Gg NH_3-N	35	34	32	31	29	27	25	25	25	25
N in manure applied on soil, Gg N	180	180	181	185	179	174	176	174	178	176
N_2O emission, Gg N_2O	3.54	3.53	3.56	3.62	3.51	3.42	3.45	3.42	3.49	3.46
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
N-excretion, housing, Gg N	236	243	247	245	252	252	242	250	245	240
N ab Storage, Gg N	198	204	207	207	210	212	204	211	210	208
NH_3-N emission from application, Gg NH_3-N	25	25	23	19	17	17	17	18	17	17
N in manure applied on soil, Gg N	173	179	184	187	193	195	187	193	192	191
N_2O emission, Gg N_2O	3.41	3.53	3.61	3.68	3.79	3.82	3.68	3.80	3.78	3.75

The FracGASM express the fraction of total N-excretion (N ab animal) that is volatilised as NH_3 emission in housings, storage and application. The FracGASM has decreased from 0.27 in 1990 to 0.22 in 2009 (Table 6.33). This is the result of an active strategy to improve the utilisation of the nitrogen in manure.

Table 6.33 FracGASM 1990 – 2009.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total N-excretion, Gg N	297	292	292	292	283	274	274	273	280	272
NH_3-N emission from manure, Gg NH_3-N	80	78	77	76	72	68	66	66	68	66
FracGASM	0.27	0.27	0.27	0.26	0.26	0.25	0.25	0.25	0.25	0.25
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total N-excretion, Gg N	272	279	282	280	286	287	277	284	275	267
NH_3-N emission from manure, Gg NH_3-N	66	67	66	61	61	58	55	57	55	54
FracGASM	0.25	0.24	0.24	0.24	0.24	0.23	0.23	0.22	0.21	0.22

N-fixing crops

To estimate the emission from N-fixing crops, IPCC Tier 1b is applied. The emission calculated is based on nitrogen content, the fraction of dry matter and the content of protein for each harvest crop type. Data for crop yield is based on data from Statistics Denmark. For nitrogen content in the plants, the data is taken from Danish feedstuff tables (Danish Agricultural Advisory Centre). The estimates for the amount of nitrogen fixed in crops are made by the Faculty of Agricultural Science (Kristensen, 2003, Høgh-Jensen et al., 1998, Kyllingsbæk, 2000).

$$N_2O\text{ - }N_{N\text{-fix}} = \sum (Ts_{i,\text{ yield}} \cdot N_{i,\text{ pct}} \cdot (1 + N_{i,\text{ pct in root and stubble}}) \cdot A_{\text{pct fix}}) \cdot EF_{N2O}$$

Where:

N_2O-N = nitrous oxide emission
$Ts_{i,\text{ yield}}$ = dry matter yield, kg per ha for crop type *i*
$N_{i,\text{ pct}}$ = nitrogen percentage in dry matter
$N_{i,\text{ pct root + stubble}}$ = nitrogen percentage in root and stubble
$A_{\text{pct fix}}$ = percentage of nitrogen which is fixed
EF_{N2O} = emission factor, IPCC standard value of 1.25 pct

The Danish inventory includes emissions from clover-grass, despite the fact that this source is not mentioned in the IPCC GPG. Area with grass and clover covered approximately 19 % of the total agricultural area in 2009 and, for this reason, represents an important contributor to the national emission from N-fixing crops.

In Table 6.34 and Annex 3E Table 11 and Table 12 the background data for estimating the N-fixing is listed. The emission from N-fixing crops decreases from 1990-2009, largely due to a reduction in agricultural area.

Table 6.34 Emissions from N-fixing crops 2009.

N_2O emission from nitrogen fixing crops	Crop yield 2009, tonnes	N-fixing, kg N per tonnes crop yield	N-fixing total 2009, kg N fix	N_2O emission, Gg N_2O
Legumes to maturity[a]	22 400[b]	37.3	835	0.016
Lucerne	282 200	7.7	2 162	0.042
Crops for silage	1 000 800	6.1	1 215	0.024
Legumes/marrow-stem kale	NO	6.1	NO	NO
Grass and clover in rotation	15 103 400	8.2	32 656	0.641
Grass not in rotation	3 682 400	8.2	1 508	0.030
Fields with catch crop	497 000	8.2	1 075	0.021
Peas for conservation[a]	10 576	37.3	394	0.008
Seeds of leguminous grass crops			825	0.016
- Red clover	381[c]	200[d]		
- White clover	4 077[c]	180[d]		
- Black medic	84[c]	180[d]		
Total N-fix			40 670	
Total N_2O emission				0.799

[a] Dry matter content for straw is 0.87 and the N-fraction is 0.010.

[b] Yield of seed, yield of straw is 60 % of yield of seed.

[c] Area, ha.

[d] kg N per ha.

Crop residue

To estimate the emission from crop residue, IPCC Tier 1b is applied. N_2O emissions from crop residues are calculated as the total aboveground quantity of crop residue returned to soil. For cereals, the aboveground residues are calculated as the amount of straw plus stubble and husks. The total amount of straw is given in the annual census and reduced by the amount used for feeding, bedding and bio fuel in power plants. Straw for feed and bedding is subtracted because this quantity of removed nitrogen returns to the soil via manure.

$$N_2O - N_{crop\ residue,j} = \sum_{1}^{N} ha_{i,\,j} \cdot (N_{i,\,stubble} + N_{i,\,husks} + N_{i,\,tops} + N_{i,\,leafs}) \cdot EF_{N_2O}$$

Where:

i	= crop type
j	= year
ha	= on which the crop is grown
N_i	= nitrogen derived from husks, stubble, plant tops and leaf debris, kg ha^{-1}
EF_{N2O}	= emission factor, IPCC standard value of 1.25 %

National values for nitrogen content are used provided by the Faculty of Agricultural Sciences (Djurhuus and Hansen 2003). It is calculated based on relatively few observations, but is at present the best available data. Data for yield and area cultivated are collected from Statistic Denmark. Background data is given in Annex 3E Table 13 and Table 14.

The national emission from crop residues has decreased 14 % from 1990 to 2009 (Table 6.35). This decrease is a result of a fall in cultivated area of beets for feeding, which has been replaced by cultivation of green maize.

Another reason is a fall in the agricultural area and a greater part of the straw is harvest – 52 % in 1990 and 64 % in 2009.

Table 6.35 Emissions from crop residue 1990 – 2009.

Crop residue	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Stubble	18.9	18.5	19.0	19.1	18.3	18.2	18.7	18.8	18.9	18.7
Husks	11.4	11.1	11.8	11.4	11.5	11.6	12.3	12.5	12.6	11.8
Top of beets and potatoes	7.1	7.1	6.7	7.2	6.1	5.8	5.9	5.5	5.7	5.4
Leafs	6.8	6.7	6.7	10.1	10.4	10.3	9.7	8.1	7.9	8.7
Straw	15.1	14.3	6.1	3.9	5.4	10.4	10.7	11.6	11.4	10.1
Crop residue, total, Gg N	59.3	57.7	50.3	51.7	51.7	56.3	57.3	56.5	56.5	54.7
N_2O emission, Gg	1.17	1.13	0.99	1.01	1.02	1.10	1.12	1.11	1.11	1.07
$Frac_R$	0.86	0.85	0.85	0.86	0.85	0.85	0.84	0.85	0.85	0.84
$Frac_{NCRO}$	0.018	0.018	0.018	0.017	0.017	0.017	0.017	0.017	0.017	0.017
$Frac_{NCRBF}$	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Stubble	18.6	18.6	18.3	17.6	17.0	17.6	17.8	17.4	17.9	17.5
Husks	12.0	12.3	11.5	12.0	12.0	12.3	12.4	12.1	11.9	12.4
Top of beets and potatoes	5.3	5.2	5.5	4.9	5.0	4.9	4.4	4.5	4.4	4.2
Leafs	9.0	9.2	9.1	9.1	8.5	9.4	9.4	9.3	7.9	7.0
Straw	10.8	11.6	9.0	9.0	10.7	10.2	10.0	9.3	8.1	10.0
Crop residue, total, Gg N	55.7	56.9	53.4	52.6	53.2	54.4	54.0	52.6	50.2	51.2
N_2O emission, Gg	1.09	1.12	1.05	1.03	1.05	1.07	1.06	1.03	0.98	1.01
$Frac_R$	0.84	0.84	0.84	0.85	0.84	0.85	0.85	0.85	0.86	0.87
$Frac_{NCRO}$	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017
$Frac_{NCRBF}$	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04

Frac vaules

The fraction value $Frac_{NCRO}$, $Frac_{NCRBF}$ and $Frac_R$ is calculated for all years by using the definitions as given in IPCC Reference Manual pp 4.92 – 4.94.

The $Frac_{NCRO}$ and $Frac_{NCBRF}$ are calculated as the N-content in harvest crops divided with the total amount of dry matter in harvest crops. $Frac_{NCBRF}$ covers all crops which is N-fixing crops and $Frac_{NCRO}$ all the non N-fixing crops. In Table 6.36 the national calculated fraction values are compared to default values given in the Reference Manual. The national values differ slightly during the years and are a bit higher than the IPCC default values. For N-fixing crops the explanation could be that Denmark includes fields with clover grass, which has a high N-content. The higher national $Frac_{NCRO}$ could be a consequence of the relatively great part of straw is harvest and used for feeding, bedding and heating. As provided in Statistics Denmark nearly 65 % of the straw in 2009 is harvest.

The fractions $Frac_R$ are given in kg N pr kg crop-N as given in the Reference Manual. The fraction is calculated as N-content in the hole above ground crop biomass that is removed from the field as a crop product divided with total N-content in all parts of plants above ground.

The national $Frac_R$ is particularly higher than IPCC default. The national value express, that 84 % to 87 % of the total N in crops is removed from the field. The remaining 16 % to 13 % are the N-content in straw and tops from beets and potatoes which are left on the field. From 1990 to 2009 the

$Frac_R$ is increased as a consequence of a fall in cultivated area of feeding beets.

Table 6.36 Frac values.

Fractions	Text in CRF Table 4.Ds2 – additional information	Unit	IPCC default values	National Values 1990-2009
$Frac_{NCRO}$	Fraction of residue dry biomass that is N (all other crops than N-fixing crop)	Kg N pr kg dm	0.015	0.017-0.018
$Frac_{NCRBF}$	Fraction of total above-ground biomass of N-fixing crop that is N	Kg N pr kg dm	0.03	0.04
$Frac_R$	Fraction of N in the hole above ground crop biomass that is removed from the field as a crop product	kg N pr kg crop-N	0.45	0.84-0.87

Cultivation of histosols

N_2O emissions from histosols are based on the area with organic soils multiplied by the default emission factor given by IPCC. New data for the area of histosols indicate that the area is smaller than before assumed. The area of histosols is shown in Table 6.37. The emission factor is IPCC default and constant for all years 1990-2009, 8 kg per ha.

Table 6.37 Area of histsols in ha, 1990-2009.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Area, ha	43 971	43 880	43 780	43 686	43 559	43 436	43 343	43 242	43 145	43 028
Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Area, ha	42 919	42 814	42 716	42 620	42 523	42 410	42 299	42 184	42 070	41 955

Other Direct Emissions

The category, "Other", includes emission from sewage sludge and sludge from the industrial production applied to agricultural soils as fertiliser. Information about industrial waste, sewage sludge applied on agricultural soil and the content of nitrogen is provided by the Danish Environmental Protection Agency. It is assumed that 1.9 % of N-input applied to soil volatises as NH_3.

Table 6.38 Emission from sludge applied on agricultural soils 1990 – 2009.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Nitrogen in sewage sludge, t N	3 115	3 207	3 847	4 935	4 446	4 635	4 545	3 973	3 750	3 669
Nitrogen in industrial waste, t N	1 529	2 732	3 023	4 519	4 500	4 500	4 630	4 514	5 110	4 364
NH_3-N emission, t NH_3-N	58	60	72	93	83	87	85	74	70	69
N applied as fertiliser to the soil, t N	4 586	5 879	6 797	9 362	8 863	9 048	9 090	8 413	8 790	7 965
N_2O emission, Gg N_2O	0.09	0.12	0.13	0.18	0.17	0.18	0.18	0.17	0.17	0.16
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Nitrogen in sewage sludge, t N	3 625	3 518	3 600	3 151	2 675	2 173	2 158	2 167	2 394	2 375
Nitrogen in industrial waste, t N	5 147	7 274	8 000	8 000	10 000	10 000	11 000	11 000	11 000	11 000
NH_3-N emission, t NH_3-N	68	66	67	59	50	41	40	41	45	45
N applied as fertiliser to the soil, t N	8 705	10 726	11 532	11 092	12 625	12 132	13 117	13 126	13 349	13 330
N_2O emission, Gg N_2O	0.17	0.21	0.23	0.22	0.26	0.24	0.26	0.26	0.26	0.26

Pasture, Range and Paddock Manure

The amount of nitrogen deposited on grass is based on estimations from the NH_3 inventory. It is assumed that 5 %, on average, of the nitrogen from dairy cattle and heifers is excreted on grass (expert judgement from the Danish Agricultural Advisory Centre – Aaes, O.). N-excretion on grass has decreased due to a reduction in the number of dairy cattle. An

NH_3 emission factor of 7 % is used for all animal categories based on investigations from the Netherlands and the United Kingdom (Jarvis et al., 1989a, Jarvis et al., 1989b and Bussink, 1994).

Table 6.39 Nitrogen excreted on grass 1990 – 2009.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
N-excretion, grass, Gg N	34	35	35	36	35	36	36	35	35	34
NH_3-N emission, Gg NH_3-N	2	2	2	3	2	2	3	2	2	2
N deposited on grass, Gg N	32	33	33	33	33	33	33	33	32	32
N_2O emission, Gg	1.00	1.03	1.03	1.04	1.02	1.04	1.05	1.02	1.02	1.00
FracGRAZ	0.13	0.13	0.13	0.13	0.14	0.14	0.14	0.14	0.14	0.14
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
N-excretion, grass, Gg N	34	35	34	30	28	26	25	23	23	23
NH_3-N emission, Gg NH_3-N	2	2	2	2	2	2	2	2	2	2
N deposited on grass, Gg N	32	33	31	28	26	24	23	22	22	22
N_2O emission, Gg	1.00	1.02	0.98	0.88	0.81	0.76	0.72	0.68	0.69	0.69
FracGRAZ	0.14	0.14	0.13	0.12	0.11	0.10	0.10	0.10	0.10	0.10

$Frac_{GRAZ}$ is estimated as the volatile fraction from grazing animals compared with the total excreted nitrogen (N ab animal) (Table 6.39). The decrease in $Frac_{GRAZ}$ is due to fall in the production of grazing animals e.g. cattle.

Indirect emissions

Atmospheric deposition

To estimate the emission from atmospheric deposition, IPCC Tier 1b is applied. Atmospheric deposition includes all NH_3 emissions sources included in the Danish NH_3 emission inventory (Nielsen et al., 2010). This includes the emission from livestock manure, use of synthetic fertiliser, crops, NH_3-treated straw used as feed, field burning of crop residue and sewage sludge plus sludge from industrial production applied to agricultural soils.

The emission from atmospheric deposition has decreased from 1990 – 2009 as a result of the reduction in the total NH_3 emission, from 95 514 tonnes of NH_3-N in 1990 to 60 803 in 2009.

Table 6.40 NH_3 emission 2009.

NH_3 emission	2009
	t NH_3-N
Manure	52 315
Synthetic fertiliser	3 889
Crops	4 454
NH_3 treated straw*	NO
Burning of agricultural residue	100
Sewage sludge and sludge from the industrial production	44
Emission total	60 803
N_2O emission, Gg	0.96

*NH_3 treated straw has been prohibited from 2006.

Nitrogen leaching and Run-off

Nitrogen, which is transported through the soil, can be transformed to N_2O. The IPCC recommends an N_2O emission factor of 0.025 used, of which 0.015 is for leaching to groundwater, 0.0075 for transport to watercourses (in IPCC definition called rivers) and 0.0025 for transport out to sea (in IPCC definition called estuaries). The N_2O emission from nitrogen leaching is a sum of the emission for all three parts calculated as:

$$N_2O_{leaching} = (N_{leach-ground} \cdot EF_{ground} + N_{leach-rivers} \cdot EF_{rivers} + N_{leach-estuatires} \cdot EF_{estuatires}) \cdot \frac{44}{28}$$

In connection with the Action Plans for the Aquatic Environment, nitrogen leaching to groundwater, rivers and estuaries has been estimated, see Table 6.41. The calculation of N to the groundwater is based on two different models– SKEP/Daisy and N-LES (Børgesen & Grant, 2003) carried out by DJF and NERI (see overview of model in Annex 3E Figure 1). SKEP/DAISY is a dynamical crop growth model taking into account the growth factors, whereas N-LES is an empirical leaching model based on more than 1500 leaching studies performed in Denmark during the last 15 years. The models produce rather similar results for nitrogen leaching on a national basis (Waagepetersen et al., 2008). The SKEP/Daisy model has estimated the total N leached from 2003-2007 to be 172-159 thousand tonnes N, where as N-LES model has estimated the total N leached to be 163-154 thousand tonnes in the same period. An average of the results from the two models is used in the emission inventory.

Data concerning the N-leaching to rivers and estuaries is based on data from NOVANA (National Monitoring program of the Water Environment and Nature) received from NERI the department of Freshwater Ecology. NOVANA is a monitoring program which includes monitoring of the ecologic, physic and chemical condition of water areas and transport of water and a range of substances, including N, to lakes and the sea (Wiberg-Larsen et al., 2010). These studies include measurements from 223 monitoring stations in all parts of Denmark and have been going on from the early 1990'ies.

Table 6.41 N leaching to groundwater, rivers and estuaries in Gg, 1990-2009.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Groundwater	267	261	254	248	241	235	219	213	207	192
Rivers	104	91	102	108	139	107	46	51	102	112
Estuaries	100	86	95	97	127	91	44	46	85	95
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Groundwater	179	174	168	161	162	160	156	157	163	155
Rivers	97	79	103	53	81	67	78	98	80	61
Estuaries	82	65	88	43	67	55	64	79	64	49

Figure 6.5 shows leaching from groundwater estimated in relation to the nitrogen applied to agricultural soils as livestock manure, synthetic fertiliser and sludge. The average proportion of nitrogen leaching from groundwater has decreased from around 39 % in the middle of the nineties to around 33 % in 2009. The decline is due to an improvement in the utilisation of nitrogen in manure. The reduction in nitrogen applied is particularly due to the fall in the use of synthetic fertiliser, which has reduced by 50 % from 1990 to 2009.

The proportion of N input to soils lost through leaching and runoff ($Frac_{LEACH}$) used in the Danish emission inventory is higher than the default value of the IPCC (30 %). The high values are partly due to the humid Danish climate, with the precipitation surplus during winter causing a downward movement of dissolved nitrogen. $Frac_{LEACH}$ has decreased from 1990 and onwards. At the beginning of 1990s, manure was often applied in autumn. Now the main part of manure application takes place in the spring and early summer, where there are nearly now downward movements of soil water. The decrease in $Frac_{LEACH}$ over time is due to increasing environmental requirements and banning manure application after harvest. The data based on model estimates from DJF and NERI reflects the Danish conditions and is considered as a best estimate.

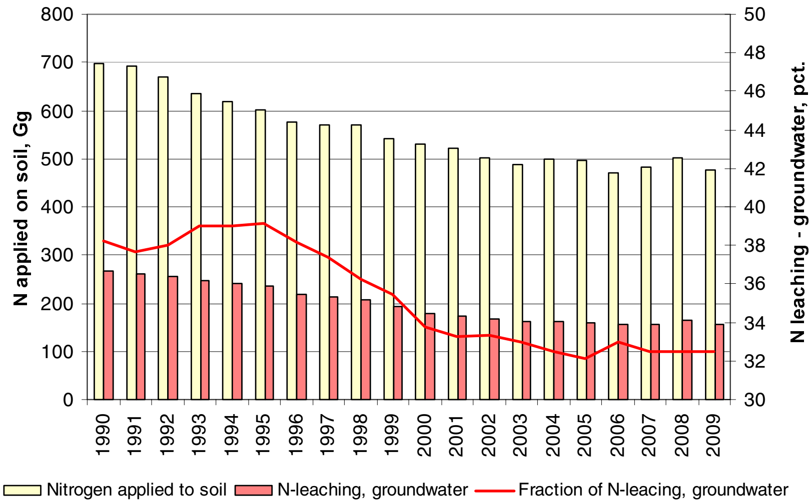


Figure 6.5 Nitrogen applied to agricultural soils and N-leaching, groundwater 1990-2009.

6.4.3 Activity data

Table 6.42 provides an overview on activity data from 1990 to 2009 used in relation to the estimation of N_2O emission from agricultural soils. The amount of nitrogen applied to agricultural soil has decreased from 1076 Gg N to 730 Gg N, corresponding to a 32 % reduction, which results in a lower N_2O emission.

Table 6.42 Activity data - agricultural soils 1990 – 2009, Gg N.

CRF – Table 4.D	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total amount of nitrogen applied on soil	1 076	1 056	1 012	985	960	936	895	888	887	835
1. Direct Emissions										
Synthetic Fertiliser	393	388	363	327	320	310	286	283	279	258
Animal Waste Applied	180	180	181	185	179	174	176	174	178	176
N-fixing Crops	44	39	33	42	40	37	36	43	48	39
Crop Residue	59	58	50	52	52	56	57	56	56	55
2. Animal Production	32	33	33	33	33	33	33	33	32	32
3. Indirect Emissions										
Atmospheric Deposition	96	92	91	89	87	82	79	78	78	74
N-leaching and Runoff	267	261	254	248	241	235	219	213	207	192
4. Other										
Industrial Waste	2	3	3	5	5	5	5	5	5	4
Sewage Sludge	3	3	4	5	4	5	5	4	4	4
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total amount of nitrogen applied on soil	808	791	762	739	749	748	720	726	754	730
1. Direct Emissions										
Synthetic Fertiliser	247	230	207	198	203	203	188	191	216	196
Animal Waste Applied	173	179	184	187	193	195	187	193	192	191
N-fixing Crops	38	36	36	31	30	34	35	35	35	41
Crop Residue	56	57	53	53	53	54	54	53	50	51
2. Animal Production	32	33	31	28	26	24	23	22	22	22
3. Indirect Emissions										
Atmospheric Deposition	73	72	70	70	69	66	63	63	62	61
N-leaching and Runoff	179	174	168	161	162	160	156	157	163	155
4. Other										
Industrial Waste	5	7	8	8	10	10	11	11	11	11
Sewage Sludge	4	4	4	3	3	2	2	2	2	2

6.4.4 Time-series consistency

The N_2O emissions from agricultural soils have reduced by 32 % from 1990 to 2009. This is largely due to a decrease in the use of synthetic fertiliser and a decrease in N-leaching as a result of national environmental policy, where action plans have focused on decreasing the nitrogen losses and on improving the nitrogen utilisation in manure.

Table 6.43 Emissions of N_2O from Agricultural Soils 1990 – 2009, Gg N_2O.

CRF – Table 4.D	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total N_2O emission	24.44	23.83	23.11	22.64	22.61	21.63	19.87	19.77	20.48	19.55
1. Direct Emissions	13.93	13.68	12.95	12.52	12.22	11.97	11.52	11.56	11.64	11.01
Synthetic Fertiliser	7.72	7.62	7.13	6.42	6.28	6.09	5.61	5.56	5.47	5.08
Animal Waste Applied	3.54	3.53	3.56	3.62	3.51	3.42	3.45	3.42	3.49	3.46
N-fixing Crops	0.87	0.76	0.64	0.83	0.78	0.73	0.70	0.85	0.94	0.76
Crop Residue	1.17	1.13	0.99	1.01	1.02	1.10	1.12	1.11	1.11	1.07
Cultivation of Histosols	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63
2. Animal Production	1.00	1.03	1.03	1.04	1.02	1.04	1.05	1.02	1.02	1.00
3. Indirect Emissions	9.42	9.01	9.00	8.89	9.19	8.44	7.13	7.01	7.64	7.39
Atmospheric Deposition	1.50	1.45	1.43	1.40	1.36	1.28	1.24	1.22	1.23	1.17
N-leaching and Runoff	7.92	7.56	7.57	7.49	7.83	7.16	5.89	5.79	6.41	6.22
4. Other	0.09	0.12	0.13	0.18	0.17	0.18	0.18	0.17	0.17	0.16
Industrial Waste	0.03	0.05	0.06	0.09	0.09	0.09	0.09	0.09	0.10	0.09
Sewage Sludge	0.06	0.06	0.07	0.10	0.09	0.09	0.09	0.08	0.07	0.07
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total N_2O emission	18.76	18.14	17.91	16.63	17.23	16.98	16.57	16.98	17.29	16.52
1. Direct Emissions	10.74	10.49	10.08	9.85	10.05	10.17	9.75	9.89	10.33	10.04
Synthetic Fertiliser	4.86	4.51	4.07	3.89	3.99	3.98	3.70	3.75	4.25	3.86
Animal Waste Applied	3.41	3.53	3.61	3.68	3.79	3.82	3.68	3.80	3.78	3.75
N-fixing Crops	0.75	0.70	0.72	0.62	0.59	0.67	0.68	0.68	0.69	0.80
Crop Residue	1.09	1.12	1.05	1.03	1.05	1.07	1.06	1.03	0.98	1.01
Cultivation of Histosols	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63
2. Animal Production	1.00	1.02	0.98	0.88	0.81	0.76	0.72	0.68	0.69	0.69
3. Indirect Emissions	6.84	6.42	6.62	5.68	6.12	5.81	5.84	6.15	6.01	5.52
Atmospheric Deposition	1.15	1.13	1.11	1.09	1.09	1.04	1.00	0.99	0.97	0.96
N-leaching and Runoff	5.69	5.28	5.52	4.59	5.03	4.77	4.84	5.16	5.04	4.57
4. Other	0.17	0.21	0.23	0.22	0.25	0.24	0.26	0.26	0.26	0.26
Industrial Waste	0.10	0.14	0.16	0.16	0.20	0.20	0.22	0.22	0.22	0.22
Sewage Sludge	0.07	0.07	0.07	0.06	0.05	0.04	0.04	0.04	0.05	0.05

6.5 Field burning of agricultural residue (CRF sector 4F)

Field burning of agricultural residue has in Denmark been prohibited since 1990 and may only take place in connection to production of grass seeds on fields with repeated production and in cases of wet or broken bales of straw. The amount of burnt straw from the grass seed production is estimated as 15 % of the total amount produced. The amount of burnt bales of or wet straw is estimated as 0.1 % of total amount of straw. Both estimates are based on an expert judgement by the Danish Agricultural Advisory Service. The total amounts are based on data from Statistics Denmark.

From field burning is seen emissions of a series of different compounds and related to GHG emissions of the following compounds are estimated CH_4, N_2O, NO_x, CO, CO_2, SO_2 and NMVOC. For emission of NMVOC see Chapter 6.6. The emission of NO_x and CO is given CRF Table 4s2. Emission of CO_2 and SO_2 is estimated, but not reported because this is not possible in CRF tables in present format. Equation for calculating emission of various compounds:

$$Emi = BB \cdot \frac{EF}{1\,000\,000} \cdot FO$$

$$BB = CP \cdot FB \cdot FR_{dm}$$

Emi = emission of compounds, Gg
BB = total burned biomass, Gg dm
CP = crop production, t
FB = fraction burned in fields
FR_{dm} = dry matter fraction of residue
EF = emission factor, g pr kg dm
FO = fraction oxidized

Table 6.44 Factors for estimating emissions of CH_4 and N_2O, 2009.

2009		Crop production	Fraction burned in fields	Dry matter (dm) fraction of residue	Total biomass burned	EF	Fraction oxidized	Emission
		t			Gg dm	g pr kg dm		Gg
CH_4	Mixed cereals	6 280 000	0.001	0.85	5 338	2.7	0.90	0.013
CH_4	Straw from seeds of grass	399 010	0.15	0.85	50 874	2.7	0.90	0.124
N_2O	Mixed cereals	6 280 000	0.001	0.85	5 338	0.07	0.90	0.0003
N_2O	Straw from seeds of grass	399 010	0.15	0.85	50 874	0.07	0.90	0.003
Total CO_2-eqv								3.97

The emission of CH_4, N_2O, NO_x, CO, CO_2 and SO_2 from field burning contributes with less than 1 % of the national emission.

The fraction value $Frac_{BURN}$ is now calculated by using the definitions as given in IPCC Reference Manual pp 4.92 – 4.94. $Frac_{BURN}$ is calculated as the amount of N in burned straw divided with the total amount of N in crop residue and the fractions are given in kg N pr kg crop-N. For all years the value of $Frac_{BURN}$ is around 0.01 kg N pr kg crop-N, which is low compared to IPCC default value. This is due to the prohibition of field burning in Denmark.

6.6 NMVOC emission

Around 2 % of the total NMVOC emission originates from the agricultural sector, which, in the Danish emission inventory, includes emission from agricultural soils, such as arable land crops and grassland, and field burning of agricultural residue. Activity data is obtained from Statistics Denmark. The emission factor for agricultural soils is for land with arable crops is 393 g NMVOC pr ha and for grassland, 2120 g NMVOC pr ha (Fenhann and Kilde 1994), (Priemé and Christensen 1991). IPCC default value for the emission factors for field burning of agricultural residue is used. The emission from agricultural soils contributes with 85 % and field burning with 15 % of the agricultural emission in 2009.

Table 6.45 NMVOC emission from agricultural soils 1990 – 2009.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Arable crops, 1000 ha	2 322	2 307	2 293	2 254	2 044	2 064	2 075	2 138	2 125	2 064
Grassland, 1000 ha	466	462	463	484	647	446	450	403	405	398
NMVOC emission, Gg	1.90	1.89	1.88	1.91	2.18	1.76	1.77	1.69	1.69	1.65
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Arable crops, 1000 ha	2043	2 060	2 065	2 062	2 079	2 086	2 083	2 050	2 107	2 103
Grassland, 1000 ha	413	414	396	390	369	446	460	459	490	497
NMVOC emission, Gg	1.68	1.69	1.65	1.64	1.60	1.77	1.79	1.78	1.87	1.88

Table 6.46 NMVOC emission from field burning of agricultural residue 1990 – 2009.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
NMVOC emission, Gg	0.20	0.21	0.20	0.22	0.21	0.24	0.24	0.25	0.32	0.30
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
NMVOC emission, Gg	0.30	0.31	0.26	0.31	0.33	0.33	0.34	0.29	0.27	0.32

6.7 Uncertainties

Uncertainties are calculated by using both a Tier 1 and a Tier 2 approach, see chapter 1.7 for description of the Tier 2 calculation. The same uncertainties values for activity data and emission factor are used for both Tier 1 and Tier 2.

6.7.1 Uncertainty values

Uncertainty values are based on expert judgement (Olesen et al., 2001, Gyldenkærne, 2005).

Uncertainties regarding animal production, such as number of animals, feeding consumption, normative figures etc. are very small. Number of animals is estimated by Statistic Denmark and all cattle, sheep and goats have their own ID-number (ear tags) and, hence, uncertainty with regard to their numbers is almost absent. Statistics Denmark has estimated the uncertainty in the number of pigs to be less than 1 %.

The Danish Normative System for animal excretions is based on data from the Danish Agricultural Advisory Service (DAAS), which is the central office for all Danish agricultural advisory services. DAAS engages in a great deal of research as well as the collection of efficacy reports from Danish farmers for dairy production, meat production, swine production, etc. to optimise productivity in Danish agriculture. In total, feeding plans from 15-18 % of Danish dairy production, 25-30 % of pig production, 80-90 % of poultry production and approximately 100 % of fur production are collected annually. These basic feeding plans are used to develop the standard values of the "Danish Normative System".

The normative figures (Poulsen et al., 2001) are comprised of arithmetic means. Based on feeding plans, the standard deviation in N-excretion rates between farms can be estimated to ±20 % for all animal types (Hanne D. Poulsen, DJF). However, due to the large number of farms included in the norm figures the arithmetic mean, it can be assumed as a very good estimate with a low uncertainty.

Data for hectares under cultivation is estimated by Statistic Denmark and the uncertainties is based on there calculations. For the most common crops the uncertainties are below 5%.

This year the uncertainty estimates for both activity data and emission is re-evaluated and some adjustments is made. For CH_4 emission form animals (CRF category 4.A and 4.B) the uncertainties for activity data is lowered due to the combined effect of low uncertainty in actual animal numbers, relatively low uncertainty for feed consumption and excretion rates, this gives a relatively low uncertainty in the activity data as a whole – between 2% and 22%. The uncertainties for the emission factors for CH_4 emission form animals are adjusted based on IPCC 1997 and 2000.

For the N_2O emission uncertainties for the activity data is based on the uncertainties for NH_3 emission due to the high correlation between the NH_3 and N_2O emission. Uncertainties related to the N_2O emission factor is based on Good Practice Guidance. See Table 6.47 for uncertainty values for the agricultural sector.

Table 6.47 Uncertainties values for activity data and emission factors for CH_4 and N_2O.

CRF category		Emission factor	Uncertainties value for activity data, %	Uncertainties value for emission factor, %
4.A Enteric Fermentation		CH_4	2	20
4.B Manure Management		CH_4	5	20
		N_2O	22	50
4.D Agricultural Soils				
4.D1 Direct soil emissions				
	Synthetic Fertiliser	N_2O	25	100
	Animal Waste Applied to Soils	N_2O	30	100
	N-fixing Crops	N_2O	20	100
	Crop Residue	N_2O	20	100
	Cultivation of Histosols	N_2O	20	100
	Sewage N	N_2O	20	100
	Industrial Waste Used as Fertiliser	N_2O	20	100
4.D2 Animal Production		N_2O	25	100
4.D3 Indirect soil emissions				
	Atmospheric Deposition	N_2O	19	100
	N-Leaching and Runoff	N_2O	20	100
4.F Field Burning of Agricultural Residue				
		CH_4	25	50
		N_2O	25	50

6.7.2 Result of the uncertainty calculation

Table 6.48 shows the result of the Tier 1 and Tier 2 uncertainty calculation for 2009. A calculation of 1990 gives nearly the same uncertainty values for all emission sources. The overall uncertainty calculation for the agricultural sector based on Tier 1 is estimated to ±25%. Tier 2 calculation shows an uncertainty interval from -19% to +33.

For most of the emission sources the uncertainty level based on Tier 2 are nearly at the same level as for Tier 1, see Figure 6.6. The two calculations can be considered as consistent. The lowest uncertainties are seen for CH_4 emission from enteric fermentation and manure management and the highest for emission form grazing animals and this pattern is reflected in both calculations.

The biggest difference between the Tier 1 and Tier 2 uncertainty calculations is seen for N_2O from manure management.

Table 6.48 Comparison between Tier 1 and Tier 2 uncertainty calculation, 2009.

Uncertainty		Tier 1		Tier 2		
2009		Emission, Gg CO_2-eqv	Uncertainty, %	Median emission, Gg CO_2-eqv	Uncertainty, %	
			Lower and upper (±)		Lower (-)	Upper (+)
4 Agriculture total	CH_4 and N_2O	9 606	25	10 172	19	33
4.A Enteric Fermentation	CH_4	2 859	20	2 867	12	13
4.B Manure Management	CH_4 and N_2O					
	CH_4	1 228	21	1 254	11	12
	N_2O	426	55	461	20	27
4.D Agricultural soil:	N_2O					
4.D1 Direct soil emissions	N_2O	3 163	57	3 404	40	75
4.D2 Grazing animals	N_2O	213	103	214	62	161
4.D3 Indirect soil emissions	N_2O	1 712	86	1 753	54	129
4.F Field Burning of Agricultural Residues	CH_4 and N_2O					
	CH_4	3	56	0	42	70
	N_2O	1	56	1	42	70

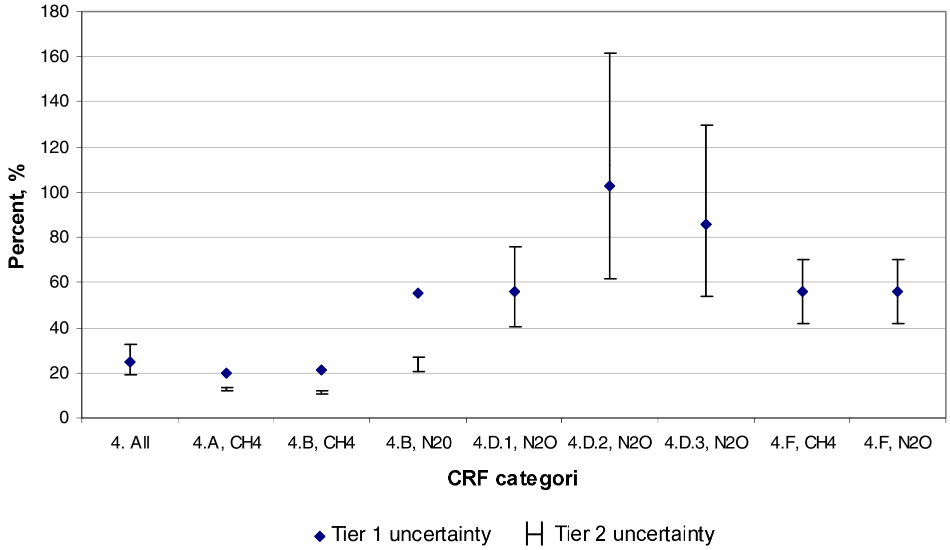


Figure 6.6 Tier 1 and Tier 2 uncertainties for the agricultural sector, 2009.

6.8 Quality assurance and quality control (QA/QC)

A first step of development and implementation of a general QA/QC plan for all sectors started in 2004 which is described in a publicised manual (Sørensen et al., 2005). The manual describes the concepts of quality work and how to handle quality management by using Critical Control Points and a list of Point of Measurements. For more detailed information of the structure in the general QA/QC plan refers to Chapter 1.6 for QA/QC.

A complete list Points of Measures (PM) are given in Table 1.2. PM related to the agricultural inventory is listed below in Chapter 6.8.2 and are primarily connected to data storage and data processing level 1. For PM not mentioned below please refer to Chapter 1.6.

The QA/QC work specific for the agricultural sector is still under development. Improvements are implemented this year and further steps will be continued next year. In connection to the implementation of the new data base system IDA some problems related to the data extensions turned up, which also has been reflected in the ERT comments and recommendations for the submission 2009. This year a set up for a quality procedure are provided, which is constructed in form of six stages described in Chapter 6.8.1. From this year, some stages are implemented and the remaining stages are still under development.

6.8.1 QA/QC procedure

The QA/QC procedure is divided in six stages as listed below:

Table 6.49: Stages of QA/QC procedure.

Stage I	**Check of input data**
	- check of data input in IDA are consistent with data from extern data suppliers
Stage II	**Check of IDA data – overall**
	- check of total emissions compared with the latest submission (2010)
	- check of total emissions for the total CO_2-eqv. and for each compound
Stage III	**Check of IDA data – specific**
	- check of annual changes of activity data, emissions factor, IEF and other important variables as GE, Nex, housing types, days of grassing
Stage IV	**Check by comparing calculation with estimates from other institutions**
	- Nex estimated by DJF
	- the Register for fertilization controlled by the Danish Plant Directorate
Stage V	**Check of data registered in CRF**
	- compare data in CRF with data from IDA
Stage VI	**Check of the inventory in general (extern review)**
	- check that data is used correctly
	- check the methodology and the calculations
	- check the methodology and the calculations

Stage I: Check of input data

At stage I is checked that of all input data in IDA is consistent with data from the extern data suppliers. Data from the Statistics, Denmark has to be checked for the livestock production, slaughter data for poultry and pigs, check of land use and crop yield. Data input from the Faculty of Agricultural Science has to be checked for feed intake, N-excretion, ammonia emission factors, manure production, dry matter content. Data from the Danish Plant Directive: distribution of housing system and the use of nitrogen in synthetic fertiliser.

Stage II: Check of IDA data - overall

At stage II a check of the overall calculations in IDA is corrected, which first step is to compare the inventory with the last reported emission inventory - submission 2010. In the case where an error cover all time-series, it can be difficult to identify this error by checking the changes in inter annual values. Therefore, a check of recalculation is needed.

Next step in stage II is a check of total emissions of CH_4, N_2O, NMVOC and the other compounds which are related to the field burning of agricultural residues. For each compounds a check of trends of times series 1990-2009 and inter annual changes is provided. Significant jumps from one year to another could indicate an error - otherwise it has to be explained.

Stage III: Check of IDA data - specific

At stage III a check of specific variable in IDA is provided for both inter annual changes and trends 1990-2009. Variables includes activity data, emissions factor, IEF and other important key parameters as feed intake, GE, Nex, housing types and days of grassing.

Stage IV: Check by comparing calculation with estimates from other institutions

The purpose of stage IV is to verify the calculations in IDA, as far as extern data estimations are available. The comparison will properly show some differences, which not necessary indicate an error, but the most important cause of the difference has to be identified.

Stage V: Check of data registered in CRF

Stage V primarily focus on the last reported year 2009 and the basis year 1990, where all input data and IEF are checked. Furthermore, CRF sum emissions are checked with sum emissions in IDA. If error occurs a more detailed check will be accomplished.

Stage VI: Check of the inventory in general

A detailed description of the methodology used to calculate the Danish agricultural emissions are published. General checks of the inventory include considerations of which data input is used, how there are used in the calculations and are more accurate data available. These questions are intended to be answered by a review of the methodology report.

Status for the QA/QC plan

All things considered, the framework for working out a specific QA/QC plan for the agricultural sector is composed. Stage I-III is provided in praxis, which has reduced the rate of errors in reporting templates CRF and in this way meet the ERT recommendations. However, some work is still needed to demonstrate the documentation of the checks. It is planned to work out a specific list showing the checked variables and this will be included in the submission 2012.

Concerning the stage IV we have provide some random check but need to provide a more systematic check. We are aware of some external calculations which can be compared with the estimations in IDA – e.g. total N-excretion in manure calculated of DJF. Furthermore, some comparisons with the Register of Fertilization administrated by the Danish Plant

Directorate can be provided. However, some efforts have to be put into finding extern available comparably estimations.

Stage VI are implemented. Two reports describing the methodology in calculation of agricultural emissions in details are published (Mikkelsen et al., 2006 and Mikkelsen et al., 2011). Both reports have been reviewed by qualified persons with comprehensive agricultural knowledge; Nicholas J. Hutchings from the Faculty of Agricultural Sciences, Aarhus University and Johnny M. Andersen from the Faculty of Life Sciences, University of Copenhagen. It has to be underlined that none of the reviewers are involved in work concerning the annual emission inventory. The reviewers have responded to all sections in the reports. In the next updated version is it planned to contact relevant reviewers to focus on specific subject area.

6.8.2 QA/QC plan expressed in Critical Control Points and Point of Measurements

Data storage level 1

Data Storage level 1	3.Completeness	DS.1.3.1	Documentation showing that all possible national data sources are included by setting down the reasoning behind the selection of datasets.

The following external data are in used in the agricultural sector, in more details see table 6.2:

- Data from the annual agricultural census made by Statistics Denmark.
- The Faculty of Agricultural Sciences, University of Aarhus (DJF).
- The Danish Plant Directorate.
- Danish Agricultural Advisory Service (DAAS).
- The Danish Energy Authority.
- Danish Environmental Protection Agency.

The emission factors come from various sources:

- IPCC guidelines.
- The Faculty of Agricultural Sciences, University of Aarhus (DJF): NH_3 emission, CH_4 emission from enteric fermentation and manure management.

Statistics Denmark

The agricultural census made by Statistics Denmark is the main supply of basic agricultural data. In Denmark, all cattle, sheep and goats have to be registered individually and hence the uncertainty in the data is negligible. For all other animal types, farms having more than 10 animal units are registered.

The Faculty of Agricultural Sciences (DJF)

DJF are responsible for the delivery of N-excretion data for all animal and housing types. Data on feeding consumption on commercial farms are collected annually by DAAS from on-farm efficacy controls. For dairy cattle, data is collected from 15-20 % of all farms, for pigs, 25-30 % and for poultry and mink, 90-100 % of all farms. The farm data are used to calculate average N-excretion from different animal and housing types. Due to the large amount of farm data involved in the dataset, N-excretion is seen as a very good estimate for average N-excretion at the Danish livestock production.

Danish Plant Directorate

Total area with the various agricultural crops is provided to the Danish Plant Directorate via the agricultural subsidy system. For every parcel of land (via a vector-based field map with a resolution of >0.01 ha), the area planted with different crops is reported. If the total crop area within a parcel is larger than the parcel area, a manual control of the information is performed by the Plant Directorate. The area with different crops, therefore, represents a very precise estimate.

All farmers are obliged to do N-mineral accounting on a farm and field level with the N-excretion data from DJF. Data at farm level is reported annually to the Danish Plant Directorate. The N figures also include the quantities of synthetic fertilisers bought and sold. Suppliers of synthetic fertilisers are required to report all N sales to commercial farmers to the Plant Directorate. The total sold to farmers is very close to the amount imported by the suppliers, corrected for storage. The total amount of synthetic fertiliser in Denmark is, therefore, a very precise estimate for the synthetic fertiliser consumed. This is also valid for N-excretion in animal manure.

The Danish Plant Directorate, as the controlling authority, performs analysis of feed sold to farmers. On average, 1600 to 2000 samples are analysed every year. Uncertainty in the data is seen as negligible. The data are used when estimating average energy in feedstuffs for pigs, poultry, fur animals, etc.

From 2005 the Danish Plant Directorate provides data for distribution of housing type.

Danish Agricultural Advisory Service (DAAS)

DAAS is the central office for all Danish agricultural advisory services. DAAS carries out a considerable amount of research itself, as well as collecting efficacy reports from the Danish farmers for dairy production, meat production, pig production, etc., to optimise productivity in Danish agriculture. From DAAS data on housing type until 2004, grazing situation and information on application of manure is received.

The Danish Energy Authority

The amount of slurry treated in biogas plants is received from the Danish Energy Authority.

Danish Environmental Protection Agency

Information on the sludge from waste water treatment and the manufacturing industry and the amount applied on agricultural soil is obtained from the Danish Environmental Protection Agency.

Data Storage level 1	1. Accuracy	DS.1.1.1	General level of uncertainty for every dataset including the reasoning for the specific values

The most important emission source is related to the animal production. Uncertainty for the animal data is very low due to the very strict environmental laws in Denmark. Standard deviation regarding the numbers of cattle and pigs has been estimated to <0.7 %. For poultry the standard deviation is <2.1 %. For all years, 25-35 % of all holdings are included in the census. The standard deviation for N-excretion between farms is reported as 25 % for dairy cattle and pigs, but due to the large numbers involved in the estimation of the average N-excretion, the average is assumed to be a precise estimate for the Danish agricultural efficacy level.

Regarding uncertainties for the remaining emission sources see Chapter 6.7.

Data Storage level 1	1. Accuracy	DS.1.1.2	Quantification of the uncertainty level of every single data value including the reasoning for the specific values.

Please, refer to Chapter 6.7 and Table 6.48.

Data Storage level 1	1. Comparability	DS.1.2.1	Comparability of the data values with similar data from other countries, which are comparable with Denmark, and evaluation of discrepancy.

The Danish N-excretion levels are generally lower than IPCC default values. This is due to the highly skilled, professional and trained farmers in Denmark, with access to a highly competent advisory system.

The feed consumption pr animal is in line with similar data from Sweden, although they are not quite comparable because Denmark is using feeding units (FE) which cannot easily be converted to energy content. Earlier, one feeding unit was defined as one kg of barley. Today, the calculations are more complicated and depend on animal type.

Data Storage level 1	4.Consistency	DS.1.4.1	The origin of external data has to be preserved whenever possible without explicit arguments (referring to other PMs).

External data received are stored in the original format in quality management database system.

Data Storage level 1	6.Robustness	DS.1.6.1	Explicit agreements between the external institution holding the data and NERI about the conditions of delivery.

NERI has established formal data agreements with all institutes and organisations which deliver data, to assure that the necessary data is available to prepare the inventory on time.

Data Storage level 1	6.Robustness	DS.1.6.2	At least two employees must have a detailed insight into the gathering of every external data set.

Please refer to Chapter 1.7.

Data Storage level 1	7.Transparency	DS.1.7.1	Summary of each dataset including the reasoning for selecting the specific dataset.

Please refer to DS 1.1.1.

Data Storage level 1	7.Transparency	DS.1.7.2	The archiving of data sets needs to be easy accessible for any person in the emission inventory.

Please refer to Chapter 1.7.

Data Storage level 1	7.Transparency	DS.1.7.3	References for citation for any external data set have to be available for any single value in any dataset.

A great deal of documentation already exists in the literature list, and also given in the quality management database system: I:/rosproj/luft_emi/inventory-/2008/4_Agriculture/level_1a_storage/

Data Storage level 1	7.Transparency	DS.1.7.4	Listing of external contacts for every dataset.

Statistics Denmark:

Mr. Ole Nielsen (oni@dst.dk)

Mr. Karsten K. Larsen (kkl@dst.dk)

Faculty of Agricultural Sciences (University of Aarhus):

Mrs. Hanne Damgaard Poulsen (hannedamgaard.poulsen@agrsci.dk)

Mr. Nick Hutchings (nick.hutchings@agrsci.dk)

Mr. Christen Duus Børgesen (Christen.Borgesen@agrsci.dk)

The Danish Agricultural Advisory Centre:

Mr. Ole Aaes (OEA@Landscentret.dk)

Mr. Eric F. Clausen (EFC@landscentret.dk)

Mr. Barthold Feidenshans'l (BAF@landscentret.dk)

Danish Plant Directorate:

Mr. Troels Knudsen (tkn@pdir.dk)

Mrs. Mette Thomsen (mth@pdir.dk)

The Danish Energy Agency:

Mr. Søren Tafdrup (st@ens.dk)

The Danish Environmental Protection Agency:

Mrs. Trine Leth Kølby (trile@mst.dk)

Data processing level 1

Data Processing level 1	1. Accuracy	DP.1.1.1	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to type of variability. (Distribution as: normal, log normal or other type of variability).

The Tier 1 methodology is used to calculate the uncertainties for the agricultural sector. The uncertainties are based on a combination of IPCC guidelines and an expert judgement (Olesen et al., 2001, Poulsen et al., 2001, Gyldenkærne, 2005) and a normal distribution is assumed. A Tier 2 is calculation is provided, please refer to Chapter 6.7.

Data Processing level 1	1. Accuracy	DP.1.1.2	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to scale of variability (size of variation intervals).

Please refer to DP 1.1.1.

Data Processing level 1	1. Accuracy	DP.1.1.3	Evaluation of the methodological approach using international guidelines.

Denmark has worked out a report with a more detailed description of the methodological inventory approach in Mikkelsen et al. (2006) and an updated version in Mikkelsen et al. (2011). The first report has been reviewed by the Statistics Sweden, who is responsible for the Swedish agricultural inventory and the updated report has been reviewed of qualified persons with comprehensive agricultural knowledge; Nicholas J. Hutchings from the Faculty of Agricultural Sciences, Aarhus University and Johnny M. Andersen from the Faculty of Life Sciences, University of Copenhagen. None of the reviewers is involved in the preparation of the annual inventory.

Furthermore, data sources and calculation methodology developments are continuously discussed in cooperation with specialists and researchers in different institutes and research sections. As a consequence, both the data and methods are evaluated continually according to the latest knowledge and information.

Data Processing level 1	1. Accuracy	DP.1.1.4	Verification of calculation results using guideline values

The methodological approach is consistent with the IPCC Reference Manual and the Good Practice Guidance. For some of the calculation differences can be seen and are explanation are given in NIR.

Enteric CH_4 emissions are, in general, lower than the IPCC default values due to the professional way farms are managed in Denmark. Enteric fermentation from dairy cows is high and comparable with North American conditions. Due to the increase in milk production pr dairy cow, there has been an increase in enteric fermentation of CH_4, and it is in line with the conditions in the USA, the Netherlands and Sweden.

The CH_4 emission from manure management is, in general, higher than the default IPCC values for Western Europe because of the higher percentage handled as slurry. However, due to the high efficacy at farm level, energy intake is lower pr head and the subsequent CH_4 emission from slurry is, thereby, lower. Denmark uses an MCF factor of 10 % as provided in the 1996 guidelines and not the 39 % in the revision to the 1996 guidelines. For further explanation, see the text in the agriculture Chapter (6.3.2).

$Frac_{LEACH}$ is higher than the default IPCC values. $Frac_{LEACH}$ has decreased from 1990 and onwards. In the beginning of 1990s, manure was often applied in autumn. The high values are partly due to the humid Danish climate, with the precipitation surplus during winter causing a downward moment of dissolved nitrogen. The decrease in $Frac_{LEACH}$ over time is caused by sharpened environmental requirements, banning manure application after harvest. As a result, most manure application occurs during spring and summer, where there is a precipitation deficit. The generally accepted leaching values in Denmark are 0.3 for mineral nitrogen and 0.45 for organic-bound nitrogen. These values are based on numerical leaching studies.

Data Processing level 1	2.Comparability	DP.1.2.1	The inventory calculation has to follow the international guidelines suggested by UNFCCC and IPCC.

The methodological approach is consistent with the IPCC Reference Manual and the Good Practice Guidance.

Data Processing level 1	3.Completeness	DP.1.3.1	Assessment of the most important quantitative knowledge which is lacking.

Regarding the reduction potential for biogas treated slurry, more information and investigation could be preferred. There is ongoing work to increase the accuracy of this emission source.

Data Processing level 1	3.Completeness	DP.1.3.2	Assessment of the most important missing accessibility to critical data sources

All known major sources are included in the inventory. In Denmark, only very few data are restricted (military installations). Accessibility is not a key issue; it is more lack of data.

Data Processing level 1	4.Consistency	DP.1.4.1	In order to keep consistency at a high level, an explicit description of the activities needs to accompany any change in the calculation procedure

The calculation procedure is consistent for all years.

Data Processing level 1	4.Consistency	DP.1.4.2	Identification of parameters (e.g. activity data, constants) that are common to multiple source categories and confirmation that there is consistency in the values used for these parameters in the emission calculations

Please refer to Chapter 1.7.

Data Processing level 1	5.Correctness	DP.1.5.1	Show at least once, by independent calculation, the correctness of every data manipulation.

During the development of the model, thorough checks have been made by all persons involved in preparation of the agricultural section.

Data Processing level 1	5.Correctness	DP.1.5.2	Verification of calculation results using time-series.

Time-series for activity data, emission factors and national emission are performed to check consistency in the methodology, to avoid errors, to identify and explain considerable year to year variations.

Data Processing level 1	5.Correctness	DP.1.5.3	Verification of calculation results using other measures.

A comparison between IPCC Tier 2 method for enteric fermentation and Denmark's Tier 2/CS is made, see Chapter 6.2.4.

Data Processing level 1	5.Correctness	DP.1.5.4	Show one-to-one correctness between external data sources and the databases at Data Storage level 2

In the database key ids is used to identify the unique data. The data on DS level 1 is linked to the key id used in the database so a clear reference from DS level 1 to higher levels of both DP and DS is secured.

Data Processing level 1	6.Robustness	DP.1.6.1	Any calculation must be anchored to two responsible persons that can replace each other in the technical issue of performing the calculations.

Please refer to Chapter 1.7.

Data Processing level 1	7.Transparency	DP.1.7.1	The calculation principle and equations used must be described.

All calculation principles are described in the NIR and the documentation report (Mikkelsen et al., 2011).

Data Processing level 1	7.Transparency	DP.1.7.2	The theoretical reasoning for all methods must be described.

All theoretical reasoning is described in the NIR and the documentation report (Mikkelsen et al., 2011).

Data Processing level 1	7.Transparency	DP.1.7.3	Explicit listing of assumptions behind methods.

All theoretical reasoning is described in the NIR and the documentation report (Mikkelsen et al., 2011).

Data Processing level 1	7.Transparency	DP.1.7.4	Clear reference to dataset at Data Storage level 1.

In the database key ids is used to identify the unique data. The data on DS level 1 is linked to the key id used in the database so a clear reference from DS level 1 to higher levels of both DP and DS is secured.

Data Processing level 1	7.Transparency	DP.1.7.5	A manual log to collect information about recalculations.

Changes compared with the last emissions report are described in the NIR and the national emission changes is given in a table under the section, "Recalculation". The text describes whether the change is caused by changes in the dataset or changes in the methodology used. Furthermore a log table is filled in when data are updated or adjusted continuously.

Data storage and processing level 2

For point of measurements not mentioned below please refer to Chapter 1.7.

Data Storage level 2	5.Correctness	DS.2.5.1	Documentation of a correct connection between all data types at level 2 to data at level 1.

A manual check-list is under development for correct connection between all data types at level 1 and 2.

Data Processing level 2	5.Correctness	DS.2.5.2	Check if a correct data import to level 2 has been made.

A manual check-list is under development for correctness of data import to level 2.

6.9 Recalculation

Below follows a survey of improvements and recalculations implemented since submission 2010.

Improvements

A number of recommendations given by ERT during the in-country review in September 2010 have been incorporated in the Danish inventory:

- MCF factor for animal housed in deep litter systems was changed to 10 % in accordance with the IPCC guidelines. This affects emissions from cattle, sheep and goats.
- MCF for poultry has been changed to 1.5 % in accordance with the IPCC guidelines.
- The emission factor for histosols have been changed to the IPCC default, 8 kg N_2O-N per ha.
- During the recalculation process an error in MCF used for grazing animals was discovered. By an erroneous configuration in IDA, the Danish calculation model, the MCF for grazing animals followed the manure type. This is now corrected to a MCF of 1% for all livestock categories.

The consequences of these changes have increased the emission from the agricultural sector with 1-3 % in the period 1990-2008.

As recommended by the ERT a more detailed description of the calculation of GE is given in Chapter 6.2.2. Furthermore is data on feed consumption for animals given in feed units (FU) and number of animals for all subcategories now included, Annex 3E Table 5 and Annex 3E Table 2, respectively. Further more information on NH_3 emission factors is provided in annex 3E Table 3 and 4, information on cultivated areas are provided in Annex 3E Table 14 and background data for N-fixing crops in Annex 3E Table 11 and 12.

A inconsistency in data for feed consumption for heifers for the period 1990-2002 have, as recommended by the ERT, been removed, see Annex 3E Table 5 and 8b.

In connection to implementation of the Danish database system to manage and calculate agricultural emissions IDA (Integrated Database model for Agricultural emissions), some problems concerning the data extensions turned up. This was also reflected in the following review and an object in various ERT comments and recommendations in submission 2009. This year an overall framework for a specific QA/QC plan is provided, which is constructed in form of six stages. Each stage focus on quality assurance and quality check in different part of the inventory process; input data, calculation in IDA, output data and emission inventory in general.

Better explanation concerning the calculation of lower emission of CH_4 and N_2O from biogas treated slurry is given.

Recalculations

Some changes in calculation of agricultural emissions 1990-2009 have taken place. The recalculation have contributed to a decreased in the total agricultural emissions for all years 1990-2009 of 4 to 10 % given in CO_2-equivalent (Table 6.50).

Table 6.50 Changes in GHG emission in the agricultural sector compared with the CRF reported last year.

GHG emission	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Previous inventory, Gg CO_2 eqv.	13 268	13 139	12 829	12 722	12 425	12 211	11 992	11 696	11 676	11 208
Recalculated, Gg CO_2 eqv.	12 384	12 205	11 971	11 903	11 768	11 436	10 891	10 755	11 023	10 582
Change in Gg CO_2 eqv.	-884	-934	-858	-819	-657	-775	-1 102	-940	-652	-626
Change in pct.	-7.1	-7.7	-7.2	-6.9	-5.6	-6.8	-10.1	-8.7	-5.9	-5.9
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Previous inventory, Gg CO_2 eqv.	10 968	10 814	10 544	10 284	10 194	10 206	10 053	10 095	10 348	
Recalculated, Gg CO_2 eqv.	10 313	10 251	10 114	9 666	9 793	9 682	9 503	9 738	9 797	
Change in Gg CO_2 eqv.	-655	-563	-429	-618	-402	-524	-550	-356	-551	
Change in pct.	-6.4	-5.5	-4.2	-6.4	-4.1	-5.4	-5.8	-3.7	-5.6	

The most significant inventory changes are mentioned below:

The recalculation of the emissions is mainly caused by changes in the emission of N_2O from 4.D.3 Indirect Emissions. The calculation of N_2O emission from leaching has been changed due to available data, which make it possible to divide the calculation of the emission in three separately parts; groundwater, rivers and estuaries. In IPCC guidelines is recommended a specific emission factor for each of these three different environmental areas, which is used in the Danish emission inventory. The recalculation gives a decrease of the emission from 4.D by 7 - 16 % in 1990 - 2008.

N-excretion from swine has been adjusted because of an error in N-excretion from sows. This correction gives rise to an increased N-excretion for all years 1990 – 2008.

The emissions of CH_4 from enteric fermentation have been recalculated due to an error in the calculation of the emission from sows. This error was reason for a doublet counting of the emission from sows, therefore gives the recalculation a decrease in the emission from enteric fermentation. In the emission of CH_4 from enteric fermentation are furthermore from this year included emissions from poultry. The emissions are very low and contribute by less than 1 % of the total emission from enteric fermentation. Data of CH_4 from enteric fermentation from fur farming have been collected but these show that the emission is approximately zero.

The calculation of the number of produced animals for poultry and swine have been adjusted due to new information. The changes vary the number of produces animals for all years 1990-2008.

New data for the housing type distribution for 2008 have been included and this give some changes in the allocation of the N-excretion on the different management systems and thereby a change in N_2O emission.

The distribution of horses on four subcategories has been implemented for the years 2003 and forward. Normative figures, feed consumption etc. for horses for the years 1990 – 2002 have been adjusted to even out the trends.

6.10 Planned improvements

The Danish emission inventory for the agricultural sector largely meets the request as set down in the IPCC Good Practice Guidance. In the years to come and based on the ERT recommendations, some specific improvements, as mentioned below, are planned:

- In the following work to improve the inventory the calculation of reduced emission from biogas treated slurry are continuously highlighted as high priority. Results from Danish investigation shows a lower emission of both CH_4 and N_2O from biogas treated slurry. The next step is to search for available data which can verify these results. It is continued planned to contact the larger biogas plant to ask for potential data material, which entirely covers the energy production concerning the slurry. Based of this knowledge it is hopefully possible to do some improvements in submission 2012.
- From 2005 information on housing type are received from the Danish Plant directorate. For previously years the distribution is based on an expert judgement from the Danish Agricultural Advisory Service. It is planned to reconsider the distribution of housing type in corporation

with DAAS and identify if there is large differences which demand adjustments.
- The overall framework concerning a specific QA/QC plan for the agricultural sector is provided. The further work to obtain improvements consists in the documentation of the comprehensive check procedure. It is planned to provide specific list showing the checked variables, which will be included in the submission 2012. Until now focus has been on checking input data received from extern suppliers and check of all calculations estimated in the Danish model complex (IDA) used to manage and calculate the agricultural emissions. The further focus will in particular be addressed to compare the calculations from IDA with estimates from other institutions as far as available data makes it possible (refer to "Stage V" in the QA/QC plan – see chapter 6.8.1).

References

Aaes, Ole. The Danish Agricultural Advisory Centre, pers. comm.

Bussink, D.W. 1994: Relationship between ammonia volatilisation and nitrogen fertiliser application rate, intake and excretion of herbage nitrogen by cattle on grazed swards. Fertil. Res. 38, 111-121.

Børgesen, C.D. & Grant, R. 2003: Vandmiljøplan II – modelberegning af kvælstofudvaskning på landsplan, 1984 til 2002. Baggrundsnotat til Vandmiljøplan II - slutevaulering. December 2003, Danmarks Jordbrugsforskning og Danmarks Miljøundersøgelser. (In Danish).

CRF, Common Reporting Format. Available at:
http://cdr.eionet.europa.eu/dk/Air_Emission_Inventories (16.02.2011)

DEA, 2010, Danish Energy Agency: S. Tafdrup. Pers. Comm.

Djurhuus, J. & Hansen, E.M. 2003: Notat vedr. tørstof og kvælstof i efterladte planterester for landbrugsjord – af 21. maj 2003. Forskningscenter Foulum, Tjele. (In Danish).

Dustan, A. 2002: Reviw of methane and nitrous oxid emission factors for manure management in cold climates. JTI – Swedish Institute of Agricultural and Environmental Engineering, Uppsala. Report 299.

EMEP/EEA air pollutant emission inventory guidebook, 2009: http://www.eea.europa.eu/publications/emep-eea-emission-inventory-guidebook-2009 (16.02.2011).

Fenhann, J. & Kilde, N.A. 1994: Inventory of Emissions to the Air from Danish Sources 1972-1992. System Analysis Department – Risø National Laboratory.

Hansen, N. E. 2010: Department of Basic Animal and Veterinary Sciences/Animal Nutrition, Faculty of Life Science, University of Copenhagen. Pers. comm., mail 13.12.2010.

Hashimoto, A. and Steed, J. 1993: Methane Emissions from Typical U.S. Livestock Manure Management Systems. Draft report prepared for ICF

Incorporated under contract to the Global Change Division of the Office of Air and Radiation, US Environmental Protection Agency, Washington, D.C., U.S.A.

Husted, S. 1994: Waste Management, Seasonal Variation in Methane Emission from Stored Slurry and Solid Manures. J. Environ. Qual. 23:585-592 (1994).

Høgh-Jensen, H., Loges, R., Jensen, E.S., Jørgensen, F.V. & Vinther, F.P. 1998: Empirisk model til kvantificering af symbiotisk kvælstoffiksering i bælgplanter. – Kvælstofudvaskning og –balancer i konventionelle og økologiske produktionssystemer (Red. Kristensen E.S. & Olesen, J.E.) s. 69-86, Forskningscenter for Økologisk Jordbrug. (In Danish).

Gyldenkærne, S. 2005: Researcher at NERI, Departement of Policy Analysis. Pers. Comm.

IPCC 1997: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. Available at: http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.html (16.02.2011).

IPCC 2000: Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. Available at: http://www.ipcc-nggip.iges.or.jp/public/gp/english/ (16.02.2011).

Jarvis, S.C., Hatch, D.J. & Roberts, D.H. 1989a: The effects of grassland management on nitrogen losses from grazed swards through ammonia volatilization; the relationship to extral N returns from cattle. J. Agric. Sci. Camb. 112,205-216.

Jarvis, S.C., Hatch, D.J. & Lockyer, D.R. 1989b: Ammonia fluxes from grazed grassland annual losses form cattle production systems and their relation to nitrogen inputs. J. Agric. Camp. 113, 99-108.

Kristensen, I.S. 2003: Indirekte beregning af N-fiksering - draft, not published. Danmarks JordbrugsForskning. (In Danish).

Kyllingsbæk 2000: Kvælstofbalancer og kvælstofoverskud i dansk landbrug 1979-1999. DJF rapport nr. 36/markbrug, Dansk Jordbrugsforskning.

Laursen, B. 1987: Normtal for husdyrgødning. Report no. 82, Institute of Food and Ressource Economics, University of Copenhagen (previously referred to as Statens Jordbrugsøkonomiske Institut). (In Danish).

Laursen, B. 1994: Normtal for husdyrgødning – revideret udgave af rapport nr. 28. Report no. 82, Institute of Food and Ressource Economics, University of Copenhagen (previously referred to as Statens Jordbrugsøkonomiske Institut). (In Danish).

Mangino, J., Bartram, D. and Brazy, A. 2001: Development of a methane conversion factor to estimate emissions from animal waste lagoons. Presented at U.S. EPA's 17th Annual Emission Inventory Conference, Atlanta GA, April 16-18, 2002.

Massé, D.I., Croteau, F., Patni, N.K. & Masse, L. 2003: Methane emissions from dairy cow and swine slurries stored at 10ºC and 15ºC. Agriculture and Agri-Food Canada, Canadian Biosystem Engineering, Volume 45 p. 6.1-6.6.

Mikkelsen, M.H. Albrektsen, R. & Gyldenkærne, S. 2011: Danish emission inventories for agriculture. Inventories 1985 - 2009. National Environmental Research Institute, Aarhus University. 136 pp. – NERI Technical Report No. 810. Available at: http://www2.dmu.dk/Pub/FR810.pdf (15.02.2011).

Mikkelsen, M.H., Gyldenkærne, S., Poulsen, H.D. Olesen, J.E. & Sommer, S.G. 2006: Emission of ammonia, nitrous oxide and methane from Danish Agriculture 1985-2002. Methodology and Estimates. NERI Research Notes Nr. 231/2006. Available at http://www2.dmu.dk/Pub/AR231.pdf (15.02.2011).

Møller, H.B. 2003: Pers. comm. Department of Agriculture Engineering, Research Centre Bygholm, Faculty of Agricultural Sciences.

Nielsen, L.H., Hjort-Gregersen, K., Thygesen, P. & Christensen, J. 2002: Samfundsøkonomiske analyser af biogasfællesanlæg - med tekniske og selskabsøkonomiske baggrundsanalyser. Report no. 136, Institute of Food and economics. Available at (In Danish): http://www.foi.life.ku.dk/Publikationer/Rapporter/~/media/migration%20folder/upload/foi/docs/publikationer/rapporter/nummererede%20rapporter/130-139/136.pdf.ashx (23.08.2010).

Nielsen, O-K., Winther, M., Mikkelsen, M.H., Hoffmann, L., Nielsen, M., Gyldenkærne, S., Fauser, P., Plejdrup, M.S., Albrektsen, R. & Hjelgaard, K. 2010: Annual Danish Informative Inventory Report to UNECE. Emission inventories from the base year of the protocols to year 2008. National Environmental Research Institute, Aarhus University, Denmark. 565pp. – NERI Technical Report no 776. Available at: http://www2.dmu.dk/Pub/FR776.pdf (15.02.2011).

Olesen, J.E., Fenhann, J.F., Petersen, S.O., Andersen, J.M. & Jacobsen, B.H. 2001: Emission af drivhusgasser fra dansk landbrug. DJF rapport nr. 47, markbrug, Danmarks Jordbrugsforskning, 2001. (In Danish).

Olesen, J.E., Jørgensen, H., Danfær, A., Gyldenkærne, S., Mikkelsen, M.H., Asmon, W.A.H. and Petersen, S.O. 2005: Evaluering af mulige tiltag til reduktion af landbrugets metanemissioner. Arbejdsrapport fra Miljøstyrelsen Nr. 11 /2005. Chapter 1 (Allan Danfær): Methane emission from dairy cows. Available at: http://www2.mst.dk/Udgiv/publikationer/2005/87-7614-699-5/pdf/87-7614-700-2.pdf (08-02-2010).

Poulsen, H.D. 2010: Normative figures 2000-2010. Faculty of Agricultural Sciences, Aarhus University. Available at: http://www.djf.au.dk/ny_navigation/institutter/institut_for_husdyrbiologi_og_sundhed/husdyrernaering_og_miljoe/normtal (23.08.2010).

Poulsen, H.D., Børsting, C.F., Rom, H.B. & Sommer, S.G. 2001: Kvælstof, fosfor og kalium i husdyrgødning – normtal 2000. DJF rapport nr. 36 – husdyrbrug, Danmarks Jordbrugsforskning. (In Danish).

Poulsen, Hanne Damgaard 2010: The Faculty of Agricultural Science, Pers. Comm.

Poulsen, H.D., Lund, P., Sehested, J., Hutchings, N. & Sommer, S.G. 2010: Quantification of nitrogen and phosphorus in livestock manures – the Danish normative system. Not published.

Poulsen, H.D. & Kristensen, V.F., 1997: Normtal for husdyrgødning – en revurdering af danske normtal for husdyrgødningens indhold af kvælstof, fosfor og kalium. Beretning nr. 736, Faculty of Agricultural Sciences, Aarhus University. (In Danish).

Poulsen, H.D. & Kristensen, V.F. 1998: Standards Values for Farm Manure – A revaluation of the Danish Standards Values concerning the Nitrogen, Phosphorus and Potassium Content of Manure. DJF Report No. 7 - Animal Husbandry. Danish Institute of Agricultural Sciences. Available at: http://web.agrsci.dk/djfpublikation/djfpdf/djfhd7.pdf (24.02.2011)

Priemé, A. & Christensen, S. 1991: Emission of methane and non-methane volatile organic compounds in Denmark – Sources related to agriculture and natural ecosystems. National Environmental Research Institute. NERI, Technical Report No. 19/1999.

Sommer, S.G., Møller, H.B. & Petersen, S.O. 2001: Reduktion af drivhusgasemission fra gylle og organisk affald ved Biogasbehandling. DJF rapport - Husdyrbrug, 31, 53 pp. (In Danish).

Sommer, S.G., Petersen, S.O. & Møller, H.B. 2004: Algorithms for calculating methane and nitrous oxide emissions from manure management. Nutrient Cycling in Agroecosystems, Volume 69, No. 2: 143-154.

Sommer, S.G., Petersen, S.O. & Sogaard, H.T. 2000: Greenhouse gas emissions from stored livestock slurry. Journal of Environmental Quality, 29: pp. 744-751.

Statistics Denmark - Agricultural Statistic from year 1990 to 2009. Available at: www.dst.dk (15.02.2011).

Sørensen, P.B., Illerup, J.B., Nielsen, M., Lyck, E., Bruun, H.G., Winther, M., Mikkelsen, M.H., & Gyldenkærne, S. 2005: Quality manual for the greenhouse gas inventory Version 1. National Environmental Research Institute, Denmark. 25 pp. – Research Notes from NERI no. 224. – Available at:
http://www2.dmu.dk/1_viden/2_Publikationer/3_arbrapporter/rapporter/AR224.pdf (16.02.2011).

Tafdrup, S. 2010: Danish Energy Agency, Pers. Comm.

Wang, S.-Y. & Huang, D.-J. 2005: Assessment of Greenhouse Gas Emissions from Poultry Enteric Fermentation, Asian-Aust. J. Anim. Sci. Vol 18, No. 6: 873-878.

Wiberg-Larsen, P., Windolf, J., Baattrup-Pedersen, A.., Bøgestrand, J., Ovesen, N.B., Larsen, S.E., Thodsen, H., Sode, A., Kristensen, E., Kronvang, B. & Kjeldgaard, A. 2010: Vandløb 2009. NOVANA. Danmarks Miljøundersøgelser, Aarhus Universitet. 100 s. – Faglig rapport fra DMU nr. 804. Available at (In Danish):
http://www2.dmu.dk/Pub/FR804.pdf (22.02.2011).

Waagepetersen, J., Grant, R., Børgesen, C.D. & Iversen, T.M. 2008: Midtvejsevaluering af Vandmiljøplan III. Available at (In Danish):
http://pure.agrsci.dk:8080/fbspretrieve/2617161/VMPIII_midtvejs_2008.pdf (22.02.2011).

Woodbury, J.W. and Hashimoto, A. 1993: "Methane Emissions from Livestock Manure." In International Methane Emissions, US Environmental Protection Agency, Climate Change Division, Washington, D.C., U.S.A.

7 LULUCF (CRF sector 5)

7.1 Overview of the sector

This chapter covers only the territory of Denmark without the Faroe Islands and Greenland. Greenland is submitting a separate NIR and the corresponding CRF tables for the Greenlandic territory to UNFCCC. This can bee found as Chapter 16 in this NIR.

Denmark (Capital: Copenhagen) is situated around 56°N and 13°E and covers 43,098 km^2. No permanent ice is occurring and only very small insignificant areas with rocks. The climate is according to IPCC GPG 2003 cold and wet. Denmark is an intensive agricultural country where most of the area is affected by agriculture. The average temperature in the standard 30 year, 1961-1990 was 7.7 °C with a minimum temperature in February of 0.3 °C and a maximum in July of 17.0 °C. Year 2009 had an average mean temperature of 8.8 °C, which was the eight warmest year ever recorded since 1873 and slightly cooler than 2008, which had an average temperature of 9.4 °C (www.dmi.dk) or 22 % above 1961-1990.

All land is classified into Forest, Cropland, Grassland, Wetlands, Settlements or Other Land.

The following abbreviations are used in accordance with definitions in the IPCC guidelines:

A: Afforestation, areas with forest established after 1990 under article 3.3.
R: Reforestation, areas which have temporarily been unstocked for less than 10 years - included under article 3.4.
D: Deforestation, areas where forests are permanently removed to allow for other land use, included under article 3.3.
FF: Forest remaining Forest, areas remaining forest after 1990.
FL: Forest Land meeting the definition of forests.
CL: Cropland.
GL: Grassland.
SE: Settlements.
OL: Other land, unclassified land.
FM: Forest Management, areas managed under article 3.4.
CM: Cropland Management, areas managed under article 3.4.
GM: Grazing land Management, areas managed under article 3.4.

The LULUCF sector differs from the other sectors in that it contains both sources and sinks of carbon dioxide. LULUCF are reported in the new CRF format. Removals are given as negative figures and emissions are reported as positive figures according to the guidelines. For 2009 emissions from LULUCF were estimated to be a net sink of approximately 1,118 Gg CO_2-eqv. or 1.8 % of the total reported Danish emission.

Approximately 2/3 of the total Danish land area is cultivated and 13.4 per cent are with forest. Together with high numbers of cattle and pigs there is a high (environmental) pressure on the landscape. To reduce the impact an active policy has been adopted to protect the environment. The adopted policy aims at doubling the forested area within the next 80-100 years, restoration of former wetlands and establishment of protected national parks. In Denmark almost all natural habitats and all forests are protected. Therefore only limited conversions from forest or wetlands into cropland or grassland are occurring.

A land use/land cover map was produced for the Kyoto reference year 1990 and for the year 2005 based on EO data (23 August 1990) and other data produced from 1992-2005. From 2005 and onwards is used knowledge on the development in Denmark combined with vector maps. Table 7.1 shows the overall development from 1990 to 2009. The preliminary result is an increase in the afforsted area of 43,420 hectares, but also that deforestation has taken place of approximately 6,808 ha in that period. Afforestation is mainly taking place on CL and OL not previous classified as forest. Areas which are deforestated are mainly converted to GL and SE. Since 1990 has more than 67,000 hectares been changed into SE and other infra structures. No FL, CL and GL are converted into OL by definition.

Table 7.1 Land Use Change from 1990 to 2009 based on EO and other GIS vector layers. The figures are given in hectares.

1990\2009	Forest	Cropland	Grassland	Wetlands	Settlement	Other	Sum
Forest	532979	919	4512	37	1340	0	539788
Cropland	25846	2783683	46651	5493	61506	0	2923179
Grassland	1148	5944	106652	1202	2156	0	117102
Wetlands	4	0	0	1596	0	0	1600
Settlement	0	611	319	0	384517	0	385447
Other	16422	2764	4846	10012	1944	306697	342685
Sum	576399	2793921	162979	18340	451464	306697	4309800
Percentage	13,4 %	64,8 %	3,8 %	0,4 %	10,5 %	7,1 %	100 %

A detailed QA/QC process of the developed Land Use matrix will be performed during 2011, as this process has not been fully completed by March 2011.

The emission data are reported in the new CRF format under IPCC categories 5A (Forestry), 5B (Cropland), 5C (Grassland), 5D (Wetlands) and 5E (Settlements) and 5F (Other Land). Denmark is free from ice and rocks and Other Land therefore represents unmanaged areas inclusive beaches and sand dunes.

Fertilisation of Forests and Other Land is negligible and all fertiliser consumption is therefore reported in the agricultural sector. All liming is reported under Cropland because only very limited amounts are used in forestry and on permanent grassland. Field burning of wooden biomass is prohibited in Denmark and therefore reported as not occurring. Wildfires are very seldom and if occurring very small in Denmark and hence reported as NO.

Savannas and rice cultivation do not occur in Denmark.

Table 7.2 gives an overview of the emission from the LULUCF sector in Denmark. Forests have been sinks in Denmark for the last decade but due to the age distribution of the forests - containing a majority of mature forests - a slight decrease of the carbon stock is observed, as the old forests are regenerated with young trees and a net source were observed, which later again is turned into a sink. Cropland is ranging from being a net source from up to 3,200 Gg in 1990 to be a net source of 1,347 Gg in 2009. The high fluctuations in Cropland is related to the actual crop yield that year and the climatic conditions. Low yields combined with high temperatures reduce the total amount of C in agricultural soils whereas a year with a high yield and low temperatures increase the C-stock in soil. From 1990 and onwards a general decrease in the emission from Cropland is estimated due to a higher incorporation of straw (ban of field burning), demands of growing of catch crops in the autumn, a change from low yielding spring barley to high yielding winter wheat, an increased C-stock in hedgerows and a reduced consumption of lime. The area with restored wetlands has increased and consequently the accumulation of organic matter has also increased here leading to a lower net source.

Table 7.2 Overall emission (Gg CO_2) from the LULUCF sector in Denmark, 1990-2009.

Greenhouse gas source and sink categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
5. Land Use, Land-Use Change and Forestry, CO_2	**3.135,78**	**1.929,90**	**3.698,42**	**452,56**	**2.327,66**	**1.661,28**	**495,98**	**1.698,41**	**670,74**	**2.775,35**
A. Forest Land	-714,42	-856,25	-737,50	-978,60	-804,24	-964,48	-936,49	-976,59	-1.046,38	-603,80
B. Cropland	3.199,86	2.410,69	3.978,49	1.159,04	2.741,86	2.370,26	1.107,80	2.376,73	1.452,91	2.813,57
C. Grassland	474,29	233,12	297,74	163,26	273,57	165,96	205,48	168,70	170,68	416,62
D. Wetlands	86,54	78,21	77,79	65,29	43,76	45,97	64,75	86,01	49,95	36,51
E. Settlements	89,50	64,13	81,90	43,57	72,71	43,57	54,45	43,57	43,57	112,45
F. Other Land	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
5. Land Use, Land-Use Change and Forestry, N_2O	**2.894,72**	**2.766,21**	**3.633,19**	**2.886,80**	**2.285,58**	**3.576,33**	**2.900,92**	**-100,50**	**-2.127,92**	**-1.130,61**
A. Forest Land	524,50	483,60	221,29	307,86	44,54	-64,73	-465,94	-3.256,31	-4.874,22	-2.736,44
B. Cropland	1.934,64	1.852,56	3.131,15	2.202,45	1.891,10	3.356,74	3.078,90	2.888,90	2.500,76	1.346,95
C. Grassland	317,64	308,42	185,56	265,54	241,26	195,48	194,63	195,98	197,58	199,15
D. Wetlands	33,63	40,22	48,75	42,27	47,22	40,93	39,16	16,72	-6,44	4,99
E. Settlements	84,31	81,42	46,44	68,68	61,47	47,91	54,18	54,20	54,41	54,75
F. Other Land	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
5. Land Use, Land-Use Change and Forestry, CO_2-eqv. CO_2 and N_2O	3.154,77	1.946,91	3.716,44	467,75	2.344,64	1.676,10	511,34	1.712,86	685,00	2.793,93
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
5. Land Use, Land-Use Change and Forestry, CO_2	**2.894,72**	**2.766,21**	**3.633,19**	**2.886,80**	**2.285,58**	**3.576,33**	**2.900,92**	**-100,50**	**-2.127,92**	**-1.130,61**
A. Forest Land	524,50	483,60	221,29	307,86	44,54	-64,73	-465,94	-3.256,31	-4.874,22	-2.736,44
B. Cropland	1.934,64	1.852,56	3.131,15	2.202,45	1.891,10	3.356,74	3.078,90	2.888,90	2.500,76	1.346,95
C. Grassland	317,64	308,42	185,56	265,54	241,26	195,48	194,63	195,98	197,58	199,15
D. Wetlands	33,63	40,22	48,75	42,27	47,22	40,93	39,16	16,72	-6,44	4,99
E. Settlements	84,31	81,42	46,44	68,68	61,47	47,91	54,18	54,20	54,41	54,75
F. Other Land	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
5. Land Use, Land-Use Change and Forestry, N_2O	**0,06**	**0,05**	**0,04**	**0,05**	**0,05**	**0,04**	**0,04**	**0,04**	**0,04**	**0,04**
A. Forest Land	0,04	0,04	0,04	0,04	0,04	0,04	0,04	0,04	0,04	0,04
B. Cropland	0,02	0,01	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00
C. Grassland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Wetlands	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
E. Settlements	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
F. Other Land	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
5. Land Use, Land-Use Change and Forestry, CO_2-eqv. CO_2 and N_2O	**2.914,53**	**2.782,35**	**3.646,85**	**2.901,74**	**2.299,86**	**3.589,53**	**2.914,05**	**-87,55**	**-2.115,16**	**-1.118,02**

7.2 Forest remaining forest (5.A.1)

7.2.1 Forests and forest management

National Forest Inventory

In 2002, a new sample-based National Forest Inventory (NFI) was initiated (Nord-Larsen et al., 2008). This type of forest inventory is very similar to inventories used in other countries, e.g. Sweden or Norway. The NFI has replaced the National Forest Census.

The NFI is a continuous sample-based inventory with partial replacement of sample plots based on a 2 x 2 km grid covering the Danish land surface. At each grid intersection, a cluster of four circular plots (primary sampling unit, PSU) for measuring forest factors (e.g. wood volume) are placed in a 200 x 200 m grid. Each circular plot (secondary sampling unit, SSU) has a radius of 15 meters. When plots are intersected by different land-use classes or different forest stands, the individual plot is divided into tertiary sampling units (TSU).

About one third of the plots is assigned as permanent and will be re-measured in subsequent inventories every five years. Two thirds are temporary and are moved randomly within the particular 2x2 km grid cell in subsequent inventories. The sample of permanent and temporary field plots has been systematically divided into five non-overlapping, interpenetrating panels that are each measured in one year and constitute a systematic sample of the entire country. Hence all the plots are measured in a 5-year cycle.

Based on analysis of aerial photos, each sample plot (SSU) is allocated to one of three basic categories, reflecting the likelihood of forest or other wooded land (OWL) cover in the plot: (0) Unlikely to contain forest or other wooded land cover, (1) Likely to contain forest, and (2) Likely to contain other wooded land. All plots in the last two categories are inventoried in the field.

In the first years of the NFI (2002-2008) the average number of clusters (PSU) and sample plots (SSU) are 2,196 and 8,604, respectively. On average 1,627 plots (SSU) were identified as having forest or other wooded land cover based on the aerial photos and were thus selected for inventory. However, during the first rotation of the NFI, measurements were not obtained for some plots. Missing plot observations were caused by a number of factors, including start up problems that resulted in insufficient time to complete the measurements and prohibited access to some plots on privately owned land. In 2005, the Forest Act was revised, so consequently forest owners are obliged to provide access. On average 322 sample plots were missing in the 2002-2008 inventories.

Each plot is divided into three concentric circles with radius 3.5, 10 and 15 m. A single calliper measurement of diameter is made at breast height for all trees in the 3.5 m circle. Trees with diameter larger than 10 cm are measured in the 10 m circle and only trees larger than 40 cm are measured in the 15 m circle. On a random samples of 2-6 trees further measurements of total height, crown height, age and diameter at stump height are made and the presence of defoliation, discoloration, mast, mosses and lichens are recorded. The presence of regeneration on the plots is registered and the species, age and height of the regeneration are recorded. Stumps from trees harvested within a year from the measurement are measured for diameter.

Deadwood is measured on the sample plots. Standing deadwood with a diameter at breast height diameter larger than 4 cm is measured according to the same principles as live trees. Lying deadwood with a diameter of more than 10 cm is measured within the 15 m radius sample plot. Length of the lying deadwood is measured as the length of the tree that exceeds 10 cm in diameter and is within the sample plot. The diameter is measured at the middle of the lying deadwood measured for length. In addition to the size measurements of deadwood the degree of decay is recorded on an ordinal scale.

Forest area mapping

Due to differences in methodologies major inconsistencies in forest areas and other forest variables are observed between the different forest inventories (i.e. the 1990 and 2000 Forest Census and the 2006 National Forest Inventory). With the objective to obtain time consistent and precise estimates of forest areas to report to UNFCC and the Kyoto protocol, two projects have aimed at mapping the forest area in Denmark based on satellite images. Forest area and forest area change have been estimated for the years 1990 and 2005.

A land use/land cover map was produced for the Kyoto reference year 1990 and for the year 2005 based on EO data (23 August 1990) and other data produced from 1992-2005 and for 2005 using NFI in situ data. Forest maps are developed using Landsat imagery mainly Landsat 5 (TM) and 7 (ETM+) data to classify and estimate the area of forest cover types in Denmark. Portions of seven scenes covering the whole country were classified into forest and non-forest classes. The approach involved the integration of sampling, image processing, and estimation. A detailed QA/QC process will be performed during 2011, as this process has not been fully completed by February 2011.

The product is specified by a Minimum Mapping Unit (MMU) of 0.5 ha, a geometric accuracy of < 15 m RMS and a thematic accuracy of 90% +/- 5% for the six major Kyoto classes: Forest, Grass, Crop, Wetland, Urban, and Other.

Forest definition

The forest definition adopted in the NFI is identical to the FAO definition (TBFRA, 2000). It includes "wooded areas larger than 0.5 ha, that are able to form a forest with a height of at least 5 m and crown cover of at least 10%. The minimum width is 20 m." Temporarily non-wooded areas, fire breaks and other small open areas, that are an integrated part of the forest, are also included.

Methodological issues for forests

Based on analysis of aerial photos, each sample plot (SSU) is allocated to one of three forest status categories (Z), reflecting the likelihood of forest or other wooded land (OWL) in the plot: (0) Unlikely to be covered by forest or other wooded land, (1) Likely to be covered by forest, and (2) Likely to be covered by other wooded land.

On individual sample plots (j) the forest cover percentage (X) is calculated as the proportion of the forest area (A) to the total plot area of the 15 m radius circle (A15). The average forest percentage ($\overline{X}$) on plots with forest status Z=1 (and 2) is calculated as the sum of the forest percentages times an indicator variable (R) that is 1 if Z equals 1 (or 2) and 0 otherwise, divided by the number of plots with forest status Z=1 (or 2).

The overall average forest percentage ($\overline{\overline{X}}$) is calculated as the sum of: (1) observed forest cover percentages of the individual sample plots, (2) the number of unobserved sample plots with forest status Z=1 times the average forest cover percentage of sample plots with forest status 1, and (3) the number of unobserved sample plots with forest status 2 times the average forest cover percentage of observed sample plots with forest status Z=2 divided by the number of observed and unobserved sample plots. In this context sample plots with forest status 0 are regarded as observed and assumed to have a forest cover percentage of 0. Finally, the overall forest area (A_{Forest}) is calculated as the overall average forest percentage times the total land area (A_{total}).

Table 7.3 Estimation of forest percentage and forest area.

Equation	Description
$X_j = \frac{A_j}{A_{15,j}}$	The forest percentage (X) of the jth sample plot (SSU) is estimated as the forested area (A) divided by the total area of the 15 m radius sample plot ($A_{15,j}$).
$\bar{X}_Z = \frac{1}{n_Z}\sum_Z X_j R_j$	Average forest percentage ($\bar{X}$) of all inventoried plots (SSU) with forest status Z based on aerial photos. R_j is an indicator variable that is 1 for inventoried plots and 0 otherwise. n_Z is the number of inventoried plots identified as forest or OWL from the air photos.
$\bar{\bar{X}} = \frac{1}{n}\left(\sum_{j=1}^{n} X_j R_j + N_{21}\bar{X}_1 + N_{22}\bar{X}_2\right)$	Overall average forest percentage ($\bar{\bar{X}}$). n is the total number of inventoried and non-inventoried sample plots. N_{21} and N_{22} is the number of non- inventoried sample plots with forest and OWL, respectively.
$A_{Forest} = \bar{\bar{X}} \cdot A_{Total}$	Total forest area. A_{Total} is the total land area, $\bar{\bar{X}}$ is the estimated forest percentage and A_{Forest} is the total forest area.

When estimating the forest area with a specific characteristic (k), such as age class (i.e. forest established before or after 1990), the proportion of the plot area with the particular characteristic is found by summing the forested plot areas times an indicator variable (R) that is 1 if the plot has the kth characteristic and 0 otherwise. Subsequently the plot area with the kth characteristic is divided by the total forested plot area.

The total forest area with a particular characteristic (A_k) is found as the forest area percentage with the particular characteristic k times the total forest area. In case of species and age classes, the species are identified as the main species on the plot to resemble the management classes used in the previous National Forest Census from 2000. The age classes are 10 year intervals derived from field observations.

Table 7.4 Estimation of forest area with a specific characteristic.

Equation	Description
$\bar{X}_k = \dfrac{\sum_{j=1}^{n} R_{jk} A_j}{\sum_{j=1}^{n} A_j}$	Proportion of the forest area with a given characteristic ($\bar{X}_k$). R_{jk} is an indicator variable which is 1 if the the forest area on the j'th sample plots has the k'th characteristic and 0 otherwise. A_j is the sample plot area and n is the total number of inventoried sample plots with forest cover.
$A_k = \bar{X}_k \cdot A_{Forest}$	Total area with a given characteristic (A_k). $\bar{X}_k$ is the estimated proportion of the forest area with the k'th characteristic and A_{Forest} is the total forest area.

Estimation of volume, biomass and carbon pools

For estimation of volume, biomass and carbon of individual trees, we use the volume functions developed for the most common Danish forest tree species (Madsen, 1985, Madsen 1987 and Madsen and Heusèrr 1993). The functions use individual tree diameter and height as well as quadratic mean diameter of the forest stand as independent variables. For calculation of biomass and carbon the first step is to estimate the height of trees with no height measurements. Based on the trees measured for both height and diameter, diameter-height regressions are developed for each species and growth region (Nord-Larsen et al. 2008). The functions use the observed mean height and mean diameter on each sample plot for creating localized regressions using the regression form suggested by Sloboda et al. (1993). For plots where no height measurements are available, generalized regressions are developed based on the Näslund-equation modified by Johannsen (1992).

Table 7.5 Estimation of diameter-height equations.

Equation	Description
$h_{ij} = 13 + \left(\bar{h}_j - 13\right) \cdot \exp\left(\alpha_1 \cdot \left(1 - \dfrac{\bar{d}_j}{d_{ij}}\right) + \alpha_2 \cdot \left(\dfrac{1}{\bar{d}_j} - \dfrac{1}{d_{ij}}\right)\right)$	Site specific dh-regression for calculating height of trees not measured for height. h_{ij} and d_{ij} is the height and diameter of the i'th tree on the j'th sample plot. $\bar{h}_j$ and $\bar{d}_j$ are the average height and diameter of trees measured for height on the jth sample plot. α_1 and α_2 are species and growth-region specific parameters
$h_{ij} = 13 + \beta_1 \cdot \exp(-\dfrac{\beta_2}{d_{ij}})$	General dh-regression for calculating height of trees not measured for height. h_{ij} and d_{ij} is the height and diameter of the i'th tree on the j'th sample plot. β_1 and β_2 are species and growth-region specific parameters

The next step is to estimate the quadratic mean diameter of the trees on the sample plot. As the trees are measured in different concentric circles depending on their diameter, the basal area on each sample plot is estimated by scaling the basal area of each tree (standing or felled) according to the circular area in which the tree has been measured. A similar calculation has been made for the number of stems. Finally, mean squared diameter is calculated from the basal area and stem numbers.

Table 7.6 Estimation of quadratic mean diameter.

Equation	Description
$g_{ij} = \frac{\pi}{4} d_{ij}^2$	Basal area (*g*) of the *i*th tree on the *j*th plot is calculated from the diameter at breast height (*d*) (1.3 m above ground) assuming a circular stem form.
$G_j = \sum_{i=1}^{m} \frac{1}{A_{c,ij}} g_{ij}$	Basal area per hectare (*G*) the jth sample plot is calculated as the scaled sum of individual tree basal areas. Basal area (*g*) of the *i*th tree on the *j*th sample plot is scaled according to the plot area ($A_{c,ij}$) of the *c*'th concentric circle (c=3,5; 10; 15 m).
$N_j = \sum_{i=1}^{m} \frac{1}{A_{c,ij}}$	Stem number per hectare (*N*) the *j*th sample plot is calculated as the scaled number of individual trees. The *i*th tree on the *j*th sample plot is scaled according to the plot area ($A_{c,ij}$) of the *c*'th concentric circle (c=3,5; 10; 15 m).
$D_{g,j} = \sqrt{\frac{4}{\pi} \frac{G_j}{N_J}}$	The mean squared diameter is calculated from the calculated basal area and stem number for each plot.

Based on the diameter, estimated or measured height of individual trees and the squared mean diameter before thinning, the volume of individual trees is estimated using the species specific volume functions by Madsen (1987) and Madsen & Heusèrr (1993). The volume of trees less than 3 meters tall is estimated using an alternative function. The calculated volumes are total stem volume over bark for conifers and total above ground volume over bark for deciduous species.

Using the above ground volume of the individual tree, the total volume (below and above ground) is estimated using expansion factors. For coniferous species an expansion factor model developed for Norway spruce (Skovsgaard & Bald, 2010) is applied whereas for deciduous species an expansion factor model developed for beech (Skovsgaard & Nord-Larsen, 2010) is used. Biomass of the individual tree is subsequently calculated as the total volume times the basic density. Species specific basic densities are based on Moltesen (1988).

Table 7.7 Estimation of biomass and carbon of trees.

Equation	Description
$v_{ij} = F(d_{ij}, h_{ij}, D_{g,j})$	The volume (*v*) of the *i*'th tree on the *j*th sample plots is calculated using the existing volume functions (*F*) using the tree diameter and height and the quadratic mean diameter.
$E_{ij} = F(d_{ij}, h_{ij})$	Expansion factor model for beech and Norway spruce
$v_{tot,ij} = v_{ij} \cdot E_{ij}$	The total above and below ground volume (v_{tot}) of the ith tree on the jth sample plot. V_{ij} is the calculated volume of the tree and *E* is the expansion factor (1.2 for deciduous species and 1.8 for conifers).
$B_{ij} = V_{tot,ij} \cdot Density_{ij}$	Biomass (*B*) of the *i*th tree on the *j*th sample plot is estimated as the total volume (V_{Tot}) times the species specific density.
$C_{ij} = B_{ij} \cdot 0.5$	Carbon of the *i*th tree on the *j*th sample plot is calculated as the biomass (*B*) times 0.5.

Total or regional volume, biomass and pools of carbon are estimated based on the estimates of individual tree volumes, biomass and carbon. First, volume, biomass or carbon per hectare is estimated for each of the concentric circles (c=3.5, 10 or 15 m radius) on each plot as the plot area depends on the diameter of the tree. Using the estimates from individual plots, the area weighted mean volume, biomass or carbon per hectare for the three concentric circles is estimated. The overall mean volume, biomass or carbon is estimated as the sum of the average volumes for the three circles. Finally, the total or regional volume, biomass or carbon is estimated as the forest area times the overall mean volume.

Table 7.8 Estimation of total biomass and carbon pools.

Equation	Description
$V_{cj} = \frac{1}{A_{cj}} \sum_{i=1}^{m} R_{c,i} v_{ij}$	Volume, biomass or carbon per hectare (*V*) of the *c*th concentric circle on the *j*th sample plot (*c*=3,5; 10; 15 m). R_c is an indicator variable that is 1 if the *i*th tree is measured on the *c*th circle and 0 otherwise. $A_{c,ij}$ is the area of the *j*th sample plot and *c*th concentric circle; *m* is the number of trees on the *j*th sample plot.
$\overline{V}_c = \frac{\sum_{j=1}^{n} A_{cj} V_{cj}}{\sum_{j=1}^{n} A_{cj}}$	The average area weighted volume, biomass or carbon per hectare ($\overline{V}$) of the *c*th concentric circle. $A_{c,ij}$ is the area of the *j*th sample plot and *c*th concentric circle; *n* is the number of sample plots.
$\overline{\overline{V}} = \overline{V}_{3,5} + \overline{V}_{10} + \overline{V}_{15}$	The overall average volume, biomass or carbon per hectare ($\overline{\overline{V}}$) is estimated as the sum of the average volume, biomass or carbon per hectare ($\overline{V}_c$) for the three concentric circles (*c*=3.5, 10 and 15)
$V = \overline{\overline{V}} \cdot A_{Skov}$	Total volume, biomass or carbon *V* is the overall average volume, biomass or carbon per hectare ($\overline{\overline{V}}$) times the forest area A_{Forest}.

The total volume, biomass or carbon pools with a given characteristic are estimated in a similar way as the total figures. First, volume, biomass or carbon per hectare with the given characteristic is estimated for each of the concentric circles (c=3.5, 10 or 15 m radius) on each plot. Using the estimates from individual plots, the area weighted mean volume, biomass or carbon per hectare with the given characteristic for the three concentric circles is estimated. The overall mean volume, biomass or carbon is estimated as the sum of the average volumes for the three circles. Finally, the total or regional volume, biomass or carbon with the given characteristic is estimated as the forest area times the overall mean volume.

Table 7.9 Estimation of biomass and carbon with a given characteristic.

Equation	Description
$V_{cj,k} = \frac{1}{A_{cj}} \sum_{i=1}^{m} R_{c,ij} R_{k,ij} v_{ij}$	Volume, biomass or carbon per hectare (V) with the kth characteristic of the cth concentric circle on the jth sample plot (c=3,5; 10; 15 m). R_c is an indicator variable that is 1 if the ith tree is measured on the cth circle and 0 otherwise. R_k is an indicator variable that is 1 if the tree has kth characteristic and 0 otherwise. $A_{c,ij}$ is the area of the jth sample plot and cth concentric circle; m is the number of trees on the jth sample plot.
$\overline{V}_{c,k} = \frac{\sum_{j=1}^{n} A_{cj} V_{cj,k}}{\sum_{j=1}^{n} A_{cj}}$	The average area weighted volume, biomass or carbon per hectare ($\overline{V}$) with the kth characteristic of the cth concentric circle. $A_{c,ij}$ is the area of the jth sample plot and cth concentric circle; m is the number of trees on the jth sample plot.
$\overline{\overline{V}}_k = \overline{V}_{3,5,k} + \overline{V}_{10,k} + \overline{V}_{15,k}$	The overall average volume, biomass or carbon per hectare with the kth characteristic ($\overline{\overline{V}}$) is estimated as the sum of the average volume, biomass or carbon per hectare ($\overline{V}_{c,k}$) for the three concentric circles (c=3.5, 10 and 15)
$V_k = \overline{\overline{V}}_k \cdot A_{Forest}$	Total volume, biomass or carbon with the k^{th} characteristic (V_k) is the overall average volume, biomass or carbon per hectare ($\overline{\overline{V}}_k$) times the forest area A_{Forest}.

Dead wood volume, biomass and carbon content

The volume of standing dead trees is calculated similarly to the calculations for live trees. The volume of lying dead trees within the sample plot is calculated as the length of the dead wood times the cross sectional area at the middle of the dead wood. Biomass of the dead wood is calculated as the volume times the species specific basic density and a reduction factor according to the structural decay of the wood. Finally, carbon content for each standing or lying dead tree is calculated by multiplying the dead wood biomass by 0.5.

Table 7.10 Estimation of biomass and carbon content of dead wood.

Equation	Description
$v_{s,ij} = F\left(d_{s,ij}, h_{s,ij}, D_{g,j}\right)$	The volume (v_s) of the *i*th standing, dead tree on the *j*th sample plots is calculated using the existing volume functions (*F*) using the tree diameter and height and the squared mean diameter.
$v_{s,tot,ij} = v_{s,ij} \cdot E_{ij}$	The total above and below ground volume ($v_{s,tot}$) of the *i*th standing, dead tree on the *j*th sample plot. v_s is the calculated volume of the tree and *E* is the expansion factor (1.2 for deciduous species and 1.8 for conifers).
$v_{l,ij} = \frac{\pi}{4} d_{l,ij}^2 \cdot l_{l,ij}$	Volume of lying dead trees (v_l) is calculated as the length (*l*) and the ith tree on the jth sample plot times the cross sectional area. The cross sectional area is calculated from the mid-diameter (d_l) of the dead wood.
$B_{s,ij} = v_{s,ij} \cdot D_{ij} \cdot r_{k,ij}$ $B_{l,ij} = v_{l,ij} \cdot D_{ij} \cdot r_{k,ij}$	Biomass of the *i*th standing (B_s) or lying (B_l) tree on the jth sample plot is calculated as the volume (v_s or v_l) times the species specific density (*D*) and a the *k*th reduction factor according to the structural decay of the wood observed in the field.
$K_{s,ij} = B_{s,ij} \cdot 0.5$ $K_{l,ij} = B_{l,ij} \cdot 0.5$	Carbon in standing or lying dead wood (C_s or C_l) is calculated as the biomass (B_s or B_l) times 0.5.

Total or regional volume, biomass and carbon pools of deadwood are estimated based on the estimates of volumes, biomass and carbon for individual dead trees or pieces of dead wood. First, deadwood volume, biomass or carbon per hectare is estimated for each of the concentric circles (*c*=3.5, 10 or 15 m radius). Estimates for lying dead wood are made using the 15 m circle. Using the estimates from individual plots, the area weighted mean volume, biomass or carbon per hectare of deadwood for the three concentric circles is estimated. The overall mean deadwood volume, biomass or carbon is estimated as the sum of the average volumes for the three circles. Finally, the total or regional deadwood volume, biomass or carbon is estimated as the forest area times the overall mean volume.

Table 7.11 Estimation of total biomass and carbon pools of dead wood.

Equation	Description
$V_{D,cj} = \frac{1}{A_{cj}} \sum_{i=1}^{m} R_c v_{s,ij} + R_c v_{l,ij}$	Deadwood volume, biomass or carbon pools per hectare (V_D) for the *c*th circle and the *j*th sample plot. v_s and v_l is the volume of standing and lying deadwood respectively. R_c is an indicator variable that is 1 if the tree is measured in the *c*th circle and 0 otherwise. A_C is the sample plot area of the *c*th circle. *m* is the number of trees within the *j*th sample plot.
$\overline{V}_{D,c} = \frac{\sum_{j=1}^{n} A_{cj} V_{cj}}{\sum_{j=1}^{n} A_{cj}}$	The average area weighted deadwood volume, biomass or carbon per hectare ($\overline{V}_D$) of the cth concentric circle. $A_{c,ij}$ is the area of the jth sample plot and cth concentric circle; *n* is the number of sample plots.
$\overline{\overline{V}}_D = \overline{V}_{D,3,5} + \overline{V}_{D,10} + \overline{V}_{D,15}$	The overall average deadwood volume, biomass or carbon per hectare ($\overline{\overline{V}}_D$) is estimated as the sum of the average volume, biomass or carbon per hectare ($\overline{V}_{D,c}$) for the three concentric circles (c=3.5, 10 and 15)
$V_D = \overline{\overline{V}}_D \cdot A_{Forest}$	Total deadwood volume, biomass or carbon V_D is the overall average deadwood volume, biomass or carbon per hectare ($\overline{\overline{V}}_D$) times the forest area A_{Forest}.

Forest soils: forest floors and mineral soil

Introduction

Following the election of art. 3.4 it was necessary to supplement the NFI by an additional inventory in order to document that forest soils is not an overlooked source for CO_2 emissions. The monitoring of soil C-stocks concerns two of the five carbon pools identified by IPCC (2003), litter (forest floor) and mineral soil to a depth of minimum 30 cm.

There is relatively good information from various soil profile databases on carbon stocks in the mineral soil to 1 m depth for well-drained Danish forest soils (Vejre et al., 2003; Krogh et al., 2003). However, there is little spatially systematic information on forest soils and therefore also limited possibility to sample new country-representative information in order to explore the development in forest soil carbon stocks over time. This is most pronounced for the quickly changing litter carbon pool and in particular for the moist and wet forest soils.

The monitoring of forest soils aim to document that forest soils are not a major source for emissions of CO_2, i.e. that there is no detectable depletion in soil carbon. In the provisions for the Kyoto Protocol reporting given in the so-called Kyoto Rulebook it is said that "accurate estimation and reporting is not obligatory for a certain pool if the country can demonstrate that the pool is not a source". This may be called the "no source principle" (Somogyi & Horvath, 2007). According to IPCC (2003) the necessary documentation may come from various sources such as:

- Representative and verifiable sampling and analysis to show that the pool has not decreased.

- Reasoning based on sound knowledge of likely system responses.
- Surveys of peer-reviewed literature for the activity, ecosystem type, region and pool in question.
- Combined methods.

Based on literature and reasoning based on sound knowledge there is little evidence to support that the soil C pool in forest remaining forest would currently be changing to an extent that would be detectable by sampling with decadal frequency. For well-drained soils there may be changes in soil carbon stocks at fine spatial resolution (ha-level) due to clearcutting and replanting, but for the entire forest area with the whole range of age classes, the assumption is that soil carbon stocks are unchanged over time. In fact, the conversion toward close-to-nature forestry with continuous crown cover and abandonment of clearcutting suggests a future increase in soil carbon stocks rather than depletion (Brunner et al., 2005; Yanai et al., 2000). Areas with wet forest soils have probably been sources for increased CO_2 emissions in a period after ditching and drainage activities took place from the late 19th century. These activities led to increased mineralization of peaty soils. However, during the last 20 years, drainage activities have diminished strongly and has almost ceased in state forests. Here, the natural hydrological conditions are actively restored by filling up ditches in some areas. It is expected that this change in management will lead to sequestration of carbon as these forest soils gradually get wetter.

Since the reporting in 2009 for 1990-2007, quantitative information has become available; a project (SINKS) initiated in 2007 has delivered data on soil C change based on repeated sampling of soil C pools in forests remaining forests, and more data on soil C pools will be available before the project ends. The preliminary data suggest that forest soil C pools are not sources for CO_2 and thus support that more accurate estimates of litter and soil C pool removals/emissions do not need to be included in the reporting.

New data

The only existing systematic sampling of Danish forest soils has been conducted within the so-called Kvadratnet ("square grid", http://www.landbrugsinfo.dk/Planteavl/Goedskning/Naeringsstoffer/Kvadratnet-for-nitratundersoegelser/Sider/Startside.aspx). Given the time constraints of the commitment period and reporting deadlines, changes in soil carbon stocks could only be assessed by resampling soils within this monitoring grid.

The "Kvadratnet" monitoring grid is 7x7 km and by 1990 it included 108 plots with forest cover (Østergaard & Mamsen, 1990). It was established in the 1980's in order to optimize the applied amounts of fertilizer in agriculture by monitoring nitrate leaching to groundwater resources in the most common land uses. Soil sampling and analysis was conducted in 1986-90 in all 108 forest plots of Kvadratnettet, and a subset of 25 plots was resampled in 1994 (Breuning-Madsen & Olsson, 1995) as a part of the Pan-European forest monitoring programme, which uses these 25 plots for assessment of forest condition. The 25 plots resampled in 1994 have been resampled again in 2007 as a part of the demonstration project BioSoil under the Pan-European forest monitoring programme Forest Focus (http://biosoil.jrc.it/presentation/), and in 2008/2009 the other 83 plots were resampled, except for one plot for which the land owner did not grant access to re-sampling).

Mineral soil samples from 1990 are thus available from 108 forest plots. The sampling was complete for the period 2007-2010, while soil-archive samples from 1990 were missing for six plots. Soil samples from 1986-1987 were used for one of these plots while it was not possible to retrieve archived soil samples for the last five plots. The sampling of O-horizons was also complete for the 108 plots for the period 2007-2009, while O-horizon samples from 1990 were only available from 32 plots. Soil samples and results from 1994 were only used to check other data.

The plots were in all cases (with a few exceptions due to practical circumstances) designed as a 50 x 50 m square. In 2007-09 ten forest floor and mineral soil samples were collected along a transect determined as diagonal from south-west to north-east corner of the square. In the 1990 sampling 16 soil cores were taken randomly across the square plot, while forest floor samples were only collected occasionally in an unspecified manner.

The O-horizon samples from 2007-2009 were area-based samples (Vesterdal & Raulund-Rasmussen, 1998) removed from a 25 x 25 cm area, that were brought to the laboratory in separate bags.

The mineral soil samples from 2007-2009 were taken in the ten spots where O-horizons had been removed. A 2-3 cm thick soil corer was used. Samples from 4-5 different horizons were pooled in the field. The division into horizons differed slightly between the three sampling campaigns: 1986-1990, 2007 and 2008/2009. In 1986-1990 the division was 0-25, 25-50, 50-75 and 75-100 cm; in 2007 (the 25 BioSoil plots) it was 0-10, 10-20, 20-40, 40-80 and 80-100 cm; and in 2008/2009 0-10, 10-25m 25-50, 50-75 and 75-100 cm.

In the lab, all samples were dried at 40 ^{o}C until constant weight. Before sieving through a 2 mm sieve, more clay-rich mineral soil samples were crushed in a mortar, while sandy soil samples were gently crushed or sieved directly. The stones (>2 mm) left after sieving were weighed (DW_{stone}), while the fine soil (<2 mm) was dried at 40 ^{o}C for at least 48 h, and then weighed (DW_{soil}). A sub-sample of the fine soil, about 20 g, was removed after thorough mixing for finer grinding in an agate mortar.

The ten O-horizon samples from each plot were weighed separately, and then ground in Retsch grinder through a 2 mm net. From each of the ten samples, 10 % of the material was removed after thorough mixing to get a pooled sample for the plot. About 100 ml of the pooled sample was removed after thorough mixing and then ground more finely in a Tecator mill.

Mineral soil samples were analysed by dry combustion (Elementar Analyzer) for total organic carbon (TOC) and O-horizon samples for total carbon by a laboratory certified according to ISO 10694. Analyses were done by Agrolab/ Institut Koldingen, Sarstedt, Germany.

For each of the plots, the mineral soil carbon stocks in 2007-2009, $C_{m\text{-}2009}$ (tC ha^{-1}), was calculated as

$$C_{m-2009} = \sum_{i=1}^{4(or5)} d_{m-2009} \cdot 10000 \cdot (1 - RV_{stone-2009}) \cdot \rho_{soil} \cdot c_{soil-2009}$$

where d_m is the depth of a given horizon (m), and ρ_{soil} is the bulk density of soils (g cm^{-3}) assessed by use of published pedotransfer functions (Vejre et al., 2003). $c_{soil-2009}$ is the C concentration (mg g^{-1}). RV_{stone} is the relative volume of the stone (versus that of the fine soil):

$$RV_{stone-2009} = \frac{DW_{stone-2009} / \rho_{stone}}{DW_{stone-2009} / \rho_{stone} + DW_{soil-2009} / \rho_{soil}}$$

where ρ_{stone}=2.65 g cm^{-3}, $DW_{soil-2009}$ (g)is the dry weight of the fine soil (<2 mm) in the soil samples from 2007-2009 and $DW_{stone-2009}$ (g) is correspondingly the weight of stones in the soil sample (>2 mm).

For each of the plots, the forest floor carbon stocks in 2007-2009, $C_{ff-2009}$ (tC ha^{-1}), was calculated as

$$C_{ff-2009} = \sum_{i=1}^{10} DW_{ff-2009,i} \cdot 0.0016 \cdot c_{ff-2009}$$

where $DW_{ff-2009,i}$ (g dry weight) is the dry weight of sample number i, i=1-10 and $c_{ff-2009}$ is the C concentration of the pooled sample per plot (mg g^{-1})

The mineral soil dry weight in 1990 was calculated in the same manner as for 2007-2009, assuming that the relative stone volume was identical to that of 2007-2009. The forest floor depth was, however, not measured in 1990, nor was an area-based forest floor weight recorded. Forest floor depth (d_{ff}, m) measured for profiles on some of the plots 1986-1989 was used instead, while forest floor densities for the individual plots were obtained from the new measurements performed in 2007-2009. When data was available, forest floor C-stocks in 1990, $C_{ff-1990}$ (tC ha-1) were calculated as

$$C_{ff-1990} = d_{ff} \cdot 10000 \cdot \rho_{ff-2009} \cdot c_{ff-1990}$$

where $c_{ff-1990}$ (mg g^{-1}) is the carbon concentration of the forest floor samples from 1990 (measured in 2009), and $\rho_{ff-2009}$ (g m^{-3}) is the average bulk density of the forest floor for the individual plot as measured in 2009:

$$\rho_{ff-2009} = \frac{\sum_{i=1}^{10} DW_{ff,i}}{0.25 \cdot 0.25}$$

Considering the forest structure in Denmark with many small forests (about 70 % of the forest estates are of less than 5 ha) the "Kvadranet" is a very coarse grid. Even if the grid was fully sampled, it is therefore unlikely that the 108 plots represent the Danish forest area of approximately 500.000 ha. We thus evaluated based on power analyses that further sampling was necessary for future monitoring and chose to include a subset of the permanent plots of the National Forest Inventory (NFI) for this purpose.

It will not be possible, as with the "Kvadratnet", to resample soils of the NFI plots for changes in soil C within the short time frame before Kyoto Protocol reporting. From 2012 and onward the NFI plots can be resampled to better support the work to demonstrate that soil carbon stocks are not a source for CO_2 emissions. As the Danish reporting of the three forest carbon pools aboveground biomass, belowground biomass and dead wood is based on the NFI, this will also ensure the link between monitoring of all five forest carbon pools identified by IPCC (2003). In the first reporting efforts, however, information on C-stocks and site properties from the NFI will enable better upscaling of results from "Kvadratnet" to the Danish forest area.

Changes in forest soil carbon stocks in forests planted before 1990

The preliminary results from the "Kvadratnet" showed that there is a large variation in soil C pools among sites for both forest floors and mineral soils. The mean C pool of forest floors was about 22 and 28 tC ha^{-1} in 1990 and 2007-09, respectively. The corresponding C pools for mineral soils were 156 in 1990 and 157 tC ha^{-1} in 2007-09 (Table 7.12). The mean changes in forest floor and mineral soils pools between 1990 and 2007-2009 (5.6 and 1.5 tC ha^{-1} yr^{-1} respectively) were not significant (Table 7.13, Figure 7.1a-b).

Table 7.12 Basic statistics on soil C pools measured in the "Kvadratnet".

	Mean Pool	Standard deviation	Minimum	Maximum
	tC ha^{-1}			
Forest floor 1990	22.12	19.12	0.76	80.34
Forest floor 2007-2009	27.68	30.05	3.94	164.48
Mineral soil 1990	155.78	115.91	29.31	848.14
Mineral soil 2007-2009	157.26	100.34	18.66	853.08

Table 7.13 Basic statistics on the differences in C soil pools between 1990 and 2007-2009 and statistics from a simple t-test (H_0: change in soil C-stock = 0).

	Total number of sites	Number of sites in t-test	Mean change	Std	Mininmum	Maximum	P-value
			(tC ha^{-1})				
Forest floor	108	31	5.56	24.78	-61.44	84.13	0.22
Mineral soil	108	104	1.48	47.56	-182.62	131.51	0.75

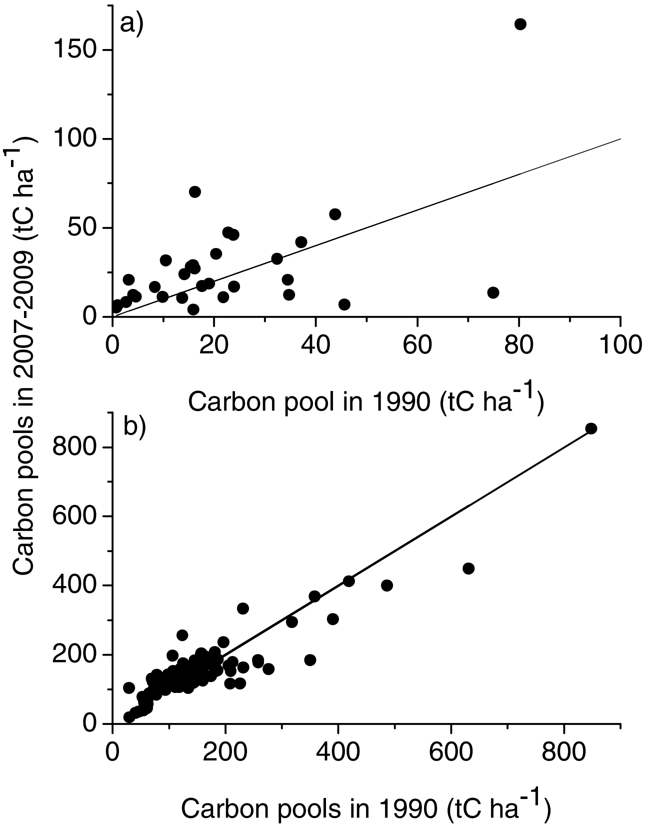


Figure 7.1 C pools in forest soils for forest before 1990. a) Forest floor C in 2007-2009 versus 1990, b) Mineral soil C in 2007-2009 versus 1990. Lines: y=x.

Some mineral soils had one or several horizons of organic origin and these soils had very high soil C-stocks to 1 m depth (>300 tC ha^{-1}), and these will probably be handled separately in further work with the data. Determination of true changes in organic soils requires that the total depth of the organic layer is known, while soils were only sampled until 1 m in SINKS.

Uncertainties and time-series consistency

Danish national forest inventories have developed over the years from the earliest inventories more than a century ago. More recently the development has been quite rapid, which may lead to inconsistencies in estimation of forest carbon pools in relation to LULUCF.

In the 1990 forest census the number of questionnaires sent to respondents was 22,300. In the subsequent inventory the number of respondents increased to 32,300. Not unexpectedly this led to a substantial increase in estimated forest area, which is not possible to separate from the actual increase in forest area that occurred during that period of time. Also, it is not possible to single out the effect of the increased number of questionnaires on estimates of species distribution, carbon pools etc.

In 2002, the sample based forest inventory released the previous forest census for the first time enabling annual forest statistics. The NFI includes areas and forest owners that have not previously been included in the forest census. Firstly because not every forest owner was included in the previous surveys and secondly because not all forest areas according to the FAO definitions would be perceived as forest by the respondents.

Consequently, the change from questionnaire based forest census to sample based forest inventory has lead to an increase in forest area estimates that is not possible to separate from the actual increase in forest area that occurred during that period of time.

Specifically, in relation to the reporting of carbon pools in forest, the change from questionnaire based forest census to sample based forest inventory has changed the calculation of forest volume, biomass and carbon. In the forest census, forest carbon is estimated from the reported forest area within different species, age and site classes and a number of forest growth models. In the forest inventory, forest volume is measured on the plots. This has lead to a substantial increase in forest volume, biomass and carbon estimates, mainly due to the methodological differences.

In the estimation of carbon emissions from existing forests, the information collected in relation to different forest census and inventories is combined with the satellite based land use/land cover map for the Kyoto reference year 1990 and for the year 2005. Hereby, consistent estimates of emissions from existing forests are obtained.

Below is made and a first Tier 1 estimate of the uncertainty in the forest, Table 7.14. This will be evolved before the next submission.

Table 7.14 First Tier 1 estimate of the uncertainty in the forest.

		1990	2008					
		Emission/sink, Gg CO_2-eqv.	Emission/sink, Gg CO_2-eqv.	Activity data, %	Emission factor, %	Combined uncertainty	Total uncer-tainty, %	Uncertainty 95 %, Gg CO_2-eqv.
5. LULUCF		-887.5	1464.1				16.9	247.0
5.A Forests		-698,8	-2702,2				36,0	971,6
Broadleaves, Forest remaining forest	CO_2	-659,0	-1011,8	15	50	52,2	52,2	528,2
Conifers, Forest remaining forest	CO_2	-65,9	-1579,4	15	50	52,2	52,2	824,5
Broadleaves, Land converted to forest	CO_2	3,4	-78,4	15	50	52,2	52,2	40,9
Conifers, Land converted to forest	CO_2	7,1	-44,7	15	50	52,2	52,2	23,4
Drainage of forest soils	N_2O	15,7	12,0	30	75	80,8	80,8	9,7

QA/QC and verification

A continuous focus on the measurements of carbon pools in forest will contribute to QA/QC and verification in the following submissions. As we gain more data through resampling of permanent plots in the NFI this will further support the verification of the data reported. These will be available for the reporting performed in 2013.

Ongoing development of the NFI in terms of sampling procedures and estimation methods are essential for the continued QA/QC process of the NFI.

Integration with multi phase and multi scale inventory - through e.g. other in-situ data like LiDAR scanning or remote sensing like satellite imagery will through research contribute to the continued QA/QC process of the NFI and the carbon stock estimates for forests.

Recalculations and changes made in response to the review process

As response to review comments a full recalculation of forest carbon pools have been performed for the period 1990 to 2009.

The carbon stock change for forests has been estimated based on best available data - which include the following main data sources:

- National Forest Inventory - NFI - conducted by Forest and Landscape Denmark for The Danish Forest and Nature Agency, Ministry of Environment. The NFI started in 2002 and is a continuous forest inventory with partial replacement. The rotation is 5 years. (Nord-Larsen et al., 2008; Nord-Larsen et al., 2010) - See Chapter 7.1.2 for further details.
- Forest Census 1990 and 2000, conducted by Statistics Denmark - in cooperation with The Danish Forest and Nature Agency and Forest and Landscape Denmark. (Danmarks Statistik 1994, Larsen & Johannsen 2002) - See below for short description.
- Mapping of the forest area based on satellite images in 1990 and 2005, with suppport from ESA - GMES - FM and the Ministry of Climate and Energy. See Chapter 7.1 for further details.

Forest Census

From 1881 to 2000, a National Forest Census has been carried out roughly every 10 years based on questionnaires sent to forest owners (Larsen and Johannsen, 2002). Since the data was based on questionnaires and not field observations, the actual forest definition may have varied. The basic definition was that the tree covered area should be minimum 0.5 ha to be a forest. There were no specific guidelines as to crown cover or the height of the trees. Open woodlands and open areas within the forest were generally not included. All values for growing stock, biomass or carbon pools based on data from the National Forest Census were estimated from the reported data on forest area and its distribution to main species, age class and site productivity classes. The two last censuses were carried out in 1990 and 2000.

The 1990 National Forest Census was based on reported forest statistics from 22,300 respondents, resulting in information on area, main species, age class distribution and productive indicators. The estimated forest area was 445,000 ha or 10.3% of the land. Of the total forest area 64% was coniferous forest and 34% was deciduous forest (the remainder was temporarily unstocked). The total volume was estimated at 55.2 mio. cubic metres of which 57% was coniferous.

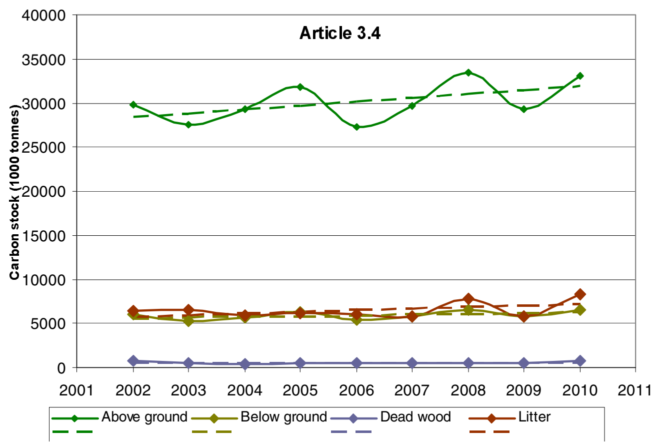
The number of respondents in the 2000 National Forest Census was 32,300, which is considerably higher than in the 1990 survey. The change in the number of respondents probably contributed to the observed increase in forest area and growing stock between the 1990 and 2000 census. The estimated forest area was 486,000 ha or 11.3% of the land. Of the total forest area 60% was coniferous forest and 36% was deciduous forest (the remainder was temporarily unstocked). The total volume was estimated at 77.9 mio. cub. metres of which 63% was coniferous.

Recalculation for 1990 - 2009

Based on mapped forest area in 1990 and in 2005 a recalculation of carbon stored in both forest remaining forest and in afforestation since 1990 have been performed. The forest areas in 1990 as well as in 2005 have been mapped to be larger than previously estimated for the times. The recalculation of carbon stock in 1990 and in 2000 used age distribution as reported in census 1990 and in 2000 as an expression of the total forest land allocation to species and ages. Based on the actual measurements of carbon storage in different species and age classes with the current National Forest Inventory, the total standing carbon stock was calculated. For each of the years 1990 - 2000 calculated a standing carbon stock as a moving average, corrected for the deforestation which was detected. Wind throws and the effects of these are included in the overall estimation of changes in carbon stock. As carbon stock is based on moving average the annual effect is not dramatic. For a more detailed description of the analyses see Johannsen et al. (2009).

Since the NFI was initiated in 2002, the first full cycle of measurements was completed in 2006. Under the assumption that changes occur gradually, these measurements are representative of 2004, corresponding to the period midpoint. Calculation of carbon stock in the period 2001-2003 is based on NFI in 2004 and carbon stock as calculated for 2000. For 2004-2010 carbon stock is calculated solely on the basis of the NFI using additional information about the total forest area from satellite image mapping.

For 2009 and 2010 carbon stock at the period midpoints can only be calculated using data from 3 and 1 years, respectively (i.e. data collected in 2008-2010 and 2010). As the data include a limited sample of the plots included in a full 5-year measurement circle, estimates have a larger uncertainty resulting in relatively large year-to-year variation. To obtain reasonable estimates of carbon stocks on 2009 and 2010, estimates were obtained using linear regression. Estimates of carbon stocks from data collected in individual years from 2002 to 2010 were regressed against the measurement years using weighted regression. Individual weights were calculated as the number of measured sample plots relative to the number of forest covered plots (based on an evaluation of aerial photographs. Finally, the estimated regression model is used to estimate carbon stocks for 2009 and 2010. When full 5-year measurements are available for 2009 and 2010 these will be used in place of the regression based estimates (Figure 7.2).



Figur 7.2 Prediction models for carbon stock estimates in 2009 and 2010.

In the transition from the recalculation of data 1990 - 2005 to the NFI based data there is a number of basic structural elements of the Danish forests that become visible. One issue is the significantly higher proportion of broadleaved trees, due to mixed stands that previously was reported as purely conifers. This causes the amount of carbon in broadleaved category to increase steadily until 2005, where after the overall trend of the forest carbon pools result in first a slow down of carbon accumulation and in the last year a decline. The main reasons for the change in pattern is a combination of gradual change in inventory and a gradual change in forest management and the current structure of the forests. For conifers a decline is recalculated for the period since 2000, as the proportion of conifers has declined with the NFI data and in the later years is influenced by the overall gradual change in forest management and the current structure of the forests.

The data for 2008 and a preliminary forecast until 2020 show a decreasing trend of forest carbon stock. This is due to the current high proportion of old trees, which face rejuvenation. Hereby large old trees felled and replaced by new small trees. The net result is that the total carbon stock decreases. This has gradually affected the estimates for the years since 2007 and hence a decline in carbon stock is seen for 2008. If the forests had a completely even distribution of ages, carbon stock would be virtually constant - assuming unchanged harvesting and growth. Changes in forest management, may affect the development of forests. Thus, a postponement of cutting of old trees - will postpone the decline in carbon storage. Conversely, increased logging (e.g. due to increased demand, increased price or similar) may lead to a sharper decline in carbon stock.

For the afforested areas a steady increase in carbon stocks is expected also in the future years. The rate of increase of area will depend on both availability of land and on possible subsidies for afforestation. Deforestation occurs mainly in relation to other specific projects e.g. for nature restoration or test areas for wind mills.

Planned improvements

A further QA/QC of the Land Use matrix will be performed before the next submission.

Documentation for carbon pools in soil and litter is expected to be further improved in the next submission.

7.2.2 Land converted to forests

Forest area

See section 7.2.1 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

Forest definition

See section 7.2.1 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories (e.g. land use and land-use change matrix)

Methodological issues for land converted to forest

See also section 7.2.1

With respect to the option for distinguishing forest with and without harvesting, it is not possible with the available data. Data from the National Forest Inventory is utilised based on the land use mapping to identify sample plots on AR areas. It is - however not possible to determine the amount of harvesting. As we furthermore apply an approach utilising total carbon stock change growth and harvesting is included in the overall estimation.

Arable land to forest - mineral soils

Introduction

Changes in soil carbon pools following afforestation were for the first time been included in the NIR for 2008 covering the period until 2006. The included soil C pool changes concerned only C sequestration due to development of forest floors, i.e. the organic layer on top of the mineral soil. We included C sequestration in this layer since national scientific projects had indicated that this was the soil compartment mainly prone to changes following land-use change. In the previous NIRs we did not account for possible changes in C pools of the mineral soil; based on chronosequence studies of afforested stands (http://www.sl.kvl.dk/af-forest/), no consistent changes had been detected in mineral soil organic matter during the first 30 years following afforestation (Vesterdal et al., 2002a; Vesterdal et al., 2007). This is also supported by the finding that there was no significant difference in mineral soil C-stocks in paired forest-cropland sites at 28 different sites in Denmark (Vesterdal et al., 2002b). These conclusions are supported by new data.

New data

New information on carbon pools in forest soils is available from the national project, SINKS. In this project forest soils are sampled in two grids, "Kvadratnettet" and the National Forest Inventory (NFI), see section 7.2.1 for a description.

Apart from 108 plots in forests planted before 1990, the "Kvadratnet" included 15 plots in afforestation since 1990. The sampling took place together with the sampling in forests planted before 1990, and was thus complete for the period 2007-2009. Archived soil samples from 1990, when the plots were arable land, were missing for 1 plot.

The sampling, the sample preparation, chemical analyses and calculations were similar to that performed from forests planted before 1990, see 1.2.1.3.

Few of the 300 plots sampled in the NFI grid are probably also located in forests planted since 1990. The sampling is currently being performed, and these data will be reported in the next NIR.

Changes in forest soil carbon stocks in forests planted on arable land since 1990

The average C sequestration rates for forest floors for broadleaves and conifers were estimated from the information from scientific projects in afforestation chronosequences; the average annual sequestration of C in forests floors was 0.09 and 0.31 tC ha^{-1} yr^{-1} under broadleaves and conifers, respectively (Table 7.15.). These rates of change have been used for calculation of forest floor C sequestration in afforested land, however, the accumulation of conifer forest floors is assumed to start after 8 years based on observations from chronosequence and other field data.

Table 7.15 Forest floor C sequestration rates in afforestation areas for different species in national chronosequential studies.

Tree species category	Tree species	Study type	Age (yr)	Forest floor C sequestration	Source*

				(tC ha^{-1} yr^{-1})	
Broadleaves	Oak	Chronosequence	29	0.08	1
	Oak	Stand	30	0.02	2
	Oak	Stand	30	0.05	2
	Oak	Stand	30	0.04	2
	Oak	Stand	30	0.02	2
	Oak	Stand	30	0.13	3
	Oak	Stand	40	0.09	3
	Beech	Stand	30	0.09	2
	Beech	Stand	30	0.10	2
	Beech	Stand	30	0.12	2
	Beech	Stand	30	0.13	2
	Beech	Stand	30	0.18	3
	Beech	Stand	40	0.14	3
	Average (SEM)			*0.09 (0.01)*	
Conifers	Norway	Chronosequence	30	0.35	1
	Spruce	Chronosequence	41	0.43	1
		Stand	30	0.21	2
		Stand	30	0.15	2
		Stand	30	0.20	2
		Stand	30	0.30	2
		Stand	30	0.30	3
		Stand	40	0.65	3
	Sitka spruce	Stand	30	0.43	2
		Stand	30	0.24	2
		Stand	30	0.22	2
		Stand	30	0.25	2
	Average (SEM)			*0.31 (0.04)*	

* 1) Vesterdal et al. (2007), 2) Vesterdal & Raulund-Rasmussen (1998), 3) Vesterdal et al. (2008).

The results from scientific projects have lately been checked by analysis of preliminary results from the "Kvadratnet". The afforested plots in the monitoring grid also revealed large variation in soil C pools among for both forest floors and mineral soils (Table 7.16). The mean C pool of the forest floor among the afforested sites was about 2.5 tC ha^{-1} in 2007-2009 (and supposedly 0 tC ha^{-1} at the time of the afforestation) while the mean C pools for mineral soils were 114 and 108 tC ha^{-1} in 1990 and 2007-2009 respectively (Table 7.17). The mean change in mineral soils pools between 1990 and 2007-2009 (-1.87 tC ha^{-1} yr^{-1}) was not significant (Table 7.16 and Figure 7.2) while there, as expected, was a significant sequestration of C in the forest floor due to litterfall inputs and subsequent build up of the organic layer (Table 7.17, Figure 7.3). The age of the afforested stands ranged from 8-19 years, so only the establishment phase was covered.

Table 7.16 Basic statistics on soil C pools measured in the "Kvadratnet".

	Mean C pool	Std	Min	Max
		(tC ha^{-1})		
Forest floor at the time of the afforestation	-	-	-	-
Forest floor 2007-2009	2.53	1.79	0.25	5.56
Mineral soil 1990	113.63	35.37	68.00	186.06
Mineral soil 2007-2009	107.83	41.25	52.82	220.06

7.17 Statistics from a simple t-test on the change in soil C between ca. 1990 and 2009 for forests after 1990.

	Total number of sites	Number of sites in t-test	Mean change	Std	Min	Max	P-value
				(tC ha^{-1})			
O-horizon	15	15	2.53	1.79	0.25	5.56	<.0001

Mineral soil	15	14	-1.87	17.59	-35.32	34.00	0.70

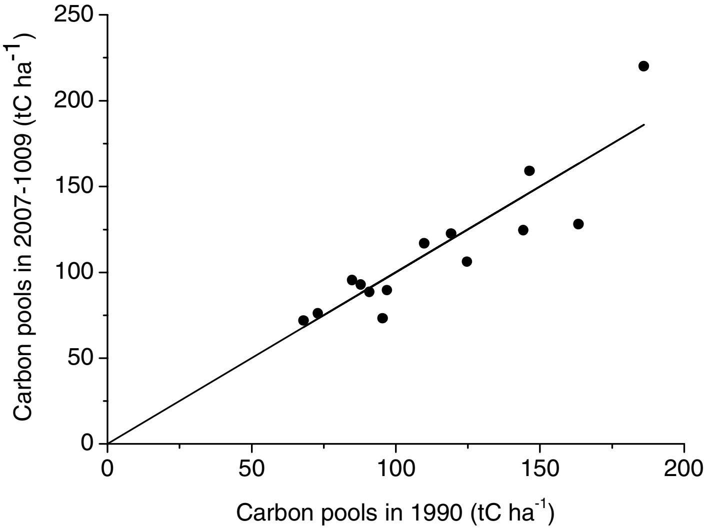


Figure 7.3 C pools in mineral soils in 2009 versus 1990. Forests established on arable land since 1990. Line: y=x.

The amount C in the forest floors increased with the age of the afforested stand (Figure 7.3), while this was not the case for the mineral soil (Figure 7.4).

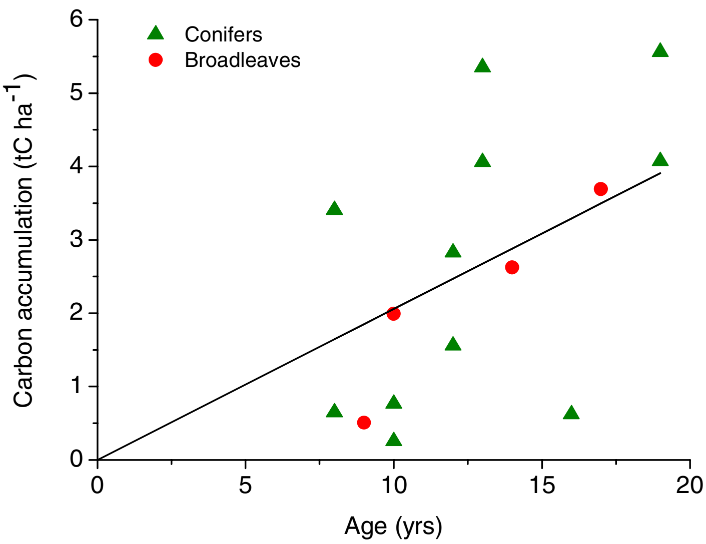


Figure 7.4 Forest floor C pools in forests afforested since 1990 in the "Kvadratnet". The regression was forced through (0,0) (C acc. = 0.2057 x age, R^2=0.3124, p<0.0001).

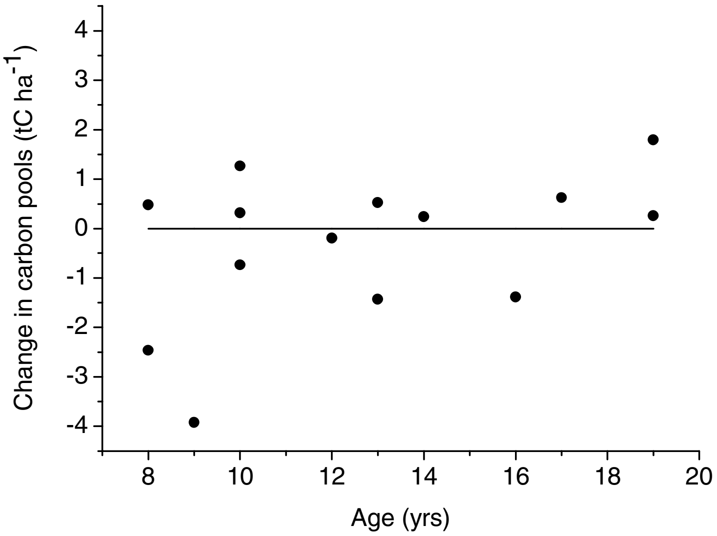


Figure 7.5 Change in mineral soil C-stocks for forests since 1990. Line: y=0 (Regression line (not shown): R^r=0.0005, p=0.9356).

Average C sequestration rates for forest floors for broadleaves and conifers were also estimated from "Kvadratnettet" in order to check the forest floor C sequestration rates used in reporting; in this case the average annual sequestration of C in forests floors was 0.16 and 0.20 t C ha^{-1} yr^{-1} under broadleaves and conifers, respectively (Table 7.18). These values are intermediate compared to the values obtained from 30-40 yr-old stands.

Table 7.18 Forest floor C sequestration rates in afforestation areas for different species. Data from the "Kvadratnet".

Tree species category	Tree species	Study type	Age (yr)	Forest floor C sequestration ($tC\ ha^{-1}\ yr^{-1}$)	Site
Broadleaves	Oak	Monitoring plots	14	0,19	837
	Oak	Monitoring plots	17	0,22	301
	Maple	Monitoring plots	9	0,06	485
	Lime	Monitoring plots	10	0,20	571
	Average (SEM)			*0.16 (0.07)*	
Conifers	Norway spruce	Monitoring plots	19	0,21	479
	Sitka spruce	Monitoring plots	13	0,41	335
	Sitka spruce	Monitoring plots	10	0,03	340
	Normann fir	Monitoring plots	13	0,31	31
	Normann fir	Monitoring plots	16	0,04	171
	Normann fir	Monitoring plots	12	0,13	235
	Normann fir	Monitoring plots	8	0,08	292
	Normann fir	Monitoring plots	12	0,24	689
	Silver fir	Monitoring plots	19	0,29	66
	Larch	Monitoring plots	8	0,43	334
	Mixed conifers	Monitoring plots	10	0,08	509
	Average (SEM)			*0.20 (0.14)*	

Lastly we combined all data to explore the trends in forest floor C-stocks among broadleaves and conifers (Figure 7.6). The rates used seem reasonable, even if the inclusion of new data indicate that it might be too high for conifers in the stand establishment phase. Thus, accumulation of conifer forest floors is assumed to start after 8 years of chronosequences. This is reasonable since observations in chronosequences indicate that there is little litterfall in conifer stands to build up forest floors during the first 10 years.

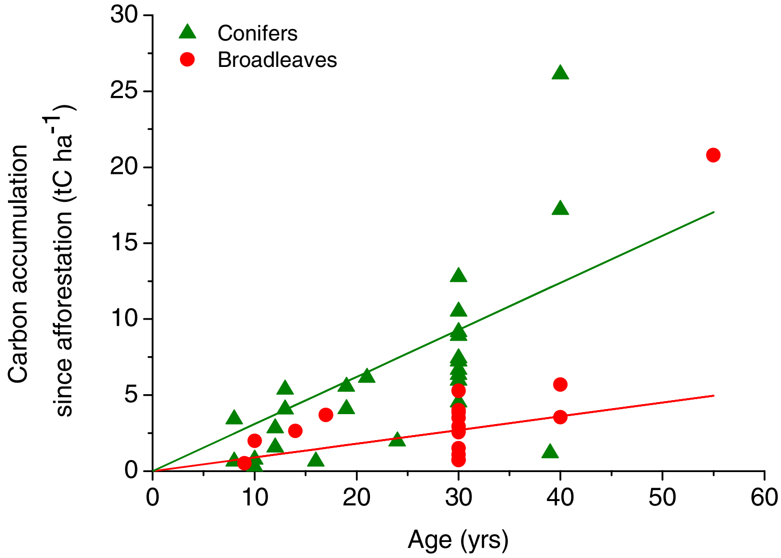


Figure 7.6 Forest floor C pools in afforested plots. All available data from chronosequential studies and the "Kvadratnet" are included. Lines show the C sequestration rates used in the reporting: 0.31 tC ha^{-1} yr^{-1} for conifers and 0.09 tC ha^{-1} yr^{-1} for broadleaves.

Several previous national field studies mentioned above (Vesterdal et al. 2002a, 2002b, 2007) did not suggest measurable decadal changes in mineral soil C following afforestation. In the SINKS project, soil C content to 100 cm in forest land (art. 3.4) was compared with soil C in the same depth found in a parallel project for cropland soils (Table 7.19). These data also support that mineral soils are neither sinks nor sources for CO_2 following afforestation of former cropland. Using a transition time of 50 years, these soil C contents were used to calculate the small rates of soil C-stock change for cropland to forest conversion.

Table 7.19 Mineral soil C content (Mg ha^{-1}) in cropland and forest land based on Kvadratnettet. N: number of plots, mean and standard deviation (std).

Land use	Sandy soils			Clayey soils		
	N	mean	std	N	mean	std
Cropland		137			158	
Forest land	53	129	49	42	157	58
Grassland and Other land	19	150	84		150[a]	84[a]

[a] Same data as for sandy soils.

In conclusion, preliminary results from the SINKS project shows that mineral soil C pools for forests on former arable land are neither sinks nor sources for CO_2 The data from the SINKS project support the conclusions drawn from Vesterdal et al. (2002, 2007), Vesterdal and Raulund-Rasmussen (1998), and Vesterdal et al. (2008) for forest floors.

Until final results from the SINKS project are available we continue to use the previously used average C sequestration rates: 0.09 tC ha^{-1} yr^{-1} for broadleaves and 0.31 for conifers. During the Kyoto commitment period 2008–2012, it is thus estimated that the Danish afforestation activities will result in sequestration of 20-25 Gg CO_2 yr^{-1} in the forest floor.

The sequestration of CO_2 in forest floors in forests established since 1990 has gradually increased to about 20 Gg CO_2 in 2008. The annual CO_2 sequestration will increase much more over the next decades when cohorts of afforestation areas enter the stage of maximum current increment.

Uncertainties and time-series consistency
See section 7.2.1 and 7.2.2 for recalculation since 1990.

QA/QC and verification
A continuous focus on the measurements of carbon pools in land converted to forest will contribute to QA/QC and verification in the following submissions. See also Chapter 7.2.1

Recalculations, including changes made in response to the review process
As response to review comments a full recalculation of forest carbon pools have been performed for the period 1990 to 2010.

The carbon stock change for forests has been estimated based on best available data - which include the following main data sources:

- National Forest Inventory - NFI - conducted by Forest and Landscape Denmark for The Danish Forest and Nature Agency, Ministry of Environment. The NFI started in 2002 and is a continous forest inventory with partial replacement. The rotation is 5 years. (Nord-Larsen et al 2008 and Nord-Larsen et al 2010) - See Chapter 7.1.2 for further details.
- Forest Census 1990 and 2000, conducted by Statistics Denmark - in cooperation with The Danish Forest and Nature Agency and Forest and Landscape Denmark. (Danmarks Statistik 1994, Larsen & Johannsen 2002) - See Chapter 7.2.1 for a short description.
- Mapping of the forest area based on satellite images in 1990 and 2005, with suppport from ESA - GMES - FM and the Ministry of Climate and Energy. - See Chapter 7.1 for further details.

Recalculation for 1990 - 2009
Based on mapped forest area in 1990 and 2005 a recalculation of carbon stored in afforestation since 1990 have been performed. Since the NFI was initiated in 2002, it is representative from 2005. Calculation of carbon stock in the period 2000-2004 is based on NFI in 2005 and carbon stock as calculated for 2000. For 2005-2009 carbon stock is calculated solely on the basis of the NFI - with additional information about the total forest area from satellite image mapping.

For the afforestated areas a steady increase in carbon stocks is estimated. With the utilisation of the NFI since 2005 the data for the carbon pools under AR is based on direct measurements of change in total carbon stock.

Planned improvements
A QA/QC of the Land Use matrix will be performed before the next submission.

Documentation for carbon pools in soil and litter is expected to be further improved in the next submission.

7.3 Cropland (5B)

7.3.1 Cropland and cropland management (5B1)

The total Danish cropped agricultural area of approximately 2.7 million hectare can relate to approximately 700 000 individual fields, which again is located at 220 000 land parcels. This gives an average field size of less than four ha. The actual crop grown in each land parcel (LPIS) is known from 1998 and onwards. Since 1990 has the agricultural area recorded by Statistics Denmark decreased from 2.78 million hectare to 2.62 million hectare (Table 7.19). The total crop yield is however at the same level and increasing due to improved cropping techniques. The main reason for the loss of land for agricultural purposes is urbanisation and afforestation. The major part of the agricultural area is grown with annual crops: cereals, grass in rotation, oilseed, sugarbeets, potatoes and temporarily set-a-side. Permanent grass outside rotation with none or very little fertiliser application rates (>25 kg N per ha per year) is reported under Grassland. All nitrogen consumption is reported under Agriculture 4D2.

Table 7.19 shows the development in the agricultural area from 1990 to 2009 (Statistics Denmark). A general trend is a continuous decrease of 6 000 - 7 000 ha per year in the agricultural area.

Table 7.19 Cropland area in Denmark 1990-2009 according to Statistics Denmark and the Land Use Matrix, hectares.

	1990	1995	2000	2005	2007	2008	2009
Annual crops (CL) 1	2236535	1969275	1938633	1953306	1923448	1976815	2044954
Grass in rotation (CL)	306325	310568	330834	342417	352640	390536	310842
Permanent grass (CL and GL)	217235	207122	166261	192968	196630	189962	191529
Horticulture – vegetables (CL)	16428	12915	10803	9557	9978	11341	11563
Perennial fruit trees – perennial wooden crops (CL)	7892	8367	8010	8237	8322	8294	7723
Set-a-side and other land (CL)	3861	217801	192441	200751	171743	90947	57364
Total agricultural land area reported by Statistics Denmark	2788276	2726048	2646982	2707236	2662761	2667895	2623975
Willow in the cropland for energy purposes (CL)	667	986	1304	1622	1749	1813	2567
Hedgerows (CL)	61326	61015	60558	60170	60033	59929	59840
"Other agricultural land"	60230	86797	131739	37715	67208	54532	90451
Total land area reported under Cropland	2917942	2885130	2853301	2822144	2808157	2801039	2793921

[1]CL refers to that the area is treated under Cropland. GL refers to Grassland.

Cropland area

The Cropland area is defined as the agricultural area as given by Statistics Denmark, Perennial wooden crops (fruit trees, orchards and willow), hedgerows (perennial trees/bushes not meeting the forest definition) in the agricultural landscape and "Other agricultural land". The latter is defined as the difference in the area between the total Cropland area as defined by the performed Remote Sensing (see Table 7.1) minus agricultural crops in rotation as given by statistics Denmark minus the area with fruit trees and the area with hedgerows. "Other agricultural land" is thus comparable small areas and probably without agricultural and wooden crops, which cannot be allocated to other land use categories. In the inventory carbon in living biomass for "Other agricultural land" is given the same value as for annual crops so than inter-annual changes in the cropland area from Statistics Denmark are eliminated.

The area with Perennial wooden crops are the area given by Statistics Denmark and for some categories it is split further down with data from the EU crop subsidiary system, which gives information on which crops are grown where on species level.

The main data for land use in Cropland (5.B.1) is the agricultural area given by Statistics Denmark. Both annual agricultural and wooden perennial crops are allocated into grids (climatic, soil type and municipality) with the help of the EU Land Parcel Information System (LPIS). LPIS contains information of the exact position of the field. The survey data from Statistics Denmark differs a little from the LPIS system (<±2% for the major crops). Area and yield data from each region is used for the calculations as reported by Statistics Denmark.

The area with hedgerows is based on analysis of aerial photos from 1990 and 2005 combined with planting and removal statistics of hedges from the Ministry of Food, Agiculture and Fisheries. The major part of the hedge erection is subsidies in Denmark and therefore monitored.

Cropland definition

The land area under "CL" consists of: Cropland with annual crops, cropland with wooden perennial crops, area with hedgerows and "Other agricultural area". The latter consists of small undefined areas lying inside the area, which is allocated as cropland in the cropland area.

For purposes of the calculations for annual crops is used a division as follows: Winter and spring wheat, rye, triticale, winter and spring barley, oat, winter and spring rape, grass for grass seed production, grassland in rotation, potatoes, sugar beets, peas, maize for silage, cereals for silage, vegetables and miscanthus.

For purposes of perennial wooden crops is used a division as follows: Apple, Pears, Cherries, Plumes, Rosehips, Elderberries, Hazel and Walnuts, Grapes, Other fruit trees, Black current, Other fruit bushes, Hedgerows and Willows.

Biomass from Christmas trees in the agricultural area is reported under forests.

Cropland - Methodological issues

The following data sources are used for determination of cropland area, for determination of any land-use changes, for allocation of natural and administrative parameters, for development of emission factors for soils and biomass and for calculation of carbon stocks in soils and biomass at various times. Agricultural area data from Statistics Denmark, 1980 to 2009

- Area and harvest surveys from Statistics Denmark, 1980 to 2009.
- Area with willow from the agricultural subsidiary system.
- EUs Land Parcel Information System, 2000 and onwards (grown crops on field and soil level).
- Digital soil map, 1:25.000.

- Arial photos of hedgerows in 1990 and 2005.
- Hedgerow planting data 1977 to 2009.
- Lime consumption data 1990 to 2009.

The model for C-stock changes in hedges is based on a growth model from the National Forest Inventory (NFI) classified into plant and soil type and height.

Emissions from living biomass

For annual agricultural crops on cropland remaining cropland (5B1) it is assumed that no changes in above-ground, below-ground, dead biomass and litter are occurring cf. IPPC 2003 (3.3.1.1.1). The variations in the actual agricultural area collected by Statistics Denmark may vary up to 100,000 hectares per year. When estimating the C-stock in living biomass such changes may create large variations between years, which may be artefacts. As the amount of living biomass is defined according to the time where the peak of living biomass is occurring the variation in the area from Statistics Denmark create large fluctuations in the C-stock in living biomass compared to other sources. To counteract this problem the sub-division "Other agricultural land" has been created with a default C-stock of living biomass as in the designated agricultural area. The default C-stock in living biomass is equivalent to an average spring barley crop with aboveground biomass of 9,577 kg DM (dry matter) pr hectare and a below ground DM of 2,298 kg pr hectare. Default dry matter values for the different crop categories used in the inventory is given in Table 7.20.

Table 7.20 Default values for the amount of DM (dry matter, kg per hectare) used for estimating C-stock changes where land use conversions takes place.

		Dry matter, kg DM pr hectare	
		Above ground biomass	Below ground biomass
Cropland		9 577	2 298
Grassland	Improved Grassland	2 400	6 720
	Unmanaged Grassland	2 200	6 160
Wetlands	Peat extraction	0	0
	Other Wetland	3 600	10 080
Settlements		2 200	2 200
Other land		4 000	4 000

Fruit trees and other perennial wooden plants

Fruit trees, other perennial commercial wooden plants and durable horticultural plantations are reported separately under Cropland (Table 5.B). These are only of minor importance in Denmark. The total area for different main classes and the used C-stock in above-ground and below-ground biomass are given in Table 7.21. Due to the limited area and small changes between years the CO_2 removal/emission is calculated without a growth model for the different tree categories. Instead the average stock figures are used in Table 7.21 multiplied with changes in the area to estimate the annual emissions/removals. Perennial horticultural crops account for approximately 0.07 % of the standing C-stock. Christmas trees are reported under forest (5.A).

The carbon fraction of dry matter (DM) is assumed to be 0.5 for all species. For parameter estimation of living biomass, see Gyldenkærne et al. 2005 for fruit trees, for willow and Micanthus:

http://www.nordicbiomass.dk/dansk/nye_afgroeder.asp

Table 7.21 Mg living biomass per hektar and area, ha, with perennial wooden trees and – bushes, 1988-2008.

	Living biomass, Mg DM per ha	1990	1995	2000	2005	2008	2009
Black currant	5.20	1269	1828	1492	2001	2071	1848
Other berries	5.20	344	275	351	486	485	490
Rosehip	13.99	89	69	79	108	118	149
Cherries	25.45	1787	2653	2804	2131	1951	1864
Plumes	25.45	46	26	33	54	52	60
Hazelnut and Walnuts	25.45	36	25	20	21	31	31
Apples	33.76	2726	1658	1678	1751	1797	1730
Pears	13.99	351	546	441	413	442	372
Elderberry	25.45	7	5	7	10	8	11
Grapes	5.20	20	19	23	24	23	36
Other fruit trees	13.99	166	121	99	143	163	160
Rowan-berries	33.76	1	7	2	3	8	16
Willow	14.79	667	986	1304	1622	1813	2567
Miscanthus	10.54	20	32	44	57	64	64
Total, ha		7530	8250	8377	8823	9025	9398

Hedgerows

Since the beginning of the early 1970s governmental subsidiaries have been given to increase the area with hedgerows to reduce soil erosion. Annually financial support is given to approximately 600-800 km of hedgerow pr year. There are no figures on how many hedgerows that have been removed in the same period as these to a large extend are not protected. Therefore 144 aerial photos on a 2x2 km^2 square for 1990 and 2005 has been analysed to monitor and detect changes in the landscape. The squares are distributed throughout Denmark in a stratified way according to primarily soil and wind conditions (Figure 7.7). A very large dynamic in the location of the hedges between 1990 and 2005 was observed (Figure 7.8). Only areas not meeting the definition of forests and areas not classified under Perennial Wooden crops (fruit trees, willows etc.) were included in the analysis. The hedges were further allocated into eight different regions, mainly according to soil type (e.g. growth pattern).

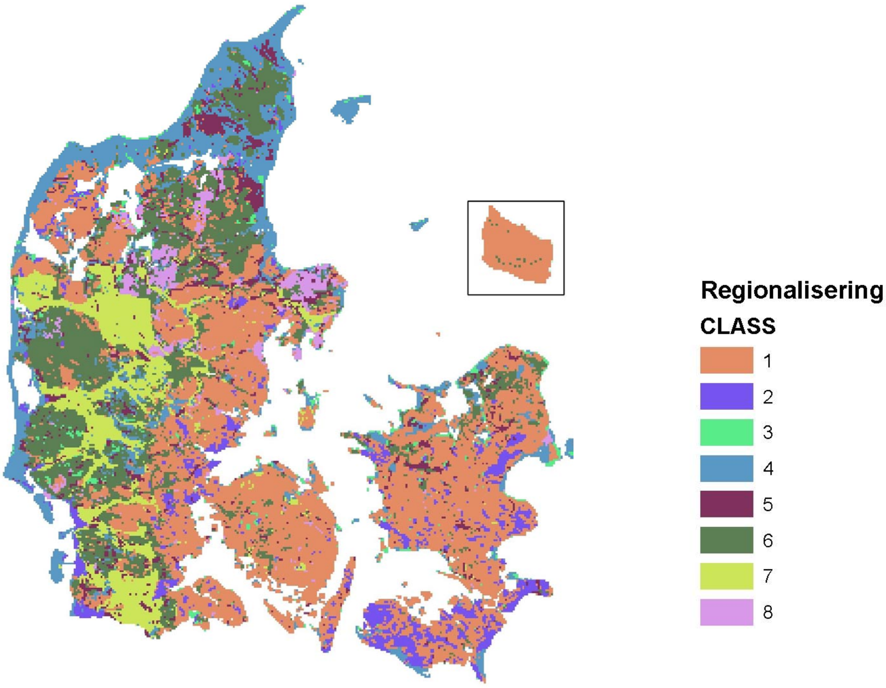


Figure 7.8 The dynamics of hedgerows in the Danish Landscape 1990 to 2005. Blue colour indicates no changes, red colours are removed hedges and green colours are new hedges (Source: M. Fuglsang, NERI).

The overall results from the analysis of hedges are shown in Table 7.22. The total area with hedges has decreased with 2 % but the total volume and the C-stock has increased due to changed sizes and composition.

Table 7.22 Hedges in the cropland 1990 and 2005.

	1990	2005	Change 1990-2005
Area, ha	61,326	60,093	-2.0%
Volume, mio. m3	4,139	4,402	6.4%
C-stock, Gg	939	1,072	14.2%

In Table 7.23 is shown the actual planting and removal rates for hedgerows. In the 1970s and 1980s there was less concern to protect and maintain the hedgerows. Therefore there was a substantial loss in hedgerows. The governmental subsidiary is headed towards broadleaved hedgerow replacing old single-rowed conifers (mainly *Picea glauca*). In 1990 75 % of the replaced conifers hedgerows were replaced with 3- to 6-rowed broad-leaved hedges. In 2005 only 20 % are replacements and the remaining are new hedges cf. Table 7.23. The Ministry of Food, Agriculturure and Fisheries is responsible for all administration, registration and mapping of all subsidised hedgerow planting in Denmark.

Table 7.23 Hedges planted and removed under the governmental subsidiary system 1985 to 2009.

	1985	1990	1995	2000	2005	2008	2009
Planted 3-rowed, km	1082	928	560	852	390	400	244
Planted 6-rowed, km	0	0	252	250	115	150	57
Small biotopes, <0.5 ha							57
Percentage removed, %	75%	75%	36%	27%	20%	20%	20%
Percentage new, %	25%	25%	64%	74%	80%	80%	80%
Hedges removed, ha	608	522	218	219	76	83	45

The biomass estimation of the hedges is based on measurements made in the Danish NFI where plots with similar height and plant species are used as transfer functions. Figure 7.9

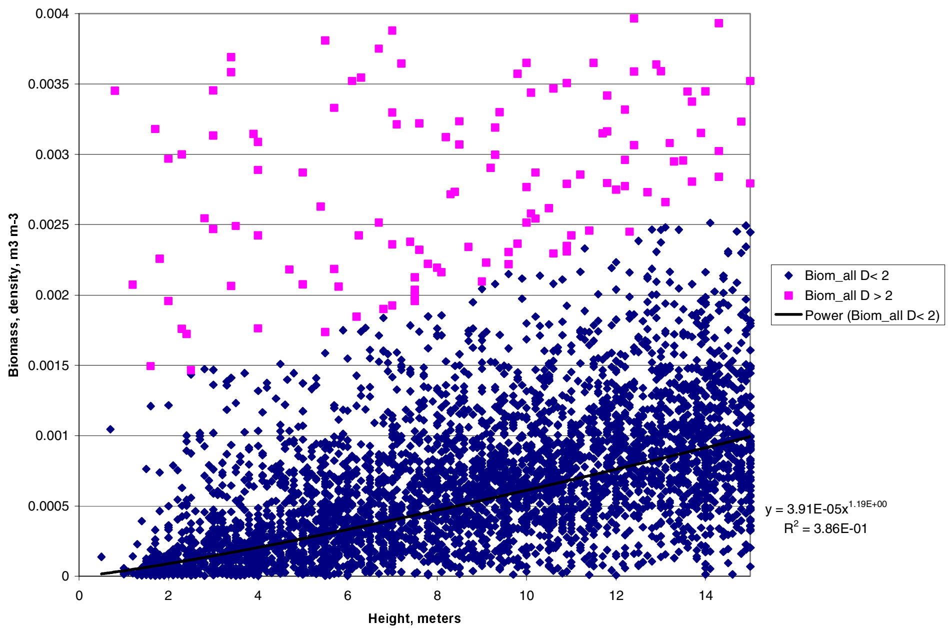


Figure 7.9 Biomass function estimated as m^3 biomass per m^3 versus tree height in NFI plots less than 15 meter (Courtesy Thomas Nord-Larsen, SL, LIFE, KU).

Emission from soils

Based on a GIS analysis of the data in the LPIS and a new produced soil map of the organic soil the agricultural area is distributed between mineral soils and organic soils and subdivided into cropland and permanent grassland.

An updated version of C-TOOL is used for mineral soils (Petersen et al. 2010).

Mineral soils – 5B1

For C changes in for agricultural crops a 3-pooled dynamic soil model is used (Petersen, 2003; Petersen et al. 2002, 2005, 2010, Gyldenkærne et al. 2005) to calculate the soil carbon dynamics in relation to the Danish commitments to UNFCCC. C-TOOL is only used in CL. No change in the C-stock in soils under perennial wooden plants, hedgerows and "Other agricultural cropland" is expected and reported as IE. These areas are also only a very minor part of the cropland area. For agricultural crops is C-TOOL run on a regional level.

C-TOOL

C-TOOL is a 3-pooled dynamic model, where the approximate average half-live times for the three different pools, Fresh organic matter (FOM), Humified organic matter (HUM) and ROM (Resilient Organic Matter) are 0.6-0.7 years, 50 years and 600-800 years, respectively. The main part of biomass returned to soil each year is in the first and easiest degradable FOM pool. This pool consist of mainly fresh straw, fresh manure, root residues, fungi and small animals fluctuates very much between years depending on the harvest yield and climatic conditions. A simple diagram of C-TOOL is shown in Figure 7.10.

C-TOOL is parameterised and validated against long-term field experiments (100-150 years) conducted in Denmark, UK (Rothamsted) and Sweden and is "State-of-art". A detailed description of C-TOOL can be found at www.agrsci.dk/c-tool/index.htmls.

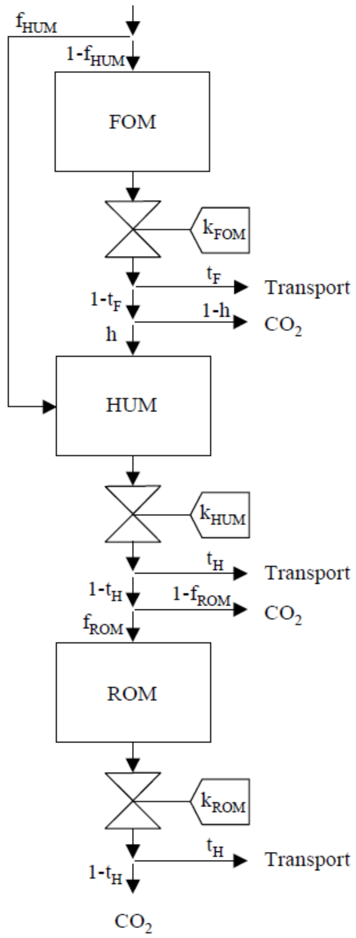


Figure 7.10 A simple diagram of C-TOOL. Please refer to www.agrsci.dk/c-tool for more information.

Input data to C-TOOL and out put

As C input to each region is for each year taken the actual crop area and crop yield from Statistics Denmark for that particular region and crop species as given by Statistics Denmark (www.dst.dk Table AFG, AFG07, HST7 and HST77). The dry matter content depends on the actual crop. For cereals it is 15 %.

The amount of agricultural residues returned to soil is the amount estimated by Statistics Denmark (www.dst.dk Table HALM and HALM1). The dry matter content depends on the actual crop. For cereals it is 16 %.

The amount of animal manure produced and applied to soil is estimated with the same methodology as in the Agricultural sector for estimating CH_4 and N_2O emission where annually updated feeding and excreting data are provided for the regulation of the animal production in Denmark. Here detailed data on the number of animal, housing and manure type are available on farm level. This also includes data whether the manure has been biogassed or not. The manure data are used as input to C-TOOL.

In Figure 7.11 is shown the overall input of C to the agricultural soils. Due to a ban of field burning in 1990, increased management and demand on catch crops an increase in the C input to soils can be seen.

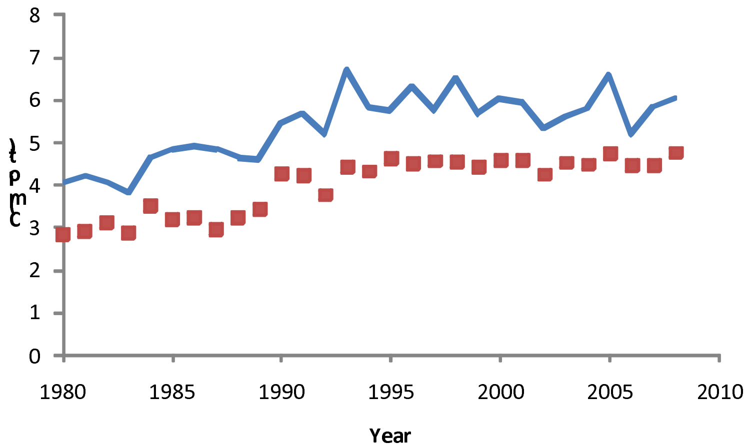


Figure 7.11 Calculated C input to the soil (red squares) and modelled (blue curve) development of the FOM pools, million tonnes C.

Since 1997 there has been a demand for growing N catch crops in Denmark in order to reduce N leaching. Besides reducing the N leaching these crops increase the carbon stock in the soil. Between 120,000 and 200,000 hectares of the agricultural area has this additional crop every year. The demand for catch crops has altered the way of farming in two main ways. For farmers with cattle the farmers are sowing grass seed in their normal cereal fields. This grass sword must not be ploughed into the soil before winter/next spring. For farmers growing grass seed, which is common in Denmark, old grass seed fields are not ploughed before next spring in contradiction to the current situation where it would be ploughed early autumn. It has been estimated that the obligatory catch crops are increasing the amount of C returned to soil with 0.36 to 2.14 tonnes C per hectare per year (Olesen et al. 2004). The area with catch crops in each region is estimated from each farms obligatory N accounting, in which the area of catch crops area given on farm level (www.pdir.dk).

C-TOOL is initiated with data from 1980 and run multipliable times until stability, before the emissions from 1980 and onwards was calculated. Actual monthly average temperatures are used as temperature driver. The main drivers in the degradation of soil biomass are temperature and humidity. The Danish climate is quite humid with winter temperatures around zero degrees Celsius and hence the importance of soil humidity on the model outcome is low in contradiction to temperature, which has a high effect on the emission. As mentioned, when biomass is returned to the soil the major part of it is quite easily degradable. Warm winters with unfrozen soils in connection with high inputs of biomass will therefore, as a result, yield high emissions from the soil compared to more cold years, which will yield low emissions.

In recent years (1999-2009) Denmark has experienced very warm winters. In 18 out of the last 20 years the annual average temperature has been above the average temperature from 1961 to 1990. Year 2009 was the eight warmest year ever registered in Denmark with an average temperature of 8.8 °C or 1.1 °C above the average from 1961 to 1990.

Year 2006 resulted in a high loss due to the warmest year up to then combined with a harvest yield 5 % below the average for 1997 to 2009 (measured as kernel yield from cereals) (Figure 7.11). In this year the organic matter input from crop residues and animal manure were not able to compensate for the loss (Figure 7.12). 2007 was not as warm, which led to an increase in the C-stock. 2009 was cooler than 2008 but 2009 gave the highest cereal yield ever monitored in Denmark despite the fact that the agricultural area has decreased since 1980. This led to a very high input of organic matter into the soil, which again increased the soil C-stock.

The FOM-pool (Fresh Organic Matter), which has a very fast turn over rate, consists of approx. 1.0 % of the total C content in the agricultural soil. Because of its large fluctuation between individual years and its small impact on the overall trend in the long-term development of the carbon stock in the soil, it has been agreed with the previous ERT during the in-country review in 2010, that all input sources are included in the modelling but in the reporting on the development an instant turn over of the FOM pool is used. The reported development is thus the two pools, HUM (Humified Organic Matter) and ROM (Resilient Organic Matter) which account for 99 % of the total amount of carbon in the soil. Figure 7.12 shows the development in the two pools. As can be seen there is a small increase in the total modelled C-stock from 2008 to 2010 but a decrease in HUM and ROM. A new warm year with normal harvest yields will speed up the degradation of the FOM pool and as a consequence the two lines will get closer again.

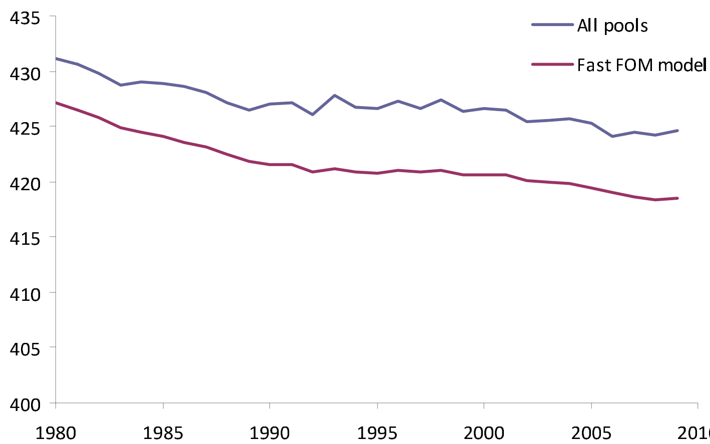


Figure 7.12 The development in the C-stock in agricultural soils, Tg C.

As a whole the modelled emissions are found to be the most realistic emissions estimates for Denmark. As described in the agricultural sector the Danish farmers have faced increased demands for lower environmental impact since the mid-1980s. The general effect on the C-stock in soil is that the 1980s showed a decrease in the C-stock. In the 1990s the C-stock seemed to stabilise due to the higher input of organic matter. Due to the increased global warming a declining C-stock was modelled between 2000 and 2009. Since 1990 C-TOOL has estimated a loss of 0.75 % of the total C-stock in the agricultural soils. No precise uncertainty calculation has been made. However, it must be assumed that uncertainty in the estimate in the annual loss/gain is around 25 %. As Denmark has very good data on harvest yields and area data the uncertainty in the trend is very low. The estimated annual amounts of C in the agricultural soils are given in Table 7.24.

Table 7.24 Modelled carbon stock (0-100 cm) in mineral soils from 1980 to 2009, Tg C.

Year	All pools	Fast FOM model
1980	431,19	427,15
1981	430,66	426,47
1982	429,82	425,76
1983	428,68	424,86
1984	429,06	424,44
1985	428,88	424,03
1986	428,55	423,62
1987	428,02	423,19
1988	427,19	422,55
1989	426,48	421,88
1990	427,02	421,60
1991	427,16	421,50
1992	426,13	420,94
1993	427,82	421,13
1994	426,76	420,92
1995	426,56	420,82
1996	427,31	421,02
1997	426,64	420,90
1998	427,48	420,97
1999	426,37	420,68
2000	426,65	420,63
2001	426,51	420,57
2002	425,48	420,15
2003	425,60	419,99
2004	425,70	419,89
2005	425,25	419,42
2006	424,09	419,00
2007	424,48	418,64
2008	424,28	418,42
2009	424,59	418,45

Independent verification of C-TOOL

An independent validation of C-TOOL has been performed by soil sampling in the Danish Agricultural grid. The grid was established in 1987 and in a 7 x 7 km^2 grid square. In 1987 > 600 agricultural plots were sampled and analysed for C. Half of them were resampled in 1998 and a full resampling were made in 2008/2009. Figure 7.13 shows the development in the C-stock in 0-50 cm depth in the paired plots. Although there is some variability the overall conclusion is that no trend can be measured or estimated in the Danish agricultural soils.

The conclusion is therefore that the modelled outcome from C-TOOL represents a proper value for the development of the C-stock in the Danish agricultural soils.

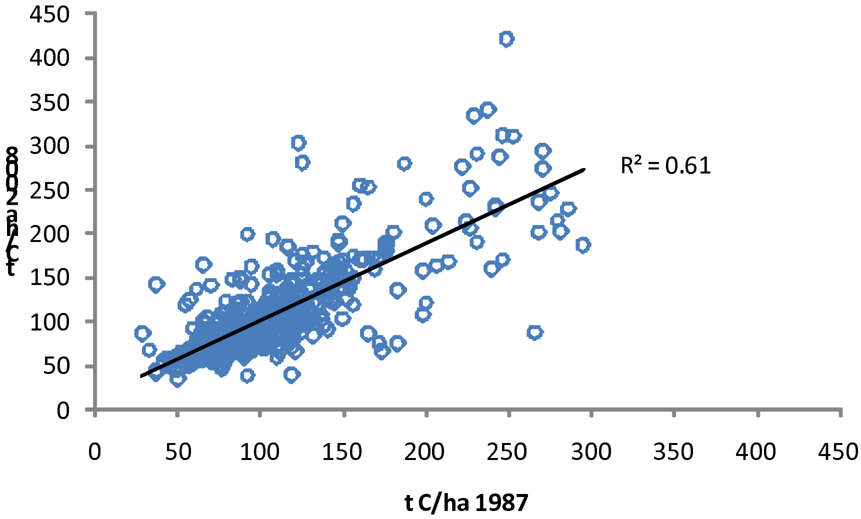


Figure 7.13 The change in C-stock in soil (0 - 50 cm) in >600 paired agricultural plots from 1987 to 2009.

Organic soils - 5B1

A complete new soil map of the organic soils has been made for the inventory (Figure 7.14). The new soil map is a statistical map based on >10.000 soil samples down to the mineral soil in 30 cm intervals combined with a very detailed digital elevation map (DEM) for each 1.6 x 1.6 m^2 covering the entire Denmark, water table maps and old maps with organic soils. The definition of an organic soil in the new map is 20 % organic matter with a dept of minimum 30 cm (Greve et al. 2011, in prep.). The total area with organic soils has been estimated to approx. 106,642 ha of which approx. 42.000 hectares has been located to cropland and 27.000 hectares to grassland (Figure 7.15).

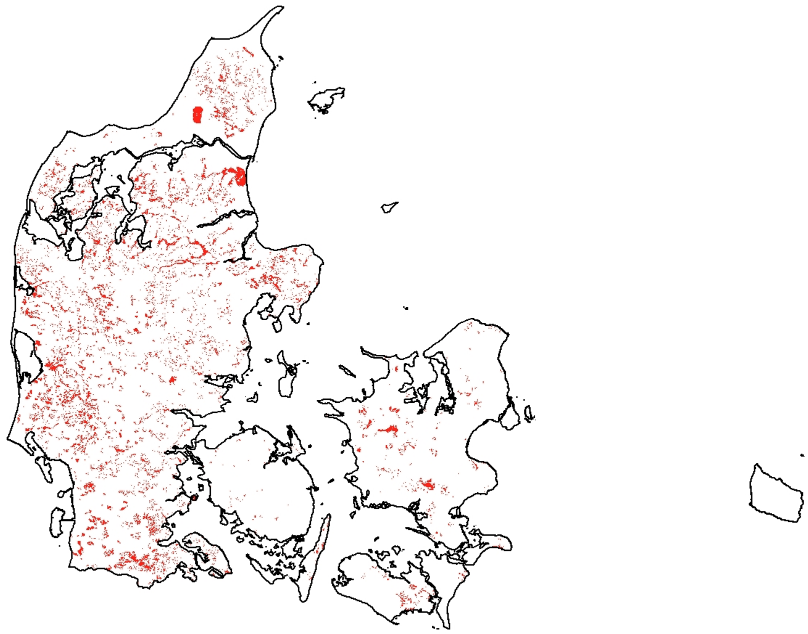


Figure 7.14 The new organic soil map for Denmark for year 2010, > 20% OM (Greve et *al*. In prep).

On top of the organic soil map has been laid digital maps where 99 % of all Danish farmers fields (>670.000 fields) from the EU subsidiary system are precisely mapped with an uncertainty down to < ± 1.5 meter. The actual grown crop is known for each field. In total more than 240 different crop types or combination of crop and crop management are recorded.

It was previously estimated that there was around 80.000 hectares of organic soil under agricultural farming. The new map has shown that only around 42.000 hectare is farmed and that the dept of the organic layer has become very shallow. The major reason for the drastic reduction is that Denmark is quite flat with shallow organic layers, which combined with intensive utilisation has oxidized a major part of the organic matter.

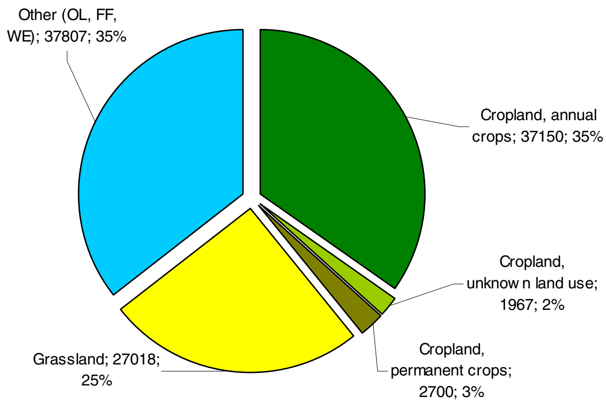


Figure 7.15 The distribution of organic soils on sectors. Figures are given in hectares and percentages.

One outcome is that during recent years more and more previously organic soils do not qualify to be organic by definition and that the area will decrease rapidly in future.

Emission factors for organic soils

An intensive research programme has been carried out to monitor the CO_2 emission on three organic soils in Denmark with annual crops in rotation and permanent fertilized grassland (Elsgaard et al. 2011, in prep). The overall result is shown in Table 7.25 compared with the IPCC default values. Maljanen et al. (2010) recently reviewed the GHG balance of managed organic peatlands in the Nordic countries. For areas with agricultural grasslands, the available studies suggested a net CO_2 emission of 4.9 ± 3.2 t C m^{-2} yr^{-1} (mean +/- standard deviation, n = 4). The available studies (n = 4) represented three Finnish and one Norwegian site (Lohila et al., 2004; Maljanen et al., 2001, 2004; Grønlund et al., 2008). The upscaled annual emission from the Danish declining C-stock is in line with these figures when taking into account the differences in temperatures. Considering that the IPCC temperate cold zone covers the major part of Europe the measured Danish values also seems to be in line with the IPCC guidelines. Emission from organic soils on permanent grassland is reported under Grassland (Table 5.C.1).

Table 7.25 Emission factors from organic soils, tonne C per ha per year.

	Cropland		Grassland	Uncertainty
	Annual crops and grass in rotation	Fertilised permanent grass	Permanent grass	
	8.7	5.17	1.25	90 %
IPCC, Cold temperate	5.0		1.25[a]	90 %
IPCC, Warm temperate	10.0		2.5	90 %

[a] There seems to be an error in the guidelines on the emission from grassland. It is assumed that the figure should be one forth of the emission from annual crops (5 t C per ha).

The dominating use of the organic soils is fertilised annual crops and grass in rotation.

As emission factor for N_2O the IPCC 2003 default value of 8 kg N_2O-N per ha per year is used. This emission is reported in the agricultural sector, 4D2.

To account for the loss of more than 150,000 hectares of agricultural soils since 1990, which are converted to settlements and afforestation, it is assumed that the share and use of the organic soils in 2010 is the same as back to 1990. As only a new soil map for 2010 exists all CO_2 emissions from organic soils are converted from other Land Use categories to Cropland reported under 5.B.1 and not under the respective land use conversion classes 5.B.2.1 to 5.B.2.5. The related N_2O emission is reported in the agricultural sector in Table 4.Ds1.

The total emission from the organic soils are given in Table 7.26.

Table 7.26 Emissions from organic soils 1990 to 2009.

Greenhouse gas source and sink categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Cropland, Gg C pr yr	-366,3	-365,6	-364,8	-364,0	-362,9	-361,9	-361,1	-360,3	-359,5	-358,5
Grassland, Gg C pr yr	-37,2	-37,0	-36,9	-36,6	-36,4	-36,2	-36,1	-35,9	-35,7	-35,8
Total organic soils	-403,5	-402,5	-401,6	-400,6	-399,3	-398,1	-397,2	-396,2	-395,2	-394,3

Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Cropland, Gg C pr yr	-357,6	-356,7	-355,9	-355,1	-354,3	-353,3	-352,4	-351,5	-350,5	-349,6
Grassland, Gg C pr yr	-35,5	-35,3	-35,0	-35,0	-34,8	-34,6	-34,4	-34,2	-34,1	-33,9
Total organic soils	-393,1	-392,0	-390,9	-390,1	-389,1	-387,9	-386,8	-385,7	-384,6	-383,5

Uncertainties and time-series consistency

A Tier 1 uncertainty analysis has been made for part of the LULUCF sector cf. Table 7.27. The uncertainty in the activity data for the agricultural sector is very low. The highest uncertainty is associated to the emission factors. Especially the emission/sink from mineral soils and organic soils has a high influence on the overall uncertainty.

The LULUCF sector contributes to a large extend to the total estimated uncertainty. In recognition of the difficulties in analyses of uncertainty, the estimated uptake of CO_2 in the forestry sector must be treated with caution.

Table 7.27 Tier 1 uncertainty analysis for Cropland for 2009.

		1990 Emission/sink, Gg CO_2-eqv.	2009 Emission/sink, Gg CO_2-eqv.	Activity data, %	Emission factor, %	Combined uncertainty	Total uncertainty, %	Uncertainty 95 %, Gg CO_2-eqv.
5.B Cropland		2580,1	1161,1				75,2	873,1
Living biomass	CO_2	174,0	75,7	10	50	51,0	51,0	38,6
Dead organic matter	CO_2	6,0	1,3	10	50	51,0	51,0	0,7
Mineral soils	CO_2	1053,6	-198,0	10	75	75,7	75,7	149,8
Organic soils	CO_2	1343,3	1281,7	10	90	90,6	90,6	1160,6

The time-series are complete.

QA/QC and verification

A general QA/QC plan is developed for cropland. The following Points of Measures (PM) are taken into account.

- Collection and error check on in-data.
- Control of sums.
- Comparison with other data.

The area estimates for cropland and grassland in 2010 are very precise due to unrestricted access to detailed data from EUs Integrated Administration and Control System (IACS) on agricultural crops on field level and the use of the vector based Land Parcel Information System (LPIS). This access includes both Statistics Denmark and NERI. The total uncertainty in the major crop data is estimated by Statistics Denmark to be <2 %. Together with detailed soil maps this gives a unique possibility to estimate the agricultural crops on different soil types and hence track changes in land use. However, IACS and LPIS are only available from

1998 and onwards, and estimates for 1990 are therefore more uncertain. The QA of crop data is made by Statistics Denmark.

Data on newly planted and removed hedgerows are based on subsidised hedgerows and QA is carried out by the Ministry of Food, Agriculture and Fisheries who is responsible for the administration of the subsidiaries. The uncertainty in the number of plants used for the hedgerows is not estimated but is assumed to be very low because of the subsidiary system.

There is an unknown uncertainty in the number of un-registered removal of hedgerows. A linear approach has therefore been made "missing" hedges over the years. Establishment of wetlands is based on vector maps received from every county in Denmark. The uncertainty is not estimated but assumed to be very low due to the subsidised system.

As shown in Figure 7.12 and 7.13 the loss estimated by C-TOOL seems very close to the results from >600 paired soil samples.

A range of experts from the Faculty of Agricultural Sciences, Aarhus University, are repeatedly involved in discussions and report writings on topics related to the inventory.

Recalculations, including changes made in response to the review process

Recalculations have been made for all emission estimates for Cropland.

The review in 2009 has recommended a sensitivity analysis of C-TOOL. This was presented during the in-country review in 2010. All other comments from the ERT has been reflected and incorporated in this submission.

Previously all three carbon pools were included in the carbon stock estimate for mineral soils. Based on an agreement with the ERT in 2010 only the emissions from the very slow acting HUM and ROM pools are included in the inventory and the FOM pool is assumed to be in transition state before it returns to the air. HUM an ROM pools represent 99 % of the carbon stock in the soil.

New area estimates for organic soils has been incorporated as well as national emission factors.

All changes have been implemented for all years.

Planned improvements

Further verification of the emission factors for organic soils will take place as well as the distribution between Cropland and Grassland back in time.

7.3.2 Land converted to cropland (5B2)

Agriculture covers more than 63 % of the total area giving a large impact on the environment. As a consequence there are many initiatives to transfer agricultural land into natural habitats and forest, and the continuous development of infrastructure demands more land. Land converted to cropland is not very common. The land use matrix showed that

10,238 hectares were converted from 1990 to 2009. A major part is GL converted to CL. A small area seems to be converted from SE to CL. As this seems unlikely a thoroughly quality control will be performed before the next submission.

Approaches used for representing land

The area converted from Other land use to Cropland is based on remote sensing of the Danish area in 1990 and 2005 combined with data in LPIS on which crops are grown in each field. If the land use in a particular pixel is an annual crop or other cropland species the conversion is recorded as a conversion to Cropland.

Methodological issues

Change in carbon stock in living biomass

For land converted to cropland a standard default gain value of 9,577 kg DM (dry matter) per hectare in above-ground biomass and 2,298 kg DM per hectare in below-ground biomass is used. This value is equivalent to the average harvest of living biomass for all cereals grown in Denmark from 2000 to 2009, including straw, stubble and glumes. For conversion from DM to carbon a default fraction of 0.5 kg C per kg DM is used.

For conversion from cropland to other land use categories the same value is used but recorded as a loss of carbon in the respective category (5A2, 5C2, 5D2 and 5E2).

The loss in living biomass for conversion from another land use category into CL is estimated as the default value for DM in that particular land use category. I.e. for deforestated areas the average C-stock per hectare for all deforestated areas is used.

Change in carbon stock in dead organic matter

When forest land is converted to cropland it is assumed that all dead organic matter will have an instant oxidation. The actual amount depends on which type of forest is converted.

Conversion from other categories is assumed as NO as no dead organic matter is reported for these categories.

Change in carbon stock in soils

The actual amount depends on which type of land it is converted from, see Table 7.19. To reach the new equilibrium state is used a default transition period of 50 years. The default IPCC-value of 20 years seems according to Danish investigations not to be applicable for Danish conditions.

Uncertainties and time-series consistency

The time-series are complete.

See uncertainties and time-series consistency in Section 7.3.1.

QA/QC and verification

See QA/QC and verification in Section 7.3.

Recalculation

See recalculation in Section 7.3.

Planned improvements

See planned improvements in Section 7.3.

7.4 Grassland (5C)

7.4.1 Grassland remaining grassland (5C1)

Denmark is an intensive agricultural country with many small holders and small fields where CL and GL are mixed together making it difficult to distinguish between dedicated CL and dedicated GL. According to the Danish Land Parcel Information System (LPIS) there are approx. 63,000 fields of total 189,721 ha with permanent GL in 2008 giving an average size of three ha. Some of them cannot bee seen as permanent GL and are therefore included in CL.

Grassland area

The total area with grassland has been estimating the Land Use matrix. In 1990 it was estimated to 117,000 ha increasing to 163,000 ha in 2009. This increase is mainly due to the fact that CL is turned into GL.

Grassland definition

The Danish definition of grassland is common grazing land according to the LPIS, heath land, which may or may not are used for sheep grazing as well as all other areas not meeting the definitions of forest land.

GL is defined as grassland in the LPIS reported as permanent and receiving zero or <25 kg N per ha per yr and land reported as grassland from the EO investigation as well as some heath land.

The grazing land area is sub-divided into strict “Grazing land” and “Other grassland”. Grazing land is areas where cattle and sheep are fenced (often common grassland) and only a small grass sword is available. The area with “grazing land” is limited to approx. individual 340 fields. In total common grazing land were 7,300 hectares in 2009. These areas are primarily located on islands and other low laying and remote areas. These areas do not have any wooden vegetation.

Other grassland includes heath land and other areas, e.g. scrub land, which may be grazed by cattle and sheep or land which is kept open for recreational purposes. “Other Grassland” may contain bushes and other wooden plants, which do not meet the thresholds for forest. This is land where the crown cover is below 10 % and where the height at maturity do not reach 5 meter.

Methodological issues for grassland

The area for grazing land is the area in the LPIS and the rest of the Grassland is the residual part of the grassland area.

Change in carbon stock in living biomass

No changes in living biomass are assumed for GL remaining GL except for a minor conversion between “Grazing land” and “Other grassland”.

Change in carbon stock in dead organic matter

No changes in dead organic matter are estimated as this is not occurring for this category.

Change in carbon stock in soils

No changes in the carbon stock in mineral soils are assumed. For organic soils the default IPCC 2003 EF of 1,250 kg C per ha per year is used (there is a likely error in the guidelines as the value is given as 0.25 kg C per ha per year).

Uncertainties and time-series consistency

Table 7.28 Tier 1 uncertainty analysis for Grassland for 2009.

		1990 Emission/sink, Gg CO_2-eqv.	2008 Emission/sink, Gg CO_2-eqv.	Activity data, %	Emission factor, %	Combined uncertainty	Total uncertainty, %	Uncertainty 95 %, Gg CO_2-eqv.
5.C.Grassland		474,3	199,2				63,7	126,9
Living biomass	CO_2	304,4	34,9	10	50	51,0	51,0	17,8
Dead organic matter	CO_2	31,7	2,6	10	50	51,0	51,0	1,3
Mineral soils	CO_2	1,0	24,4	10	75	75,7	75,7	18,5

The time-series are complete.

QA/QC and verification

See QA/QC and verification in Section 7.3.1.

Recalculations

Small changes in the area matrix have been made and the new soil map of the organic soils has been implemented in combination with a new emission factor for organic soils.

Planned improvements

None.

7.4.2 Land converted to grassland (5C2)

As agriculture covers more than 63 % and in order to reduce the environmental impact there is a strategy for turning CL into GL and where deforestation takes place it is often turned into GL.

Approaches used for representing land

The area converted from other land use to GL is based on remote sensing of the Danish area in 1990 and 2005 combined with data in LPIS on which crops are grown in each field.

Methodological issues

Change in carbon stock in living biomass

For land converted to "grazing land" a standard default gain value of 2,400 kg DM (dry matter) per hectare in above-ground biomass (IPCC 2006, Table 6.4) and 6,720 kg DM per hectare in below-ground biomass (IPCC 2006, Table 6.1) is used. For "Other grassland" not purely free of wooden trees/bushes it is assumed that there is a living biomass of 2,200 kg DM per ha in above ground biomass and 6,160 kg DM per ha in below ground biomass (R:S-factor of 2.8, IPCC 2003 default guideline). For conversion from DM to C a default fraction of fraction of 0.5 kg C per kg DM is used.

For conversion from grassland to other land use categories the same value is used, but recorded as a loss of carbon in the respective category (5A2, 5B2, 5D2 and 5E2).

Change in carbon stock in dead organic matter
When forest land is converted to GL it is assumed that all dead organic matter will be cleared. The actual amount depends on which type of forest is converted.

Conversion from other categories is assumed as NA as no dead organic matter is reported for this category.

Change in carbon stock in soils
The actual amount depends on which type of land it is converted from, see Table 7.19. To reach the new equilibrium state a default transition period of 50 years is used. The default IPCC-value of 20 years seems according to Danish investigations not to be applicable for Danish conditions.

Uncertainties and time-series consistency
See Section 7.3.1.

7.5 Wetlands (5D)

Wetland includes:

- unmanaged fully water covered wetlands (lakes and rivers),
- unmanaged partly water covered wetlands (fens and bogs),
- managed water reservoirs (currently not occurring in Denmark),
- managed drained land for peat extraction,
- managed partly water covered wetlands (re-established wetlands on primarily former cropland and grassland).

7.5.1 Wetlands remaining wetlands – peat extraction (5D1)

Until a more thoroughly QA/QC of the EO and other data sources has been performed WE remaining WE consists only of land for peat extraction. Due to environmental concerns the area used for peat extraction has been reduced since 1990 and no new peat excavations licences has been issued.

Wetland area
The total area with peat extraction is about 300 hectares open surface (Lykke Larsen, Pindstrup Mosebrug, personal comm.). Based on aerial photos it is etimated that 1 596 hectares are land connected to the peat extraction areas.

Approaches used for representing land areas
The area for wetlands remaining wetlands is a vector map layer made by NERI based on aerial photos of the four excavation sites (Figure 7.16). The actual three locations are Fuglsø mose on Djursland, Lille Vildmose

and Store Vildmose – both in Northern Jutland. All four sites are nutrient poor raised bogs.

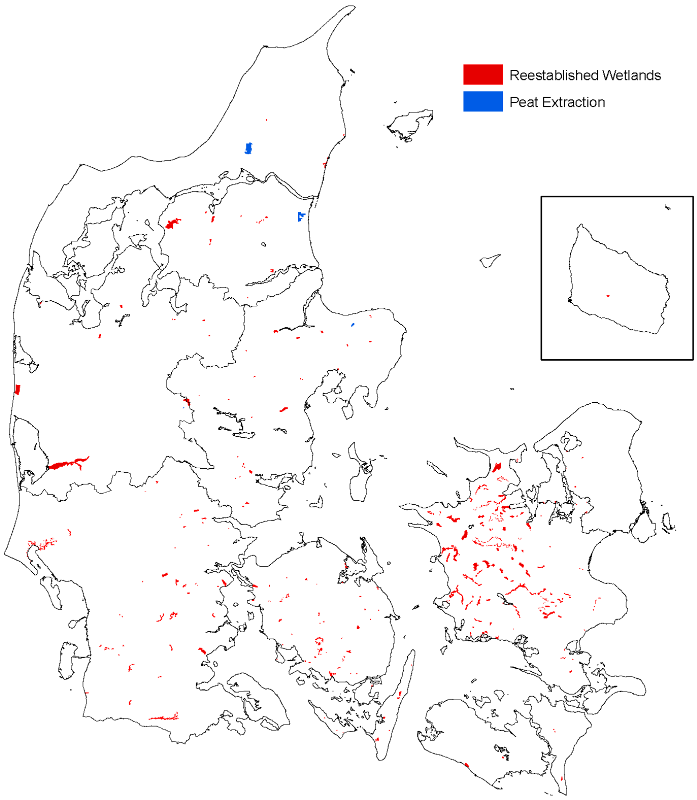


Figure 7.13 Areas with established wetlands, increased water tables and peat extraction in 2008.

Methodological issues for peat land

Change in carbon stock in living biomass

No living biomass is occurring on the peat extraction sites.

Change in carbon stock in dead organic matter

Dead organic matter is not occurring.

Change in carbon stock in soils

The surface emission from the open area is calculated according Tier 1 (IPCC, 2003) for nutrient poor areas with an emission factor of 0.5 tonnes C per hectare land with peat extraction per year.

The amount of excavated peat (m^3 per year) is for each individual extraction site reported to and published by Statistics Denmark (www.dst.dk, Table RST). The total amount of peat excavated has since 1990 been reduced from 399,000 m^3 to 211,000 m^3 in 2009. For conversion to C is used a density factor of 200 kg per m^3 (personal comm. with Pindstrup Mosebrug, www.pindstrup.dk) who is responsible for the major part of the extraction sites, a DM content of 0.5, an ash content of 0.02 (www.pdir.dk) and a C-content of 0.58 kg C per kg OM.

Nitrous oxide emission

The nitrous oxide emission from peat land is estimated from the total N-turnover multiplied with the default IPCC emission factor of 1.25 %. The C:N-ration in the peat is estimated to 36 in an analysis from the Danish Plant Directorate (www.pdir.dk). Hence the N_2O emission is estimated to 0.546 kg N_2O per tonnes C. Only nitrogen in the degradation of the surface is accounted for in the inventory. N_2O from N in the excavated peat is not estimated.

Uncertainties and time-series consistency

Table 7.29 Tier 1 uncertainty analysis for WE remaining WEs and re-established WE for 2008.

		1990 Emission /sink, Gg CO_2-eqv.	2008 Emission /sink, Gg CO_2-eqv.	Activity data, %	Emission factor, %	Combined uncertainty	Total uncertainty, %	Uncertainty 95 %, Gg CO_2-eqv.
5.D Wetlands		86,7	5,1				63,4	3,2
Living biomass	CO_2	0,4	-11,3	20	50	53,9	53,9	6,1
Dead organic matter	CO_2	0,1	0,1	20	100	102,0	102,0	0,1
Soils	CO_2	86,1	16,2	20	100	102,0	102,0	16,5
Land for peat extraction	N_2O	0,1	0,1	50	100	111,8	111,8	0,2

The time-series are complete.

QA/QC and verification

The peat excavation area has been verified with aerial photos and the amount of excavated peat is made by Statistics Denmark.

Recalculation

None.

Category-specific planned improvements

No improvements are planned.

7.5.2 Land converted to wetland (5D2)

In order to restore nature and reduce the environmental impact Denmark has actively re-established WE (Figure 7.16). The size of each restoration project range from less than 1 ha up to 2,500 ha. The benefit of the restoration programme is more nature but also a reduction in leaching of nitrogen into lakes, rivers and coastal water. The establishment of WE takes place either as large areas turned into lakes or low laying fens.

Since 1990 16,707 ha has been established. These are partly on land classified as OL, but also conversion on CL and GL are frequent. A major part is restored as a part of the Danish Action Plan for the Aquatic Environment part two (VMP II, running from 1997 to 2006) where land was bought for this purpose. It is accounted for that the establishment often takes place in connection to existing wetlands.

Water reservoirs for human purposes have not been established for the last 100 years and therefore currently reported as NO.

Approaches used for representing land areas

Geographical vector layers are available for almost all established WE.

Methodological issues

Change in carbon stock in living biomass

For land converted to partly covered wetland a standard default gain value of 4,000 kg DM (dry matter) per hectare in above-ground biomass and 1,200 kg DM per hectare in below-ground biomass is used. For conversion from DM to C a default fraction of 0.5 kg C per kg DM is used.

For conversion from wetland to other land use categories the same value but recorded as a loss of carbon in the respective category (5A2, 5B2, 5C2 and 5E2) are used.

Change in carbon stock in dead organic matter

When forest land is converted to wetland it is assumed that all dead organic matter will be cleared. The actual amount depends on which type of forest is converted.

Conversion from other categories is assumed as NA as no dead organic matter is reported for this category.

Change in carbon stock in soils

A default C sequestration of 0.5 tonnes C per hectare is assumed for land converted to WE.

Nitrous oxide emission

No estimates for the N_2O emission from re-established wetlands have been made.

Methane emission

CH_4 emissions are not estimated due to lack of methodology.

Uncertainties and time-series consistency

The time-series are complete.

QA/QC and verification

No verification has been made yet.

Recalculation

A recalculation has been made due to new area data on the established WE has been obtained.

Planned improvements

A full WE map for the entire Denmark is planned where the area is subdivided into fully water covered and partly water covered areas for both WE remaining WE and land converted to WE. A literature study for updated values for living biomass as well as for an eventual gain in soil carbon for WE will be made and incorporated in the next submission.

7.6 Settlements (5E)

The annual changes in C-stock in settlements are assumed to be negligible, and because no estimates have been made, most changes are reported as NE in the CRF Table 5.E. For reporting purposes for land use conversions a default biomass in low buildings, grave yards is established.

7.6.1 Settlements remaining Settlement (5E1)

Settlement area

The total area with SE has been estimated to 385,447 hectares in 1990 increasing to 451,464 hectares in 2009 or approx. 10 % of the total Danish area.

Settlement definition

Settlements are defined as all areas with infrastructures, roads, grave yards, sport facilities etc.

Methodological issues

Change in carbon stock in living biomass

No changes in carbon stocks are reported for SE remaining SE.

Change in carbon stock in dead organic matter

No changes in carbon stocks are reported for SE remaining SE.

Change in carbon stock in soils

No changes in carbon stock in soils are assumed.

Uncertainties and time-series consistency

Table 7.30 Tier 1 uncertainty analysis for Settlements for 2009.

		1990	2009					
		Emission/sink, Gg CO_2-eqv.	Emission/sink, Gg CO_2-eqv.	Activity data, %	Emission factor, %	Combined uncertainty	Total uncertainty, %	Uncertainty 95 %, Gg CO_2-eqv.
5.E Settlements		89,5	54,7				77,6	42,5
Living biomass	CO_2	89,5	54,7	20	75	77,6	77,6	42,5

The time-series are complete.

QA/QC and verification

No QA/QC has been performed.

Recalculations

A recalculation of the area has been made due to a QA/QC analysis.

Planned improvements

None.

7.6.2 Land converted to Settlement (5E2)

Land converted to SE is mostly taking place around the big cities and primarily on cropland.

Settlement area

The area converted from other land use to SE is based on remote sensing of the Danish area in 1990 and 2005 combined with the cadastral maps and road vector maps. From 2005 and onwards the development in the number of houses and other buildings in the cadastral maps is used.

Methodological issues

Change in carbon stock in living biomass

For land converted to single-family houses a standard default gain value of 2,200 kg DM (dry matter) per hectare in above-ground biomass and 2,200 kg DM per hectare in below-ground biomass is used. For conversion from DM to C a default fraction of 0.5 kg C per kg DM is used.

For conversion from settlements to other land use categories the same value is used, but recorded as a loss of carbon in the respective category (5A2, 5B2, 5C2 and 5D2).

Change in carbon stock in dead organic matter

When forest land is converted to settlements it is assumed that all dead organic matter will be cleared. The actual amount depends on which type of forest is converted.

Conversion from other categories is assumed as NA as no dead organic matter is reported for these categories.

Change in carbon stock in soils

No changes in carbon stock in soil are assumed.

Uncertainties and time-series consistency

See uncertainties and time-series consistency in Section 7.6.1

The time-series are complete.

QA/QC and verification

No QA/QC has been performed.

Category-specific recalculations

A recalculation has been performed due to QA/QC of the remote sensing.

Planned improvements

No improvements are planned.

7.7 Other land

No permanent snow cover exists in Denmark and only a very small insignificant area with rocks and cliffs. OL is restricted to beaches and sand dunes. The official land area is 43 098 km^2. This area includes rivers and lakes.

No land use changes from 5A, 5B, 5C, 5D and 5E is reported. The total area with OL is reported to 342,685 hectares in 1990 decreasing to 306,697 hectares in 2009.

7.8 Direct N_2O emissions from N fertilization of Forest Land and Other land use – 5(I)

Only a very small amount of nitrogen fertilisers are used in the Danish forests and primarily to Christmas trees. All emissions are reported under Agriculture Table 4.Ds1 since there is only one common national statistics for N fertilization in agriculture and forestry.

7.9 Non-CO_2 emissions from drainage of forest soils and wetlands – 5(II)

A large proportion of the Danish forest area may be considered as drained in the sense that the natural hydrology has been modified by establishment of ditches. Large forest areas have been drained in order to enable establishment of Norway spruce in depressions, fens and pond areas. As an example, a major state forest Gribskov in Northern Zealand by 1850 had an estimated wetland area 400% larger than that of 1988 (http://www.skovognatur.dk/Ud/Beskrivelser/Hovedstaden/Gribskov/VandetTilbage.htm). During the recent years, there has been an effort to restore wetland habitat in the state forests and several drained areas have been restored by filling up ditches, and in many areas of the state forests ditches are no longer maintained and will be gradually more and more ineffective over time.

Very few data exist for N_2O emissions in Danish forests. A national project and EU projects have provided data for hydrological gradients in mini-catchments in an old-growth forest and an afforestation area (Christiansen et al., in prep.) and data for one intensively studied beech forest plot (Skiba et al., 2009). For general application at the national level, tier 1 methods will be applied based on default emission factors (IPCC GPG). Emission factors will be compared with the few examples of emission factors data from national projects.

7.9.1 Methodological issues

Equation 3a.2.1 of IPCC GPG was used for estimation of direct N_2O emissions from drained forest soils (tier 1).

Default emission factors (IPCC GPG, Table 3a.2.1) were used for calculation of N_2O emissions. Danish organic soils were considered to be "Nutrient Rich" based on the general presence of fens (minerotrophic peat) and the relatively high N deposition to Danish forests. Rewetted forest soils were assumed to have an N_2O emission corresponding to the natural level and emissions were therefore by default set to zero in accordance with IPCC GPG.

7.9.2 Areas of drained forest soils

Based on expert judgement, the area of drained forest soils were 65 % of mineral forest soils and 75 % of organic forest soils in 1990. It is further judged that the amount of drained forest soils have decreased in the period until 2008 resulting in an area of drained forest soils with 55 % of mineral forest soils and 50 % of organic forest soils. Organic soils constituted 5 % of the forest area based on information on presence of peat from the NFI. A more detailed analysis of forest soils including a mapping is under preparation and will be utilised for the next reporting.

7.9.3 Emissions of N_2O from drained forest soils

Estimates of N_2O emissions (Gg N_2O per year) from drained forest soils in 1990 and 2008 are based on the IPCC 2003 values. This means that for mineral soils is 0,06 kg N_2O-N per ha per year and for organic soils 0,6 kg N_2O-N per ha per year.

Emission factors are generally in reasonable accordance with those obtained in national projects. In mini-catchments Christiansen et al. (in prep.) found average annual emissions of 0.56±1.1 kg N_2O-N per ha per year for an afforested stand (30 years) and of 0.78±4.2 kg N_2O-N per ha per year for an old-growth forest. Both sites included hydrological gradients from wet/moist to well-drained conditions. For a well-drained Danish beech forest site, Skiba et al. (2009) reported average annual emissions of 0.45±0.48 kg N_2O-N per ha per year.

7.10 N_2O emissions from disturbance associated with land-use conversion to cropland – 5(III)

The main land-use conversion involving deforestation is the conversion from forest to grassland. This land-use change is expected to be a source for N_2O emissions due to the decomposition of forest floors and corresponding increased mineralization of N. It is assumed that forest floors are completely decomposed during the conversion. Emissions of N_2O are based on default emission factors (IPCC, 2003).

7.10.1 Methodological issues

For all deforestated areas it is assumed that the forest floor disappears regardless if the land use conversion is into CL, GL, WE or SE. This is in contradiction to the guidelines and Table 5(III), which is only related to disturbance associated with land-use conversion to CL.

Emissions of N_2O from deforestation were assumed to originate only from mineralization of forest floors since SOC-stocks in mineral soils are assumed constant following land-use change from forestry to grassland. The average nitrogen content of forest floors based on the repeated soil inventory was used to estimate the N mineralized for confers and broadleaves, respectively. A proportion of 1.25 % of the N stock mineralized is assumed to be emitted as N_2O-N.

7.10.2 Emissions of N_2O from deforestation and land-use conversion

The average N content of broadleaf and conifer forest floors for Danish forest plots are given in Table 7.31 together with the estimated N fraction emitted as N_2O. According to IPCC (2003), a default fraction of 1.25 % is assumed emitted as N_2O-N during mineralization of the total N content following conversion.

Table 7.31 Total N content of forest floors in Denmark from the systematic grid "Kvadratnettet". The total N content is used for estimation of the amount of N (1.25%) emitted as N_2O during mineralization of the total forest floor N content following land-use change from forest to grassland.

Tree species	Number of plots	Mean N content (kg ha^{-1})	Standard dev. (kg ha^{-1})	Min N content (kg ha^{-1})	Max N content (kg ha^{-1})	N_2O-N, (kg ha^{-1})
Broadleaves	48	359	310	42	1472	4.5
Conifers	60	728	637	20	3447	9.1

In 1990, emissions of N_2O from deforestation were estimated at 0.0098 Gg N_2O for mineral soils and 0.0005 Gg N_2O for organic soils. In 2009 the figures were 0.0013 and 0.0001 Gg N_2O for mineral and organic soils, respectively.

7.11 CO_2 emissions from agricultural lime application – 5(IV)

Liming of agricultural soils has taken place for many years. Only a very little amount of lime is applied in forests (<0.5 %) and on permanent grassland. Therefore all liming is included in the inventory under cropland (Table 5(IV)).

The Danish Agricultural Advisory Centre (DAAC) has published the lime consumption for agricultural purposes annually since 1960 (Table 7.32). DAAC are collecting data from all producers and importers. By legislation all producers and importers are obligated to have their products analysed for acid neutralisation content. The analysis is carried out by the Danish Plant Directorate and published annually (PDIR 2004). The published data from DAAC are corrected for acid neutralisation contents for each product and thus given in pure $CaCO_3$. For that reason there is no need to differ between lime and dolomite as made in the guidelines, as this has already been included in the background data. The data from DAAC includes all different products used in agriculture, including e.g. $CaCO_3$ from the sugar refineries.

The amount of lime used in private gardens has been estimated from the main supplier to private gardens. According to the company (Kongerslev Havekalk A/S, pers. comm.) they are responsible for 80 % of the sale to private gardens. Their sales figures have been used to estimate the total consumption in private gardens. Furthermore, the figures are corrected for acid neutralisation capacity according to the data from the Danish Plant Directorate. This gives an approximate amount of 2,300 tonnes $CaCO_3$ per year in private gardens. This figure has been used for all years.

A very small consumption of CAN (Calcium Ammonium Nitrate) and Urea is taking place in Denmark. The amount of CO_2 included in these two fertilisers are included in the lime consumption. Data is taken from the annual fertiliser statistics published by Statistics Denmark.

The amount of lime used for agricultural purposes has declined with 70 % since 1990. From 2000 to 2009 the consumption has been very stable around 500 Gg $CaCO_3$ although the sold amount of lime in 2009 fell to 412 Gg $CaCO_3$. 500 Gg is expected to be the lowest consumption needed to maintain appropriate pH values in the Danish agricultural soils at the moment. The main reason for the reduced lime consumption is a decreased need for acid neutralisation due to less SO_X deposition in Denmark (which also can be seen in the Norwegian inventory) and a reduced consumption of fertilisers containing ammonium. The inter-annual variation is primarily due to weather conditions (if it is possible to drive in the fields) and the economy in agriculture.

The amount of C is calculated according to the guidelines where the carbon content is 12/100 of the $CaCO_3$. It is assumed that all C disappear as CO_2 the same year as the lime is applied.

Table 7.32 Lime and CAN application to cropland and grassland and in forests, 1988-2009.

Greenhouse gas source and sink categories	1990	1991	1992	1995	2000	2005	2008	2009
Agriculture, Gg $CaCO_3$	1283	1049	810	1125	590	497	518	410
Private gardens, Gg $CaCO_3$	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3
Total, Gg $CaCO_3$	1417	1184	946	1277	682	504	525	424
Total, Gg C pr yr	623	521	416	562	300	221	231	186

Table 7.33 Tier 1 uncertainty analysis for Liming for 2009.

		1990 Emission/sink, Gg CO_2-eqv.	2008 Emission/sink, Gg CO_2-eqv.	Activity data, %	Emission factor, %	Combined uncertainty	Total uncertainty, %	Uncertainty 95 %, Gg CO_2-eqv.
5(IV) Liming	CO_2	622,9	186,2	5	50	50,2	50,2	93,6

The time-series is complete.

The collected data is assumed to be very reliable. It is assumed that the uncertainty is in the range of 10 %. The emission factor may be overestimated due to expected leaching of CO_3^{--}, however no data is available on this issue.

7.12 Biomass burning – 5(V)

Controlled burning of wooden biomass is only taking place to very small and insignificant amounts and hence not reported.

No estimates for wild fires are reported. Due to the cold and wet conditions in Denmark are there only sporadic and small wild fires in the summer accounting for less than 2-10 hectares per year.

References

Breuning-Madsen, H. & Olsson, M. 1995: Jordbundsundersøgelser i EU's Kvadratnet for monitering af skovsundhed, Danmark. Rapport, Geografisk Institut, Københavns Universitet, 15 s + 8 bilag.

Grønlund, A., Hauge, A., Hovde, A., and Rasse, D.P. (2008). Carbon loss estimates from cultivated peat soils in Norway: a comparison of three methods, Nutr. Cy. Agroecos., 81, 157–167.

Gundersen, P. 1998: Effects of enhanced nitrogen deposition in a spruce forest at Klosterhede, Denmark, examined by moderate NH4NO3 addition. For. Ecol. Manage. 101, 251-268.

Johannsen, V.K. 2002: Selection of diameter-height curves for even-aged oak stands in Denmark. Dynamic growth models for Danish forest tree species, Working paper 16, Danish Forest and Landscape Research Institute, Hørsholm, Denmark. 70 p.

Larsen, P.H. & Johannsen, V.K. (eds.) 2002: Skove og plantager 2000. Danmarks Statistik, Skov & Landskab og Skov- og Naturstyrelsen. 171 p. ISBN: 87-501-1287-2.

Lohila, A., Aurela, M., Tuovinen, J.-P., and Laurila, T. (2004). Annual CO2 exchange of a peat field growing spring barley or perennial forage, J. Geophys. Res., 109, D18116, doi:10.1029/2004JD004715.

Madsen, S.F. 1987: Vedmassefunktioner for nogle vigtige danske skovtræarter. Det Forstlige Forsøgsvæsen 40, 47-242.

Madsen, S.F. 1987: Vedmassefunktioner for nogle vigtige danske skovtræarter. Det Forstlige Forsøgsvæsen 40, 47-242.

Madsen, S.F. & Heusèrr, M. 1993: Volume and stem taper functions for Norway spruce. Forest and Landscape Research 1, 51–78.

Maljanen, M., Martikainen, P. J., Walden, J., and Silvola, J. (2001). CO2 exchange in an organic field growing barley or grass in eastern Finland, Global Change Biol., 7, 679–692.

Maljanen, M., Komulainen, V.-M., Hytönen, J., Martikainen, P.J., and Laine, J. (2004). Carbon dioxide, nitrous oxide and methane dynamics in boreal organic agricultural soils with different soil management, Soil Biol. Biochem., 36, 1801–1808.

Maljanen, M., Sigurdsson, B.D., Guđmundsson, J., Óskarsson, H., Huttunen, J.T. and Martikainen, P.J. (2010). Greenhouse gas balances of managed peatlands in the Nordic countries – present knowledge and gaps. Biogeosciences 7, 2711-2738.

Moltesen, P. 1985: Skovtræernes ved og anvendelse. Skovteknisk Institut, Frederiksberg. 132 p.

Nord-Larsen, T., Johannsen, V.K., Bastrup-Birk, A & Jørgensen, B.B. (eds.) 2008: Skove og plantager 2006. Skov og Landskab and Skov- og Naturstyrelsen, Hørsholm. 185 p. ISBN: 978-87-7903-368-9.

Petersen, B.M. 2010: Available at: www.agrsci.dk/c-tool

Prins, E. 2009: Prins Engineering: Available at: http://www.prinsengineering.com

Skovsgaard. J.P. & Bald, C. 2010: Biomass functions for Norway spruce in Denmark. (in prep.).

Skovsgaard, J.P. & Nord-Larsen, 2010: Biomass and expansion functions for beech in Denmark. (in prep.).

Sloboda, B., Gaffrey, D. & Matsumura, N. 1993: Regionale und lokale Systeme von Höhenkurven für gleichaltrige Waldbestände. Allg. Forst- u. J. Ztg. 164, 225-228.

Vejre, H., Callesen, I., Vesterdal, L. & Raulund-Rasmussen, K. 2003: Carbon and Nitrogen in Danish forest soils – Contents and distribution determined by soil order. Soil Science Society of America Journal 67: 335-343.

Vesterdal, L. & Raulund-Rasmussen, K. 1998: Forest floor chemistry under seven tree species along a soil fertility gradient. Canadian Journal of Forest Research 28: 1636-1647.

Vesterdal, L., Dalsgaard, M., Felby, C., Raulund-Rasmussen, K. & Jørgensen, B.B. 1995: Effects of thinning and soil properties on accumulation of carbon, nitrogen and phosphorus in the forest floor of Norway spruce stands. Forest Ecology and Management 77: 1-10.

Vesterdal, L., Ritter, E. & Gundersen, P. 2002a: Change in soil organic carbon following afforestation of former arable land. Forest Ecology and Management 169: 141-151.

Vesterdal, L., Jørgensen, F.V., Callesen, I., Raulund-Rasmussen, K. 2002b: Skovjordes kulstoflager - sammenligning med agerjorde og indflydelse af intensiveret biomasseudnyttelse. In: Christensen, B.T. (ed.), Biomasse til energiformål - konsekvenser for jordens kulstofbalance i land- og skovbrug. DJF rapport Markbrug nr. 72.

Vesterdal L., Rosenqvist, L., van der Salm, C., Hansen, K., Groenenberg B.-J. & Johansson, M.-B. 2007: Carbon sequestration in soil and biomass following afforestation: experiences from oak and Norway spruce chronosequences in Denmark, Sweden and the Netherlands. In: Heil G., B. Muys and K. Hansen. Environmental Effects of Afforestation in North-Western Europe - From Field Observations to Decision Support. Springer, Plant and Vegetation 1: 19-52.

Vesterdal, L., Schmidt, I.K., Callesen, I., Nilsson, L.O. & Gundersen, P. 2008: Carbon and nitrogen in forest floor and mineral soil under six common European tree species. For. Ecol. Manage. 255: 35-48.

8 Waste (CRF sector 6)

8.1 Overview of the sector

The waste sector consists of the CRF source category 6.A Solid Waste Disposal on Land, 6.B. Wastewater Handling, 6.C. Waste Incineration and 6.D. Waste Other.

For the CRF category 6.A. Solid Waste Disposal on Land, the CH_4 emissions reported in this chapter is a result of calculations in continuation of previously used and reported methodology. Analysis and investigations have been initiated as a result of the 2010 in-country review.

For the CRF category 6.B. Wastewater Handling, improvements to the CH_4 methodology as well as N_2O emissions have been performed and implemented. Improvement to the methodology for reporting the methane emissions for Denmark have been implemented and is presented in this chapter. Smaller corrections to the national N_2O emission factor have occurred. The chapter presents improved QA/QC procedures and recalculations reflecting the recommended improvement as results of the 2010 in-country review.

For the CRF source category 6.C. Waste Incineration, the main emissions are included in the energy sector since the vast majority of waste incinerated in Denmark is used in the energy production. The Waste Incineration category includes non-biogenic CO_2, CH_4 and N_2O emissions from the minor sources of cremation of corpses and carcasses.

The source sector 6.D. Waste Other covers emissions from combustion of biogas in biogas production plants (mentioned as Gasification of biogas in the CRF tables) for the years 1994-2005 where these emissions existed. Emissions from this activity are not occurring in 2006 - 2009. The Waste Other category also includes calculations of CO_2, CH_4 and N_2O emissions from the sources of accidental building and vehicle fires and compost production. Emissions from compost production are new in this year's submission

In Table 8.1.1, an overview of all the emissions is presented. The emissions are taken from the CRF tables and are presented as rounded figures.

Table 8.1.1 Emissions for the waste sector, Gg CO_2 equivalents.

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
6 A. Solid Waste Disposal on Land	CH_4	1111	1138	1153	1171	1138	1104	1103	1057	1023	1059
6 B. Wastewater Handling	CH_4	66	66	67	67	68	69	70	72	72	71
6 B. Wastewater Handling	N_2O	109	107	95	113	120	115	98	92	95	92
6 C. Waste incineration	CH_4	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
6 C. Waste incineration	N_2O	0.20	0.20	0.20	0.21	0.21	0.21	0.21	0.21	0.21	0.22
6 D Other	CO_2	22	23	24	22	23	25	26	25	23	25
6 D Other	CH_4	29	32	35	37	40	37	44	50	51	60
6 D Other	N_2O	11	12	14	15	16	15	18	21	25	34
6. Waste	Total	1349	1379	1387	1426	1406	1366	1359	1316	1289	1341
Continued		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
6 A. Solid Waste Disposal on Land	CH_4	1069	1088	1053	1097	1017	1019	1080	1064	1057	1039
6 B. Wastewater Handling	CH_4	74	74	72	74	73	74	74	74	74	75
6 B. Wastewater Handling	N_2O	99	93	108	86	83	94	81	93	111	81
6 C. Waste incineration	CH_4	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
6 C. Waste incineration	N_2O	0.22	0.22	0.23	0.22	0.23	0.24	0.27	0.28	0.28	0.29
6 D Other	CO_2	24	24	24	25	23	24	25	26	28	28
6 D Other	CH_4	63	65	64	66	63	68	72	80	73	81
6 D Other	N_2O	41	41	50	50	30	31	34	39	36	40
6. Waste	Total	1370	1385	1371	1399	1289	1310	1366	1376	1381	1344

6.A. Solid Waste Disposal on Land is the dominant source in the sector with contributions in the time-series varying from 76.5 % (2008) to 83.1 % (1992) of the total emission, given in CO_2 equivalents, originating from the waste sector. The contribution in 2009 is 77.3 %. Throughout the time-series, the emissions are decreasing due to a reduction in the amount of waste deposited. Comparing 1990 and 2009 the decrease is 6.4 %.

6.B. Wastewater Handling. For this source, N_2O contributes the most to the sectoral total, varying between contributions of 5.9 % (2006) and 8.5 % (1994). In 2009 the contribution is 6.0 %. CH_4 from this source contributes with between 4.7 % (1993) and 5.7 % (2004) of the sectoral total. In 2009 the contribution is 5.6 %. The CH_4 emissions increase steadily over the time-series, the emission in 2009 is 12.7 % higher than in 1990.

6.C. Waste Incineration. This source contributes with CH_4 and N_2O emissions from human and animal cremations. The contribution to CO_2-eqv. emissions from the sum of CH_4 and N_2O is for the time-series 1990-2009 below 0.03 %. The trend for the total emissions 1990 - 2009 from this source is increasing; compared to 1990 the 2009 emission is 45.5 % higher. This increase is almost entirely caused by the increase in animal cremation as this activity has risen with 793 % from 1990 to 2009.

6.D. Waste Other. This source contributes with CO_2, CH_4 and N_2O emissions from accidental fires and compost production. The contribution to the time-series 1990-2009 has increased from 4.6 % (1990) to 11.1 % (2009). Throughout the time-series 1990-2009, this category increases with 138.2 %.

As a result for the entire waste sector, the sectoral total emission in CO_2 equivalents, Table 8.1.1, is fluctuating but more or less constant throughout the time-series, the emission in 2009 compared to 1990 has decreased 0.4 %.

8.2 Solid Waste Disposal on Land (CRF Source Category 6A)

For many years, only managed waste disposal sites have existed in Denmark. Unmanaged and illegal disposal of waste is considered to play a negligible role in the context of this category. The amount of deposited waste has decreased markedly throughout the time-series. The increase in waste deposited from 2005-2007 levels to 2008 is due solely to an increase in Ash and Slag deposited (cf. Table 8.2.2). The general development for solid waste is a result of action plans by the Danish government called the "Action plan for Waste and Recycling 1993-1997" and "Waste 21 1998-2004" (The Danish Government 1999). The latter plan had, inter alia, the goal to recycle 64 %, incinerate 24 % and deposit 12 % of all waste. The goal for deposited waste was met in 2000. Further, in 1996 a municipal obligation to assign combustible waste to incineration was introduced. In 2003, the Danish Government set up targets for the year 2008 for waste handling in a "Waste Strategy 2004-2008" report (The Danish Government 2003). According to this strategy, the target for 2008 is a maximum of 9 % of the total waste to be deposited. In the waste statistics report for the year 2004, data shows that this target was met, since 7.7 % of total waste was deposited in 2004 (Danish Environmental Protection Agency 2006a). Further in 2005 the amount decreased compared to 2004 and was only 6.9 % of the total waste amount (DEPA 2006b). In 2006 and 2007 the contribution decreased further to 6.5 and 6.4 %, respectively. In 2008 the contribution was 6.9 %. The Danish Government in 2009 set up targets for 2012 according to which a maximum of 6 % the total waste produced is to be deposited (The Danish Government 2009).

8.2.1 Source category description

Disposal of waste takes place at 134 registered sites (year 2001, DEPA 2006b). The organic degradable fraction of the total amount of deposited waste at these sites generates CH_4, of which some is collected and used as biogas in energy-producing installations at 26 sites (DEPA 2003).

The emission estimates for the CH_4 emission is decreasing with 6.5 % from 1990 to 2009. For this submission the methodology chapter, activity data, input parameters and uncertainties have been explained in more detail by purpose of increasing transparency in the emission inventory for this category.

A quantitative overview of this source category and its main data are shown in Table 8.2.1 presenting the amounts of landfilled waste, the annual generated CH_4, the recovered CH_4 collected at landfill sites and used for energy production, the amount of CH_4 oxidised in the top layers and the resulting net emissions for the years 1990-2009. The amount of waste and the resulting CH_4 emission can be found in the CRF tables submitted as well.

Table 8.2.1 Annual amounts of deposited waste, generated methane, recovered methane collected for biogas production, oxidised methane in the top layer and resulting net emission for the Danish SWDS, 1990-2009.

Year	Waste	Generated methane	Recovery methane	Methane oxidised in the top layers	Net methane emission	
	ktonnes	ktonnes CH_4	ktonnes CH_4	ktonnes CH_4	ktonnes CH_4	ktonnes CO_2-eqv
1990	3 175	59.3	0.5	5.9	52.9	1 111
1991	3 032	60.9	0.7	6.0	54.2	1 138
1992	2 890	62.4	1.4	6.1	54.9	1 153
1993	2 747	63.7	1.7	6.2	55.8	1 171
1994	2 604	64.9	4.6	6.0	54.2	1 138
1995	1 957	65.8	7.4	5.8	52.6	1 104
1996	2 507	66.5	8.2	5.8	52.5	1 103
1997	2 083	67.1	11.1	5.6	50.3	1 057
1998	1 859	67.3	13.2	5.4	48.7	1 023
1999	1 467	67.5	11.5	5.6	50.4	1 059
2000	1 482	67.6	11.0	5.7	50.9	1 069
2001	1 300	67.6	10.0	5.8	51.8	1 088
2002	1 174	66.9	11.2	5.6	50.2	1 053
2003	966	66.0	7.9	5.8	52.3	1 097
2004	1 000	64.8	11.0	5.4	48.4	1 017
2005	957	63.6	9.7	5.4	48.5	1 019
2006	976	62.6	5.5	5.7	51.4	1 080
2007	956	61.7	5.4	5.6	50.6	1 064
2008	1 045	60.8	4.8	5.6	50.3	1 057
2009	753	59.7	4.7	5.5	49.5	1039

The decrease in the emission throughout the time-series is much less than the general decrease in the amount of waste deposited. This is due to the time involved in the degradation processes generating the CH_4, which is reflected in the model used for emission calculation (Annex 3G, Table 3G.1).

8.2.2 Methodology

The CH_4 emission at the Danish SWDSs is based on a First Order Decay (FOD) model according to an IPCC tier 2 approach (IPCC 1997, 2000 and 2006). The model calculations are performed using national statistics on landfill site characteristics and amounts of waste fractions deposited each year.

Modelling of decay processes as first order kinetics is described as exponential decay. When a quantity N is the subject to this type of decay, the mathematical formulation is

$$\frac{dN}{dt} = -k \cdot N \qquad \text{Eq. 8.21}$$

where k is the decay constant. Equation (1) can be solved for the simple case of a momentarily single deposition at time t (W_t) yielding:

$$N(t) = W_t \cdot e^{-kt} \qquad \text{Eq. 8.2.2}$$

where k relates to the half-life time for the degradable organic matter, set equal to 14 years, as:

$$t_{1/2} = \frac{ln2}{k} \Rightarrow k = \frac{ln2}{t_{1/2}} \qquad \text{Eq. 8.2.3}$$

A half-life time of 14 years corresponding to the default methane generation constant of k=0.050 year^{-1} (refer IPCC 2000, page 5.7). The amount generated methane decreases exponentially over time according to first order degradation kinetics of the content of degradable organic carbon in the deposited waste.

At a given year (t) the amount of decomposable degradable organic carbon (D*DOCm*(t)) is a result of accumulated contributions from all former years deposit of waste (*W*(*x*)), where *x* is year since depositing. The residue of organic matter left from a waste deposited of at landfill sites *x* years ago is calculated using the exponential decomposition rule (Eq. 8.2.2).

$$DDOCm(t) = W_t \cdot DOC \cdot DOC_f \cdot MCF + DDOCm(t-1) \cdot e^{-k} \qquad \text{Eq. 8.2.4}$$

where *MCF*, the waste management or methane correction factor has been set to 1, which is the default value for managed SWDS charactering the situation in Denmark (page 5.9, IPCC 2000), *DOC* is the fraction of degradable organic carbon of the waste deposited and DOC_f is the fraction of DOC which is dissimilated to account for that not all DOC degrades or degrades very slowly; for Denmark the default value of 0.5 is used (IPCC 2000, page 5.9).

Eq. 8.2.4 assumes that the deposit of decomposable degradable organic carbon takes place momentarily once a year and just after the time *t*, where *t* is defined as whole years (integer: *t*=1,2,..), so Eq. 4 consists of two overall contribution that may be expressed as

$$DDOCm(t) = New\ deposit + Residue\ of\ \ former\ years\ deposit$$

The total amount of degraded organic matter during year *t* (*DDOCm decomp$_T$*) is assumed to be equal to the degradation during year t of the organic matter that was deposited at the beginning of the year (*DDOCm*(*t*-1)):

$$DDOCm\ decomp_T = DDOCm(t-1) \cdot (1 - e^{-k}) \qquad \text{Eq. 8.2.5}$$

Based on equation 8.2.4 and 8.2.5 it is possible to calculate the degraded amount of organic matter in a step wise manner based on last year result. This amount is assumed to generate the CH_4 as described by

$$CH_4\ generated_T = DDOCm\,decomp_T \cdot F \cdot 16/12 \qquad \text{Eq. 8.2. 6}$$

where *F* is the fraction of methane in the gas from landfills, set to 0.5 (IPCC 2000, page 5.10; DEPA, 2010) and 16/12 is the conversion factor from units of C to CH_4

For deriving at the net emissions, the amount of recovered or collected methane as well as the amount of oxidised methane in the SWDS top layers needs to be subtracted:

$$CH_4\ Emissions = \left(\sum_x CH_4\ generated_{x,T} - R_T \right) \cdot (1 - OX_T) \qquad \text{Eq. 8.2.7}$$

where:

CH_4 Emissions = CH_4 emitted in year T, Gg

T = inventory year

x = waste category or type/material

R_T = recovered CH4 in year T, Gg

OX_T = oxidation factor in year T, (fraction)

R_T is the amount of recovered CH_4 at the Danish disposal sites which are used for biogas to energy production, *B*. Energy-producing installations at 26 sites (DEPA 2003) are registered. The Danish Energy Agency registers the gas amounts recovered at disposal sites in energy units (TJ) (DEA, 2010). The amount of gas in energy unit is converted to volume of gas using the calorific value of 20 MJ per m^3. As for the FOD-model the content of CH_4 in the gas recovered is estimated to 50% and the density of CH_4 is 0.718 kg per m^3. The amount of CH_4 recovered, *R(t)*, is calculated as:

$$R_T = \frac{B \cdot 0.5 \cdot 0.718}{20}$$

The CH_4 recovered is reported in Table 8.2.1 in units of ktonnes.

OX_T is the assumed oxidation of CH_4 in the top layer. The amount oxidised is uncertain and varies according to SWDS characteristics and management practices (DEPA, 2010). For the Danish model an oxidation factor (OX) of 0.1 used; i.e. the default value for industrialised countries with well-managed disposal sites (IPCC, 2000 and DEPA, 2010).

In the below section the methane generation potentials per unit mass of individual ISAG waste categories, total amount of decomposable degradable organic carbon present at the Danish landfills, yearly degraded amounts of organic carbon and resulting yearly CH_4 emissions is presented.

Activity data and emission factors

The data used for the amounts of municipal solid waste deposited at managed solid waste disposal sites are (according to the official registration) worked out by the Danish Environmental Protection Agency (DEPA) in the so-called ISAG database (DEPA 1996a, 1998a, 1999a, 2001a, 2001b, 2002a, 2004a, 2004b, 2005a, 2006a, 2006b, 2008, 2010).

The amounts of waste deposited are registered and published in the national ISAG database according to eight categories as provided in Table 8.2.2.

Table 8.2.2 Waste amounts of the ISAC waste categories, Gg.

Year	Domestic Waste	Bulky Waste	Garden Waste	Com-mercial & office Waste	Industrial Waste	Building & construction Waste	Sludge	Ash & Slag	Waste Total
1990	198.9	250.7	85.2	109.3	822.4	951.4	222.1	535.0	3 175.1
1991	198.7	259.0	70.7	120.0	824.3	804.3	193.3	562.0	3 032.3
1992	198.4	267.3	56.1	130.7	826.2	657.2	164.6	589.0	2 889.6
1993	198.2	275.7	41.6	141.3	828.1	510.1	135.8	616.0	2 746.8
1994	198.0	284.0	27.0	152.0	830.0	363.0	107.0	643.0	2 604.0
1995	190.0	286.0	17.0	128.0	779.0	321.0	101.0	135.0	1 957.0
1996	132.0	275.0	6.0	135.0	822.0	317.0	117.0	703.0	2 507.0
1997	83.0	248.0	6.0	170.0	707.0	264.0	130.0	475.0	2 083.0
1998	98.0	234.0	20.0	161.0	746.0	266.0	124.0	210.0	1 859.0
1999	117.0	239.0	3.0	164.0	582.0	224.0	126.0	12.0	1 467.0
2000	85.0	264.0	7.0	152.0	611.0	269.0	94.0	0.0	1 482.0
2001	50.0	180.0	3.0	150.0	583.0	260.0	64.0	10.0	1 300.0
2002	37.0	161.0	4.0	137.0	520.0	229.0	48.0	38.0	1 174.0
2003	24.0	143.0	4.0	131.0	379.0	170.0	55.0	60.0	966.0
2004	11.0	132.0	5.0	140.0	452.0	172.0	42.0	46.0	1 000.0
2005	11.9	164.5	5.4	152.4	352.2	207.7	34.6	28.0	956.7
2006	13.5	156.4	5.7	150.8	375.3	203.9	39.4	30.6	975.5
2007	19.0	146.2	6.4	160.4	364.1	171.9	43.4	44.4	955.6
2008	20.0	109.0	7.0	152.0	389.0	177.0	33.0	158.0	1 045.0

The organic carbon content of the waste categories is a key parameter for estimating the CH_4 emission. Until now the degradable organic carbon (DOC) content of the waste composition in Denmark has been based on the results from an investigations on waste streams in Denmark (DEPA, 1993) covering the below listed waste types:

- Waste food
- Cardboard
- Paper
- Wet cardboard and paper
- Plastics
- Other combustible
- Glass
- Other, not combustible

Waste types was assessed according to the national waste statistics reported each year in the ISAC database as shown in Table 8.2.3. The DOC contents of the analysed waste types (DEPA, 1993) are provided in the last row of Table 8.2.4.

Table 8.2.3 Fractional distributions of the ISAC waste categories according to waste types (DEPA, 1993) and DOC content of the waste types given in units of mass fraction.

	Waste types, *i*									
	Food waste	Card-board	Paper	Wet Carc board and paper	Plastics	Other Combus-tible	Glass	Metal	Other not Combus-tible	Total
ISAC waste categories, *j*										
Domestic Waste	0.379	0.017	0.128	0.264	0.068	0.034	0.017	0.047	0.047	1.00
Bulky Waste		0.078	0.233		0.047	0.457	0.085	0.085	0.016	1.00
Garden Waste						0.760			0.240	1.00
Commercial & office Waste	0.252	0.311	0.039	0.107	0.049	0.097	0.049	0.049	0.049	1.00
Industrial Waste	0.062	0.019	0.070	0.015	0.012	0.058	0.037	0.183	0.543	1.00
Building & constr. Waste						0.070			0.930	1.00
Sludge						0.290			0.710	1.00
Ash & slag									1.000	1.00
DOC content, DOC_i	0.20	0.40	0.40	0.20	0	0.20-.57	0	0	0	

Table 8.2.3 shows the fractional distributions of the upper row waste types (DEPA, 1993) for each ISAG waste category listed in the left column.

For the category 'Other combustible' in the tenth column of Table 8.2.3 a separate expert judgement of the DOC content of the ISAC waste categories are presented in Table 8.2.4.

Table 8.2.4 DOC content, given in units of mass fraction, for the waste type "Other combustible"

	Domestic Waste	Bulky Waste	Garden Waste	Commercial & office Waste	Industrial Waste	Building & constr. Waste	Sludge	Ash & slag
DOC content, DOC_i	0.20	0.40	0.25	0.40	0.35	0.40	0.57	0.0

The DOC content and fractional waste type distribution for each ISAG waste category, as shown in Table 8.2.3 and 8.2.4, have been kept for the whole time-series. As such only the amounts of deposited waste within each ISAG waste categories changes in time according to the national waste statistics provided in Table 8.2.2.

The methane generation potential per unit waste type *i* may be obtained from the equation:

$$\frac{L_{o,i}}{W_i} = DOC_f \cdot MCF \cdot F \cdot 16/12 \cdot DOC_i$$

$$\Downarrow \qquad \text{Eq. 8.2.8}$$

$$\frac{L_{o,i}}{W_i} = 0.33 \cdot DOC_i$$

Waste amounts are reported yearly for the j ISAC categories and a methane generation potential per unit ISAG waste category, $L_{o,j,}$ may be espressed as:

$$L_{o,j} = W_j \cdot \sum_{i=1}^{i=n} f_{i,j} \cdot \frac{L_{o,i}}{W_i} \qquad \text{Eq. 8.2.9}$$

Where $f_{i,j}$ is the fraction of i =1 to i =n waste types contributing to each ISAC waste category j and $L_{o,j}$ the resulting methane generation potential mass unit ISAC waste category j. The methane generation potential per unit ISAC waste category is presented in Table 8.2.5.

Table 8.2.5 Methane generation potential per mass unit for the individual ISAG waste categories, Gg CH_4 pr Gg waste.

ISAC waste category, j	$L_{o,j}/W_j$
Domestic Waste	0.644
Bulky Waste	0.1023
Garden Waste	0.0633
Commercial & office Waste	0.0835
Industrial Waste	0.0237
Building & constr. Waste	0.00934
Sludge	0.0551
Ash & slag	0.0

The methane generation potentials per ISAC waste category mass is multiplied by the amount of the individual waste amounts reported for deposition each year equals the total organic degradable waste deposited calculated in units of potential CH_4 emission (In former submissions termed potential methane emission) (Nielsen et al., 2010 and Table 8.2.6, column five).

Model Results

The yearly amounts of the different waste categories (Table 8.2.2) and their emission generation potentials per mass unit (Eq. 8.2.9 and Table 8.2.5) are used to calculate the amount of deposited potential CH_4 emission for each year and generated methane (Eq. 8.2.6). The CH_4 captured by biogas installations at some of the sites is subtracted from the generated methane emission. The resulting net emission is obtained by subtracting the CH_4 (Eq. 8.2.7).

The waste amounts, total decomposable degradable and yearly degraded organic matter and the calculated CH_4 emissions are presented in Table 8.2.6.

Table 8.2.6 Waste deposited, total organic degradable matter, amounts of yearly degraded organic matter and resulting CH_4 emissions for 1990-2009.

Year	Total Deposited Waste	Total amount of decomposable degradable organic carbon in the SWDS, Eq. 8.2.4	Amount of degraded organic matter, Eq. 8.2.5	Deposited potential CH_4 emission	Generated CH_4 emission, Eq. 8.2.6	Biogas collected	Annual net emission before oxidation	Annual net emission after ox. 0.1, Eq. 8.2.7	Implied emissions factor	
		[Gg]				[Gg CH_4]			Gg CH_4/Gg waste	Gg CH_4/Gg DDOCm
1990	3 175	30 360	1 448	95.7	59.3	0.5	58.8	52.9	0.0167	0.0365
1991	3 032	31 570	1 467	93.6	60.9	0.7	60.2	54.2	0.0179	0.0370
1992	2 890	31 783	1 525	91.5	62.4	1.4	61.0	54.9	0.0190	0.0360
1993	2 747	32 792	1 535	89.4	63.7	1.7	62.0	55.8	0.0203	0.0363
1994	2 604	32 852	1 584	87.3	64.9	4.6	60.2	54.2	0.0208	0.0342
1995	1 957	33 165	1 587	85.2	65.8	7.4	58.4	52.6	0.0269	0.0331
1996	2 507	33 772	1 602	80.3	66.5	8.2	58.4	52.5	0.0210	0.0328
1997	2 083	33 646	1 631	77.2	67.1	11.1	55.9	50.3	0.0242	0.0309
1998	1 859	33 999	1 625	71.7	67.3	13.2	54.1	48.7	0.0262	0.0300
1999	1 467	33 487	1 642	72	67.5	11.5	56.1	50.4	0.0344	0.0307
2000	1 482	33 839	1 618	68.7	67.6	11	56.6	50.9	0.0343	0.0315
2001	1 300	33 170	1 635	67.8	67.6	10	57.6	51.8	0.0399	0.0317
2002	1 174	33 378	1 602	54.1	66.9	11.2	55.7	50.2	0.0427	0.0313
2003	966	32 534	1 612	47.7	66	7.9	58.1	52.3	0.0541	0.0324
2004	1 000	32 766	1 572	41	64.8	11	53.8	48.4	0.0484	0.0308
2005	957	31 919	1 583	40.9	63.6	9.7	53.9	48.5	0.0507	0.0307
2006	975	32 159	1 542	42.9	62.6	5.5	57.2	51.4	0.0527	0.0334
2007	956	31 332	1 553	42.8	61.7	5.4	56.3	50.6	0.0530	0.0326
2008	1 045	31 650	1 514	42.6	60.8	4.8	55.9	50.3	0.0482	0.0332
2009	753	30 572	1 529	38.3	59.7	4.7	55.0	49.5	0.0657	0.0324

The implied emission factor (IEF) in the CRF tables reflects an aggregated emission factor for the model so far calculated as the net methane emission divided by the total amount of waste deposited (tenth column in Table 8.2.6).

The total waste amount in the second column of Table 8.2.6 is the sum of the amounts of the different ISAG waste categories (Table 8.2.2) and thereby includes Industrial Waste, Building and Construction Waste. The total waste amount is reported as the activity data for the Annual Municipal Solid Waste (MSW) at SWDSs in the CRF Table 6.A.

The time trend for the total decomposable degradable organic matter and yearly degraded organic matter, provided in the third and fourth column in Table 8.2.6, indicates a beginning visible effect of the targets set by the Danish waste strategies.

This IEF in units of Gg CH_4/Gg waste has increased through the timevseries from 1990 to 2009, despite the general decreasing trend in the amount of waste. The total amount of decomposable degradable organic matter might be a more appropriate measure of activity (Nielsen et al., 2010) in the calculation of the aggregated IEF. Implied emission factor calculated by use the D*DOCm* as activity data shows and overall decrease through the time-series from 1990 to 2009 and is presented in the last column of Table 8.2.6.

8.2.3 Uncertainties and time-series consistency

Input parameter uncertainty

Tier 1

Input parameter uncertainties considered in the tier 1 uncertainty analyse are based on the IPCC (IPCC 2000, page 5.12, Table 5.2) default values and provided in Table 8.2.13.

Table 8.2.7 Tier 1 input parameter uncertainty, %.

Parameter	Parameter ID	Uncertainty %	Note
The Waste amount sent to SWDS	*W*	10	Since the amounts are based on weighing at the SWDS the lower value in IPCC (2000), is used
Degradable Organic Carbon DOC	*DOC*	50	
Fraction of DOC dissimilated	DOC_f	30	
Methane Correction Factor	*MCF*	10	IPCC, 2006
Fraction of CH_4 in landfill gas		10	
Methane Generation Rate Constant		100	see the text

The waste amounts are registered in a national database held by the Danish EPA and assessed to be of high quality resulting in the adoption of an uncertainty for reported waste amounts of 10%. The default uncertainty range for the methane generation constant, k, is: -40 % to +300 %.;for the tier 1 uncertainty calculation set to 100% (Limpert et. al., 2001). For the remaining parameters default input parameters and uncertainties are used until country-specific parameters becomes available (see Chapter 8.2.6).

The uncertainty on the implied emission factor, U_{ief}, is based on uncertainty estimates in Table 8.2.7 and is approximated with IPCC (2000) Equation 6.4 equals

U_{ief} % = SQRT($50^2+30^2+10^2+10^2+100^2$) = 117.9 %

These uncertainties give the combined tier 1 uncertainty on the emission from SWDS of: SQRT($10^2+117.9^2$) = 118.3 %

A complete Tier 1 uncertainty analysis reported according to the IPCC (IPCC, 2000, Table 6.1) is provided in Table 8.2.8.

Results

The results of Tier 1 uncertainty model for 2009 are presented in Table 8.2.8. The above derived input parameter uncertainties are used in the Tier 1 calculation.

Table 8.2.8 Uncertainty estimates for total emissions in 2009 and emission trends from the Tier 1 uncertainty model, Gg CO_2-eqv.

Pollutant	Emission, Gg CO_2-eqv	Uncertainty, %	Trend, %	Uncertainty, %
	2009	Lower and upper (±)	1990-2009	Lower and upper (±)
CH_4	1039	2	83	0,23

Input parameter uncertainties and characteristic for the tier 2 uncertainty model are provided in Table 8.2.9.

Table 8.2.9 Tier input parameter uncertainties, %.

Parameter	ID	median	ln median	Stdev %	ln stdev %	Lower truncation	Upper truncation
Log-normal distributed input parameter uncertainties, Tier 2							
Oxidation factor	*OX*	0,1	-2,31	10	3,03	0,06	0,43
Fraction of DOC dissimilated	DOC_F	50	3,91	30	0,55	35	50
Fraction of CH_4 in landfill gas	*F*	50	3,91	50	0,83	35	65
Half-life	$t_{½}$	14	2,64	50	1,62	4,62	23,10
Methane generate rate contant	*k*	0,05	0,26			0,03	0,15
Normal distributed parameter uncetainties, Tier 2							
i	*DOCi*						
Food waste		21		50		20	60
Cardboard		39		50		20	60
Paper		40		50		20	60
Wet cardbord and paper		20		50		20	60
Plastics		0		50		0	10
$DOC_{Other\ combustable,j}$	*DOCi,j*						
Domestic waste		20		50		0	50
Bulky waste		40		50		20	50
Garden waste		25		50		20	50
Commercial & office waste		40		50		20	60
Industrial waste		35		50		20	60
Building and constructuin waste		40		50		20	60
Sludge		58		50		20	60
Ash &Slag		1		50		0	10
Masses of ISAC waste fractions	W_j			10			

Uncertainty estimates are based on 10.000 Monte Carlo FOD model simulations using input parameter characteristics as presented in Table 8.2.9 are presented in Table 8.2.10.

Table 8.2.10 Uncertainty estimates for total emissions in 1990 and 2009 and for the emission trends from the Tier 2 uncertainty model, Gg CO_2-eqv.

	1990			2009			1990-2009		
	Median emission [Gg]	Uncertainty, %		Median emission [Gg]	Uncertainty, %		Median trend, %	Uncertainty, %	
Pollutant		Lower (-)	Upper (+)		Lower (-)	Upper (+)		Lower (-)	Upper (+)
CH_4	41.57	20.75	74.55	33.59	16.09	53.67	2.86	-2060	2022
		-50.1	79.3		-52.1	59.8			

The level uncertainties for 1990 and 2009 for this year's submission are similar to last year regardless the increased number of input parameters with defined uncertainties included in the Monte Carlo simulations. The uncertainty range on the time trend between 1990 and 2009 is high. and the trend estimate positive opposite of the observed trend in the net mission reported in Table 8.2.1.

The truncated uncertainty ranges for the log-normally distributed input parameters was defined based on expert knowledge. Planned improvements of the waste composition, and implementation of individual half-lives for the individual waste categories, are expected to lower the uncertainty on the results from the Tier 2 uncertainty analysis.

8.2.4 Time-series consistency and completeness

Registration of the amount of waste has been carried out since the beginning of the 1990s in order to measure the effects of action plans. The activity data is, therefore, considered to be consistently long enough to make the activity data input to the FOD model reliable. For further information on activity data and on the general behaviour of the FOD model, refer to Annex 3G.

The consistency of the emissions and the emission factor is a result of the same methodology and the same model used for the whole time-series. The parameters in the FOD model are the same for the whole time-series. The use of a model of this type is recommended in IPCC (1997) and IPCC (2000). The half-life time parameter used is the default value recommended by IPCC (2000).

As regards completeness, the waste amounts used, as registered in the ISAG system, do not only include traditional Municipal Solid Waste (MSW), but also non-MSW as Industrial Waste, Building and Construction Waste and Sludge. The composition of these waste types is, according to Danish data, used to estimate DOC values for the waste types (refer IPCC 2000, page 5.10).

8.2.5 QA/QC and verification

QA/QC-procedure

In previous reviews it was recommended to improve the description; in the last review especially transparency was mentioned. The methodology and presentation of activity data have been changed in this year's inventory in accordance to the recommendations made by the ERT during the in-country review in 2010.

No formal agreements with regard to data deliverance has been obtained, since it is a statutory requirement that waste amounts are reported to DEPA, the agreement may potentially not be required (refer to the remarks under DS.1.3.1). The ISAG database is replaced by a new waste data system launched in 2011, by purpose of collecting more detailed information on waste generation and treatment; the list of waste given in the EU Directive 75/442/EEC. Collaboration regarding data delivery is in place.

In general terms, for this part of the inventory, the Data Storage (DS) Level 1 and 2 and the Data Processing (DP) Level 1 can be described as follows:

Data Storage Level 1

The external data level refers to the placement of original data for amounts of waste categories or fractions. These categories/fractions are linked to data on waste types with known content of degradable organic carbon, see Section 8.2.2. Data for CH_4 recovery are used. Further (external) data are parameters to the FOD model. For further details on the external data, refer to the table below.

Table 8.2.11 Details on external data.

File or folder name	Description	AD or Emf.	Reference	Contacts	Data agreement/ Comment
I:\ROSPROJ\LUFT_EMI\Inventory\2009\6_Waste\Level_1a_Storage\6A Solid Waste Disposal	Basic data DS1 Report on 2007 and 2008 amounts according to the waste fractions.	Activity data	Danish Environmental Protection Agency (DEPA), Waste Statistics (Affaldsstatistik)	Unit for Soil and Waste Martin Sune Møller (masmo@mst.dk)	The amounts are registered due to statutory requirements
I:\ROSPROJ\LUFT_EMI\Inventory\2009\6_Waste\Level_1a_Storage\6A Solid Waste Disposal	Basic data DS1 Dataset for energy-producing SWDS	CH_4 recovery data	The Danish Energy Authority (DEA)	Peter Dal (pd@ens.dk)	Prepared due to the obligation of DEA
I:\ROSPROJ\LUFT_EMI\Inventory\2009\6_Waste\Level_1b_Processes\6A Solid Waste Disposal	Excel file with the FOD model swds_fod_model.xls DP1	Parameters of the FOD model	IPCC 1997 and 2000	Marianne Thomsen (mth@dmu.dk)	

Data Processing Level 1

This level, for SWDS, comprises a stage where the external data are treated internally, preparing for the input to the NERI First Order of Decay model, see Section 8.2.2. The model runs are carried out and the output stored.

Data Storage Level 2

Data Storage Level 2 is the placement of selected output data from the FOD model as inventory data on SNAP levels in the Access (CollectER) database.

Points of measurement

The present stage of QA/QC for the Danish emission inventories for SWDS is described below for DS and DP level 1 Points of Measurement (PMs). This is to be seen in connection with the general QA/QC description in Section 1.6 and, especially, 1.6.10 on specific description of PMs common to all sectors, general to QA/QC.

Data Storage level 1	1. Accuracy	DS.1.1.1	General level of uncertainty for every dataset including the reasoning for the specific values

With regard to the general level of uncertainty, the amounts in waste fractions/categories are rather certain (percent uncertainty set equal to 10%, cf. Table 8.2.8) due to the statutory environment for these data, while the distribution of waste fractions according to waste type and their content of DOC is more uncertain (percent uncertainty set equal to 50%, cf. Table 8.2.8). It is generally accepted that FOD models for CH_4 emission estimates offer the best and the most certain way of estimation. The half-life in the FOD models is an important parameter with some uncertainty (cf. Table 8.2.8).

Data Storage level 1	1. Accuracy	DS.1.1.2	Quantification of the uncertainty level of every single data value including the reasoning for the specific values.

The uncertainties of the DEPA data are not available in the DEPA reporting. The uncertainties are taken from IPCC (1997) and (2000). DEA data on CH_4 recovery are considered to be precise. Refer to Section 8.2.3 on uncertainty.

Data Storage level 1	2.Comparability	DS.1.2.1	Comparability of the data values with similar data from other countries, which are comparable with Denmark, and evaluation of discrepancy.

Only some comparison of Danish data values from external data sources with corresponding data from other countries has been carried out in order to evaluate discrepancies. For many countries SWDS waste amounts do not – as for the Danish data – include waste from industrial sources, which presents a difficulty with regard to comparison.

Data Storage level 1	3.Completeness	DS.1.3.1	Documentation showing that all possible national data sources are included by setting down the reasoning behind the selection of datasets.

The following external data sources are used for the inventory on SWDS (refer also to the table above):

- Danish Environmental Protection Agency, ISAG database: amounts of the various waste fractions deposited (refer to Section 8.2.2).
- A Danish investigation on the waste types in waste fractions and the content of degradable organic carbon in waste types.
- Danish Energy Authority: Official Danish energy statistics: CH_4 recovery data.

The selection of sources is obvious. The ISAG database is based on statutory registrations and reporting from all Danish waste treatment plants for all waste entering or leaving the plants. Information concerning waste in the previous year must be reported to the DEPA each year, no later than 31 January. Registration is made by mass for the individual waste categories. For recovery data, the DEA registers the energy produced from plants where installations recover CH_4. for the energy statistics.

For the parameters of the FOD model, references are made to IPCC (1997), IPCC (2000) and IPCC (2006).

Data Storage level 1	4.Consistency	DS.1.4.1	The origin of external data has to be preserved whenever possible without explicit arguments (referring to other PMs).

The origin of external activity data has been preserved as much as possible. The starting year for the FOD model used is 1960, using historic data for waste quantities. Since 1994, data is according to the Danish ISAG reporting system. For further information on the origin of activity data, refer to Annex 3G. Files are saved for each year of reporting. In this way changes to previously received data is reflected and explanations are given.

The FOD model and its parameters have been used consistently, throughout the time-series, refer to Section 8.2.3.

Data Storage level 1	6.Robustness	DS.1.6.1	Explicit agreements between the external institution holding the data and NERI about the conditions of delivery.

It is a statutory requirement that amounts of waste are reported annually to DEPA, no later than January 31 for the previous year which corresponds well with the inventory development. No explicit agreement has been made.

Data Storage level 1	7.Transparency	DS.1.7.1	Summary of each dataset including the reasoning for selecting the specific dataset

The summary of the dataset can be seen in Tables presented in Section 8.2.2. For the reasoning behind the selection of the specific dataset, refer to DS 1.3.1.

Data Storage level 1	7.Transparency	DS.1.7.3	References for citation for any external dataset have to be available for any single value in any dataset.

These references exist in the description given in the Section 8.2.2., under methodology.

Data Storage level 1	7.Transparency	DS.1.7.4	Listing of external contacts for every dataset

The following list shows the person responsible and contact information for delivery of data:

Danish Environmental Protection Agency: Martin Sune Møller, (masmo@mst.dk)

Danish Energy Authority: Peter Dal (pd@ens.dk)

Data Processing level 1	1. Accuracy	DP.1.1.1	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to type of variability. (Distribution as: normal, log normal or other type of variability)

Tier 1 and Tier 2 uncertainty calculations are made. The use of the Tier 1 methodology presumes a normal distribution of activity data and emission factor variability. The extent to which this requirement is fulfilled still needs to be elaborated. The influence of the uncertainty on the half-life time has been implemented at Tier 2 uncertainty assessment together with all other relevant input parameters (cf. Section 8.2.3).

Data Processing level 1	1. Accuracy	DP.1.1.2	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to scale of variability (size of variation intervals)

The uncertainty assessment has been given in Section 8.2.3.

Data Processing level 1	1. Accuracy	DP.1.1.3	Evaluation of the methodological approach using international guidelines

An evaluation of the methodological approach, in comparison with the Tier 1 level, has been made, see Section 8.2.4. This shows that the emissions from waste estimated according to the default methodology from IPCC (1997) and IPCC (2000) will deviate considerably from those in this submission, also since the waste amounts estimated in the latter methodologies deviate from those used for Denmark.

Data Processing level 1	1. Accuracy	DP.1.1.4	Verification of calculation results using guideline values

From the evaluation carried out, see DP.1.1.3, it is clear that no direct verification can be carried out, since the method is a Tier 2 method, in accordance with IPCC (1997) and IPCC (2000).

Data Processing level 1	2.Comparability	DP.1.2.1	The inventory calculation has to follow the international guidelines suggested by the UNFCCC and IPCC.

The calculation used is a Tier 2 methodology from IPCC (1997, 2000 and 2006).

Data Processing level 1	3.Completeness	DP.1.3.1	Assessment of the most important quantitative knowledge which is lacking.

There is no quantitative knowledge in the methodology on either (1) the shift over time in waste types within waste fractions and in DOC content in waste types or (2) possible individual conditions relating to the SWD sites. On going research might change this lack. In this NIR a complete Tier 2 uncertainty Monte Carlo simulation on the FOD model has allowed for and trend and level uncertainty quantification at Tier 2.

Data Processing level 1	3.Completeness	DP.1.3.2	Assessment of the most important cases where access is lacking with regard to critical data sources that could improve quantitative knowledge.

There is no direct data to elucidate the points mentioned under DP.1.3.1.

Data Processing level 1	4.Consistency	DP.1.4.1	In order to keep consistency at a high level, an explicit description of the activities needs to accompany any change in the calculation procedure.

There is no change in calculation procedure during the time-series and the activity data is, as far as possible, kept consistent for the calculation of the time-series.

Data Processing level 1	5.Correctness	DP.1.5.1	Show at least once, by independent calculation, the correctness of every data manipulation.

The model has been checked to give the results to be expected on fictive input data with known result, se Annex 3G.

Data Processing level 1	5.Correctness	DP.1.5.2	Verification of calculation results using time-series

The time-series of activities and emissions in the FOD-model output, in the SNAP source categories and in the CRF format have been prepared.

The time-series are examined and significant changes are checked and explained. Comparison is made with the previous year's estimate and any major changes are verified.

Data Processing level 1	5.Correctness	DP.1.5.3	Verification of calculation results using other measures

The correct interpretation in the model of the methodology and the parameterisation has been checked, refer DP.1.5.1.

Data Processing level 1	5.Correctness	DP.1.5.4	Shows one-to-one correctness between external data sources and the databases at Data Storage level 2

Data transfer control is made from the external data sources and to the SNAP source categories at level 2. This control is carried on further to the aggregated CRF source categories.

Data Processing level 1	7.Transparency	DP.1.7.1	The calculation principle and equations used must be described

The calculation principle and equations are described in Section 8.2.2. Transparency have improved by a more detailed description of equations used in Section 8.2.2 .

Data Processing level 1	7.Transparency	DP.1.7.2	The theoretical reasoning for all methods must be described

The theoretical reasoning is described in Section 8.2.2 and, due to the used of the Tier 2 method in IPCC (1997) and (2000), is also described in these IPCC reports.

Data Processing level 1	7.Transparency	DP.1.7.3	Explicit listing of assumptions behind all methods

The assumption is that the emissions can be described according to a FOD model as described in IPCC (1997) and (2000) for SWDS. The FOD model is runned with the input parameters and uncertainties as they are listed in Section 8.2.3.

Data Processing level 1	7.Transparency	DP.1.7.4	Clear reference to dataset at Data Storage level 1

Refer to the table at the start of this Section (8.2.4).

Data Processing level 1	7.Transparency	DP.1.7.5	A manual log to collect information about recalculations

Recalculation and the changes in the emission inventories are described in the NIR whenever occurring. The logging of the changes takes place in the yearly model file. No recalculation have occurred this year.

Data Storage level 2	5.Correctness	DS.2.5.1	Documentation of a correct connection between all data types at level 2 to data at level 1

The full documentation for the correct connection exists through the yearly model file, its output and report files made by the CollectER database system.

Data Storage level 2	5.Correctness	DS.2.5.2	Check if a correct data import to level 2 has been made

This check is performed, comparing model output and report files made by the CollectER database system, refer to DS.2.5.1.

Suggested QA/QC plan for SWDS

The following points are a list of QA/QC tasks to be considered directly in relation to the SWDS part of the Danish emission inventories:

Data at storage level 1

- Verified data on half-lifes according to waste fractions
- Updated and verified waste characterisation including
- Literature study and documentation of waste compositions and DOC content according to the Danish waste categories.

Data processing level 1

- A more detailed presentation of the influence of individual input parameters and associated uncertainties.
- Implementation of individual half-lives for the individual waste fractions in the FOD model.

QA on evaluation and verification

It is good practice, and a QA procedure, to compare the emission estimates included in the inventories with the IPCC default methodology (cf. Nielsen et al., 2010)

8.2.6 Source specific Recalculations

For the submissions in 2011, no recalculations have occurred.

8.2.7 Source specific planned improvements

Refer to Suggested QA/QC plan for SWDS above.

References for Chapter 8.2

Danish Energy Agency, 2009: Energy Statistics 2008. Available at: http://www.ens.dk/en-US/Info/FactsAndFigures/Energy_statistics_and_indicators/Annual%20Statistics/Sider/Forside.aspx (last accessed March 2011)

Danish Environmental Protection Agency (DEPA), 2010: Affaldsstatistik 2007 og 2008. (In Danish: Waste Statistics 2007 and 2008. Summary and conclusion in English). Available at: http://www.mst.dk/NR/rdonlyres/204B82C6-C3BE-43A4-824A-C30EED54CF9F/0/Affaldsstatistik2007og2008.pdf (May 14, 2010)

Danish Environmental Protection Agency (DEPA), 2008: Affaldsstatistik 2006. (In Danish: Waste Statistics 2006.) Orientering fra Miljøstyrelsen nr

2 2008. Available at:
http://www2.mst.dk/udgiv/publikationer/2008/978-87-7052-753-8/pdf/978-87-7052-754-5.pdf (last accessed March 2011)

Danish Environmental Protection Agency (DEPA), 2006b: Affaldsstatitik 2005 (In Danish: Waste Statistics 2005). Orientering fra Miljøstyrelsen nr. 6. Available at:
http://www2.mst.dk/common/Udgivramme/Frame.asp?pg=http://www2.mst.dk/Udgiv/publikationer/2006/87-7052-284-7/html/default.htm (last accessed March 2011)

Danish Environmental Protection Agency (DEPA), 2006a: Waste Statistics 2004. Available at:
http://www2.mst.dk/common/Udgivramme/Frame.asp?pg=http://www2.mst.dk/Udgiv/publications/2006/87-7614-962-5/html/default_eng.htm (last accessed March 2011)

Danish Environmental Protection Agency (DEPA), 2005a: Waste Statistics 2003. Available at:
http://www2.mst.dk/common/Udgivramme/Frame.asp?pg=http://www2.mst.dk/Udgiv/publications/2005/87-7614-585-9/html/default_eng.htm (last accessed March 2011)

Danish Environmental Protection Agency (DEPA), 2004a: Waste Statistics 2001. Available at:
http://www2.mst.dk/common/Udgivramme/Frame.asp?pg=http://www2.mst.dk/Udgiv/publications/2004/87-7614-105-5/html/default_eng.htm (last accessed March 2011)

Danish Environmental Protection Agency (DEPA), 2004b: Waste Statistics 2002. Available at:
http://www2.mst.dk/common/Udgivramme/Frame.asp?pg=http://www2.mst.dk/Udgiv/publications/2004/87-7614-107-1/html/default_eng.htm (last accessed March 2011)

Danish Environmental Protection Agency (DEPA), 2002a: Waste Statistics 2000. Available at:
http://www2.mst.dk/common/Udgivramme/Frame.asp?pg=http://www2.mst.dk/Udgiv/publications/2002/87-7972-027-7/html/default_eng.htm (February 24, 2009)

Danish Environmental Protection Agency (DEPA), 2001a: Waste Statistics 1998. Available at:
http://www2.mst.dk/common/Udgivramme/Frame.asp?pg=http://www2.mst.dk/Udgiv/publications/2001/87-7944-351-6/html/default_eng.htm (last accessed March 2011)

Danish Environmental Protection Agency (DEPA), 2001b: Waste Statistics 1999. Available at:
http://www2.mst.dk/common/Udgivramme/Frame.asp?pg=http://www2.mst.dk/Udgiv/publications/2001/87-7944-381-8/html/default_eng.htm (last accessed March 2011)

Danish Environmental Protection Agency (DEPA), 1999a: Waste Statistics 1997. Available at:

http://www2.mst.dk/common/Udgivramme/Frame.asp?pg=http://www2.mst.dk/Udgiv/publications/2000/87-7909-433-3/html/default_eng.htm (last accessed March 2011)

Danish Environmental Protection Agency (DEPA), 1998a: Waste Statistics 1996. Available at:
http://www2.mst.dk/common/Udgivramme/Frame.asp?pg=http://www2.mst.dk/Udgiv/publications/1998/87-7909-106-7/html/default_eng.htm (last accessed March 2011)

Danish Environmental Protection Agency (DEPA), 1996a: Affaldsstatistik 1995 (In Danish: Waste Statistics 1995. Orientering fra Miljøstyrelsen nr 14 1997) Available at:
http://www2.mst.dk/Udgiv/publikationer/1996/87-7810-704-0/pdf/87-7810-704-0.pdf (last accessed March 2011)

Intergovernmental Panel on Climate Change (IPCC), 2006: 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Available at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html (last accessed March 2011)

Intergovernmental Panel on Climate Change (IPCC), 2000: Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. Available at:
http://www.ipcc-nggip.iges.or.jp/public/gp/english/index.html (last accessed March 2011).

Intergovernmental Panel on Climate Change (IPCC), 1997: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. Available at:
http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.html (last accessed March 2011).

Limpert, E., Stahel, W. A. & Abbt, M. 2001: Log-normal Distributions across the Sciences: Keys and Clues.. BioScience *Vol. 51 No. 5*

Nielsen, O., Lyck, E., Mikkelsen, M. H., Hoffmann, L., Gyldenkærne, S., Winther, M., Nielsen, M., Fauser, P., Thomsen, M., Plejdrup, M. S., Albrektsen, R., Hjelgaard, K., Johannsen, V. K., Vesterdal, L., Rasmussen, E., Arfaoui, K. & Baunbæk, L. 2010: Denmark's National Inventory Report 2010: Emission Inventories 1990-2008 - Submitted under the United Nations Framework Conventionon Climate Change and the Kyoto Protocol. National Environmental Research Institute, Aarhus University. 1178 pp - NERI Technical Report No 784. Available at:
http://www.dmu.dk/Pub/FR784.pdf (last accessed March 2011).

The Danish Government, 2009. Affaldsstrategi 2009-2012 1. delstrategi. (In Danish: Waste Strategy 2009-2012. Available at:
http://www.mst.dk/NR/rdonlyres/747FBCE2-A3D4-444F-BF60-D1747C36516D/0/Endelig1delafAffaldsstrategi200912.pdf (last accessed March 2011)

The Danish Government, 2003. Affaldsstrategi 2005-2008. (In Danish: Waste Strategy 2005-2008. Available at:
http://www2.mst.dk/Udgiv/publikationer/2003/87-7972-971-1/pdf/87-7972-973-8.pdf (last accessed March 2011).

The Danish Government, 1999. Waste 21. Waste Management plan 1998-2004. Available at: http://www2.mst.dk/Udgiv/publications/1999/87-7909-571-2/pdf/87-7909-570-4.pdf (last accessed March 2011).

8.3 Wastewater Handling (CRF Source Category 6B)

The Danish waste water treatment system is characterised by few big and advanced WWTPs and many smaller WWTPs. From 1993 to 2009 the amount of waste water treated at the most advanced technological WWTPs in Denmark has increased from 53 % to more than 90 %. 10 % of the population are not connected to the collective sewer system and for this part of the population, i.e. scattered houses, sludge from septic tanks are collected once per year or as appropriate by judgement of the local authorities (DEPA, 1991; DEPA, 1999). Municipal collection and transportation of sludge from septic tanks for treatment at the centralised WWTPs occurs to some extent, the frequency set by the authorities and in general septic tanks are emptied one time each year. Improvements of the decentralised waste water treatment system as well as the sewer system are ongoing in Denmark (DEPA, 2010).

The review team has requested better documentation of derived country-specific emission factors for the methane emissions as well as country-specific activity data. Accordingly, a presentation of methodological improvements, emission factors, activity data and recalculations are presented the following sub-chapters.

8.3.1 Source category description

This source category includes an estimation of the emission of CH_4 and N_2O from wastewater handling; i.e. wastewater collection and treatment. CH_4 is produced during anaerobic conditions and treatment processes, while N_2O may be emitted as a bi-product from nitrification and denitrification processes under anaerobic as well as aerobic conditions (e.g. Adouani et al., 2009; Kampschreur et al, 2009).

No distinction between emissions from industrial and municipal WWTPs is made, as Danish industries to a great extent are coupled to the municipal sewer system and waste water streams from households and industries therefore mixed in the sewer system prior to further treatment at centralised WWTPs. The contribution from the industry to the influent waste water at the centralised WWTPs has increased from zero to around 40% from 1987 to 2010 with the highest influent contribution occurring at the biggest and most advanced technological WWTPs in Denmark (Thomsen & Lyck, 2005; ASEP 2010). Monitoring data on the mixed household and industrial influent biological oxygen demand (BOD) are available for all WWTPs with a capacity above 30 PE treating more than 90 % of the Danish waste water.

It should be mentioned that no activity data are available industrial WWTPs for which effluent amounts of N are reported. Therefore, a contribution from industries having separate waste water treatment is unknown and i.e. not included in the Danish inventory for category 6.B. Waste water handling.

Methane emission

The unspecified fugitive methane emission has this year been specified according the following identified systems and processes contribution to the fugitive methane emission from waste water handling in Denmark. Fugitive methane releases from the municipal and private WWTPs have been divided into contributions from 1) the sewer system, primary settling tank and biological N and P removal processes, 2) from anaerobic treatment processes in closed systems with biogas extraction and combustion for energy production and 3) septic tanks. The individual contribution to the net methane emission for 1990 to 2009 is given in Table 8.3.1.

Table 8.3.1 Methane produced in anaerobic digester tanks (gross anaerobic processes), recovered for energy production, emitted from sewer system, primary settling tanks and biological N and P removal processes, released from anaerobic processes (gross – recovered methane).and net CH_4 emission from the 6.B Wastewater handling in Denmark, 1990-2009, Gg.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
$CH_{4,\ gross\ anaerobic\ processes}$	16.64	16.60	16.66	17.13	18.60	20.08	24.34	28.77	26.85	25.01
$CH_{4,\ recovered}$	16.48	16.44	16.49	16.95	18.41	19.88	24.10	28.48	26.58	24.76
$CH_{4,\ sewer\ system\ and\ WWTP}$	0.17	0.17	0.17	0.18	0.19	0.21	0.23	0.24	0.26	0.25
$CH_{4,\ septic\ tanks}$	2.81	2.82	2.83	2.84	2.85	2.86	2.87	2.88	2.89	2.90
$CH_{4,\ emission\ from\ anaerobic\ treatment}$	0.17	0.17	0.17	0.17	0.19	0.20	0.24	0.29	0.27	0.25
$CH_{4\ emission}$	3.15	3.16	3.17	3.19	3.23	3.27	3.34	3.41	3.42	3.40
Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
$CH_{4,\ gross\ anaerobic\ processes}$	34.58	35.14	26.73	32.31	28.28	30.50	29.84	30.30	29.53	30.21
$CH_{4,\ recovered}$	34.24	34.78	26.47	31.99	28.00	30.19	29.54	30.00	29.24	29.90
$CH_{4,\ sewer\ system\ and\ WWTP}$	0.25	0.24	0.24	0.24	0.25	0.25	0.25	0.25	0.25	0.25
$CH_{4,\ septic\ tanks}$	2.91	2.92	2.93	2.95	2.96	2.96	2.97	2.98	3.00	3.00
$CH_{4,\ emission\ from\ anaerobic\ treatment}$	0.35	0.35	0.27	0.32	0.28	0.30	0.30	0.30	0.30	0.30
$CH_{4\ emission}$	3.51	3.52	3.44	3.51	3.49	3.52	3.52	3.54	3.55	3.56

Based on the data shown in Table 8.3.1, the amount of recovered methane for energy production has increased 82 % in 2009 compared to 1990. The emission from the sewer system and primary settling tanks and biological N and P removal processes has increased by 46 % and for the emission from the scattered houses, i.e. people not connected to the sewer system, an increase of 7 % is observed from 1990 to 2009.

In the NIR 2010 and the amount of methane recovered was reported to be only 56 % (1990-2008) compared to 82 % for the time-series 1990-2009 reported in Table 8.3.1. The reason for this difference is the recalculation of the emission factor according to equation 8.3.3 due to the derived yearly country-specific emission factors for anaerobic treated sludge (cf. Chapter 8.3.5 and Table 8.3.4).

Nitrous oxide emission

N_2O formation and releases both during the treatment processes at the WWTPs and also from discharged effluent waste water are included.

The emission of N_2O from wastewater handling is calculated as the sum of contributions from wastewater treatment processes at the WWTPs and from sewage effluents. The emission from effluent wastewater, i.e. indirect emissions, includes separate industrial discharges, rainwater-conditioned effluents, effluents from scattered houses, from mariculture and fish farming. In Table 8.3.2, emission of N_2O from effluent and the contribution from direct N_2O emissions to the total N_2O emission, i.e. the sum of indirect and direct N_2O emissions, is presented.

Table 8.3.2 Total N_2O emission originating from treatment processes at the Danish WWTPs (direct emissions) and effluents to the Danish surface waters (indirect emissions), tonnes.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
$N_2O_{indirect}$	265	252	219	273	268	238	180	158	154	147
N_2O_{direct}	88	92	87	90	119	134	135	139	152	148
$N_2O_{,\ total}$	353	344	306	363	387	372	315	297	306	295
Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
$N_2O_{indirect}$	157	134	137	109	119	111	109	116	103	108
N_2O_{direct}	161	165	211	168	150	193	152	185	256	153
$N_2O_{,\ total}$	318	299	348	277	269	304	261	301	359	261

Regarding the calculated time trend in indirect N_2O emission from 1990 to 2009 has decreased 59 % N_2O, and the direct N_2O emission has increased 74 %. In absolute figures the indirect emission is a major contributor and the resulting total N_2O emission has decreased 26 % from 1990 to 2009.

8.3.2 Methodology and data

The methodology developed for this submission for estimating emission of methane and nitrous oxide from wastewater handling follows the IPCC Guidelines (IPCC, 1997) and IPCC Good Practice Guidance (IPCC, 2000). A revised methodology is presented for estimating CH_4 and no changes have occurred for the inventory of N_2O emissions for wastewater handling in Denmark in this year's inventory compared to 2010 (Nielsen et al., 2010) . This section is divided into methodological issues related to the CH_4 and N_2O emission calculations, respectively.

Methane emissions from private and municipal WWTPs

The methane emissions from WWTP are divided into a contribution from the sewer system, primary settling tank and biological N and P removal processes, $CH_{4,\ sewer+MB}$ and from anaerobic treatment processes in closed systems with biogas extraction for energy production, $CH_{4,AD}$:

$$CH_{4,WWTP} = CH_{4,sewer+MB} + CH_{4,AD} \qquad \text{Eq. 8.3.1}$$

<u>The fugitive emissions from the sewer system, primary settling tank and biological N and P removal processes, $CH_{sewer+MB}$, are estimated as:</u>

$$CH_{4,sewer+MB} = EF_{sewer+MB} \cdot TOW_{inlet}$$

$$\Downarrow \qquad \text{Eq. 8.3.2}$$

$$CH_{4,sewer+MB} = B_o \cdot MCF_{sewer+MB} \cdot TOW_{inlet}$$

where

TOW_{inlet} equals the influent organic degradable matter measured as biological oxygen demand (BOD) in the influent waste water flow,

Bo is the default maximum CH_4 producing capacity, i.e. 0.6 kg CH_4 per kg BOD (IPCC, 1997),

$MCF_{sewer+MB}$ is the fraction of DOC that is anaerobically converted in sewers and WWTPs. MCF_{WWTP} equals **0.003** based on an expert judgement of a conservative estimate of the fugitive methane emission from the primary settling tanks and biological treatment processes is well below 0.1% of influent BOD, while the fugitive emission from the sewer system is unknown.

The emission factor, $\boldsymbol{EF_{sewer+MB}}$, for these tree processes and systems equals **0.00018 kg CH_4 per kg BOD.**

<u>The methane emission from anaerobic digestion is calculated as:</u>

$$CH_{4,AD} = EF_{AD} \cdot TOW_{inlet} \cdot (1 - MR_{AD})$$
$$\Downarrow \qquad \text{Eq. 8.3.3}$$
$$CH_{4,AD} = B_o \cdot MCF_{AD} \cdot f_{AD} \cdot TOW_{inlet} \cdot (1 - MR_{AD})$$

where

Bo is the default maximum CH_4 producing capacity, i.e. 0.6 kg CH_4 per kg BOD (IPCC, 1996),

$\boldsymbol{MCF_{AD}}$ is extent to which degradation occurs under anaerobic conditions = 1,

$\boldsymbol{TOW_{inlet}}$ equals the influent organic degradable matter measured as biological oxygen demand (BOD) in the influent waste water flow,

$\mathbf{f_{AD}}$ is the fraction of sludge treated in anaerobic closed systems.

$\boldsymbol{MR_{AD}}$ is the methane generation and combustion efficiency = 99 %

The methane recovery, MR_{inlet}, for the anaerobic wastewater treatment with biogas production has been set to 99% according to expert knowledge (personal communication, Professor Jes Vollertsen, Aalborg University and ASEP, 2010).

Methane emissions from septic tanks

In Denmark 10% of the population are not connected to the municipal sewer system. For this fraction of the population, decentralised waste water handling in occurring in terms septic tanks. Only little knowledge in known about the frequency of collection and no measurements of the methane emissions from septic tanks and the pumping and management of septage, including its transportation to a wastewater treatment facility exist. Methane emission from septic tanks is calculated as:

$$CH_{4,st} = EF_{st} \cdot f_{nc} \cdot P \cdot DOC_{st}$$
$$\Downarrow \qquad \text{Eq. 8.3.4}$$
$$CH_{4,st} = B_o \cdot MCF_{st} \cdot f_{nc} \cdot P \cdot DOC_{st}$$

where

Bo is the default maximum CH_4 producing capacity, i.e. 0.6 kg CH_4 per kg BOD (IPCC, 1996).

MCF_{st} is methane conversion factor depends on the extent to which BOD settles in the septic tanks. **MCF_{st}** has been set equal to 0.5 (IPCC, 2006) assuming that degradation for the settles DOC occurs under 100% anaerobic conditions.

F_{nc} is the fraction of the population that are not connected to the sewer system, i.e. scattered houses which equals 10 %.

DOC_{st} is the per capita produced degradable organic matter (DOC) which equals 18 250 kg BOD per 1000 persons per year (IPCC, 2000).

P is the population number

Using the default maximum methane producing capacity and a correction factor of 0.5 (IPCC guidelines, 2006, Table 6.3) results in an emission factor, **EF_{st}, equal to 0.03**.

Yearly activity data and emission factors used for calculation the net methane emission

Monitoring data on the influent biological oxygen demand (BOD) are available for mixed industrial and household wastewater, which are used for calculating the total organic waste (TOW) in the influent wastewater. From 1990 to 1998, the IPPC default methodology for household wastewater has been applied by accounting and correcting for the industrial influent load (Thomsen & Lyck, 2005). For the years 1999 to 2009 monitoring data from the national monitoring program exists (cf. Table 8.3.9). For the year 2009 the national total TOW data are calculated based on monitoring data from approximately 1000 municipal WWTPs; each WWTP represented by an average of 12 measurements. Yearly BOD data are calculated from measured BOD per litre influent waste water multiplied by the influent amount of water. The time-series for activity data on TOW are presented in Table 8.3.3.

Table 8.3.3 Total degradable organic waste (TOW) calculated by use of the default IPCC method corrected for contribution from industry to the influent TOW (1990-1998) and country-specific data (1999-2009).

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Contribution from industrial inlet BOD	2.5	2.5	2.5	5.0	13.6	22.2	30.8	39.4	48.0	41.0
Population-Estimates (1000)	5140	5153	5170	5188	5208	5228	5248	5268	5287	5305
TOW [Gg] corr deafulat IPPC	96.62	96.39	96.71	99.42	107.97	116.59	125.28	134.02	142.80	
TOW [Gg]; country-specific data										140.25
Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Contribution from industrial inlet BOD	42	38	38	37	40.5	40.5	40.5	40.5	40.5	40.5
Population-Estimates (1000)	5322	5338	5351	5384	5398	5411	5427	5447	5476	5482
TOW [Gg]; corrected IPPC method										
TOW [Gg]; country-specific data	141.49	144.36	156.18	160.21	153.06	149.83	146.59	148.88	145.11	148.41

*TOW = (1+I/100) x (P x D_{dom}), where P is the Population number, D_{dom}= 18 250 kg BOD pr 1000 persons pr yr and I is the percent contribution from industry to the influent wastewater TOW content.

A country-specific emissions factor for calculating the amount of methane produced during anaerobic treatment processes, the gross methane emission (cf. Table 8.3.1), at the Danish WWTPs have been derived. From this emission factor the fugitive emissions from anaerobic treatment processes has been calculated according to equation 8.3.3. The emission factor varies according the national statistics on the fraction of wet weight sludge treated anaerobic as reported in the Danish sludge database and presented in Table 8.3.4.

Table 8.3.4 Country-specific emission factor for estimating the methane generated during anaerobic treatment processes, kg CH_4/kg BOD.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Fraction of wet weight sludge treated in anaerobic processes , F_{AD}	0.29	0.29	0.29	0.29	0.29	0.29	0.32	0.36	0.31	0.30
EF =MCF*f_{AD}*B_o	0.17	0.17	0.17	0.17	0.17	0.17	0.19	0.21	0.19	0.18
Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Fraction of wet weight sludge treated in anaerobic processes, F_{AD}	0.41	0.41	0.29	0.34	0.31	0.34	0.34	0.34	0.34	0.34
EF =MCF*f_{AD}*B_o	0.24	0.24	0.17	0.20	0.18	0.20	0.20	0.20	0.20	0.20

The Danish sludge database have low reporting statistics for the years 2006-2009 why the fraction of sludge treated anaerobic have been set equal to the reported fraction in 2005.

Overall methane emission time trends

The trends in the CH_4 emission from the Danish WWTPs, as summarised in Table 8.3.1, are presented graphically in Figure 8.3.1.

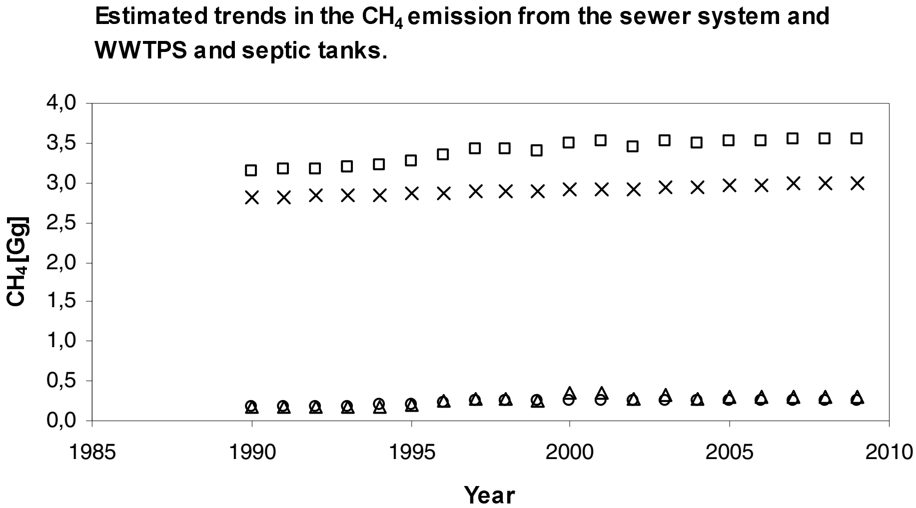


Figure 8.3.1 Time trends for net methane emission (open squares), from septic tanks (crosses), from anaerobic treatment processes (open triangles), and from sewer system, primary settling tank and biological N and P removal processes, $CH_{sewer+MB}$, (open circles).

The net methane emissions has increased from 3.15 Gg in 1990 to 3.56 Gg methane in 2009 corresponding to an increase in net methane emissions from wastewater handling of 13 %.

N_2O emissions from WWTPs

N_2O may be generated by nitrification (aerobic processes) and denitrification (anaerobic processes) during biological treatment. Starting material in the influent may be urea, ammonia and proteins, which are converted to nitrate by nitrification. Denitrification is an anaerobic biological conversion of nitrate into dinitrogen. N_2O is an intermediate of both processes. Danish investigation indicates that N_2O is formed during aeration steps in the sludge treatments process as well as during anaerobic treatments; the former contributing most to the N_2O emissions during sludge treatment (Gejlsberg et al., 1999). A review by Kampschreur et al. (Kampschreur et al., 2009) documents that around 90% of the emitted N_2O originates from activated sludge processes. Based on this review an average of two highest EF values from activate sludge process, i.e. 0.6 % N_2O (Wicht et al., 1995) and 0.035 % (Czepiel et al., 1995), both reported in units of per cent N load in the influent wastewater ,was used to derive a national EF for the direct emission of nitrous oxide.

The direct N_2O emission from wastewater treatment processes is calculated according to equation 8.3.5:

$$E_{N_2O} = EF_{N_2O,direct} \cdot m_{N,\text{influent}} \cdot \frac{M_{N_2O}}{2 \cdot M_N} \qquad \text{Eq. 8.3.5}$$

where

***EF**$_{N2O,direct}$* is set equal to a fraction of 0.0032 of the N load in the influent waste water.

$m_{N,influent}$ is the yearly reported N load in the Danish Water Quality Parameter Database provided in Table 8.3.5.

M_{N2O} **/**M_{N2} is the mass ratio i.e. 44/28 to convert the fraction of discharged N emitted as laughter gas from units in mass of total N to emissions in mass N_2O.

The country-specific EF value of 0.0032 may be expressed as $EF_{N2O,direct}$ = **4.99 g N_2O pr kg N load** in the influent wastewater by reducing eq. 8.3.5 to:

$$E_{N_2O} = EF_{N_2O,direct} \cdot m_{N,\inf luent} \qquad \text{Eq. 8.3.6}$$

The methodology here adopted for estimating the direct N_2O emission only relies on the influent N load as activity data.

The indirect N_2O emission from WWTPs is calculated according to equation 8.3.7:

$$E_{N_2O,WWTP,effluent} = D_{N,WWTP} \cdot EF_{N_2O,WWTP,effluent} \cdot \frac{M_{N_2O}}{2 \cdot M_N} \qquad \text{Eq. 8.3.7}$$

where

$D_{N.WWTP}$ is the effluent discharged sewage nitrogen load consisting of contributions from municipal wastewater treatment plants, the separate industry, effluent from mariculture and fish farming, rainwater conditioned effluents and scattered houses not connected to the sewerage system (cf. Table 8.3.5).

$EF_{N2O.WWTP.effluent}$ is the IPCC default emission factor of **0.01 kg N_2O-N pr kg sewage-N** produced (IPCC (1997) GL, p 6.28)

M_{N2O} **/**M_{N2} is the mass ratio i.e. 44/28 to convert the fraction of discharged N emitted as laughter gas from units in mass of total N to emissions in mass N_2O.

Yearly activity data and emission factors for calculating the nitrous oxide emission

Data on the N content in the influent and effluent waste water flows are provided in Table 8.3.5. The effluent data provided in the table constitutes a sum of the N content in effluent waste water from municipal wastewater treatment plants, the separate industry, effluent from mariculture and fish farming, rainwater conditioned effluents and scattered houses.

Table 8.3.5 Nitrogen content in the influent and effluent waste water, tonnes.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Influent waste water from municipal WWTPs*	17 614	18 477	17 391	18 012	23 866	26 808	27 096	27 891	30 394	29 686
Effluent wastewater, total**	16 884	16 032	13 953	17 403	17 079	15 152	11 431	10 068	9 796	9 363
% N reduction in effluent N	4	18	25	40	57	67	76	83	83	83
Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Influent waste water from municipal WWTPs	32 342	32 999	42 224	33 645	29 989	38 746	30 481	37 079	51 370	30 623
Effluent wastewater, total	10 005	8 553	8 740	6 927	7 589	7038	6 935	7 381	6 558	6 878
% N reduction in effluent N	86	87	89	89	87	90	88	88	93	87

*Data on the influent wastewater N load from municipal WWTPs are available from the Danish Water Quality Parameter Database held by the Agency for Spatial and Environmental Planning ** Effluent waste water, total includes separate industrial discharges, rainwater conditioned effluent, scattered houses, mariculture and fish farming and effluents from WWTPs (DEPA. 1994, 1996a, 1997, 1998, 1999a, 2000, 2001a, 2002, 2003a, 2004b, 2005a, 2005b and ASEP 2007, 2009, 2010.

The significant reduction in the effluent waste water content of nitrogen is a driver for the increasing direct N_2O emission.

Overall nitrous oxide emission time trends

The trends in the direct N_2O emission from WWTPs, the indirect emission from wastewater effluent and the total, as summarised in Table 8.3.2, are presented graphically in Figure 8.3.2.

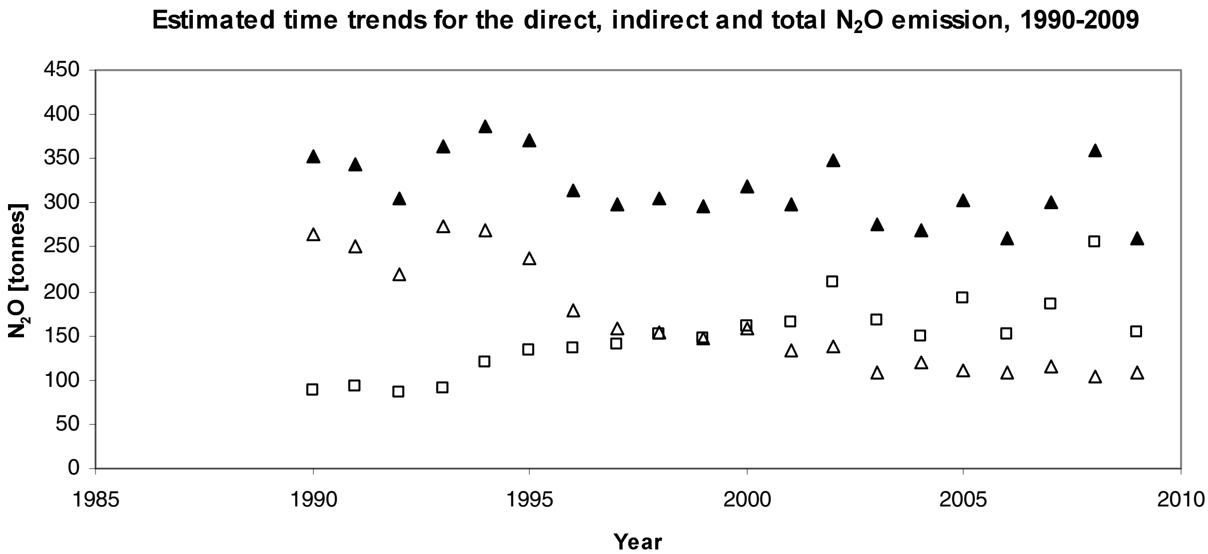


Figure 8.3.2 Time trends for direct emission of N_2O (open squares), indirect emission, i.e. from wastewater effluents (open triangles), and total N_2O emission (black triangles).

The yearly fluctuations may be caused by several factors such as e.g. climatic condition such as rainwater variation and as a result varying contributions to the influent N and varying characteristics of especially the industrial contributions to the influent. Furthermore, infiltration of groundwater, as well as exfiltration of wastewater (DEPA, 1994, 1995, 1996, 1998, 1999a, 2000, 2001a, 2002, 2003a, 2004a, 2005a, 2005b; ASEP, 2007, 2009, 2010; Vollertsen et al, 2002), may contribute to the "noise" or fluctuation in the time trend of the calculated indirect N_2O emission.

The direct emission trend increases slightly, reaching a stable but fluctuating level from 2002 onwards. The decrease in the emission from effluent wastewater is due to the technical upgrade and centralisation of the Danish WWTPs following the adoption of the Action Plan on the Aquatic Environment in 1987. The decrease in the indirect emission from wastewater effluent from 265 in tonnes N_2O in 1990 to 108 tonnes N_2O in 2009 caused by a decrease in wastewater effluent nitrogen loads from around 4 % in 1990 to 90 % from 2002-2009. The indirect emission is the major contributor to the emission of nitrous oxide in the period 1990-1997. However, from 2002-2009, the direct N_2O emission is the major contributor to the total N_2O emission.

8.3.3 Uncertainties and time-series consistency

Two set of uncertainty estimates are made for the Danish emission inventory for greenhouse gases based on Tier 1 and Tier 2 methodology, respectively. The uncertainty models follow the methodology in IPCC

Good Practise Guidance (IPCC, 2000). Tier 1 is based on the simplified uncertainty analysis and Tier 2 is based on Monte Carlo simulations.

Input parameter uncertainties

Uncertainty levels for activity data and emission factors are listed in Table 8.3.6. Uncertainty levels are given in percentage related to the 95 % confidence interval assuming a normal distribution.

Default IPCC values are assumed to be given at 95 % confidence level. For the country-specific activity data, the standard deviation of different data sources has been used for deriving percent uncertainty estimates6.

Table 8.3.6 Input parameter uncertainties in year 1990 and 2009, for activity data and emission factors used Tier 2 uncertainty model, %.

Source	Uncertainties value for activity data, %		Uncertainties value for emission factor, %	
	1990	2009	1990	2009
CH_4, sewer system and WWTP	33	33	32	32
CH_4, septic tanks	31	31	36	36
CH_4, emission from anaerobic treatment [Gg]	33	33	34	34
N_2O, indirect	45	16	17	17
N_2O,direct	38	12	27	27

Uncertainties have been from IPPC default values and uncertainties in-country-specific parameters, respectively (cf. Annex 3G, Table 3G.2).

Results

The results of Tier 1 uncertainty model for 2009 are presented in Table 8.3.7 and based on input parameter uncertainties at the same aggregation level as reported in last years NIR (Nielsen et al. 2010). The contribution to the total emission uncertainty is highest for methane followed by the direct N_2O emission and indirect N_2O emission. Regarding the time trend, the largest uncertainty is observed for the direct N_2O which also shows the largest increasing trend. When looking at the total trend, the large increasing trend for the direct N_2O emissions is levelled out by a similar decreasing trend for indirect N_2O emission. The total emission from wastewater handling in 2009 is 156 Gg CO_2-eqv; the associated the uncertainty is 79 %. Based on the Tier 1 uncertainty model, the trend for the total emission for source category 6.B. Wastewater Handling is -11 % and the trend uncertainty ± 54 %.

Table 8.3.7 Uncertainty estimates for total emissions in 2009 and emission trends from the Tier 1 uncertainty model, Gg CO_2-eqv

	Emission [Gg CO_2-eqv]	Uncertainty, %	Trend, %	Uncertainty, %
	2009	Lower and upper (±)	1990-2009	Lower and upper (±)
CH_4	75	43	13	99
$N_20_{, indirect}$	34	15	-59	48
$N_2O_{, direct}$	47	32	74	129
Total	156	79	-11	54

For the tier 2 uncertainty model, the input parameter uncertainties provided in Table 8.3.6 have been used. The resulting uncertainty estimates are presented in Table 8.3.8.

Table 8.3.8 Uncertainty estimates for total emissions in 1990 and 2009 and for the emission trends from the Tier 2 uncertainty model, Gg CO_2-eqv.

	1990			2009			1990-2009		
Gg CO_2-eqv	Median emission [Gg]	Uncertainty, %		Median emission [Gg]	Uncertainty, %		Median trend, %	Uncertainty, %	
		Lower (-)	Upper (+)		Lower (-)	Upper (+)		Lower (-)	Upper (+)
N_2O	110	31	47	81	15	17	29	126	182
CH_4	67	35	55	75	33	53	-9	522	491
Total	178	38	62	156	18	34	22	269	304

By comparing the results of the Tier 1 and 2 uncertainty estimates high discrepancies are observed for the median trend and associated uncertainties for methane. The input parameter uncertainty data used for the tier 2 uncertainty analysis (Table 8.3.6) results in a negative trend for methane, which does not reflect the nature of the 1990-2009 times trend as presented in Figure 8.3.1). The estimated medium negative trend is possible due to the very high uncertainty levels combined with a small increase of 13 % in absolute numbers for the time trend 1990-2009. The misleading result from the Tier 2 uncertainty analysis for methane is the reason for similar discrepancies in results from the Tier 1 and 2 trend uncertainty estimates. Detailed data on the derived input parameter uncertainties are presented in Annex 3G and high priorities a given to the reduction of uncertainties in input parameters (cf. Chapter 8.3.6).

Time-series consistency and completeness

Registration of the activity data needed for the calculation of nitrous oxide emission from the effluent water has been registered as a measure of the effectiveness (distance to target) of the Action Plan on the Aquatic Environment since 1987, whereas the sludge data base are based on voluntary reporting.

Consistency and completeness have been improved by access to the Danish Water Quality Parameter Database (www.miljoeportal.dk) and the Danish Sludge Database held by DEPA. A first evaluation and quality assessment of the existing sludge data are presently in Nielsen et al, 2010. A second stage data gap filling and harmonisation of plant-specific data between different data sources will be performed and expected to improve the accuracy of the activity data used for calculating both methane and laughter gas emissions.

At this point, data regarding industrial on-site wastewater treatment processes is not available at a level that allows for calculation of the on-site industrial contribution to CH_4 or N_2O emissions. The degree to which industry is covered by the estimated emission is, therefore, dependent on the amount of industrial wastewater connected to the municipal sewer system. Any direct emissions from pre-treatment on-site are not covered in this inventory.

8.3.4 QA/QC and verification

QA/QC-procedure

The methodology for estimating emissions from wastewater handling was introduced for the first time in the inventory submission in March-April 2005. The methodology for estimating the methane emission has been revised for the current submission as presented in the preceding sections. Activity data has been presented and recalculations are provided in Chapter 8.3.5.

In general terms, for this part of the inventory, the Data Storage (DS) Level 1 and 2 and the Data Processing (DP) Level 1 can be described as follows:

Data Storage Level 1

The external data level refers to the placement of input data used for deriving yearly activity and emission factors; references in terms of report and databases used for deriving input for the emission calculations. Reports and a list of links to external data sources are stored in a common data storage system including all sectors of the yearly NIRs.

Table 8.3.9 Overview of yearly stored external data sources at DS level1.

http, file or folder name	Description	AD or EF	Reference	Contact(s)	Data agreement/ comment
NERI data-exchange folder I:\ROSPROJ\LUFT_EMI\Inventory\2009\6_Waste\Level_1a_Storage\6B Waste Water*	Inventory data storage system	AD and EF	NERI	Marianne Thomsen (mth@dmu.dk)	
Report series published and available from the Danish Environmental Protection Agency: www.mst.dk	Reported sludge and water quality parameters	AD	Report series from DEPA: "*Wastewater sewage sludge from municipal and private wastewater treatment plants*" (1997-2005) "*Point sources*" (1993-2005)	Karin Dahlgren (kdl@blst.dk) Marianne Thomsen (mth@dmu.dk)	Public available reports
Report series published and available from the Danish Nature Agency (DNA): www.nst.dk			Report serie: "*Point sources*" (2006-2008)	Anna Gade Holm (angho@nst.dk) Marianne Thomsen (mth@dmu.dk)	Public available reports
Danish Water Quality parameter Database	Yearly reported wastewater characteristics at plant level which includes all years 1990-2009	AD	www.miljoeportalen.dk	Marianne Thomsen (mth@dmu.dk)	Authorised access
Danish Sludge Database	Yearly reported sludge characteristics at plant level	AD	DEPA	Linda Bagge (bagge@mst.dk) Marianne Thomsen (mth@dmu.dk)	none
http://www.statistikbanken.dk/FU5	Population statistics	AD	Statistics Denmark	Marianne Thomsen (mth@dmu.dk)	Public access

*The data storage level 1 consists of DEPA reports and data extracted from other sources listed in the Table.

Data Processing Level 1

This level, for wastewater handling, comprises a stage where the external data are treated internally, preparing for the input to the country-specific models. Programming as to automatically calculations based on activity data and emission factors are not yet fully operational. Calculations are carried out and the output stored in a not editable format each year. The DP at level 1 has been improved to fit into a more uniform and easily accessible data reporting format. Regarding the derivation of activity data and emission factors used in the model calculations, this year's improvements are documented in Chapter 8.3.1.

Data Storage Level 2

Data Storage Level 2 is the placement of selected output data from the country-specific models as inventory data on SNAP levels in the Access (CollectER) database.

Points of measurement

The present stage of QA/QC for the Danish emission inventories for wastewater handling is described below for DS and DP level 1 Points of Measurement (PMs). This is to be seen in connection with the general QA/QC description in Section 1.6 and, especially, 1.6.10 on specific description of PMs common to all sectors, general to QA/QC.

Data Storage level 1	1. Accuracy	DS.1.1.1	General level of uncertainty for every dataset including the reasoning for the specific values

This years tier 2 uncertainty calculations have shown high uncertainties levels on the trend in the methane emission. The input parameter uncertainties have been derived from standard deviations between activity data extracted from national databases and reported national statistics as shown in Table 8.3.9.

Data Storage Level 1	1. Accuracy	DS.1.1.2	Quantification of the uncertainty level of every single data value including the reasoning for the specific values.

Uncertainties on defaults numbers are taken from the IPCC GL and GPG. Uncertainty of activity data are based on simple standard deviations accompanying the yearly reported monitoring data.

Data Storage level 1	2.Comparability	DS.1.2.1	Comparability of the data values with similar data from other countries, which are comparable with Denmark, and evaluation of discrepancy.

Comparison of Danish data values with data sources from other countries has been carried out in order to evaluate discrepancies as presented in the national verification report by Fauser et al., 2006 and the methodology report by Thomsen & Lyck, 2005 and Nielsen et al, 2010.

Data Storage level 1	3.Completeness	DS.1.3.1	Documentation showing that all possible national data sources are included by setting down the reasoning behind the selection of datasets.

Methodology, reasoning and relevance of data sources used as input at DS level 1 have been improved. Activity for the whole time-series has been provided in Chapter 8.3.2.

Direct nitrous emissions from separate industries and methane emission from industrial WWT are not included in the inventory.

Data Storage level 1	4.Consistency	DS.1.4.1	The origin of external data has to be preserved whenever possible without explicit arguments (referring to other PMs).

The origin of external activity data are preserved and saved for each year of reporting in a non editable format. In this way changes to previously received data and calculations is reflected and explanations are given.

Data Storage level 1	6.Robustness	DS.1.6.1	Explicit agreements between the external institution holding the data and NERI about the conditions of delivery.

This point may still be critical due to the missing timing full reporting and completeness of the databases held by the ASEP and DEPA respectively with respect to the submission date of the yearly NIR.

Data Storage level 1	7.Transparency	DS.1.7.1	Summary of each dataset including the reasoning for selecting the specific dataset

A summary of the data set can be seen in section 8.3.1 and 8.3.2 including the reasoning behind the selection of the specific dataset.

Data Storage level 1	7.Transparency	DS.1.7.3	References for citation for any external dataset have to be available for any single value in any dataset.

External datasets are either directly accessible or specifically cited in terms of reports given in the list of references including link to internet accessible formats. Data sets are stored every year in the given data exchange folder at NERI (cf. Table 8.3.9).

Data Storage level 1	7.Transparency	DS.1.7.4	Listing of external contacts for every dataset

Contact persons related to the delivery of specific data related to wastewater and sewage sludge are provided in Table 8.3.9.

Data Processing level 1	1. Accuracy	DP.1.1.1	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to type of variability. (Distribution as: normal, log normal or other type of variability)

Tier 1 and 2 uncertainty calculations are made. Normal distributions of activity data and emission factor variability are assumed. Uncertainties are reported in section 8.3.3.

Data Processing level 1	1. Accuracy	DP.1.1.2	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to scale of variability (size of variation intervals)

The uncertainty assessment has been given in Section 8.3.3.

Data Processing level 1	1. Accuracy	DP.1.1.3	Evaluation of the methodological approach using international guidelines

An evaluation of the methodological approach, in comparison with the check and default IPCC methodology and is presented in Thomsen & Lyck, 2005.

Data Processing level 1	1. Accuracy	DP.1.1.4	Verification of calculation results using guide-line values

This has been performed in Thomsen & Lyck, 2005 and Fauser et al., 2006.

Data Processing level 1	2.Comparability	DP.1.2.1	The inventory calculation has to follow the international guidelines suggested by the UNFCCC and IPCC.

The calculations follow the IPCC GL and GPG. Exemptions have been documented when ever occurring.

Data Processing level 1	3.Completeness	DP.1.3.1	Assessment of the most important quantitative knowledge which is lacking.

- Data on separate industrial WWTPs

Data Processing level 1	3.Completeness	DP.1.3.2	Assessment of the most important cases where access is lacking with regard to critical data sources that could improve quantitative knowledge.

Information on methane emissions for separate industries may be of importance.

Data Processing level 1	4.Consistency	DP.1.4.1	In order to keep consistency at a high level, an explicit description of the activities needs to accompany any change in the calculation procedure.

Methodological improvements for calculation the methane emission have been described and activity data have been presented. Recalculations for the whole time-series are provided in Chapter 8.3.5.

Data Processing level 1	5.Correctness	DP.1.5.1	Show at least once, by independent calculation, the correctness of every data manipulation.

The model has been checked by comparison with the IPCC default methodologies as presented in Thomsen & Lyck, 2005.

Data Processing level 1	5.Correctness	DP.1.5.2	Verification of calculation results using time-series

The time-series of activities and emissions in the model output, in the SNAP source categories and in the CRF format have been prepared. The time-series are examined and significant changes are checked and explained.

Data Processing level 1	5.Correctness	DP.1.5.3	Verification of calculation results using other measures

The correct interpretation in the model of the methodology and the parameterisation has been checked as far as possible, refer DP.1.5.1.

Data Processing level 1	5.Correctness	DP.1.5.4	Shows one-to-one correctness between external data sources and the databases at Data Storage level 2

Data transfer control is made from the external data sources and to the SNAP source categories at level 2. This control is carried on further to the aggregated CRF source categories.

Data Processing level 1	7.Transparency	DP.1.7.1	The calculation principle and equations used must be described

The calculation principle and equations are described in Section 8.3.2.

Data Processing level 1	7.Transparency	DP.1.7.2	The theoretical reasoning for all methods must be described

The theoretical reasoning is described in Section 8.4.3 and in Thomsen & Lyck, 2005.

Data Processing level 1	7.Transparency	DP.1.7.3	Explicit listing of assumptions behind all methods

The assumption is that the emissions can be described according to the applied methodology and models as these are developed in accordance to the IPCC GL and GPG for wastewater handling.

Data Processing level 1	7.Transparency	DP.1.7.4	Clear reference to dataset at Data Storage level 1

Refer to the Table 8.3.9 and DS.1.1.1 above.

Data Processing level 1	7.Transparency	DP.1.7.5	A manual log to collect information about recalculations

Recalculation changes in the emission inventories are described in the NIR. The logging of the changes takes place in the yearly model file.

Data Storage level 2	5.Correctness	DS.2.5.1	Documentation of a correct connection between all data types at level 2 to data at level 1

The full documentation for the correct connection exists through the yearly model file, its output and report files made by the CollectER database system.

Data Storage level 2	5.Correctness	DS.2.5.2	Check if a correct data import to level 2 has been made

This check is performed, comparing model output and report files made by the CollectER database system, refer to DS.2.5.1.

8.3.5 Recalculations

For Waste Water handling recalculations was made for 1990 to 2008 for CH_4 and N_2O emissions from wastewater handling.

The methane emission waste water handling have this year been specified according to contributions from 1) the sewer system, 2) in primary settling tanks 3) during biological N and P removal and 4) from anaerobic treatment processes in closed systems with biogas extraction and combustion for energy production. In this years inventory an estimation methane emissions from the septic system has been included. Recalculations are shown in Table 8.3.10.

Table 8.3.10 CH_4 emissions from wastewater handling 6.B. Recalculation performed in the 2011 submission for 1990-2008.

Current submission	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CH_4, gross anaerobic processes [Gg]	16.64	16.60	16.66	17.13	18.60	20.08	24.34	28.77	26.85	25.01
CH_4, recovered [Gg]	16.48	16.44	16.49	16.95	18.41	19.88	24.10	28.48	26.58	24.76
CH_4, sewer system and WWTP	0.17	0.17	0.17	0.18	0.19	0.21	0.23	0.24	0.26	0.25
CH_4, septic tanks	2.81	2.82	2.83	2.84	2.85	2.86	2.87	2.88	2.89	2.90
CH_4, emission from anaerobic treatment [Gg]	0.17	0.17	0.17	0.17	0.19	0.20	0.24	0.29	0.27	0.25
CH_4 emission [Gg]	3.15	3.16	3.17	3.19	3.23	3.27	3.34	3.41	3.42	3.41
Previous submission	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CH_4, gross anaerobic processes [Gg]	14.49	14.46	14.51	14.91	16.20	17.49	18.79	20.10	21.42	21.04
Not emitted CH_4 [Gg]	13.04	13.01	13.06	13.42	14.58	15.74	16.91	18.09	19.28	18.93
CH_4,net (Gg) new method	1.45	1.45	1.45	1.49	1.62	1.75	1.88	2.01	2.14	2.10
Percent change 2009 vs 2008 time-series	117.7	118.6	118.6	114.0	99.5	87.1	77.9	69.8	59.7	61.9
Continued										
Current submission	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CH_4, gross anaerobic processes [Gg]	34.58	35.14	26.73	32.31	28.28	30.50	29.84	30.30	29.53	30.21
CH_4, recovered [Gg]	34.24	34.78	26.47	31.99	28.00	30.19	29.54	30.00	29.24	29.90
CH_4, sewer system and WWTP	0.25	0.26	0.28	0.29	0.28	0.27	0.26	0.27	0.26	0.27
CH_4, septic tanks	2.91	2.92	2.93	2.95	2.96	2.96	2.97	2.98	3.00	3.00
CH_4, emission from anaerobic treatment [Gg]	0.35	0.35	0.27	0.32	0.28	0.30	0.30	0.30	0.30	0.30
CH_4 emission [Gg]	3.51	3.53	3.48	3.56	3.51	3.54	3.53	3.55	3.55	3.57
Previous submission	2000	2001	2002	2003	2004	2005	2006	2007	2008	
CH_4, gross anaerobic processes [Gg]	21.22	21.65	23.43	24.03	22.96	22.47	21.99	22.51	22.54	
Not emitted CH_4 [Gg]	19.10	19.49	21.08	21.63	20.66	20.23	19.79	20.25	20.28	
CH_4,net (Gg) new method	2.12	2.17	2.34	2.40	2.30	2.25	2.20	2.25	2.25	
Percent change 2009 vs 2008 time-series	65.6	63.2	48.5	48.1	53.0	57.4	60.7	57.9	57.7	

Furthermore, a yearly emission factor for the anaerobic processes has been implemented as reported in Chapter 8.3. Recalculations are provided in Table 8.3.11.

Table 8.3.11 Methane "emission factors" for the fraction of sludge treated anaerobically (CH_4, gross anaerobic processes) . Percent change in the EF used in the recalculation performed in the 2011 submission for 1990-2008.

Current submission	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
MCF	0.29	0.29	0.29	0.29	0.29	0.29	0.32	0.36	0.31	0.30
Bo [kg CH_4/kg BOD]	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF[kg CH_4/kg BOD] =MCF*Bo	0.1723	0.1723	0.1723	0.1723	0.1723	0.1723	0.1943	0.2147	0.1880	0.1783
Previous submission	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
MCF	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Bo [kg CH_4/kg BOD]	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF[kg CH_4/kg BOD] =MCF*Bo	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Percent change 2009 vs 2008 time-series	15	15	15	15	15	15	30	43	25	19
Continued										
Current submission	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
MCF	0.41	0.41	0.29	0.34	0.31	0.34	0.34	0.34	0.34	0.34
Bo [kg CH_4/kg BOD]	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
EF[kg CH_4/kg BOD] =MCF*Bo	0.2444	0.2434	0.1712	0.2017	0.1848	0.2035	0.2035	0.2035	0.2035	0.2035
Previous submission	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
MCF	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	
Bo [kg CH_4/kg BOD]	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	
EF[kg CH_4/kg BOD] =MCF*Bo	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	
Percent change 2009 vs 2008 time-series	63	62	14	34	23	36	36	36	36	

Updated quality assured data on the N content in the effluent wastewater for 2005-2009, have resulted changes the indirect N_2O emission.

Correction of an error in the EF algorithm for direct N_2O emissions has resulted in the direct N_2O emission an increase of 13.7 % of the direct N_2O emission.

The percent change in the direct, indirect and total N_2O emission in this years (1990-2009) versus last years (1990-2008) reported time-series are shown in Table 8.3.12.

Table 8.3.12 N_2O emissions from wastewater handling 6.B. Recalculation performed in the 2011 submission for 1990-2008.

Current submission	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Direct N_2O emission [Gg]	0.088	0.092	0.087	0.090	0.119	0.134	0.135	0.139	0.152	0.148
Indirect N_2O emission [Gg]	0.265	0.252	0.219	0.273	0.268	0.238	0.180	0.158	0.154	0.147
Total N_2O emission	0.353	0.344	0.306	0.363	0.387	0.372	0.315	0.297	0.306	0.295
Previous submission	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Direct N_2O emission [Gg]	0.077	0.081	0.076	0.079	0.118	0.118	0.119	0.122	0.133	0.130
Indirect N_2O emission [Gg]	0.265	0.252	0.219	0.273	0.268	0.238	0.180	0.158	0.154	0.147
Total N_2O emission	0.343	0.333	0.296	0.352	0.386	0.356	0.298	0.281	0.287	0.277
Percent change in the direct N_2O emission	13.73	13.73	13.73	13.73	1.25	13.73	13.73	13.73	13.73	13.73
Percent change in the indirect N_2O emission	0	0	0	0	0	0	0	0	0	0
Percent change in the total N_2O emission	3.1	3.3	3.5	3.1	0.4	4.5	5.5	6.0	6.4	6.4
Continued										
Current submission	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Direct N_2O emission [Gg]	0.161	0.165	0.211	0.168	0.150	0.193	0.152	0.185	0.256	0.153
Indirect N_2O emission [Gg]	0.157	0.134	0.137	0.109	0.119	0.111	0.109	0.116	0.103	0.108
Total N_2O emission	0.319	0.299	0.348	0.277	0.269	0.304	0.261	0.301	0.359	0.261
Previous submission										
Direct N_2O emission [Gg]	0.142	0.145	0.185	0.148	0.132	0.170	0.134	0.163	0.225	
Indirect N_2O emission [Gg]	0.157	0.134	0.137	0.109	0.119	0.111	0.109	0.100	0.112	
Total N_2O emission	0.299	0.279	0.323	0.256	0.251	0.280	0.242	0.263	0.337	
Percent change in the direct N_2O emission	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	
Percent change in the indirect N_2O emission	0	0	0	0	0	0.1	0.4	15.9	-7.8	
Percent change in the total N_2O emission	6.5	7.1	7.9	7.9	7.2	8.4	7.8	14.6	6.6	

8.3.6 Planned improvements

Suggested QA/QC plan for wastewater handling
Special focus will be on the improvement of the quality of activity data used in the calculation of the methane emission. Expected result is a lowering of the uncertainty level in the time trend.

References for Chapter 8.3

Adouania, N., Lendormia, T., Limousya, L., Sirea, O., 2010: Effect of the carbon source on N2O emissions during biological denitrification. *Resources, Conservation and Recycling*, 54, 299-302.

Agency for Spatial and Environmental Planning (ASEP), 2010: Point sources 2008. In Danish: Punktkilderapport 2008. Det nationale program for overvågning af vandmiljøet; Fagdatacenterrapport. Available at: http://www.blst.dk/NR/rdonlyres/40130016-7F05-47F9-BF2E-A9756D83EDE6/0/PunktkildeRapport200815022010.pdf (last accessed, March 2011)..

Agency for Spatial and Environmental Planning (ASEP), 2009: Point sources 2007. In Danish: Punktkilderapport 2007. Det nationale program for overvågning af vandmiljøet; Fagdatacenterrapport. Available at: http://www.blst.dk/NR/rdonlyres/CBCB6E2F-D00E-418F-805C-3F6E54BA90DD/0/Punktkilderapport_.pdf (last accessed March 2011).

Agency for Spatial and Environmental Planning (ASEP), 2007: Point sources 2006. In Danish: Punktkilder 2006. Det nationale program for overvågning af vandmiljøet; Fagdatacenterrapport. Available at: http://www2.blst.dk/udgiv/Publikationer/2007/978-87-92256-36-2/pdf/978-87-92256-37-9.pdf (last accessed March 2011).

Czepiel, P., Crill, P. & Harriss, R. 1995: Nitrous oxide emissions from municipal wastewater treatment, Environmental Science and Technology, 29, 2352-2356.

Danish Environmental Protection Agency (DEPA), 2010: Anvendelse af affald til jordbrugsformål. Vejledning fra Miljøstyrelsen Nr. 1 2010. Available at: http://www.landbrugsinfo.dk/Regelinfo/Kommenteringer/Filer/pl_ri_11_054_b1.pdf (last accessed March 2011).

Danish Environmental Protection Agency (DEPA), 2009: Wastewater from municipal and private wastewater treatment plants in 2005. In Danish: Spildevandsslam fra kommunale og private renseanlæg i 2005, Orientering fra Miljøstyrelsen, nr. 3. Available at: http://www2.mst.dk/udgiv/publikationer/2009/978-87-7052-993-8/pdf/978-87-7052-994-5.pdf (last accessed March 2011).

Danish Environmental Protection Agency (DEPA), 2005a: Point Sources 2004. In Danish: Punktkilder 2004, Orientering fra Miljøstyrelsen, nr. 9. Avaible at: http://www2.mst.dk/Udgiv/publikationer/2005/87-7614-865-3/pdf/87-7614-866-1.pdf (last accessed March 2011).

Danish Environmental Protection Agency (DEPA), 2005b: Point Sources 2003. Revision. In Danish: Punktkilder 2003 – revideret udgave, Orientering fra Miljøstyrelsen, nr. 1. Avaible at: http://www2.mst.dk/Udgiv/publikationer/2005/87-7614-512-3/pdf/87-7614-513-1.pdf (last accessed March 2011).

Danish Environmental Protection Agency (DEPA), 2004a: Point Sources 2003. In Danish: Punktkilder 2003, Orientering fra Miljøstyrelsen, nr. 16. Available at: http://www2.mst.dk/Udgiv/publikationer/2004/87-7614-482-8/pdf/87-7614-483-6.pdf (last accessed March 2011).

Danish Environmental Protection Agency (DEPA), 2004b: Wastewater from municipal and private wastewater treatment plants in 2002. In Danish: Spildevandsslam fra kommunale og private renseanlæg i 2002, Orientering fra Miljøstyrelsen, nr. 5. Available at: http://www2.mst.dk/Udgiv/publikationer/2004/87-7614-195-0/pdf/87-7614-196-9.pdf (last accessed March 2011).

Danish Environmental Protection Agency (DEPA), 2003a: Point Sources 2002. In Danish: Punktkilder 2002, Orientering fra Miljøstyrelsen, nr. 10.

Available at: http://www2.mst.dk/Udgiv/publikationer/2003/87-7614-074-1/pdf/87-7614-076-8.pdf (last accessed March 2011).

Danish Environmental Protection Agency (DEPA), 2003b: Wastewater from municipal and private wastewater treatment plants in 2000 and 2001. In Danish: Spildevandsslam fra kommunale og private renseanlæg i 2000 og 2001, Orientering fra Miljøstyrelsen, nr. 9. Available at: http://www2.mst.dk/Udgiv/publikationer/2003/87-7614-005-9/pdf/87-7614-006-7.pdf (last accessed March 2011).

Danish Environmental Protection Agency (DEPA), 2002: Point Sources 2001. In Danish: Punktkilder 2001, Orientering fra Miljøstyrelsen, nr. 7. Available at: http://www2.mst.dk/Udgiv/publikationer/2002/87-7972-384-5/pdf/87-7972-385-3.pdf (last accessed March 2011).

Danish Environmental Protection Agency (DEPA), 2001a: Point Sources 2000. In Danish: Punktkilder 2000, Orientering fra Miljøstyrelsen, nr. 13. Available at: http://www2.mst.dk/Udgiv/publikationer/2001/87-7944-943-3/pdf/87-7944-944-1.pdf (last accessed March 2011).

Danish Environmental Protection Agency (DEPA), 2001b: Wastewater from municipal and private wastewater treatment plants in 1999. In Danish: Spildevandsslam fra kommunale og private renseanlæg i 1999, Orientering fra Miljøstyrelsen, nr. 3. Available at: http://www2.mst.dk/Udgiv/publikationer/2001/87-7944-356-7/pdf/87-7944-357-5.pdf (last accessed March 2011).

Danish Environmental Protection Agency (DEPA), 2000: Point Sources 1999. In Danish: Punktkilder 1999, Orientering fra Miljøstyrelsen, nr. 16. Available at: http://www2.mst.dk/Udgiv/publikationer/2000/87-7944-298-6/pdf/87-7944-299-4.pdf (last accessed March 2011).

Danish Environmental Protection Agency (DEPA), 1999a: Point Sources 1998. In Danish: Punktkilder 1998, Orientering fra Miljøstyrelsen, nr. 6. Available at: http://www2.mst.dk/Udgiv/publikationer/1999/87-7909-554-2/pdf/87-7909-554-2.pdf (last accessed March 2011).

Danish Environmental Protection Agency (DEPA), 1999b: Wastewater from municipal and private wastewater treatment plants in 1997. In Danish: Spildevandsslam fra kommunale og private renseanlæg i 1997, Miljøprojekt, nr. 473. Available at: http://www2.mst.dk/Udgiv/publikationer/1999/87-7909-330-2/pdf/87-7909-330-2.pdf (last accessed March 2011).

Danish Environmental Protection Agency (DEPA), 1998: Point Sources 1997. In Danish: Punktkilder 1997, Orientering fra Miljøstyrelsen, nr. 9. Available at: http://www2.mst.dk/common/Udgivramme/Frame.asp?http://www2.mst.dk/Udgiv/publikationer/1998/87-7909-162-8/html/default.htm (last accessed March 2011).

Danish Environmental Protection Agency (DEPA), 1997: Point Sources 1996. In Danish: Punktkilder 1996, Orientering fra Miljøstyrelsen, nr. 16. Available at:

http://www2.mst.dk/common/Udgivramme/Frame.asp?http://www2.mst.dk/Udgiv/publikationer/1998/87-7909-162-8/html/default.htm (last accessed March 2011).

Danish Environmental Protection Agency (DEPA), 1996: Point Sources 1995. In Danish: Punktkilder 1995, Orientering fra Miljøstyrelsen, nr. 16. Available at: http://www2.mst.dk/Udgiv/publikationer/1996/87-7810-709-1/pdf/87-7810-709-1.pdf (last accessed March 2011).

Danish Environmental Protection Agency (DEPA), 1994: Point Sources 1993. In Danish: Punktkilder 1993, Orientering fra Miljøstyrelsen, nr. 8. Available at: http://www2.mst.dk/Udgiv/publikationer/1994/87-7810-279-0/pdf/87-7810-279-0.pdf (last accessed March 2011).

Danish Environmental Protection Agency (DEPA), 1989: Wastewater from municipal and private wastewater treatment plants in 1987. In Danish: Spildevandsslam fra kommunale og private renseanlæg i 1987, Orientering fra Miljøstyrelsen, nr. 10. Available at: http://www2.mst.dk/Udgiv/publikationer/1989/87-503-7944-5/pdf/87-503-7944-5.pdf (last accessed March 2011).

Fauser, P., Thomsen, M., Nielsen, O., Winther, M., Gyldenkærne, S., Hoffmann, L., Lyck, E. & Illerup, J. B. 2007: Verification of the Danish emission inventory data by national and international data comparisonsDanmarks Miljøundersøgelser, Aarhus Universitet. 53 pp - NERI Technical Report No. 627. Available at: http://www2.dmu.dk/Pub/FR627_Final.pdf (last accessed March 2011).

Intergovernmental Panel on Climate Change (IPCC), 2006: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, prepared by the National Greenhouse Gas Inventories Programme, Eggleston, H.S., Buendia, L., Miwa, K., Ngara, T & Tanabe, K. (eds). Published: IGES, Japan. Available at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html (last accessed March 2011).

Intergovernmental Panel on Climate Change (IPCC), 2000: Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. Available at: http://www.ipcc-nggip.iges.or.jp/public/gp/english/index.html (last accessed March 2011).

Intergovernmental Panel on Climate Change (IPCC), 1997: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. Available at: http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.html (last accessed March 2011).

IPCC background paper, 1996: CH_4 and N_2O emissions from waste water handling. Avaiable at: http://www.ipcc-nggip.iges.or.jp/public/gp/bgp/5_2_CH4_N2O_Waste_Water.pdf (last accessed March 2011).

Kampschreur, M.J., Temmink, H., Kleerebezem, R., Jetten, M.S.M. and van Loosdrecht, M.C.M., 2009: Nitrous oxide emission during wastewater treatment.Water Research, 43:4093-4103.

Møller,J., Boldrin, A., Christensen, T.H. (2009). Anaerobic digestion and digestate use: accounting of greenhouse gases and global warming contribution. Waste Management & Research, 00:1–12, DOI: 10.1177/0734242X09344876.

Nielsen, O., Lyck, E., Mikkelsen, M. H., Hoffmann, L., Gyldenkærne, S., Winther, M., Nielsen, M., Fauser, P., Thomsen, M., Plejdrup, M. S., Albrektsen, R., Hjelgaard, K., Johannsen, V. K., Vesterdal, L., Rasmussen, E., Arfaoui, K. & Baunbæk, L. 2010: Denmark's National Inventory Report 2010: Emission Inventories 1990-2008 - Submitted under the United Nations Framework Conventionon Climate Change and the Kyoto Protocol. National Environmental Research Institute, Aarhus University. 1178 pp - NERI Technical Report No 784. Available at: http://www.dmu.dk/Pub/FR784.pdf (last accessed March 2011).

Statistics Denmark. StatBank Denmark. Available at: http://www.statistikbanken.dk-/statbank5a/default.asp?w=1024

Thomsen, M. & Lyck, E. 2005: Emission of CH_4 and N_2O from wastewater treatment plants (6B). NERI Research Note No. 208. Available at: http://www2.dmu.dk/1_viden/2_Publikationer/3_arbrapporter/rapporter/AR208.pdf (last accessed March 2011).

Vollertsen, J., Vorkamp, K., Hvitved-Jacobsen, T. and Jensen, N.A., 2002. Udsivning af spildevand fra afløbssystemer. Miljøprojekt Nr. 685.

8.4 Waste Incineration (CRF Source Category 6C)

The CRF source category *6.C. Waste Incineration,* includes cremation of human bodies and cremation of animal carcasses.

Incineration of municipal, industrial, clinical and hazardous waste takes place with energy recovery, therefore the emissions are included in the relevant subsectors under CRF sector 1A. For documentation please refer to chapter 3.2. Flaring off-shore and in refineries are included under CRF sector 1B2c, for documentation please refer to Chapter 3.5. No flaring in chemical industry occurs in Denmark.

Table 8.4.1 gives an overview of the Danish greenhouse gas emission from the CRF source category 6.C waste incineration.

CO_2 emissions from cremations of human bodies and animal carcasses are considered to be biogenic.

While emissions from human cremations have been steady over the last two decades, emissions from animal cremation have increased. In 1990, incineration of animal carcasses stood for 5 % of the total emission of CO_2-eqv. from cremations. In 2009 this number has increased to 33 %. Non-biogenic GHG emissions from cremations are very small, 0.21 Gg in 1990 and 0.30 Gg in 2009.

Table 8.4.1 Overall emission of greenhouse gases from the incineration of human bodies and animal carcasses

Year		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CO_2 emission from											
Human cremation	Gg	2.05	2.04	2.07	2.16	2.14	2.19	2.17	2.15	2.09	2.12
Animal cremation	Gg	0.12	0.12	0.13	0.14	0.15	0.15	0.16	0.17	0.18	0.28
Total biogenic	Gg	2.17	2.16	2.21	2.30	2.29	2.35	2.33	2.32	2.27	2.40
CH_4 emission from											
Human cremation	Mg	0.48	0.48	0.49	0.51	0.50	0.52	0.51	0.50	0.49	0.50
Animal cremation	Mg	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.07
Total	Mg	0.51	0.51	0.52	0.54	0.54	0.55	0.55	0.54	0.53	0.56
N_2O emission from											
Human cremation	Mg	0.60	0.60	0.61	0.63	0.63	0.64	0.64	0.63	0.61	0.62
Animal cremation	Mg	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.08
Total	Mg	0.64	0.63	0.65	0.68	0.67	0.69	0.68	0.68	0.67	0.71
6C. Waste incineration											
Non-biogenic CO_2-eqvivalents	Gg	0.21	0.21	0.21	0.22	0.22	0.23	0.22	0.22	0.22	0.23
Continued		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CO_2 emission from											
Human cremation	Gg	2.08	2.09	2.13	2.10	2.08	2.04	2.06	2.09	2.09	2.12
Animal cremation	Gg	0.34	0.35	0.35	0.36	0.44	0.59	0.86	0.99	1.03	1.03
Total biogenic	Gg	2.43	2.44	2.48	2.46	2.52	2.63	2.92	3.08	3.12	3.15
CH_4 emission from											
Human cremation	Mg	0.49	0.49	0.50	0.49	0.49	0.48	0.48	0.49	0.49	0.50
Animal cremation	Mg	0.08	0.08	0.08	0.08	0.10	0.14	0.20	0.23	0.24	0.24
Total	Mg	0.57	0.57	0.58	0.58	0.59	0.62	0.69	0.72	0.73	0.74
N_2O emission from											
Human cremation	Mg	0.61	0.61	0.63	0.62	0.61	0.60	0.61	0.61	0.61	0.62
Animal cremation	Mg	0.10	0.10	0.10	0.10	0.13	0.17	0.25	0.29	0.30	0.30
Total	Mg	0.71	0.72	0.73	0.72	0.74	0.77	0.86	0.90	0.92	0.93
6C. Waste incineration											
Non-biogenic CO_2-eqvivalents	Gg	0.23	0.23	0.24	0.24	0.24	0.25	0.28	0.30	0.30	0.30

8.4.1 Human cremation

The incineration of human bodies is a common practice that is performed on an increasing part of the yearly deceased. All Danish incineration facilities use optimised and controlled combustions, with temperatures reaching 800-850 °C, secondary combustion chambers, controlled combustion air flow and regulations for coffin materials.

However, the emissions caused by cremations can still contribute to a considerable part of the total national emissions. Emissions are calculated for greenhouse gases CO_2 (biogenic), CH_4 and N_2O.

Methodological issues

There are 31 crematoria in Denmark, some with multiple furnaces, 21 facilities are run by the church and 10 by the local authorities (DKL 2010, KM 2006).

During the 1990es all Danish crematoria were rebuilt to meet new standards. This included installation of secondary combustion chambers and in most cases, replacement of old primary incineration chambers (Schleicher et al. 2001). All Danish cremation facilities are therefore performing controlled incinerations with a good burn-out of the gases, and a low production of pollutants. But only a very few crematoria are equipped with flue gas cleaning (bag filters with activated carbon).

Following the development of new technology, the emission limits for crematoria are lowered again in 1/2011. These new standard terms were originally expected from 1/2009 but have been postponed two years for existing crematoria. Table 8.4.2 shows a comparison of the emission limits from 2/1993 and the new standard limits.

Table 8.4.2 Emission limit values mg pr Nm^3 at 11 % O_2 (Schleicher & Gram 2008).

Component	Report 2/1993	Standard terms (1/2011)
	Emission limit value mg pr normal m^3 at 11 % O_2	
CO_2	500	500
Other demands:		
Stack height	3 m above rooftop	3 m above rooftop
Temperature in stack	Minimum 150 °C	Minimum 110 °C
Flue gas flow in stack	8 – 20 m/s	No demands
Temperature in after burner	850 °C	800 °C
Residence time in after burner	2 seconds	2 seconds

Activity data

Table 8.4.3 shows the time-series of total number of nationally deceased persons, number of cremations and of the fraction of cremated corpses from the total number of deceased. Data for the total number of nationally deceased persons is collected from Statistics Denmark (2010). Data describing the number of cremations and the cremation fraction is gathered from the Association of Danish Crematoria (DKL 2010).

Table 8.4.3 Data human cremations (DKL 2010).

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Nationally deceased	60926	59581	60821	62809	61099	63127	61043	59898	58453	59179
Cremations	40991	40666	41455	43194	42762	43847	43262	42891	41660	42299
Cremation fraction, %	67.3	68.3	68.2	68.8	70.0	69.5	70.8	71.6	69.1	74.4
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Nationally deceased	57998	58355	58610	57574	55806	54962	55477	55604	54591	54872
Cremations	41651	41707	42539	41997	41555	40758	41233	41766	41788	42408
Cremation fraction, %	71.8	71.5	72.6	72.9	74.5	74.2	74.3	75.1	76.6	77.3

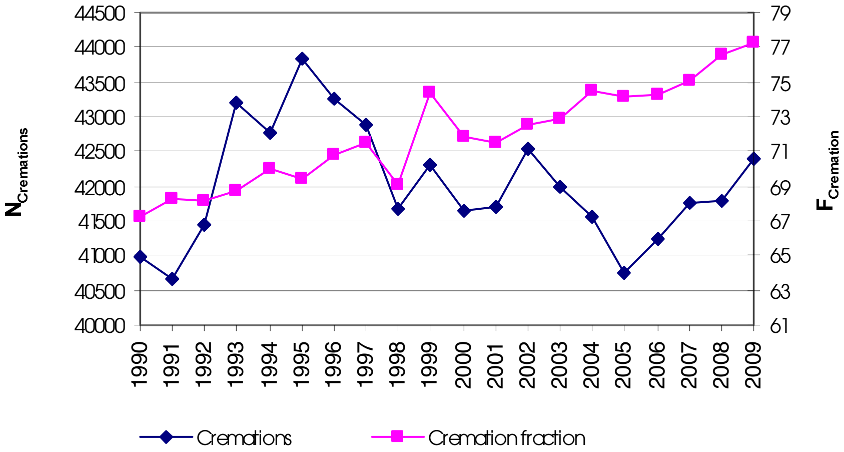


Figure 8.4.1 Time-series of cremations (DKL 2010), where the number of cremations, $N_{cremations}$, is shown at the left Y-axis. The cremation percentage, $F_{cremations}$, shows the percent of cremation deceased of the total deceased from the year 1990 to 2009.

Even though the total number of yearly cremations is fluctuating, the cremation percentage has been increasing since 1990, and is likely to continue to increase.

The average body weight is assumed to be 65 kg.

Figure 8.4.2 presents the trend of the national number of deceased persons together with the activity data for human cremation. The figure shows a direct connection between the number of deceased and the activity of human cremation as the two trends are quite similar. Figure 8.4.2 also shows the effect of the increasing fraction of cremated bodies pr deceased, as the number of cremations is not decreasing along with the number of deceased. The cremation fraction has increased from 67 % in 1990 to 77 % in 2009; the trend of this fraction is shown in Figure 8.4.1.

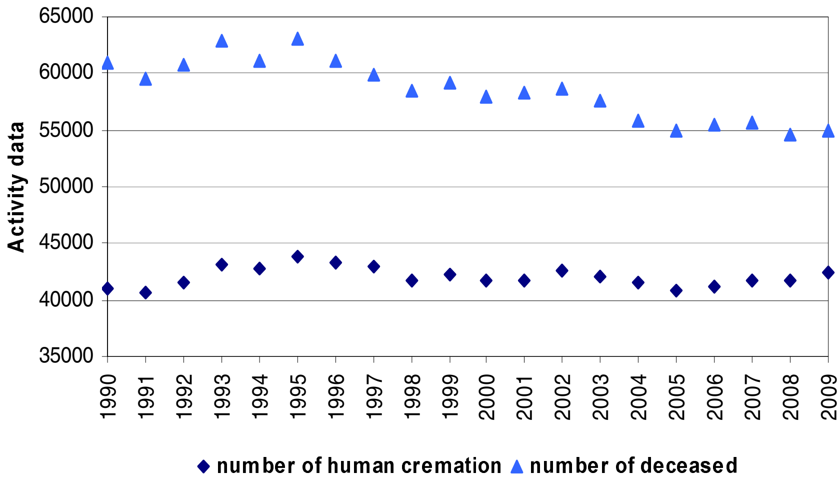


Figure 8.4.2 Trends of the activity data for cremation of human corpses and the national number of deceased persons.

Emission factors

For crematoria, emissions are calculated by multiplying the total number of cremations by the emission factors. Since there are no measurements available of the yearly emission from Danish crematoria, the estimation of emissions is based on emission factors from literature. The estimation is based on the measurements performed in countries that are comparable with Denmark. By comparable is meant countries that use similar incineration processes, similar cremation techniques including support fuel and have a similar composition of sources to lifetime exposure, lifetimes and coffins.

A literature search has provided emission factors for CO_2, CH_4 and N_2O from the two sources Fontelle et al. and Aasestad. It has not been possible to find any additional data to validate the emission factors.

Concerning the burning of animal carcasses in animal crematoria there is not much literature to be found. NAEI (2007) provides emission factors with the unit kt, but since no explanation is provided as to what amount this emission factor is valid for, the database is not of any use as a source.

Emission factors for CO_2, CH_4 and N_2O are collected from the literature search on human cremation, and it is assumed that humans and animals are similar in composition for this purpose. Emission factors from human cremation are recalculated to match the activity data for animal cremation, emission pr Mg.

Table 8.4.4 lists the emission factors and their respective references.

Table 8.4.4 Emission factors for human and animal cremation with references.

	Human cremation		Animal cremation		
Pollutant name	Unit	Emission factor	Unit	Emission factor	Reference
CO_2, biogenic	kg/body	50.1	kg/Mg	770	Fontelle et al.
CH_4	g/body	11.8	g/Mg	182	Aasestad
N_2O	g/body	14.7	g/Mg	226	Aasestad

8.4.2 Animal cremation

The burning of animal carcasses in animal crematoria follows much the same procedure as human cremation. Animal cremation facilities use similar two chambered furnaces and controlled combustion. However animals are burned in special designed plastic (PE) bags rather than coffins.

Emission from animal cremation is also similar to that of human cremation.

Animal cremations are performed in two ways, individually where the owner often pays for receiving the ashes in an urn or collectively which is most often the case with animal carcasses that are left at the veterinarian.

Methodological issues

Open burning of animal carcasses is illegal in Denmark and is not occurring, and small-scale incinerators are not known to be used at Danish farms. Livestock that is diseased or in other ways unfit for consumption is disposed of through rendering plants, incineration of livestock carcasses is illegal and these carcasses are therefore commonly used in the production of fat and soap at Daka Bio-industries.

The only animal carcasses that are approved for cremation in Denmark are deceased pets and animals used for experimental purposes, where the burning must take place at a specialised animal crematorium. There are four animal crematoria in Denmark but one of these is situated at a waste incineration company in northern Vendsyssel called AVV. The special designed cremation furnaces are at this location connected to the flue gas cleaning equipment of the waste incineration plant and the emission from the cremations are included in the yearly inventory from AVV and consequently included under waste incineration in this report. Therefore only three animal crematoria are discussed in this section.

Animal by-products are considered waste, and emission from animal crematoria must therefore comply with the EU requirements for waste incineration. The EU directive (2000/76/EF) on waste incineration has been transferred into Danish law (Statutory order nr.162[30]).

The incineration of animal carcasses is, as the incineration of human corpses, performed in special furnaces. All furnaces at Danish pet crematoria have primary incineration chambers with temperatures around 850 ºC and secondary combustion chambers with temperatures around 1100 ºC. The fuel used at the Danish facilities is natural gas.

Emissions from pet cremations are calculated for CO_2 (biogenic), CH_4 and N_2O. Emissions are estimated by using the same emission factors as for human cremation.

Activity data for the amount of animal carcasses incinerated are gathered directly from the pet crematoria. There is no national statistics available on the activity of animal crematoria. The precision of activity data therefore depends on the information provided by the crematoria.

Table 8.4.5 lists the four Danish crematoria, their foundation year and provides each crematorium with an id letter.

Table 8.4.5 Animal crematoria I Denmark.

Id	Name of crematorium	Founded in
A	Dansk Dyrekremering ApS	May 2006
B	Ada's Kæledyrskrematorium ApS	Unknown, existed in more than 25 years
C	Kæledyrskrematoriet	2006
D	Kæledyrskrematoriet v. Modtagestation Vendsyssel I/S	-

Crematoria D is situated at the AVV waste incineration site and the emission from this site is, as previously mentioned, included in the yearly inventory from AVV and consequently included under waste incineration in this report. From here on only crematoria A-C are considered.

Table 8.4.6 lists the activity data for crematoria A, B, C and the total national cremated amount for the years 1990-2009.

[30] Bekendtgørelse nr. 162 af 11. marts 2003 om anlæg der forbrænder affald.

Table 8.4.6 Activity data. Source: direct contact with all Danish crematoria.

Year	Amount cremated at crematorium A, Mg	Amount cremated at crematorium B, Mg	Amount cremated at crematorium C, Mg	Amount cremated nationally, Mg
1990	-	150	-	150
1991	-	160	-	160
1992	-	170	-	170
1993	-	180	-	180
1994	-	190	-	190
1995	-	200	-	200
1996	-	210	-	210
1997	-	220	-	220
1998	-	235	-	235
1999	-	368	-	368
2000	-	443	-	443
2001	-	452	-	452
2002	-	451	-	451
2003	-	462	-	462
2004	-	571	-	571
2005	-	762	-	762
2006	300	798	18	1 116
2007	450	802	32	1 284
2008	450	848	40	1 338
2009	450	853	36	1 339

Crematorium A delivered activity data for 2007-2009 as the interval 400-500 Mg, the exact value is assumed to be the average of this interval and the rate is assumed to be constant back to the year 2006. The activity data for Crematoria A in 2006 is rated according to the founding of the site in May of 2006.

Crematorium B delivered exact yearly activity data for the years 1998-2009. They were not certain about the founding year but have existed for more than 25 years. The estimated activity data for 1990-1997 are shown as the thick line in Figure 8.4.3 and added a trendline and the equation of the trendline.

It is not possible to extrapolate data back to 1990 because the activity, due to the steep trendline, in this case would become negative from 1993 and back in time.

Statistic data describing the national consumption for pets including food and equipment for pets was evaluated as surrogate data. These statistic data show an increase of consumption of 6 % from 1998 to 2000, in the same period the national amount of cremated animal carcasses increased with 89 % and no correlation seems to be present. Since there are no other available data on the subject of pets, it is concluded that there are no surrogate data available. The activity data for the period of 1990-1997 are estimated by en expert judgement. The estimated data are shown in Table 8.4.6 and the following Figure 8.4.3.

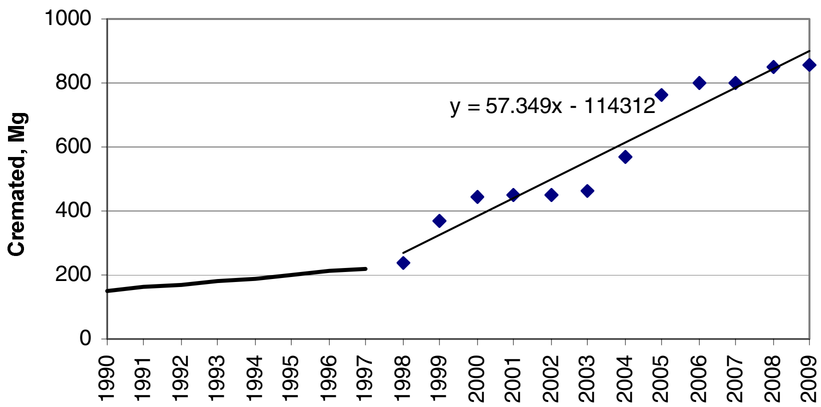


Figure 8.4.3 The amount of cremated carcasses in Mg at crematorium B, the oldest and largest crematorium in Denmark. Data from 1998-2009 are delivered by the crematorium and is considered to be exact, these data are marked as points. Data from 1990-1997 are estimated and are shown as the thick line in the figure.

8.4.3 Uncertainties and time-series consistency

Cremations

The uncertainty of the number of human cremations is miniscule, however for the purpose of uncertainty calculation it has been set to 1 %.

The uncertainty of the activity data from animal cremations is also minimal for the most recent years (1998-2009) but is increasing back in time (to 67 % in 1990). The uncertainty is set to 40 % for all years.

95 % confidence interval uncertainties used in this inventory, and at the present level of available information, are shown in Table 8.4.7

Table 8.4.7 Estimated uncertainty rates for activity data and emission factors, %.

	Human cremation		Animal cremation	
Pollutant	Activity data	Emission factor	Activity data	Emission factor
CO_2	NO		NO	
CH_4	1	150	40	150
N_2O	1	150	40	150

NO = not occurring.

Tier 1 uncertainty results

The tier 1 uncertainty estimates for waste incineration emission inventories are calculated from 95 % confidence interval uncertainties, results are shown in Table 8.4.8

The overall uncertainty interval for GHG is estimated to be ±107.3 % and the trend in GHG emission is 45.5 % ±83.9 %-age points. The uncertainties for GHG emissions are similar from the two cremation types. The main source of uncertainty in the trend in GHG emission is clearly animal cremation, with an individual trend of 792.6 % ± 479.6 %-age points. Human cremation has an individual trend of only 3.5 % ±1.4 %-age points.

Table 8.4.8 National tier 1 uncertainty estimates for waste incineration.

Pollutant	Total emission uncertainty, %	Trend 1990-2009, %	Trend Uncertainty %-age points
GHG	±107.3	45.5	±83.9
CH_4	±113.0	45.7	±88.5
N_2O	±113.0	45.5	±88.3

Tier 2 uncertainty results

The tier 2 uncertainty estimates for waste incineration emission inventories are calculated from the uncertainties presented in Table 8.4.7, results are shown in Table 8.4.9. The estimates were based on a Monte Carlo approach as described in this NIR section 1.7.

Table 8.4.9 National tier 2 uncertainty estimates for waste incineration.

Category 6C	1990 Total emission Uncertainty interval	2009 Total emission Uncertainty interval	2009 Trend Uncertainty
GHG	211.7 Mg (-54 %, +130 %)	319.3 Mg (-47 %. +96 %)	96.8 Mg (-54 %, +136 %)
CH_4	0.5 Mg (-56 %, +138 %)	0.8 Mg (-48 %, +100 %)	0.2 Mg (-56 %, +147 %)
N_2O	0.6 Mg (-56 %, +132 %)	1.0 Mg (-50 %, +98 %)	0.3 Mg (-57 %, +151%)

GHG emissions are calculated in CO_2-equivalents.

The medians for the national emissions from source category 6.C calculated with the tier 2 method, are very similar to those calculated with the tier 1 method. This is an example of how reasonably low uncertainties on small total emissions can cause small variations.

The following Figures 8.4.4, 8.4.5 and 8.4.6 show the graphical comparison of tier 1 and tier 2. Figure 8.4.4 and 8.4.5 show the uncertainties of the total emissions from 1990 and 2009 respectively and Figure 8.4.6 shows the uncertainties of the trend.

Tier 1 uncertainties are the same for 1990 and 2009 because the uncertainty input data are the same for all years. The only input data that vary over time are the activity data and for tier 2, results will vary a bit due to the calculation method.

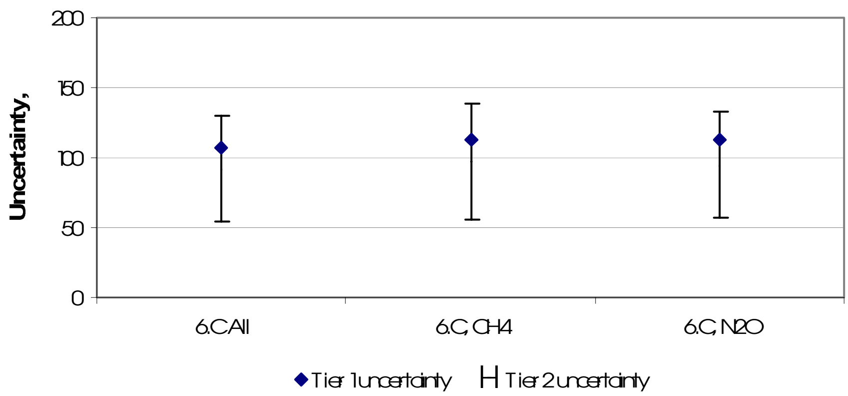


Figure 8.4.4 A graphical comparison of tier 1 and tier 2 uncertainties for 1990.

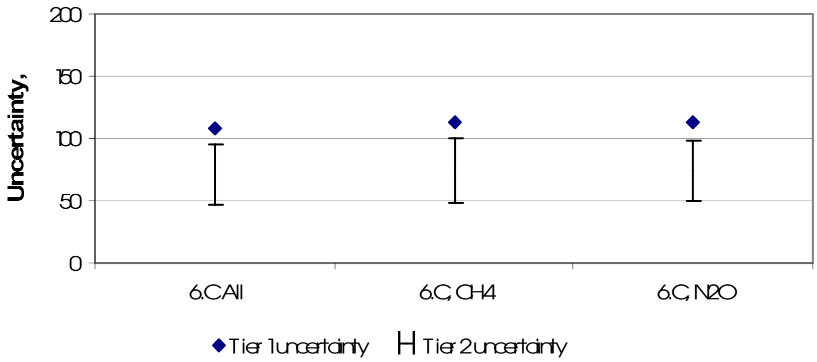


Figure 8.4.5 A graphical comparison of tier 1 and tier 2 uncertainties for 2009.

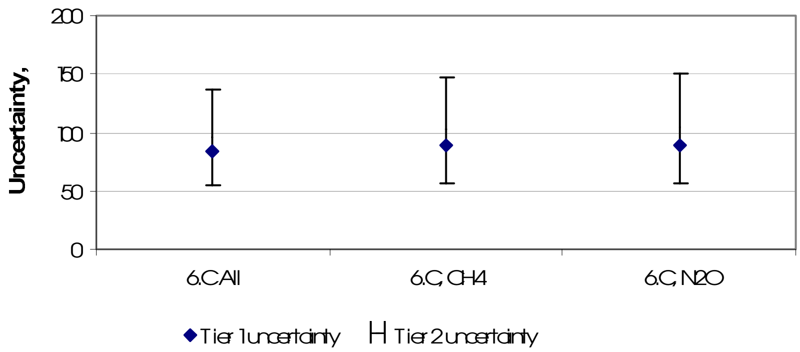


Figure 8.4.6 A graphical comparison of tier 1 and tier 2 trend uncertainties for 2009.

8.4.4 QA/QC and verification

QA/QC-procedure

The methodology for estimating emissions from waste incineration was introduced for the first time in the inventory submission in 2009. Data in this methodology currently involves activity data for 1990-2009 as presented in the preceding sections. No changes have been made in this methodology for the current submission.

In general terms, for this part of the inventory, the Data Storage (DS) Level 1 and 2 and the Data Processing (DP) Level 1 can be described as follows:

Data Storage Level 1

The external data level refers to the placement of original data for human cremation and input data used for deriving yearly activity for animal cremation.

Table 8.4.10 Overview of yearly stored external data sources at DS level1.

http, file or folder name	Description	AD or EF	Reference	Contact	Data agreement/ Comment
http://www.dkl.dk/statistik_1990_1999.aspx and http://www.dkl.dk/statistik_2000_2009.aspx	Number for cremations	AD	Association of Danish Crematories	Hanne Ring hr@dkl.dk	Public access
http://www.statistikbanken.dk/BEF5	Population statistics	AD	Statistics Denmark	Katja Hjelgaard kahj@dmu.dk	Public access
	Cremated animal carcasses	AD	Dansk Dyrekremering ApS	Knud Ribergaard info@danskdyrekremering.dk	Personal contact
	Cremated animal carcasses	AD	Ada's Kæledyrskrematorium ApS	Frederik Møller frederik@adakrem.dk	Personal contact
	Cremated animal carcasses	AD	Kæledyrskrematoriet	Annette Laursen dyrepension@skylinemail.dk	Personal contact

Data Processing Level 1

This level, for waste incineration, comprises a stage where the external data are treated internally. Adjusting the emission factors to match the country-specific average weight for human bodies and estimating the unavailable activity data for animal cremation.

Data Storage Level 2

Data Storage Level 2 is the placement of selected output data from the multiplication of activity data and emission factors as inventory data on SNAP levels in the Access (CollectER) database.

Points of measurement

The present stage of QA/QC for the Danish emission inventories for waste incineration is described below for DS and DP level 1 Points of Measurement (PMs). This is to be seen in connection with the general QA/QC description in Section 1.6 and, especially, 1.6.10 on specific description of PMs common to all sectors, general to QA/QC.

Data Storage level 1	1. Accuracy	DS.1.1.1	General level of uncertainty for every dataset including the reasoning for the specific values

Tier 1 and tier 2 uncertainty calculations have been performed. The level of uncertainty is generally low for activity data but higher for emission factors. The general level of uncertainty for waste incineration could be improved if fluegas measurements were performed.

Data Storage Level 1	1. Accuracy	DS.1.1.2	Quantification of the uncertainty level of every single data value including the reasoning for the specific values.

There are no available uncertainties from the IPCC GL or the sources used to calculate the emission inventories for waste incineration. All uncertainties are achieved by expert judgements.

Data Storage level 1	2.Comparability	DS.1.2.1	Comparability of the data values with similar data from other countries, which are comparable with Denmark, and evaluation of discrepancy.

Some comparison of Danish data values with data sources from other countries has been carried out for activity data and emission factors.

Data Storage level 1	3.Completeness	DS.1.3.1	Documentation showing that all possible national data sources are included by setting down the reasoning behind the selection of datasets.

The following external data sources are used for the inventory on waste incineration (refer also to the table above):

- Tables from Association of Danish Crematories available online.
- Direct contact with the Danish animal crematories.
- Emission factors from literature.

Data from the Association of Danish Crematories is based on yearly reporting from all Danish crematories. Specific reported data is available for the complete time-series.

Data Storage level 1	4.Consistency	DS.1.4.1	The origin of external data has to be preserved whenever possible without explicit arguments (referring to other PMs).

The origin of external activity data has been preserved as much as possible. Files are saved for each year of reporting, in this way changes to previously received data and calculations is reflected and explanations are given.

Data Storage level 1	6.Robustness	DS.1.6.1	Explicit agreements between the external institution holding the data and NERI about the conditions of delivery.

No explicit agreement has been made. The collecting of data for the emission inventories of waste incineration is unproblematic.

Data Storage level 1	7.Transparency	DS.1.7.1	Summary of each dataset including the reasoning for selecting the specific dataset

A summary of the data set can be seen in section 8.4.1 and 8.4.2. For the reasoning behind the selection of the specific dataset, refer to DS 1.3.1.

Data Storage level 1	7.Transparency	DS.1.7.3	References for citation for any external dataset have to be available for any single value in any dataset.

These references exist in the description given in the Section 8.4, under methodological issues

Data Storage level 1	7.Transparency	DS.1.7.4	Listing of external contacts for every dataset

Contact persons related to the delivery of data for waste incineration are, respectively, Hanne Ring from the Association of Danish Crematories (hr@dkl.dk), Knud Ribergaard from Dansk Dyrekremering ApS (info@danskdyrekremering.dk), Frederik Møller from Ada's Kæledyrskrematorium ApS (frederik@adakrem.dk) and Annette Laursen from Kæledyrskrematoriet (dyrepension@skylinemail.dk).

Data Processing level 1	1. Accuracy	DP.1.1.1	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to type of variability. (Distribution as: normal, log normal or other type of variability)

Tier 1 and Tier 2 uncertainty calculations are made. The use of the Tier 1 methodology presumes a normal distribution of activity data and emission factor variability. Uncertainties are reported in section 8.4.3.

Data Processing level 1	1. Accuracy	DP.1.1.2	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to scale of variability (size of variation intervals)

The uncertainty assessment has been given in Section 8.4.3.

Data Processing level 1	1. Accuracy	DP.1.1.3	Evaluation of the methodological approach using international guidelines

There is no available information in the international guidelines for the emission inventories of waste incineration.

Data Processing level 1	1. Accuracy	DP.1.1.4	Verification of calculation results using guideline values

There are no useful guideline values.

Data Processing level 1	2.Comparability	DP.1.2.1	The inventory calculation has to follow the international guidelines suggested by the UNFCCC and IPCC.

The inventory calculations are a simple multiplication of activity data and emission factors

Data Processing level 1	3.Completeness	DP.1.3.1	Assessment of the most important quantitative knowledge which is lacking.

Emission factors are gathered from literature studies. There is no Danish literature or measurements available on greenhouse gas emissions from crematories

Data Processing level 1	3.Completeness	DP.1.3.2	Assessment of the most important cases where access is lacking with regard to critical data sources that could improve quantitative knowledge.

There is no direct data to elucidate the points mentioned under DP.1.3.1.

Data Processing level 1	4.Consistency	DP.1.4.1	In order to keep consistency at a high level, an explicit description of the activities needs to accompany any change in the calculation procedure.

There is no change in calculation procedure during the time-series and the activity data is, as far as possible, kept consistent for the calculation of the time-series.

Data Processing level 1	5.Correctness	DP.1.5.1	Show at least once, by independent calculation, the correctness of every data manipulation.

No data manipulation has been performed.

Data Processing level 1	5.Correctness	DP.1.5.2	Verification of calculation results using time-series

The time-series of activities and emissions in the output, in the SNAP source categories and in the CRF format have been prepared. The time-series are examined and significant changes are checked and explained.

Data Processing level 1	5.Correctness	DP.1.5.3	Verification of calculation results using other measures

The correct interpretation in the calculation of the methodology has been checked

Data Processing level 1	5.Correctness	DP.1.5.4	Shows one-to-one correctness between external data sources and the databases at Data Storage level 2

Data transfer control is made from the external data sources and to the SNAP source categories at level 2. This control is carried on further to the aggregated CRF source categories.

Data Processing level 1	7.Transparency	DP.1.7.1	The calculation principle and equations used must be described

The calculation principle and equations are described in Section 8.4.1 and 8.4.2.

Data Processing level 1	7.Transparency	DP.1.7.2	The theoretical reasoning for all methods must be described

The calculation principle and equations are described in Section 8.4.1 and 8.4.2.

Data Processing level 1	7.Transparency	DP.1.7.3	Explicit listing of assumptions behind all methods

The average weight of a human corps is assumed to be 65 kg and CO_2 emissions from both corpses and carcasses are assumed biogenic.

Data Processing level 1	7.Transparency	DP.1.7.4	Clear reference to dataset at Data Storage level 1

Refer to the Table 8.4.7 and DS.1.1.1 above.

Data Processing level 1	7.Transparency	DP.1.7.5	A manual log to collect information about recalculations

Recalculation changes in the emission inventories are described in the NIR. The logging of the changes takes place in the yearly model file.

Data Storage level 2	5.Correctness	DS.2.5.1	Documentation of a correct connection between all data types at level 2 to data at level 1

The full documentation for the correct connection exists through the yearly model file, its output and report files made by the CollectER database system.

Data Storage level 2	5.Correctness	DS.2.5.2	Check if a correct data import to level 2 has been made

This check is performed, comparing model output and report files made by the CollectER database system, refer to DS.2.5.1.

8.4.5 Source-specific recalculations

No recalculations have been performed

8.4.6 Source-specific planned improvements

There are currently no planned improvements for this section

8.4.7 Source-specific performed improvements

GHG emissions from accidental building and vehicle fires have been moved to section 8.5 Waste Other (CRF Source Category 6D)

Source-specific QA/QC and verification is now included in this section.

Uncertainty input used in tier 1 and tier 2 calculations for cremation of animal carcasses have been analysed more thoroughly, activity data uncertainty has been changed from 50 % to 40 %. This has changed the overall tier 1 uncertainty for the CRF source category 6C from ±107.7 % to ±107.3 % and the trend from 45.5 % ±86.6 %-age points to 45.5 % ±83.9 %-age points.

References for Chapter 8.4

Aasestad, K., 2008: The Norwegian Emission Inventory 2008, Documentation of methodologies for estimating emissions of greenhouse gases and long-range transboundary air pollutants. Available at: http://www.ssb.no/english/subjects/01/04/10/rapp_emissions_en/rapp_200848_en/rapp_200848_en.pdf

Ada's kæledyrskrematorium ApS, personal contact with Frederik Møller (19/7-2010).

Dansk dyrekremering, personal contact with Knud Ribergaard.

Danske krematoriers landsforening (DKL), Association of Danish crematories, statistisk materiale 2010. Available at: http://www.dkl.dk/statistik_1990_1999.aspx and http://www.dkl.dk/statistik_2000_2009.aspx (Danish) (20/9-2010)

Fontelle, J.-P., Allemand, N., Andre, J.-M., Beguier, S., Chang, J.-P., Gueguen, C., Jacquier, G., Martinet, Y., Mathias, E., Nguyen, V., Oudart, B., Serveau, L. & Vincent, J., 2008: Organisation et méthodes des inventaires nationaux des émissions atmosphériques en France, 5ème édition, Available at: http://www.citepa.org/publications/OMINEA_5e_edition_fev2008.zip (French).

Kirkeministeriet (KM), Arbejdsgruppe foreslår, at der skal være færre krematorier, Ministry of Ecclesiastical Affairs, Dec. 2006. Available at: http://www.km.dk/generelle-sider/nyheder/single-news/arbejdsgruppe-foreslaar-at-der-skal-vaere-faerre-krematorier/2.html (Danish) (20/9-2010).

Kæledyrskrematoriet, personal contact with Annette Laursen (21/0-2010).

Kæledyrskrematoriet v. Modtagestation Vendsyssel I/S, personal contact with Flemming Nielsen (13/8-2010).

NAEI, 2007: The UK National Atmospheric Emission Inventory. Available at: http://www.naei.org.uk/emissions/selection.php (9/4-2010).

Schleicher, O. & Gram, L.K., Miljøprojekt Nr. 1191, 2008, Analyse af omkostningerne for rensning for kviksølv på krematorier i Danmark, Miljøministeriet, Miljøstyrelsen. Available at: http://www2.mst.dk/common/Udgivramme/Frame.asp?http://www2.mst.dk/udgiv/publikationer/2008/978-87-7052-594-7/html/helepubl.htm (Danish) (20/9-2010).

Schleicher, O., Jensen, A.A. & Blinksbjerg, P., 2001, Miljøprojekt Nr. 649, 2001, Måling af dioxinemissionen fra udvalgte sekundære kilder, Miljøministeriet, Miljøstyrelsen. Available at: http://www2.mst.dk/Udgiv/publikationer/2001/87-7944-868-2/pdf/87-7944-869-0.pdf (Danish) (20/9-2010).

Statistics Denmark, 2010, StatBank Denmark. Available at: http://www.statistikbanken.dk/statbank5a/default.asp?w=1024 (Danish/English) (20/9-2010).

8.5 Waste Other (CRF Source Category 6D)

This category is a catch all for the waste sector. Emissions in this category could stem from accidental fires, sludge spreading, compost production, biogas production and other combustion.

Table 8.5.1 gives an overview of the Danish greenhouse gas emission from the CRF source category 6.D waste other.

CO_2 emissions from compost production are considered to be biogenic. Buildings have a high content of wood both in the structure and in the interior; this leads to 83 % of the CO_2 emission from accidental building fires to be biogenic.

Emissions from accidental fires have been slowly increasing from both building and vehicle fires. The largest GHG emission stems from compost production, in 1990, composting stood for 60 % (38 Gg CO_2-eqv.) of the total emission of CO_2-eqv. from the other waste category, in 2009 this number has increased to 79 % (118 Gg CO_2-eqv.).

Table 8.5.1 Overall emission of greenhouse gasses from accidental fires and composting

Year		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CO_2 emission from											
Accidental building fires	Gg	91.52	94.55	102.80	90.32	90.94	105.05	106.20	98.03	87.73	94.28
- of which non-biogenic	Gg	15.37	15.88	17.27	15.17	15.27	17.64	17.84	16.46	14.73	15.83
Accidental vehicle fires	Gg	6.65	6.78	6.89	7.27	7.48	7.76	7.99	8.19	8.45	8.71
Total, non-biogenic	Gg	22.02	22.66	24.16	22.44	22.75	25.40	25.83	24.66	23.19	24.54
CH_4 emission from											
Compost production	Mg	1268.8	1397.3	1525.4	1653.6	1781.6	1632.0	1936.1	2213.7	2303.5	2717.7
Accidental building fires	Mg	117.81	121.71	132.33	116.27	117.07	135.23	136.70	126.19	112.93	121.36
Accidental vehicle fires	Mg	13.85	14.13	14.36	15.14	15.57	16.17	16.65	17.07	17.61	18.14
Total	Mg	1400.5	1533.2	1672.1	1785.1	1914.2	1783.3	2089.4	2357.0	2434.1	2857.2
N_2O emission from											
Compost production	Mg	36.17	40.04	43.90	47.76	51.61	49.53	57.87	66.58	79.61	108.32
Accidental building fires	Mg	NAV	NAV	NAV	NAV	NAV	NAV	NAV	NAV	NAV	NAV
Accidental vehicle fires	Mg	NAV	NAV	NAV	NAV	NAV	NAV	NAV	NAV	NAV	NAV
Total	Mg	36.17	40.04	43.90	47.76	51.61	49.53	57.87	66.58	79.61	108.32
6D. Waste other											
CO_2-eqvivalents	Gg	62.64	67.27	72.88	74.73	78.95	78.21	87.64	94.79	98.98	118.12
Continued		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CO_2 emission from											
Accidental building fires	Gg	92.32	90.81	87.95	99.14	85.62	88.97	92.79	105.32	104.89	105.06
- of which non-biogenic	Gg	15.50	15.25	14.77	16.65	14.38	14.94	15.61	17.64	17.68	17.62
Accidental vehicle fires	Gg	8.82	8.83	8.78	8.73	8.76	9.01	9.43	8.35	10.79	10.04
Total, non-biogenic	Gg	24.32	24.08	23.55	25.38	23.14	23.95	25.04	25.99	28.48	27.67
CH_4 emission from											
Compost production	Mg	2882.6	2951.1	2893.0	3018.1	2867.8	3086.7	3269.4	3646.1	3323.4	3699.5
Accidental building fires	Mg	118.84	116.90	113.22	127.62	110.21	114.53	119.65	135.29	135.36	135.18
Accidental vehicle fires	Mg	18.37	18.39	18.29	18.18	18.24	18.77	19.66	17.41	22.49	20.92
Total	Mg	3019.8	3086.4	3024.5	3163.9	2996.3	3220.0	3408.7	3798.8	3481.3	3855.6
N_2O emission from											
Compost production	Mg	130.90	131.67	160.07	161.25	95.47	100.56	109.60	125.24	116.79	130.61
Accidental building fires	Mg	NAV	NAV	NAV	NAV	NAV	NAV	NAV	NAV	NAV	NAV
Accidental vehicle fires	Mg	NAV	NAV	NAV	NAV	NAV	NAV	NAV	NAV	NAV	NAV
Total	Mg	130.90	131.67	160.07	161.25	95.47	100.56	109.60	125.24	116.79	130.61
6D. Waste other											
CO_2-eqvivalents	Gg	128.32	129.71	136.69	141.81	115.65	122.75	130.60	144.60	137.79	149.12

NAV = Not available.

8.5.1 Compost production

This section covers the biological treatment of solid wastes called composting. Greenhouse gasses that escape from this treatment are methane (CH_4), nitrous oxide (N_2O) and biogenic carbon oxide (CO_2).

Methodological issues

Emissions from composting have been calculated according to a country specific method.

In Denmark, composting of solid biological waste includes composting of:

- garden and park waste (GPW),
- organic waste from households and other sources,
- sludge and,
- home composting of garden and vegetable food waste.

In 2001, 123 composting facilities treated only garden and park waste (type 2 facilities), nine facilities treated organic waste mixed with GPW or other organic waste (type 1 facilities) and 10 facilities treated GPW mixed with sludge and/or “other organic waste” (type 3 facilities). 92 % of these facilities consisted entirely of windrow composting which is a low technology composting method with natural access to air. It is assumed that all facilities can be considered as using windrow composting.

Composting is performed with low technology in Denmark this means that temperature, moisture and aeration is not consistently controlled or regulated. Temperature is measured but not controlled, moisture is regulated by watering the windrows in respect to weather conditions and aeration is assisted by turning the windrows.
(Petersen & Hansen, 2003)

During composting a large fraction of the degradable organic carbon (DOC) in the waste material is converted into CO_2. Even though the windrows are regularly turned to support aeration, anaerobic sections are inevitable and will cause emissions of CH_4. (Guidelines, 2006)

Activity data

All Danish waste treatment plants are obligated to statutory registration and reporting of all wastes entering and leaving the plants. All waste streams are weighed, categorised with a waste type and a type of treatment and registered to the ISAG waste information system. (Affaldsstatistik, 2006)

Figure 8.5.1 illustrates the nationally composted amount of waste divided in the four categories mentioned earlier.

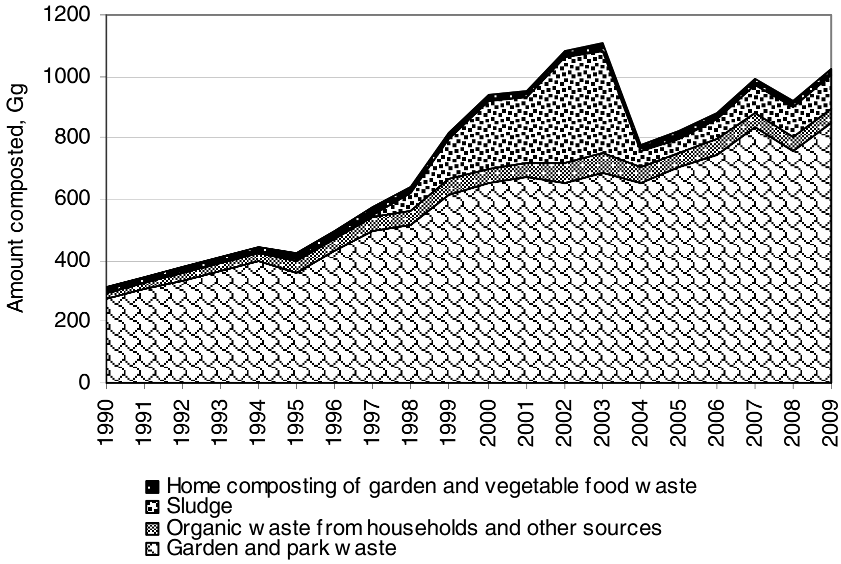


Figure 8.5.1 National amount of composted waste, these data are also shown in Table 8.5.3.

The Danish legistration on sludge (slambekendtgørelsen) was implemented in the summer of 2003. This stated that composted sludge may only be used as a fertilizer on areas not attended for growing foods of any kind in at least 2-3 years. This restriction caused the amount of composted sludge to drop drastically from 2003 to 2004.

Activity data for the years 1995-2008 is collected from ISAG data for the categories: organic waste from households and other sources and sludge. Activities for 2009 are calculated by using the development trend from earlier years.

The development in composting of sludge does not demonstrate a convincing trend that can be used for estimation of activity data for previous years. Since there is no surrogate data available for the years 1990-1994, activity data for these years are "not available".

The amounts of organic waste from households composted in the years 1990-1994 are estimated by multiplying the number of facilities treating this type of waste with the average amount composted pr facility in the years 1995-2001 (2.6-3.8 Gg pr facility pr year). The following Table 8.5.2 shows the number of composting sites divided in the three types described in "Methodological issues".

Table 8.5.2 Number of composting facilities in the years 1990-2001.

Facility type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Type 1	5	6	7	8	9	13	14	13	14	13	11	9
Type 2	38	54	70	86	102	113	108	99	102	111	115	123
Type 3	1	2	2	3	4	9	9	11	10	10	7	10
Total	44	62	79	97	115	136	133	126	130	139	138	149

Type 1 waste treatment sites normally includes biogas producing facilities, but these have been excluded in Table 8.5.2.

Petersen (2001) and Petersen & Hansen (2003) provide 1997-2001 activity data for the composting of garden and park waste (GPW). Activity data for GPW for the years 1990-1996 and 2002-2009 are estimated from the surrogate data gathered from the waste statistic reports, Waste Statistics 2007 and 2008 (and earlier years).

The waste statistics provides the development in composting and wood chipping of GPW for 1995-2008, and by looking at the trend of this development the remaining years 1990-1994 and 2009 are estimated. This data series is used as surrogate data for the estimation of activity data for composting of GPW.

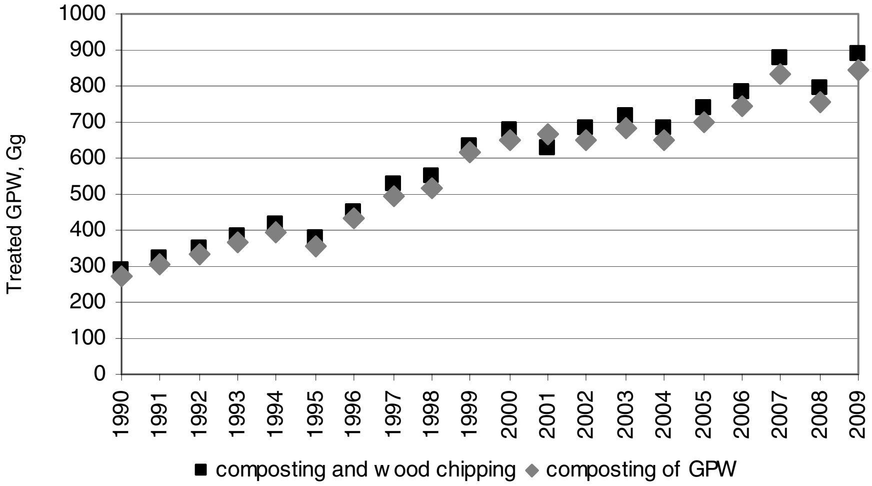


Figure 8.5.2 Composted amount of GPW.

The last waste category involved in composting is home composting of garden waste and vegetable waste. The activity data for this category is known from Petersen & Kielland (2003) to be 21.4 Gg in 2001. It is assumed that the following estimates made by Petersen & Kielland are valid for all years 1990-2009.

- 28 % of all residential buildings with private gardens (including weekend cabins) are actively contributing to home composting.
- 14 % of all multi-dwelling houses are actively contributing to home composting.
- 50 kg waste pr year will in average be composted at every contributing residential building.
- 10 kg waste pr year will in average be composted at every contributing multi-dwelling house.

The total number of occupied residential buildings, weekend cabins and multi-dwelling houses are found at the Statistics Denmark website. The calculated activity data for home composting of garden and vegetable waste are shown in Table 8.5.3

Table 8.5.3 Activity data composting, Gg.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Composting of garden and park waste	274	304	335	365	395	358	431	496	517	614
Composting of organic waste from households and other	16	19	23	26	29	40	38	47	43	49
Composting of sludge	NAV	NAV	NAV	NAV	NAV	7	6	7	57	134
Home composting of garden and vegetable food waste	20	20	20	20	21	21	21	21	21	21
Total	294	325	355	385	415	386	457	524	595	769
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Composting of garden and park waste	653	669	653	682	650	702	745	835	757	846
Composting of organic waste from households and other	47	52	63	66	53	45	48	44	46	48
Composting of sludge	218	211	348	336	53	50	67	91	94	108
Home composting of garden and vegetable food waste	21	21	22	22	22	22	22	22	22	23
Total	892	901	1022	1040	725	774	834	948	874	977

NAV = Not available.

Emission factors

The emission from composting strongly depends on both the composition of the treated waste and on process conditions such as aeration, mechanical agitation, moisture control and temperature pattern. (Amlinger et al., 2008)

The emission factors stated in Table 8.5.4 are considered the best available for the calculation of Danish national emissions from composting.

Table 8.5.4 Composting emission factors.

	Garden and park waste (GPW)	Organic waste from households and other sources	Sludge	Home composting of garden and vegetable food waste
Unit	Kg pr Mg	Kg pr Mg	Kg pr Mg	Kg pr Mg
CH_4	4.2	0.268	0.041	5.625
N_2O	0.12	0.072	0.216	0.105
Source	Boldrin et al.	Amlinger et al.	Amlinger et al.	Boldrin et al.

Emission factors for composting of GPW and for home composting of garden and vegetable food waste are derived from Boldrin et al. (2009). No other sources were found that describe the emission from home composting.

Two other sources provide emission factors for composting of GPW; Amlinger et al. (2008) and Hellebrand (1998). All three sources give very similar data. Boldrin et al. (2009) is the chosen source since this is a Danish report based on experiments from Danish waste and composting methods.

Emissions from Boldrin et al. (2009) are given in percentage of total degraded carbon or nitrogen respectively. The factors shown in Table 8.5.4 are calculated by assuming 37.5 % DOC in dry matter, 2 % N in dry matter and 50 % moisture in the waste.

The CO_2 produced and emitted during composting is short-cycled C and is therefore normally regarded as global warming neutral. (Boldrin et al., 2009)

Emission factors for composting of organic municipal waste and sludge are given by Amlinger et al. (2008).

8.5.2 Accidental fires

Accidental fires cover fires in vehicles and in buildings. Emissions from accidental fires are calculated for CO_2 and CH_4.

Methodological issues

Building fires

Emissions from building fires are calculated by multiplying the number of building fires with selected emission factors. Four types of buildings are separated with different emission factors: detached houses, undetached houses, apartment buildings and industrial buildings.

Activity data for building fires are classified in three categories: large, medium and small. The emission factors comply for full scale building fires and the activity data is therefore recalculated as a full scale equivalent where it is assumed that a medium and a small fire leads to 50 % and 5 % of a large fire respectively, and that a large fire is a full scale fire.

Vehicle fires

Emissions from vehicle fires are calculated by multiplying the number of vehicle fires with selected emission factors. Emission factors are not available for different vehicle types, whereas it is assumed that all the different vehicle types leads to similar emissions. The activity data is recalculated as an yearly combusted mass by multiplying the number of different vehicles fires with the Danish registered average weight of the given vehicle type.

Landfill fires

Accidental landfill fires have not been calculated for this year's inventory, this category is under development.

Activity data

In January 2005 it became mandatory for the local authorities to register every rescue assignment in the *online data registration- and reporting system* called ODIN, ODIN is developed and run by the Danish Emergency Management Agency (DEMA). As a result of this, some activity data from 2005 and forth can not be directly compared with older data. For example, some specific rescue assignments were not registered prior to the year 2005, and a compilation of data might therefore give the impression of a certain development, even though it is not actually the case. (DEMA 2007) All activity data are calculated from surrogate data and data from ODIN, 2006-2009 for building fires and 2007-2009 for vehicle fires.

Table 8.5.5 shows the occurrence of fires in general, building fires and vehicle fires registered at DEMA.

Table 8.5.5 Occurrence of building and vehicle fires.

Year	All fires	Building fires	Vehicle fires
1990	17,025	6,794	1,995
1991	17,589	7,019	2,006
1992	19,124	7,632	2,016
1993	16,803	6,705	2,042
1994	16,918	6,751	2,041
1995	19,543	7,799	2,120
1996	19,756	7,884	2,197
1997	18,236	7,277	2,266
1998	16,320	6,513	2,332
1999	17,538	6,999	2,388
2000	17,174	6,854	2,428
2001	16,894	6,742	2,462
2002	16,362	6,529	2,496
2003	18,443	7,360	2,507
2004	15,927	6,356	2,541
2005	16,551	6,605	2,597
2006	16,965	6,770	2,661
2007	18,529	7,855	2,385
2008	20,973	7,967	2,940
2009	19,276	7,583	2,904

The total number of fires has been adjusted by DEMA for 2007 and 2008 by adding 10 and 58 fires to the total respectively. The activity data for building and vehicle fires is adjusted for all years 1990-2005 because the calculation is now also based on the detailed data for year 2009. The total number of building fires has with this recalculation increased with 0.69 – 0.70 %.

The total number of vehicle fires has increased more drastically with the peek of 7.1 % in 1993. This increase is caused by a change in data delivery of the population of the different vehicle types. This change in input data is also described in chapter 3.3 Transport and other mobile sources.

Building fires

Activity data for accidental building fires is given by DEMA. Fires are categorised as, large, medium and small. A large fire is in this context defined as a fire that involves the use of two or more fire hoses for fire extinguishing and is assumed to typically involve a complete house, one or more apartments, or at least part of an industrial complex. A medium size fire is in this context defined as a fire involving the use of only 1 fire hose for fire-fighting and will typically involve a part of a single room in an apartment or house. A small size fire is in this context defined as a fire that was extinguished before the arrival of the fire service, extinguished by small tools or a chimney fire.

The total number of registered fires is known for the years 1990-2009. For the years 2006-2009 the total number of registered building fires are known, and by assuming that the share of building fires in respect to the total number of registered fires, can be considered as constant for every year back to 1990, the total number of building fires can be calculated for the years 1990-2005.

Furthermore the building fires that occurred in the years 2006-2009 are subcategorised into industrial building, detached house, undetached house and apartment building fires. And by once again assuming that the average of these shares are representative for the years 1990-2005, the building fires from the earlier years are also subdivided into these four building types.

Table 8.5.6 states the registered activity data for building fires for the years 2006-2009, divided in both size and building type. The calculated averages describes the average share of building fires from 2006-2009 of a certain type and size, in relation to all fires (building and non-building) of the same size and during the same four years period.

Table 8.5.6 Registered occurrence of building fires.

		Industry	Detached	Undetached	Apartment	All building fires
	large	186	821	205	101	1,313
	medium	211	824	300	542	1,877
	small	442	1,482	384	985	3,293
2006	all	839	3,127	889	1,629	6,483
	large	268	988	239	152	1,647
	medium	324	1,021	391	720	2,456
	small	369	1,432	717	932	3,450
2007	all	961	3,441	1,347	1,804	7,553
	large	244	1,153	206	145	1,748
	medium	216	1,153	306	796	2,471
	small	443	1,491	445	1,008	3,387
2008	all	903	3,797	957	1,949	7,606
	large	282	1,222	173	169	1,846
	medium	246	945	196	638	2,025
	small	507	1,404	399	1,072	3,382
2009	all	1,035	3,571	768	1,879	7,253
	large	27.39%	31.11%	20.12%	8.27%	22.75%
Average, %	medium	27.11%	28.86%	29.07%	38.25%	31.44%
	small	45.50%	40.03%	50.81%	53.48%	45.81%

The difference between the total number of building fires mentioned in Table 8.5.5 and Table 8.5.6 are container fires, container fires are included in the DEMA category of building fires, but has been subtracted in Table 8.5.6.

As mentioned above, it is assumed that the average percentages provided by the years 2006-2009 are compliable for the years 1990-2005. Hereby, similar activity data can be estimated back to 1990.

It is furthermore assumed that a medium size fire has a damage rate of 50 % compared to a large (full scale) fire and that a small size fire leads to the emission of 5 % of a large fire. From these damage rates, a full scale equivalent can be determined from the earlier calculated activity data, results are shown in the following Table 8.5.7.

Table 8.5.7 Full scale equivalent activity data for accidental building fires 1990-2009 (DEMA).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Industry	364	376	409	359	361	418	422	390	349	375
Detached	1492	1541	1676	1472	1482	1712	1731	1598	1430	1537
Undetached	332	343	373	327	330	381	385	355	318	342
Apartment	492	508	552	485	489	564	570	527	471	506
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Industry	367	361	350	394	340	354	355	448	374	430
Detached	1505	1480	1434	1616	1396	1450	1483	1 570	1804	1765
Undetached	335	329	319	359	310	322	432	470	381	291
Apartment	496	488	472	533	460	478	473	559	593	542

The amount of detailed activity data is still limited due to the few years of reported data in the ODIN system, during the next years more data will become available providing a better view at the development in the trend.

Vehicle fires

Activity data for accidental vehicle fires is, like accidental building fires, given by The Danish Emergency Management Agency (DEMA). The activity data is categorised in cars (lighter than 3500 kg), buses, trucks, vans, mobile homes, motorcycles/mopeds and tankers. These are gathered in five categories; passenger cars, buses, light duty vehicles (vans, mobile homes), heavy duty vehicles (trucks and tankers) and motorcycles/mopeds.

The total number of registered vehicles is known for all years 1990-2009 (Statistics Denmark), but the number of vehicle fires is only known for the years 2007-2009. By assuming that the share of vehicle fires in relation to the total number of registered vehicles of the respective categories can be counted as constant, the number of vehicle fires is estimated for the years 1990-2006. Table 8.5.8 states the total number of national registered vehicles, the number of vehicle fires and the average share of burned vehicles from 1990-2009.

Table 8.5.8 Different types of nationally registered vehicles and yearly numbers of vehicle fires.

	Passenger cars			Buses			Light duty vehicles		
Year	Registered nationally	Share, %	Fires	Registered nationally	Share, %	Fires	Registered nationally	Share, %	Fires
1990	1645587	0.086	1420	8109	0.432	35	280081	0.033	92
1991	1649301	0.086	1423	9989	0.432	43	286919	0.033	95
1992	1659929	0.086	1432	11259	0.432	49	294006	0.033	97
1993	1679055	0.086	1448	13513	0.432	58	304909	0.033	101
1994	1672177	0.086	1442	14261	0.432	62	314193	0.033	104
1995	1733405	0.086	1495	14371	0.432	62	323907	0.033	107
1996	1793158	0.086	1547	14594	0.432	63	331998	0.033	109
1997	1841075	0.086	1588	14690	0.432	63	340694	0.033	112
1998	1878032	0.086	1620	14894	0.432	64	351765	0.033	116
1999	1906153	0.086	1644	14953	0.432	65	364067	0.033	120
2000	1916686	0.086	1653	15051	0.432	65	379322	0.033	125
2001	1932741	0.086	1667	15005	0.432	65	391955	0.033	129
2002	1946353	0.086	1679	14971	0.432	65	406576	0.033	134
2003	1948966	0.086	1681	14988	0.432	65	422951	0.033	139
2004	1967642	0.086	1697	14991	0.432	65	452945	0.033	149
2005	2012397	0.086	1736	15126	0.432	65	494016	0.033	163
2006	2064000	0.086	1780	15148	0.432	65	540454	0.033	178
2007	2151334	0.077	1658	14983	0.367	55	534166	0.027	144
2008	2182217	0.091	1991	14802	0.459	68	535452	0.037	197
2009	2199435	0.090	1990	14715	0.469	69	523508	0.035	184

Continued

	Heavy duty vehicles			Motorcycles/mopeds		
Year	Registered nationally	Share, %	Fires	Registered nationally	Share, %	Fires
1990	45664	0.320	146	163255	0.185	302
1991	45494	0.320	145	162111	0.185	300
1992	45510	0.320	146	158362	0.185	293
1993	46228	0.320	148	155024	0.185	287
1994	47329	0.320	151	152405	0.185	282
1995	48077	0.320	154	163543	0.185	303
1996	48319	0.320	155	174479	0.185	323
1997	48785	0.320	156	187263	0.185	346
1998	49697	0.320	159	201531	0.185	373
1999	50443	0.320	161	214820	0.185	397
2000	50227	0.320	161	229231	0.185	424
2001	49885	0.320	160	238695	0.185	442
2002	49208	0.320	157	249390	0.185	461
2003	48616	0.320	155	251731	0.185	466
2004	48285	0.320	154	256779	0.185	475
2005	49286	0.320	158	256779	0.185	475
2006	50659	0.320	162	256779	0.185	475
2007	51716	0.263	136	256779	0.153	392
2008	50471	0.361	182	252779	0.199	502
2009	46464	0.336	156	247779	0.204	505

The average weight of a passenger car, bus, light commercial vehicle and truck are known for every year back to 1993 (Statistics Denmark). The corresponding weights from 1990 to 1992 and the average weight of a unit from the category "motorcycles/mopeds" are estimated by an expert judgment. The total mass of vehicle involved in fires can then be calculated from the number of vehicle fires and the average weights of the different vehicle types. It is assumed that only 70 % of the total vehicle mass involved in a fire actually burns, see Table 8.5.9.

Table 8.5.9 Average vehicle mass involved in fires.

	Passenger cars		Busses		Light duty vehicles	
Year	Vehicle fires	Average weight, kg	Vehicle fires	Average weight, kg	Vehicle fires	Average weight, kg
1990	1420	850	35	10000	92	2000
1991	1423	850	43	10000	95	2000
1992	1432	850	49	10000	97	2000
1993	1448	901	58	10068	101	2297
1994	1442	908	62	10512	104	2382
1995	1495	923	62	10807	107	2492
1996	1547	935	63	10899	109	2638
1997	1588	948	63	10950	112	2746
1998	1620	964	64	10960	116	2848
1999	1644	982	65	11140	120	2964
2000	1653	999	65	11195	125	3103
2001	1667	1012	65	11312	129	3238
2002	1679	1024	65	11387	134	3333
2003	1681	1039	65	11479	139	3442
2004	1697	1052	65	11572	149	3561
2005	1736	1068	65	11560	163	3793
2006	1780	1086	65	11684	178	4120
2007	1658	1105	55	11753	144	4505
2008	1991	1122	68	11700	197	4710
2009	1990	1134	69	11642	184	4682

Continued

	Heavy duty vehicles		Motorcycles/mopeds		Total vehicle mass	
Year	Vehicle fires	Average weight, kg	Vehicle fires	Average weight, kg	Involved in fires, Mg	Burnt, Mg
1990	146	15000	302	80	3956	2769
1991	145	15000	300	80	4036	2825
1992	146	15000	293	80	4103	2872
1993	148	14732	287	85	4325	3028
1994	151	14674	282	86	4449	3115
1995	154	14801	303	86	4619	3233
1996	155	14928	323	86	4756	3329
1997	156	14987	346	88	4878	3414
1998	159	15111	373	90	5032	3522
1999	161	15223	397	92	5182	3627
2000	161	15214	424	93	5250	3675
2001	160	14888	442	94	5255	3679
2002	157	14486	461	95	5226	3658
2003	155	14026	466	96	5194	3636
2004	154	13599	475	97	5212	3649
2005	158	13258	475	99	5364	3755
2006	162	13179	475	103	5616	3931
2007	136	13268	392	107	4973	3481
2008	182	13246	502	113	6425	4498
2009	156	12802	505	117	5977	4184

Emission factors

Building fires

For building fires, emissions are calculated by multiplying the number of full scale equivalent fires by the emission factors. The estimation of emissions is based on emission factors from literature. The estimation is based on the measurements and estimations performed in countries that are comparable with Denmark. By comparable is meant countries that have similar building traditions, in relation to the material used in building structure and interior.

In the process of selecting the best reliable emission factors for the calculation of the emissions from Danish accidental building fires, a range of different sources have been studied. Unfortunately it is difficult to do an interrelated comparison of the different sources because they all establish emission factors on different assumptions and many of these assumptions are not fully accounted for. Table 8.5.10 lists the emission factors that were chosen as the best reliable and their respective references.

Table 8.5.10 Emission factors building fires.

	Unit	Detached houses	Undetached houses	Apartment buildings	Industrial buildings	Source
CO_2 - total	Mg/fire	31.2	25.8	14.9	80.0	Blomqvist et al. 2002
CO_2 - biogenic	Mg/fire	25.8	21.3	12.3	67.6	Blomqvist et al. 2002
CO_2 - non-biogenic	Mg/fire	5.44	4.49	2.60	12.34	Blomqvist et al. 2002
CH_4	kg/fire	41.8	34.5	17.4	97.5	NAEI 2007
N_2O	-	NAV	NAV	NAV	NAV	-

NAV = not available

The average floor space in Danish buildings is stated in Table 8.5.11. The data is collected from Statistics Denmark and takes into account possible multiple building floors but not attics and basements. The average floor space in industrial buildings, schools, banks etc. is estimated to 500 square meters for all years.

Table 8.5.11 Average floor space in building types.

	Detached	Undetached	Apartment
1990	156	129	75
1991	156	128	75
1992	155	128	75
1993	155	128	75
1994	155	128	75
1995	155	129	75
1996	155	129	75
1997	155	129	75
1998	155	130	75
1999	155	130	75
2000	156	131	75
2001	160	131	75
2002	161	131	75
2003	162	131	75
2004	163	132	75
2005	162	131	76
2006	163	132	76
2007	160	132	76
2008	161	133	77
2009	162	133	77

Statistics Denmark, BOL51 and BOL 511.

Persson et al. (1998) gives for Swedish conditions an emission factor for CO_2 expressed as kg pr Mg of object burned and divided in three different objects; house, apartment and schools of average Swedish sizes. The data is based on the distribution of combustible material in the interior of the different building types, and does not take into account the combustible material in the structure itself. These emission factors are recalculated using Danish data for average building sizes, resulting in the subdivision of building types in detached, undetached, apartment and industrial buildings.

Persson et al. (1998) sets a rate of weight loss at 12.4 %, but does not specify any further on different building types. It seems quite unrealistic that the same rate of weight loss applies for houses and industrial buildings, resulting in the conclusion that there is most likely an overestimation on the emission factors for industrial buildings.

In 2002 a report on the further development of this data was published in Blomqvist et al. (2002), this report added data for the amount of combustible material in the building structure. The emission factors from this source is calculated by combining the estimated amount of combustible material in the building structure itself, with the amount of combustible interior estimated in Persson et al. (1998) for the different building types. Again, Danish data for the average floor space in different building types is used to divided the emission factors into the four categories; detached houses, undetached houses, apartment buildings and industrial buildings.

The emission factors from both Persson et al. (1998) and Blomqvist et al. (2002) are probably overestimated due to building traditions, because wood is use to a further extent in Sweden and Norway contra Denmark.

Being that Persson et al. (1998) and Blomqvist et al. (2002) are the only sources to CO_2 emission factors, Blomqvist et al. (2002) is the best available source as this provides a more recent and more detailed method. The share of CO_2 emission that stems from the burning of wood is calculated from the estimated wood contents in an average house. Blomqvist et al. (2002) specifies that an average house of 120 square meters has a structure that consists of 9000 kg wood and an interior that consists of 2780 kg wood. With a CO_2 yield factor of 1.63 kg pr kg wood and a Danish average floor area of 162 square meters, the CO_2 emission from the burning of wood in a full scale detached house fire in 2009 is 25.92 Mg pr fire.

NAEI (2007) represents the UK National Atmospheric Emissions Inventory; this is the only source that provides emission factors CH_4. NAEI presents emission factors in mass emission pr mass burned. For the recalculation of this emission factor to match the available activity data, the building masses are estimated using the same methodology as Hansen (2000) and stated in Table 8.5.12 for 2009.

Table 8.5.12 Building mass pr building type.

	Unit	Detached house	Undetached house	Apartment building	Industry building
Average floor area*	m^2	162	133	77	500
Building mass pr floor area	kg/m^2	40	40	35	30
Total building mass	Mg/fire	6.5	5.3	2.7	15.0

* 2009 numbers.

No data was available for N_2O.

Vehicle fires

In the process of selecting the best reliable emission factors for the calculation of the emissions from Danish vehicle fires, different sources have been studied. Unfortunately it is difficult to do an interrelated comparison of the different sources because they all establish emission factors on different assumptions and many of these assumptions are not fully accounted for. Table 8.5.13 lists the accepted emission factors and their respective references.

Table 8.5.13 Emission factors for vehicle fires.

	Unit	Emission factor	Source
CO_2, fossil	Mg/Mg	2.4	Lönnermark et al. 2004
CH_4	kg/Mg	5	NAEI 2007
N_2O	-	NAV	-

NAV = not available

Even though NAEI (2007) does not have any references as to where they have collected data, this is the chosen source for the CH_4 emission factor from vehicle fires because it is the only available source.

Persson et al. (1998) and Lönnermark et al. (2004) are the only available sources to CO_2 emission factors for vehicle fires. Since Lönnermark et al. (2004) is the more resent source and establishes its emission factors on experimental data, this is chosen as the best reliable source.

No data was available for N_2O.

8.5.3 Sludge spreading

Sludge from waste water treatment plants is only spread out in the open with the purpose of fertilising crop fields. Any greenhouse emissions that might derive from this activity are estimated in Chapter 6 (CRF Sector 4).

8.5.4 Biogas production

Emissions from biogas production are divided and reported in different sections of this inventory according to use.

For the biogas production from organic waste with the purpose of energy production, the fuel consumption rate of the biogas production plants refers to the Danish energy statistics. The applied emission factors are the same as for biogas boilers. See this NIR Chapter 3, Energy.

Biogas production from manure is included in this NIR Chapter 6, Agriculture.

The fugitive emissions of CH_4 from the production of biogas from sludge from waste water treatment have been set to 1% of the biogas production. The methodology used for estimation the CH_4 and N_2O emissions from wastewater handling are described in this NIR Chapter 8.3, Wastewater Handling.

Biogas production in this section only covers fugitive emissions from the handling of biological waste, sludge and manure. This includes activities like storage, pre- and after-treatment and fugitive emissions from the anaerobic digestion that is the actual production. However, emissions on these activities are considered negligible.

8.5.5 Other combustion

Other combustion sources include open burning of yard waste and wild fires.

In Denmark, the open burning of private yard waste is under different restrictions according to the respective municipality. These restrictions involve what can be burned but also the quantity, how, when and where or in some cases a complete banning. There is no registration of private waste burning and the activity data on this subject are very difficult to estimate. People are generally appealed to compost their yard waste or to dispose of it through one of the many waste disposal/recycling sites.

The occurrence of bonfires at midsummer night and in general are likewise not registered, therefore it has not been possible to obtain activity data.

Due to the cold and wet climate conditions in Denmark wild fires very seldom occurs. Controlled burnings are completely prohibited and the occasional wild fires are of such a small scale that this activity is assumed negligible.

8.5.6 Uncertainties and time-series consistency

Composting

The following Table 8.5.14 lists the 95 % confidence interval uncertainties for composting activity data and emission factors. The uncertainties are assumed valid for all years 1990-2009.

Table 8.5.14 Uncertainties composting.

Pollutant	Activity data, %	Emission factor, %
CH_4	40	100
N_2O	40	100

Accidental fires

Table 8.5.15 lists the 95 % confidence interval uncertainties for accidental building fires and accidental vehicle fires. The uncertainties are assumed valid for all years 1990-2009.

The uncertainty of the total number of accidental fires is miniscule, but the division into building and transportation types might lead to a small uncertainty, primarily caused by the category “other”. The uncertainty for both building and vehicle activity data is therefore set to 10 %. The uncertainty is lowest for recent years.

Table 8.5.15 Estimated uncertainty rates for accidental fires, %

	Building fires		Vehicle fires	
Pollutant	Activity data	Emission factor	Activity data	Emission factor
CO_2	10	500	10	500
CH_4	10	700	10	700
N_2O	10	NAV	10	NAV

NAV = not available.

Tier 1 uncertainty results

The tier 1 uncertainty estimates for the waste other emission inventories are calculated from 95 % confidence interval uncertainties, the tier 1 uncertainties for the activity data and emission factors used in this inventory, and at the present level of available information, are shown in Table 8.5.16

The uncertainty interval for GHG is estimated to be ±93.9 % and the trend in GHG emission is 138.1 % ±182.7 %-age points. The main sources of uncertainty for GHG emission are accidental fires, in particular accidental building fires. The main source of trend uncertainty for GHG emission is by far compost production.

Table 8.5.16 National tier 1 uncertainty estimates for waste other.

Pollutant	Total emission uncertainty, %	Trend 1990-2009, %	Trend Uncertainty %-age points
GHG	±93.9	138.1	±182.7
CO_2	±366.7	25.7	±55.6
CH_4	±106.3	175.3	±177.6
N_2O	±107.7	261.1	±204.3

GHG emissions are calculated in CO_2-equivalents.

Tier 2 uncertainty results

The tier 2 uncertainty estimates for the waste other emission inventories are calculated from 50 % confidence interval uncertainties, results are shown in Table 8.5.17. The estimates were based on a Monte Carlo approach as described in this NIR section 1.7.

Table 8.5.17 National tier 2 uncertainty estimates for waste other.

Category 6D	1990 Total emission Uncertainty interval	2009 Total emission Uncertainty interval	2009 Trend Uncertainty
GHG	74.4 Gg (-37 %, +77 %)	167.5 Gg (-36 %. +63 %)	92.3 Gg (-37 %, +65 %)
CO_2	28.4 Gg (-60 %, +186 %)	35.3 Gg (-61 %, +196 %)	6.8 Gg (-69 %, +250 %)
CH_4	1.5 Gg (-45 %, +90 %)	4.0 Gg (-49 %, +99 %)	2.5 Gg (-52 %, +108 %)
N_2O	36.6 Mg (-49 %, +103 %)	133.8 Mg (-43 %, +86 %)	97.1 Mg (-42 %, +82 %)

GHG emissions are calculated in CO_2-equivalents.

The medians for the national emissions from source category 6.D calculated with the tier 2 method, are in general a bit higher than those shown in Table 8.5.1.

The following Figures 8.5.3, 8.5.4 and 8.5.5 show the graphical comparison of tier 1 and tier 2 uncertainties. Figure 8.5.3 and 8.5.4 show the uncertainties of the total emissions from 1990 and 2009 respectively and Figure 8.5.5 shows the uncertainties of the trend.

Tier 1 uncertainties are the same for 1990 and 2009 because the uncertainty input data are the same for all years. The only input data that vary over time are the activity data and for tier 2, results will vary a bit because of the calculation method. The largest uncertainties lies with the accidental fires, and since the entire emission of non-biogenic CO_2 stems from accidental fires this is the compound with the highest uncertainty; see Figure 8.5.3 vs. 8.5.4 or Table 8.5.17.

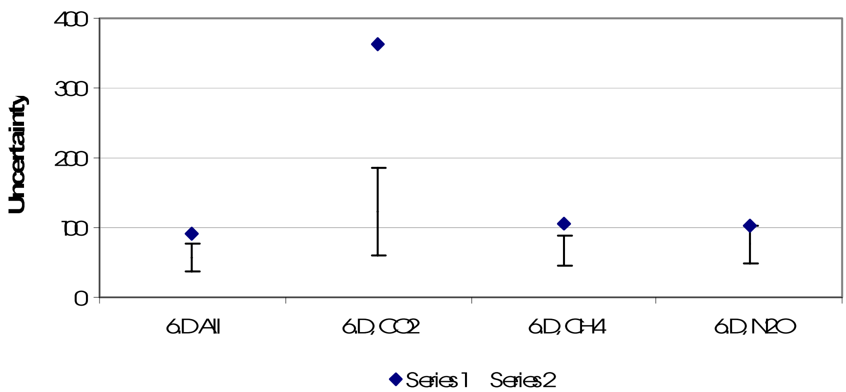


Figure 8.5.3 A graphical comparison of tier 1 and tier 2 uncertainties for 1990.

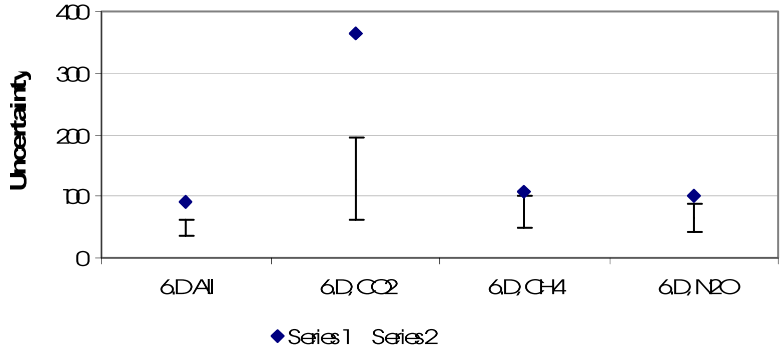


Figure 8.5.4 A graphical comparison of tier 1 and tier 2 uncertainties for 2009.

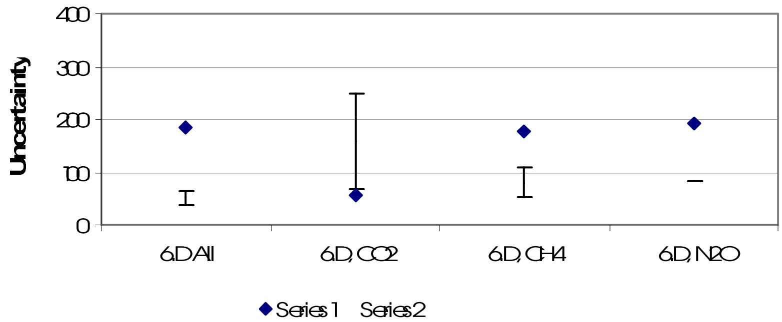


Figure 8.5.5 A graphical comparison of tier 1 and tier 2 trend uncertainties for 2009.

8.5.7 QA/QC and verification

QA/QC-procedure

The methodology for estimating emissions from other waste was introduced for the first time in the inventory submission in 2009. Data in this methodology currently involves activity data for 1990-2009 as presented in the preceding sections.

In general terms, for this part of the inventory, the Data Storage (DS) Level 1 and 2 and the Data Processing (DP) Level 1 can be described as follows:

Data Storage Level 1

The external data level refers to the placement of input data used for deriving yearly activity and emission factors; references in terms of report and databases used for deriving input for the emission calculations. Reports and a list of links to external data sources are stored in a common data storage system including all sectors of the yearly NIRs.

Table 8.5.18 Overview of yearly stored external data sources at DS level1.

http, file or folder name	Description	AD or EF	Reference	Contact	Data agreement/ Comment
http://www.statistikbanken.dk/BOL511	Average floor space in buildings	AD	Statistics Denmark	Katja Hjelgaard kahj@dmu.dk	Public access
https://statistikbank.brs.dk/sb/main/p/a0109	Categorized fires	AD	The Danish Emergency Management Agency	Steen Hjere Nonnemann shn@beredskabsstyrelsen.dk	Public access
http://www.statistikbanken.dk/BOL11 http://www.statistikbanken.dk/BOL3 http://www.statistikbanken.dk/BOL33 http://www.statistikbanken.dk/BYGB11	Building type statistics	AD	Statistics Denmark	Katja Hjelgaard kahj@dmu.dk	Public access
http://www.statistikbanken.dk/BIL10 http://www.statistikbanken.dk/BIL12 http://www.statistikbanken.dk/BIL15 http://www.statistikbanken.dk/BIL18	Weight categorisation of vehicles (passenger cars, busses, vans and trucks)	AD	Statistics Denmark	Katja Hjelgaard kahj@dmu.dk	Public access
http://www2.mst.dk/udgiv/publikationer/2010/978-87-92668-21-9/pdf/978-87-92668-22-6.pdf	Waste categories for composting	AD	Danish Environmental Protection Agency (DEPA), Waste Statistics	Katja Hjelgaard kahj@dmu.dk	Public access

Data Processing Level 1

This level, for waste other, comprises a stage where the external data are treated internally, adjusting the activity data to match the available emission factors.

Points of measurement

The present stage of QA/QC for the Danish emission inventories for waste other is described below for DS and DP level 1 Points of Measurement (PMs). This is to be seen in connection with the general QA/QC description in Section 1.6 and, especially, 1.6.10 on specific description of PMs common to all sectors, general to QA/QC.

Data Storage level 1	1. Accuracy	DS.1.1.1	General level of uncertainty for every dataset including the reasoning for the specific values

Tier 1 and tier 2 uncertainty calculations have been performed. The level of uncertainty is generally low for activity data but higher for emission factors.

Data Storage Level 1	1. Accuracy	DS.1.1.2	Quantification of the uncertainty level of every single data value including the reasoning for the specific values.

There are no available uncertainties from the IPCC GL or GPG or the sources used to calculate the emission inventories for waste other. All uncertainties are achieved by expert judgements.

Data Storage level 1	2.Comparability	DS.1.2.1	Comparability of the data values with similar data from other countries, which are comparable with Denmark, and evaluation of discrepancy.

Some comparison of Danish data values with data sources from other countries has been carried out for activity data and emission factors.

Data Storage level 1	3.Completeness	DS.1.3.1	Documentation showing that all possible national data sources are included by setting down the reasoning behind the selection of datasets.

This category is a catch all for the waste sector and there are still sources that are not covered.

Data Storage level 1	4.Consistency	DS.1.4.1	The origin of external data has to be preserved whenever possible without explicit arguments (referring to other PMs).

The origin of external activity data has been preserved as much as possible. Files are saved for each year of reporting, in this way changes to previously received data and calculations is reflected and explanations are given.

Data Storage level 1	6.Robustness	DS.1.6.1	Explicit agreements between the external institution holding the data and NERI about the conditions of delivery.

No explicit agreement has been made. The data collected for the emission inventories of waste other are publicly available.

Data Storage level 1	7.Transparency	DS.1.7.1	Summary of each dataset including the reasoning for selecting the specific dataset

A summary of the data set can be seen in section 8.5.1 and 8.5.2. For the reasoning behind the selection of the specific dataset, refer to DS 1.3.1.

Data Storage level 1	7.Transparency	DS.1.7.3	References for citation for any external dataset have to be available for any single value in any dataset.

These references exist in the description given in the Section 8.5.1 and 8.5.2, under methodological issues

Data Storage level 1	7.Transparency	DS.1.7.4	Listing of external contacts for every dataset

Contact persons related to the delivery of data for waste other are, Steen Hjere Nonnemann from The Danish Emergency Management Agency (shn@beredskabsstyrelsen.dk), all data used for the emission calculations in this category are accessible to the public and contact persons have therefore not been established.

Data Processing level 1	1. Accuracy	DP.1.1.1	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to type of variability. (Distribution as: normal, log normal or other type of variability)

Tier 1 and Tier 2 uncertainty calculations are made. The use of the Tier 1 methodology presumes a normal distribution of activity data and emission factor variability. Uncertainties are reported in section 8.5.6.

Data Processing level 1	1. Accuracy	DP.1.1.2	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to scale of variability (size of variation intervals)

The uncertainty assessment has been given in Section 8.5.6.

Data Processing level 1	1. Accuracy	DP.1.1.3	Evaluation of the methodological approach using international guidelines

There is no available information in the international guidelines for the emission inventories of waste other.

Data Processing level 1	1. Accuracy	DP.1.1.4	Verification of calculation results using guideline values

There are no useful guideline values.

Data Processing level 1	2.Comparability	DP.1.2.1	The inventory calculation has to follow the international guidelines suggested by the UNFCCC and IPCC.

The inventory calculations are a simple multiplication of activity data and emission factors

Data Processing level 1	3.Completeness	DP.1.3.1	Assessment of the most important quantitative knowledge which is lacking.

Activity data for accidental fires for the years 1990-2005 is not subcategorised into vehicles, buildings or sizes. Emission factors for calculation of greenhouse gas emissions could always be newer and better.

Data Processing level 1	3.Completeness	DP.1.3.2	Assessment of the most important cases where access is lacking with regard to critical data sources that could improve quantitative knowledge.

There is no direct data to elucidate the points mentioned under DP.1.3.1.

Data Processing level 1	4.Consistency	DP.1.4.1	In order to keep consistency at a high level, an explicit description of the activities needs to accompany any change in the calculation procedure.

There is no change in calculation procedure during the time-series and the activity data is, as far as possible, kept consistent for the calculation of the time-series.

Data Processing level 1	5.Correctness	DP.1.5.1	Show at least once, by independent calculation, the correctness of every data manipulation.

The calculations have been checked by comparing with the similar calculations from other countries.

Data Processing level 1	5.Correctness	DP.1.5.2	Verification of calculation results using time-series

The time-series of activities and emissions in the output, in the SNAP source categories and in the CRF format have been prepared. The time-series are examined and significant changes are checked and explained.

Data Processing level 1	5.Correctness	DP.1.5.3	Verification of calculation results using other measures

The correct interpretation in the calculation of the methodology has been checked.

Data Processing level 1	5.Correctness	DP.1.5.4	Shows one-to-one correctness between external data sources and the databases at Data Storage level 2

Data transfer control is made from the external data sources and to the SNAP source categories at level 2. This control is carried on further to the aggregated CRF source categories.

Data Processing level 1	7.Transparency	DP.1.7.1	The calculation principle and equations used must be described

The calculation principle and equations are described in Section 8.5.1 and 8.5.2.

Data Processing level 1	7.Transparency	DP.1.7.2	The theoretical reasoning for all methods must be described

The calculation principle and equations are described in Section 8.5.1 and 8.5.2.

Data Processing level 1	7.Transparency	DP.1.7.3	Explicit listing of assumptions behind all methods

For the emission calculation for compost production it is assumed that:

- all facilities can be considered as using windrow composting.
- 28 % of all residential buildings with private gardens (including weekend cabins) are actively contributing to home composting
- 14 % of all multi-dwelling houses are actively contributing to home composting
- 50 kg waste pr year will in average be composted at every contributing residential building
- 10 kg waste pr year will in average be composted at every contributing multi-dwelling house
- there is 37.5 % DOC in dry matter, 2 % N in dry matter and 50 % moisture in the waste.

- the CO_2 produced and emitted during composting global warming neutral

For the emission calculation for accidental building fires it is assumed that:
- a medium and a small fire leads to 50 % and 5 % of a large fire respectively, and that a large fire is a full scale fire
- a large fire is a fire that involves the use of two or more fire hoses for fire extinguishing and that it typically involve a complete house, one or more apartments, or at least part of an industrial complex
- a medium size fire is a fire involving the use of only 1 fire hose for fire-fighting and that it will typically involve a part of a single room in an apartment or house
- a small size fire is a fire that was extinguished before the arrival of the fire service, extinguished by small tools or a chimney fire
- the share of building fires in respect to the total number of registered fires, can be considered as constant for every year back to 1990
- the average shares of building categories (industrial building, detached house, undetached house and apartment building) are representative for all years back to 1990

For the emission calculation for accidental vehicle fires it is assumed that:
- all the different vehicle types leads to similar emissions
- the share of vehicle fires in relation to the total number of registered vehicles of the respective categories can be counted as constant
- that only 70 % of the total vehicle mass involved in a fire actually burns

Data Processing level 1	7.Transparency	DP.1.7.4	Clear reference to dataset at Data Storage level 1

Refer to the Table 8.5.18 and DS.1.1.1 above.

Data Processing level 1	7.Transparency	DP.1.7.5	A manual log to collect information about recalculations

Recalculation changes in the emission inventories are described in the NIR. The logging of the changes takes place in the yearly model file.

Data Storage level 2	5.Correctness	DS.2.5.1	Documentation of a correct connection between all data types at level 2 to data at level 1

The full documentation for the correct connection exists through the yearly model file, its output and report files made by the CollectER database system.

Data Storage level 2	5.Correctness	DS.2.5.2	Check if a correct data import to level 2 has been made

This check is performed, comparing output and report files made by the CollectER database system, refer to DS.2.5.1.

8.5.8 Source-specific recalculations

The calculation of emissions from accidental fires of both buildings and vehicles has been added the additional data year of 2009. This extra detailed dataset has influenced the activity data for building and vehicle fires for the years 1990-2005. The total number of building fires has with this recalculation increased with 0.69 – 0.70 %.

The activity data for accidental vehicle fires has increased more drastically with the peek of 7.1 % in 1993. This increase is caused by a change in data delivery of the population of the different vehicle types.

8.5.9 Source-specific planned improvements

Estimations of emissions from accidental landfill fires are under investigation.

8.5.10 Source-specific performed improvements

GHG emissions from accidental building and vehicle fires have been moved to this section from section 6.C (chapter 8.4).

Calculations on the emissions from compost production are new in this year's inventory.

Source-specific QA/QC and verification have been performed.

Uncertainty input-factors have been analysed and tier 1 and tier 2 calculations have been carried out for all included sources.

References for Chapter 8.5

Affaldsstatistik 2006 (Waste Statistics), Orientering fra Miljøstyrelsen Nr. 2 2008, Miljøstyrelsen, Miljøministeriet. Available at: http://www2.mst.dk/udgiv/publikationer/2008/978-87-7052-753-8/pdf/978-87-7052-754-5.pdf (Danish) (10/11-2010).

Affaldsstatistik 2007 og 2008 (Waste Statistics), fra Miljøstyrelsen Nr. 5 2010, Miljøstyrelsen, Miljøministeriet. Available at: http://www2.mst.dk/udgiv/publikationer/2010/978-87-92668-21-9/pdf/978-87-92668-22-6.pdf

Amlinger, F., Peyr, S. & Cuhls, C. 2008: Green house gas emissions from composting and mechanical biological treatment. Florian Amlinger, Stefan Peyr and Carsten Cuhls. Waste Management & Research 2008; 26; 47. Sage publications, International Solid Waste Association. Available at: http://wmr.sagepub.com/cgi/reprint/26/1/47.pdf (9/11-2010).

Blomqvist, Per, Persson, Bror and Simonson, Margaret, Utsläpp från bränder till miljön, Utsläpp av dioxin, PAH och VOC till luften, 2002 Räddnindsverket, Karlstad, FoU rapport, SP Brandteknik, Borås. Available at: http://www2.msb.se/Shopping/pdf/18193.pdf (10/11-2010) (Swedish).

Boldrin, Alessio, Andersen, Jacob K. and Christensen, Thomas H., Miljøvurdering af haveaffald i Århus kommune, Danmarks Tekniske Universitet - Miljø, 3R, 2009.

Hellebrand, H.J., Emission of Nitrous Oxide and other Trace Gases during Composting of Grass and Green Waste, Institute of Agricultural Engineering Bornim (ATB), Germany, Silsoe Research Institute. Journal of agricultural Engineering Research (1998) 69, 365-375. Available at: http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6WH1-45J55M4-36&_user=6461277&_coverDate=04%2F30%2F1998&_alid=1535242472&_rdoc=3&_fmt=high&_orig=search&_origin=search&_zone=rslt_list_item&_cdi=6837&_sort=r&_st=13&_docanchor=&view=c&_ct=9&_acct=C000034578&_version=1&_urlVersion=0&_userid=6461277&md5=40cc8dc8e0473d733187fbbc85b5c498&searchtype=a (10/11-2010).

Legistration on sludge. Bekendtgørelse om anvendelse af affald til jordbrugsformål (Slambekendtgørelsen). Available at: https://www.retsinformation.dk/Forms/R0710.aspx?id=13056 (Danish) (4/11-2010).

Lönnermark, Anders and Blomqvist, Per, Emissions from an automobile fire; elsevier, chemosphere 62 (2006); dec 2004; p1043-1056. Available at: http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V74-4GDK9KM-C&_user=6461277&_coverDate=02%2F28%2F2006&_rdoc=1&_fmt=high&_orig=search&_origin=search&_sort=d&_docanchor=&view=c&_searchStrId=1535057454&_rerunOrigin=google&_acct=C000034578&_version=1&_urlVersion=0&_userid=6461277&md5=1955f15a097419f5b19a056abe1d5288&searchtype=a (10/11-2010).

NAEI, The UK National Atmospheric Emission Inventory, 2007. Available at: http://www.naei.org.uk/emissions/selection.php (9/4-2010).

Persson, Bror and Simonson, Margaret, Fire emissions into the atmosphere, Swedish National Testing and Research Institute, Birås, Sweden, Fire Technology, Vol. 34, No. 3, 1998. Available at: http://www.springerlink.com/content/txnx8f3ry90mfvy3/fulltext.pdf (10/11-2010).

Petersen, Claus & Kielland, Martin, Statistik for hjemmekompostering 2001 (Statistics on home composting), Econet A/S. Miljøprojekt Nr. 855 2003, Miljøstyrelsen, Miljøministeriet. Available at: http://www2.mst.dk/udgiv/publikationer/2003/87-7972-960-6/pdf/87-7972-961-4.pdf (Danish).

Statistics Denmark, StatBank Denmark 2010. Available at: http://www.statistikbanken.dk/statbank5a/default.asp?w=1024 (Danish/English) (25/8-2010).

Statistik for behandling af organisk affald fra husholdninger – Revideret udgave, 1999 (Statistics for treatment of organic waste from households – revised version), Claus Petersen ECONET A/S, Miljøprojekt Nr. 654 2001, Miljøstyrelsen, Miljøministeriet. Available at:

http://www2.mst.dk/Udgiv/publikationer/2001/87-7944-932-8/pdf/87-7944-933-6.pdf (Danish) (10/11-2010).

Statistik for behandling af organisk affald fra husholdninger 2001 (Statistics for treatment of organic waste from households), Claus Petersen og Vibeke Lei Hansen ECONET A/S. Miljøprojekt Nr. 856 2003, Miljøstyrelsen, Miljøministeriet. Available at: http://www2.mst.dk/Udgiv/publikationer/2003/87-7972-962-2/pdf/87-7972-963-0.pdf (Danish).

The Danish Emergency Management Agency (DEMA), Beredskabsstyrelsen, statistikbanken. Available at: https://statistikbank.brs.dk/sb/main/p/a0109 (Danish).

The Danish Emergency Management Agency (DEMA), Beredskabsstyrelsen, Redningsberedskabets Statistiske Beretning 2007. Available at: http://www.brs.dk/folder/statistik/beretning_07/index.htm (Danish) (10/11-2010).

2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 4: Biological Treatment of Solid Waste. Available at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_4_Ch4_Bio_Treat.pdf

9 Other (CRF sector 7)

In CRF Sector 7, there are no activities and emissions for the inventories of Denmark. Until the 2009 submission in the inventories of the Kingdom of Denmark (Denmark, Faroe Islands and Greenland) emissions from Faroe Islands and Greenland were reported in Sector 7. This has been changed so that Greenland and Faroe Islands are included in full CRF's.

For further detail on the emissions from Greenland and the Faroe Islands please see Annex 9 and 11.

10 Recalculations and improvements

Previously the recalculation tables in the CRF have been incorrect due to the different geographical scopes of the inventory. However, by running five different installations of the CRF Reporter software, the data presented in Table 8 of the CRF are accurate. Explanations for the recalculations of the Danish inventory are included in Chapter 10.1.1.

The overall impact of recalculations is shown in Table 10.1. A more detailed overview is provided in tables 10.2 – 10.5.

In connection with the in-country review of the Danish GHG emission inventory in September 2010, Denmark resubmitted the inventory in October 2011. The recalculations presented in this chapter are recalculations carried out between the October 2010 submission and the present submission. The changes between the May 2010 reporting and the October 2010 reporting were limited to the agricultural sector and the LULUCF sector.

Information on recalculations for the aggregated submission of Denmark and Greenland under the Kyoto Protocol are included in Chapter 17.

10.1 Explanations and justifications for recalculations

Explanations and justifications for the recalculations performed for this submission and since submission of data in the CRF-format for submission to UNFCCC due April 15, 2010 for Denmark are given in the following sector chapters:

Energy:

• Stationary Combustion	Chapter 3.2.8
• Transport	Chapter 3.3.7
• Fugitive emissions	Chapter 3.5.8

Industry:

• Mineral products	Chapter 4.2.5
• Food and drink	Chapter 4.5.4
• Consumption of f-gases	Chapter 4.7.5

Solvents and Other Product Use	Chapter 5.8
Agriculture	Chapter 6.9

LULUCF

• Forest Land	Chapter 7.2.1, 7.2.2
• Crop Land	Chapter 7.3
• Grassland	Chapter 7.4

- Wetlands Chapter7.5
- Settlements Chapter 7.6

Waste

- Solid Waste Disposal on Land Chapter 8.2.5
- Wastewater Chapter 8.3.5
- Waste incineration Chapter 8.4.5
- Waste, Other Chapter 8.5.5

The main recalculations since the 2010 submission are:

10.1.1 Energy

Stationary Combustion

For stationary combustion plants, the emission estimates for the years 1990-2008 have been updated according to the latest energy statistics published by the Danish Energy Agency. The update included both end use and transformation sectors as well as a source category update.

The petroleum coke purchased abroad and combusted in Danish residential plants is no longer included in the inventory. The border trade have been increasing since 1990 and was 628 TJ in 2008.

The CO_2 emission factors for coal have been recalculated for 1990-2008. The recalculation has resulted in an improved time-series consistency. Due to the considerable consumption of coal, this recalculation is considerable for the years 1990-2005 before plant specific data (EU ETS) became available. The recalculation resulted in lower estimates for CO_2: -1.9 Gg in 2009 and -245 Gg in 1990.

The CO_2 emission factors for residual oil have also been recalculated based on the EU ETS data and an improved time-series implemented.

The CO_2 emission factors for LPG and kerosene have been changed and both emission factors now refer to IPCC Guidelines (1996).

Emission factors for CH_4 and N_2O that are not country specific have been updated and now all refer to IPCC Guidelines (1996).

Mobile sources

The following recalculations and improvements of the emission inventories have been made since the emission reporting in 2010.

Road transport

The total mileage per vehicle category from 2005-2008 have been updated based on new data prepared by DTU Transport. More accurate fleet and mileage figures are provided by the latter institution, split into the different vehicle layers of the emission model. An important change is the categorisation of fleet data for heavy duty trucks and buses into the numerous weight classes covered by the COPERT IV model.

The minimum and maximum percentage difference and year of numeric maximum differences (min %, max %, year of max %) for the different emission components are: CO_2 (-0.081%, 0.082 %, 1993), CH_4 (-1.3 %, -17.9 %, 2008) and N_2O (-4.6 %, 3.7 %, 1991).

National sea transport

Fuel consumption by vessels sailing between Denmark and Greenland/Faroe Islands, and between Denmark and the North Sea off shore installations has been added to this category. Previously this fuel consumption was reported under international sea transport. The corresponding minimum and maximum percentage difference and year of numeric maximum differences (min %, max %, year of max %) for the different emission components are: CO_2 (9.2 %, 30.8 %, 2008), CH_4 (4.6 %, 10.7 %, 2008) and N_2O (9.6 %, 34.0 %, 2008).

Fisheries

Due to the changes made in national sea transport, and the fuel transferral between national sea transport and fisheries made as an integral part of the Danish inventories, significant fuel consumption and emission changes have been made for the fishery sector accordingly, for 2001 onwards. The corresponding minimum and maximum percentage difference and year of numeric maximum differences (min %, max %, year of max %) are (27 %, 39 %, 2006), for all emission components.

Agriculture

The stock of harvesters have been updated for the years 2001-2008, based on discussions with the Danish Knowledge Centre for Agriculture. For gasoline fuelled ATV's the stock has been updated for 2007 and 2008. The changes in fuel consumption and emissions are between 0 and 2 % for CO_2 and N_2O, whereas for CH_4 the emission changes are 12 % and 21 %, in 2007 and 2008 respectively.

Agriculture/forestry/fisheries

The total consequences for agriculture/forestry/fisheries, expressed as minimum and maximum percentage difference and year of numeric maximum differences (min %, max %, year of max %) for the different emission components are: CO_2 (9.6 %, 12.1 %, 2006), CH_4 (4.0 %, 21.7 %, 2008) and N_2O (12.4 %, 15.5 %, 2008).

Military

Emission factors derived from the new road transport simulations have caused some emission changes from 1985-2008. The minimum and maximum emission differences (min %, max %) for the different emission components are: CH_4 (-1 %, -16 %) and N_2O (-4 %, 1 %).

Residential

A split in activity codes has been made. In this way the majority of the fuel consumption and emissions previously reported under residential (SNAP code 0809; NFR code 1A4b) are now reported under commercial/institutional (SNAP code 0811; NFR code 1A4a ii).

No changes have been made in the estimated fuel consumption and emissions for Residential and Commercial/institutional as a sum.

Commercial/institutional

A split in activity codes has been made. The majority of the fuel consumption and emissions previously reported under residential (SNAP code 0809; NFR code 1A4b) are now reported under commercial/institutional (SNAP code 0811; NFR code 1A4a ii).

No changes have been made in the estimated fuel consumption and emissions for Residential and Commercial/institutional as a sum.

Industrial non road machinery

The annual working hours for fork lifts in 2008 have been adjusted with a factor of 0.95 due to the decrease in activities caused by the global financial crisis. The total fuel consumption and emission changes in 2008 for industrial non road machinery are approximately -1 %.

Railways

No changes have been made.

Aviation

Very small emission changes between -2 % and 1 % occur for the years 2001-2008, due to inclusion of new aircraft types assigned to the representative aircraft types.

Fugitive emissions

In the emission inventory for 2009 there have been some recalculations as listed below.

Service stations

The amounts of gasoline sales used for calculation of fugitive emissions from service stations (SNAP 050503) have been updated according to the Energy Statistics for 2009 1990-2008. The NMVOC emission in 2008 has thereby increased by 6 Mg corresponding to 0.5 %.

Extraction of oil and gas

Fugitive emissions from extraction are calculated from the standard formula in the EMEP/EEA Guidebook (EMEP/EEA, 2009) based on the number of platforms. In 2009 the number of platforms has been corrected for 2007 and 2008. The NMVOC emission in 2008 has decreased by 20 Mg according to this correction corresponding to 1 %.

Gas distribution

Distribution amounts have been updated for one of three natural gas distribution companies for the years 2006-2008 due to new data availability. The NMVOC emission has decreased by 4 Mg in 2008 due to this corresponding to 10 %. Emissions from venting in gas storage have previously been included in gas transmission, but are now included in the venting and flaring category (1B2c). The emissions have not been changed for the time-series during the IPCC category shift.

Flaring in oil and gas extraction

The NMVOC emission in 2008 from flaring in the gas treatment plant has been updated for 2008 according to the environmental report leading to an increase of 2 Mg NMVOC. The increase corresponds to 12 % of the NMVOC emission from flaring in oil and gas extraction including offshore flaring. Emissions from venting in gas storage have previously been included in gas transmission, but are now included in the venting and flaring category (1B2c). The emissions have not been changed for the time-series during the IPCC category shift.

10.1.2 Industry

Emission of NMVOC from 2D2 Food and Drink has been improved by using better emission factors for production of bread and cookies, and breweries.

For F-gases there has been a change in the methodology for mobile air condition. Information on actual amounts of f-gas used for refilling is available from 2009 and has been used as an estimate on f-gas emitted during use of the air condition.

10.1.3 Solvents and Other Product Use

Further improvement of source allocation model, which combines information on Use Categories and NACE Industrial Use Categories from SPIN and use amounts from Statistics DK.

Implementation of correct 2008 import amounts for xylene, which has been verified by Statistics Denmark.

Emissions from use of fireworks have been included under Other Product Use.

10.1.4 Agriculture

Some changes for emissions from the agricultural sector have taken place. These changes reflect decreased emissions in the years 1990-2008 up to 7% compared to the total CO_2-equivalent emission from the agricultural sector. The decrease is due to an increase in the emissions of CH_4 but a higher decrease in the emission of N_2O.

As recommended by ERT during the in-country review in September 2010, the MCF factor for housing systems with deep litter stored > 1 month, is changed from 1 to 10 %. The change in MCF factors influence emissions from cattle, sheep and goats. The total CH_4 emission increased up to 4 % in CO_2-equivalents for the years 1990-2008 with an increasing trend.

The decrease in N_2O emissions is mainly due to a change in the calculation of emission form N-leaching. Because of new data it is now possible to separate the calculation of emissions from leaching in emissions from groundwater and surface drainage, rivers and estuaries.

Two changes have been made which have and increasing effect on the N_2O emission. The implied emission factor for histosols is changed from 2-3 kg N_2O-N per hectare to IPCC default value at 8 kg N_2O-N per hectare, as recommended by ERT during the in-country review in September 2010. Furthermore, has an error for N excreted from sows been corrected. The total N_2O emissions decreased up to 12 % in CO_2-equivalents for the years 1990-2008.

10.1.5 Waste

For Solid Waste Disposal no recalculations were made.

For Waste Water handling recalculations was made for 1990 to 2008 for CH_4 and N_2O emissions from wastewater handling.

The methane emission waste water handling have this year been specified according to contributions from 1) the sewer system, 2) in primary settling tanks 3) during biological N and P removal and 4) from anaerobic treatment processes in closed systems with biogas extraction and combustion for energy production. In this years inventory an estimation methane emissions from the septic system has been included.

Furthermore, a yearly emission factor for the anaerobic processes has been implemented as reported in Chapter 8.3.

Updated quality assured data on the N content in the effluent wastewater for 2005-2009, have resulted changes the indirect N_2O emission.

Correction of an error in the EF algorithm for direct N_2O emissions has resulted in the direct N_2O emission an increase of 13.7% of the direct N_2O emission.

Emissions from waste incineration have decreased as the calculated emissions from accidental building and vehicle fires have been moved from this section to the waste other section. There are no longer non-biogenic CO_2 emissions from this category.

For the category waste other; in addition to the increase in emission due to the moving of accidental fires, are the emissions of methane and nitrous oxide from compost production which are new in this year's inventory.

The sectoral total increased between 6.1 % (1990) and 12.6 % (2007). For 2008 the increase was 11.3 %.

10.1.6 LULUCF

As a consequence of the Danish election of 3.4 for forest management, cropland management and grassland management is a thoroughly investigation of the LULUCF undertaken. Some results from this investigation is included in this submission, whereas other data will be included in the final 2011 submission. This investigation include a wall-to-wall mapping of the Danish area through remote sensing (RS) for 1989/90 and 2005, a new soil map for organic soils, Danish emission factors for organic soils, monitoring of hedgerows etc. In this submission are included results from the RS which change several data. The use of RS has made it possible to estimate land use conversion to a much higher degree than previous. The changes in the land area/activity data from the remote sensing affect more or less all subsequent emission estimates.

Forestry

Based on the mapped forest area in 1990 and in 2005 a calculation of carbon stored in both the old forest (forest established pre-1990 - under the Kyoto Protocol Article 3.4) and in new forests (afforestation since 1990 - under the Kyoto Protocol Article 3.3) has been performed. The afforestation since 1990 has been mapped to be larger than previously estimated for the times.

The calculation of carbon stock in 1990 and in 2000 is based on the age distribution as reported in census 1990 and Forest in 2000 as an expression of the total forest land allocation to species and ages. Based on the actual measurements of carbon storage in different species and age classes, the total standing carbon stock has been recalculated. For each of the years 1990 - 2000 a carbon pools are calculated as a moving average, corrected for the deforestation which was detected.

Since the NFI was initiated in 2002, it is representative from 2005. Calculation of carbon stock in the period 2000-2004 is based on NFI in 2005 and carbon stock as calculated for 2000. For 2005-2009 carbon stock is calculated solely on the basis of the NFI - with additional information about the total forest area from satellite image mapping.

The recalculations have resulted in that Forestry has gone from a source of 133 Gg CO_2 in 2008 to be a net sink of -233 Gg CO_2. N_2O is only slightly affected.

Cropland, grassland, wetlands and settlements

For cropland, grassland, wetlands and settlements there has been changes in soil carbon stock from land use changes. There have been minor changes in how the agricultural land area is estimated due to the remote sensing. As new data are arriving from our research programme many new national data has been implemented. The major change come from our study on the area with organic soils where preliminary data has shown that the area is more likely only 50.000 hectares and not 80.000 hectares as previous reported. This has reduced the overall emission from cropland in 2008 from 2.687 Gg CO_2 to 2.267 Gg CO_2. Final data will be submitted on March 15. Further more there are changes in grassland, wetlands and settlements but with lesser impact.

10.1.7 KP-LULUCF

A recalculation for KP-LULUCF has been performed for all areas as a consequence of the new data and the review process.

10.2 Implications for emission levels

For the national total CO_2 equivalent emissions without Land-Use, Land-Use Change and Forestry, the general impact of the improvements and recalculations performed is small and the changes for the whole time-series are between -1.62 % (1996) and -0.38 % (2007). Therefore, the implications of the recalculations on the level and on the trend, 1990-2008, of this national total are small, refer Table 10.1.

For the national total CO_2 equivalent emissions with Land-Use, Land-Use Change and Forestry, the general impact of the recalculations is larger due to recalculations in the LULUCF sector. The changes vary between –7.92 % (2008) and +1.46 % (2001), refer Table 10.1.

Table 10.1 Recalculation performed in the 2011 submission for 1990-2008. Differences in pct of CO_2-eqv between this submission and the October 2010 submission for DK, excluding Greenland and Faroe Islands.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total CO_2 Equiv. Emissions with Land-Use Change and Forestry	-1.04	-1.41	-1.32	-1.44	-0.62	-1.04	-1.50	-1.28	-1.03	-0.61
Total CO_2 Equiv. Emissions without Land-Use Change and Forestry	-1.56	-1.51	-1.52	-1.48	-0.74	-1.20	-1.62	-1.49	-1.14	-1.04
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Total CO_2 Equiv. Emissions with Land-Use Change and Forestry	1.09	1.46	1.44	0.96	1.26	0.99	-0.17	-5.37	-7.92	
Total CO_2 Equiv. Emissions without Land-Use Change and Forestry	-1.05	-0.63	-0.49	-0.97	-0.58	-0.77	-0.57	-0.38	-0.80	

10.3 Implications for emission trends, including time-series consistency

It is a high general priority in the considerations leading to recalculations back to 1990 to have and preserve the consistency of the activity data and emissions time-series. As a consequence activity data, emission factors and methodologies are carefully chosen to represent the emissions for the time-series correctly. Often considerations regarding the consistency of the time-series have led to recalculations for single years when activity data and/or emission factors have been changed or corrected. Furthermore, when new sources are considered, activity data and emissions are as far as possible introduced to the inventories for the whole time-series based on preferably the same methodology.

The implication of the recalculations is further shown in tables 10.2-10.5.

Table 10.2 Recalculation for CO_2 performed in the 2011 submission for 1990-2008. Differences in Gg CO_2-eqv. between this and the October 2010 submission for DK. Excluding Greenland and Faroe Islands.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total National Emissions and Removals	130	-232	-174	-250	124	-58	-265	-131	-165	113
1. Energy	-200	-282	-271	-274	46	-165	-370	-274	-239	-183
1.A. Fuel Combustion Activities	-200	-282	-271	-274	51	-165	-370	-274	-239	-183
1.A.1. Energy Industries	-263	-384	-371	-414	-12	-158	-358	-271	-225	-199
1.A.2. Manufacturing Industries and Construction	-12	21	105	158	-46	-63	-74	-65	-76	-55
1.A.3. Transport	89	97	98	94	90	87	79	78	78	102
1.A.4. Other Sectors	-14	-16	-102	-112	19	-31	-16	-17	-16	-31
1.A.5. Other	-	-	-	-	-	-	-	-	-	-
1.B. Fugitive Emissions from Fuels	0	0	0	0	-6	0	0	0	0	0
2. Industrial Processes	0	0	0	0	0	0	2	0	0	0
2.A. Mineral Products	0	0	0	0	0	0	2	0	0	0
2.B. Chemical Industry	-	-	-	-	-	-	-	-	-	-
2.C. Metal Production	-	-	-	-	-	-	-	-	-	-
2.D. Other Production	-	-	-	-	-	-	-	-	-	-
2.G. Other	-	-	-	-	-	-	-	-	-	-
3. Solvent and Other Product Use	0	0	0	0	0	0	0	0	0	0
4. Agriculture	-	-	-	-	-	-	-	-	-	-
5. Land Use, Land-Use Change and Forestry (net)	328	49	95	23	77	105	103	142	74	295
5.A. Forest Land	188	155	170	117	142	117	104	107	43	157
5.B. Cropland	-157	-250	-249	-257	-273	-206	-220	-193	-215	-174
5.C. Grassland	271	108	120	99	121	102	109	104	106	145
5.D. Wetlands	0	0	0	0	4	0	0	0	1	1
5.E. Settlements	25	36	54	63	83	93	110	124	139	167
5.F. Other Land	-	-	-	-	-	-	-	-	-	-
5.G. Other	-	-	-	-	-	-	-	-	-	-
6. Waste	1	1	1	1	1	1	1	1	1	1
6.C. Waste Incineration	-21	-21	-23	-21	-22	-24	-25	-24	-22	-24
6.D. Other	22	23	24	22	23	25	26	25	23	25
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Total National Emissions and Removals	1354	1539	1387	1267	1204	1114	354	-3526	-4837	
1. Energy	-130	58	16	-185	-67	-44	71	16	-57	
1.A. Fuel Combustion Activities	-130	58	16	-185	-67	-44	71	16	-57	
1.A.1. Energy Industries	-158	-166	-162	-321	-163	-97	40	132	152	
1.A.2. Manufacturing Industries and Construction	-59	-52	-66	-99	-90	-167	-188	-298	-295	
1.A.3. Transport	112	126	121	115	113	114	127	133	127	
1.A.4. Other Sectors	-25	150	123	119	73	105	92	50	-41	
1.A.5. Other	-	-	-	-	-	-	-	-	-	
1.B. Fugitive Emissions from Fuels	0	0	0	0	0	0	0	0	-	
2. Industrial Processes	0	0	0	0	0	0	0	0	0	
2.A. Mineral Products	0	0	0	0	0	0	0	0	0	
2.B. Chemical Industry	-	-	-	-	-	-	-	-	-	
2.C. Metal Production	-	-	-	-	-	-	-	-	-	
2.D. Other Production	-	-	-	-	-	-	-	-	-	
2.G. Other	-	-	-	-	-	-	-	-	-	
3. Solvent and Other Product Use	0	0	0	0	0	0	0	0	0	
4. Agriculture	-	-	-	-	-	-	-	-	-	
5. Land Use, Land-Use Change and Forestry (net)	1483	1480	1370	1451	1269	1157	283	-3541	-4780	
5.A. Forest Land	1360	1355	1221	1277	1063	1028	159	-3746	-5008	
5.B. Cropland	-186	-197	-166	-170	-149	-237	-257	-193	-187	
5.C. Grassland	131	129	113	124	121	117	118	119	120	
5.D. Wetlands	1	1	1	1	1	1	1	1	1	
5.E. Settlements	177	191	201	219	233	247	263	278	294	

Continued									
5.F. Other Land	-	-	-	-	-	-	-	-	-
5.G. Other	-	-	-	-	-	-	-	-	-
6. Waste	1	1	1	1	1	1	0	0	0
6.C. Waste Incineration	-23	-23	-23	-24	-22	-23	-25	-26	-29
6.D. Other	24	24	24	25	23	24	25	26	28

Table 10.3 Recalculation for CH_4 performed in the 2011 submission for 1990-2008. Differences in Gg CO_2-eqv. between this and the October 2010 submission for DK. Excluding Greenland and Faroe Islands.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total National Emissions and Removals	113.5	102.9	89.6	52.4	110.8	104.5	87.6	76.8	76.6	94.0
1. Energy	2.3	2.0	-9.1	-48.8	13.2	13.0	2.4	1.0	-2.4	-1.8
1.A. Fuel Combustion Activities	2.3	1.9	-9.2	-48.8	10.9	10.5	-1.0	-2.1	-4.4	-3.2
1.A.1. Energy Industries	-12.9	-19.0	-23.9	-54.4	-8.9	-9.6	-19.9	-22.2	-19.2	-15.5
1.A.2. Manufacturing Industries and Construction	-6.5	-6.1	-5.1	-4.8	-7.8	-7.7	-8.1	-8.3	-8.0	-8.5
1.A.3. Transport	-2.5	-1.5	-1.2	-1.4	-0.7	-0.6	-0.7	-0.9	-1.2	-1.6
1.A.4. Other Sectors	24.2	28.5	21.0	11.7	28.2	28.4	27.8	29.4	24.1	22.3
1.A.5. Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.B. Fugitive Emissions from Fuels	0.0	0.1	0.1	0.1	2.3	2.5	3.4	3.0	2.0	1.4
2. Industrial Processes	-	-	-	-	-	-	-	-	-	-
3. Solvent and Other Product Use	-	-	-	-	-	-	-	-	-	-
4. Agriculture	48.6	35.5	30.5	30.6	26.1	25.0	13.6	-0.3	3.6	11.4
4.A. Enteric Fermentation	-12.6	-16.3	-18.8	-19.1	-17.0	-16.2	-18.6	-24.1	-19.7	-15.1
4.B. Manure Management	61.2	51.8	49.2	49.7	43.1	41.2	32.3	23.8	23.4	26.5
4.F. Field Burning of Agricultural Residues	-	-	-	-	-	-	-	-	-	-
5. Land Use, Land-Use Change and Forestry (net)	-	-	-	-	-	-	-	-	-	-
6. Waste	62.6	65.4	68.3	70.5	71.5	66.4	71.6	76.1	75.3	84.4
6.A. Solid Waste Disposal on Land	-	-	-	-	-	-	-	-	-	-
6.B. Waste-water Handling	35.8	36.0	36.1	35.7	33.9	32.0	30.7	29.5	26.8	27.2
6.C. Waste Incineration	-2.6	-2.7	-2.9	-2.6	-2.6	-3.0	-3.1	-2.9	-2.6	-2.8
6.D. Other	29.4	32.1	35.1	37.5	40.3	37.5	43.9	49.5	51.1	60.0
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Total National Emissions and Removals	76.5	103.5	87.8	93.6	93.3	96.4	54.7	74.8	70.3	
1. Energy	-2.3	-9.2	-11.3	-14.1	-5.7	-12.0	-22.0	-21.0	-1.5	
1.A. Fuel Combustion Activities	-2.2	-9.3	-11.4	-14.2	-5.8	-12.1	-22.1	-19.5	-0.1	
1.A.1. Energy Industries	-13.6	-12.9	-13.0	-15.0	-6.7	-8.4	-5.9	-1.4	31.0	
1.A.2. Manufacturing Industries and Construction	-8.0	-7.9	-6.3	-6.5	-6.2	-4.2	-5.6	-6.0	-5.8	
1.A.3. Transport	-2.0	-2.0	-2.2	-2.8	-2.9	-3.5	-3.6	-3.7	-3.9	
1.A.4. Other Sectors	21.3	13.5	10.2	10.1	10.0	4.0	-7.0	-8.4	-21.4	
1.A.5. Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1.B. Fugitive Emissions from Fuels	-0.1	0.1	0.1	0.1	0.1	0.1	0.1	-1.6	-1.4	
2. Industrial Processes	-	-	-	-	-	-	-	-	-	
3. Solvent and Other Product Use	-	-	-	-	-	-	-	-	-	
4. Agriculture	-10.9	22.3	15.1	20.8	13.6	16.8	-19.6	-7.7	-25.1	
4.A. Enteric Fermentation	-24.5	-11.4	-19.3	-14.8	-15.1	-13.7	-22.8	-20.1	-23.3	
4.B. Manure Management	13.6	33.7	34.3	35.6	28.6	30.5	3.1	12.4	-1.8	
4.F. Field Burning of Agricultural Residues	-	-	-	-	-	-	-	-	-	
5. Land Use, Land-Use Change and Forestry (net)	-	-	-	-	-	-	-	-	-	
6. Waste	89.7	90.4	84.0	86.8	85.4	91.6	96.4	103.6	96.9	
6.A. Solid Waste Disposal on Land	-	-	-	-	-	-	-	-	-	
6.B. Waste-water Handling	29.1	28.4	23.0	23.3	25.0	26.7	27.8	27.0	27.1	
6.C. Waste Incineration	-2.8	-2.7	-2.6	-2.9	-2.6	-2.7	-2.9	-3.2	-3.3	
6.D. Other	63.4	64.8	63.6	66.5	63.0	67.6	71.6	79.8	73.0	

Table 10.4 Recalculation for N_2O performed in the 2011 submission for 1990-2008. Differences in Gg CO_2-eqv. between this and the October 2010 submission for DK. Excluding Greenland and Faroe Islands.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total National Emissions and Removals	-990.2	-1026.0	-935.9	-902.1	-744.1	-861.4	-1182.8	-996.7	-705.0	-671.8
1. Energy	-72.4	-73.5	-65.7	-71.7	-78.3	-83.3	-92.1	-83.9	-81.6	-77.3
1.A. Fuel Combustion Activities	-72.5	-73.7	-65.9	-71.9	-78.4	-83.4	-92.2	-84.0	-81.7	-77.5
1.A.1. Energy Industries	-33.5	-35.3	-34.3	-33.8	-35.1	-37.9	-46.5	-41.7	-41.1	-37.2
1.A.2. Manufacturing Industries and Construction	-2.3	-0.2	1.7	-1.7	-10.3	-14.3	-14.7	-16.5	-16.2	-16.6
1.A.3. Transport	-1.9	-3.1	-2.2	-2.2	-2.8	-1.0	0.5	2.4	2.5	3.1
1.A.4. Other Sectors	-34.7	-35.0	-31.0	-34.1	-30.2	-30.2	-31.4	-28.2	-26.9	-26.8
1.A.5. Other	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0
1.B. Fugitive Emissions from Fuels	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
2. Industrial Processes	-	-	-	-	-	-	-	-	-	-
3. Solvent and Other Product Use	0.8	1.0	1.1	1.0	1.2	1.8	1.6	1.3	2.1	4.0
4. Agriculture	-933.0	-969.3	-888.1	-849.5	-683.5	-800.1	-1115.3	-940.0	-655.9	-637.6
4.A. Enteric Fermentation	-	-	-	-	-	-	-	-	-	-
4.B. Manure Management	11.2	10.5	11.1	10.6	8.2	13.1	12.3	12.8	15.3	17.5
4.D. Agricultural Soils	-944.2	-979.8	-899.3	-860.1	-691.6	-813.1	-1127.7	-952.8	-671.3	-655.1
4.F. Field Burning of Agricultural Residues	-	-	-	-	-	-	-	-	-	-
5. Land Use, Land-Use Change and Forestry (net)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.A. Forest Land	-	-	-	-	-	-	-	-	-	-
5.B. Cropland	-	-	-	-	-	-	-	-	-	-
5.C. Grassland	-	-	-	-	-	-	-	-	-	-
5.D. Wetlands	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.E. Settlements	-	-	-	-	-	-	-	-	-	-
5.F. Other Land	-	-	-	-	-	-	-	-	-	-
5.G. Other	-	-	-	-	-	-	-	-	-	-
6. Waste	14.5	15.8	16.9	18.2	16.5	20.2	23.0	25.9	30.4	39.1
6.B. Waste-water Handling	3.3	3.5	3.2	3.4	0.5	4.8	5.1	5.2	5.7	5.5
6.C. Waste Incineration	-	-	-	-	-	-	-	-	-	-
6.D. Other	11.2	12.4	13.6	14.8	16.0	15.4	18.0	20.6	24.7	33.6

Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total National Emissions and Removals	-665.0	-601.1	-443.1	-633.3	-426.1	-550.3	-535.8	-342.8	-526.7
1. Energy	-70.5	-65.6	-59.0	-54.4	-51.1	-50.1	-47.5	-47.4	-46.8
1.A. Fuel Combustion Activities	-70.6	-65.7	-59.2	-54.5	-51.3	-50.2	-47.6	-47.5	-46.9
1.A.1. Energy Industries	-35.1	-33.9	-32.6	-26.4	-22.9	-21.8	-23.5	-22.0	-20.6
1.A.2. Manufacturing Industries and Construction	-16.0	-17.0	-14.0	-16.8	-17.6	-18.7	-15.9	-19.1	-18.9
1.A.3. Transport	3.5	5.7	6.3	6.7	7.1	6.0	6.2	6.4	6.3
1.A.4. Other Sectors	-23.1	-20.5	-18.9	-18.0	-17.9	-15.8	-14.5	-12.8	-13.6
1.A.5. Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.B. Fugitive Emissions from Fuels	0.2	0.2	0.1	0.1	0.2	0.1	0.1	0.1	0.1
2. Industrial Processes	-	-	-	-	-	-	-	-	-
3. Solvent and Other Product Use	2.9	2.3	2.8	3.6	5.2	2.2	2.5	2.7	2.6
4. Agriculture	-644.0	-584.8	-444.5	-638.8	-415.4	-540.9	-530.6	-348.8	-525.6
4.A. Enteric Fermentation	-	-	-	-	-	-	-	-	-
4.B. Manure Management	14.8	20.7	20.7	24.4	24.2	16.8	12.3	13.9	-14.8
4.D. Agricultural Soils	-658.8	-605.5	-465.2	-663.2	-439.6	-557.7	-542.9	-362.7	-510.8
4.F. Field Burning of Agricultural Residues	-	-	-	-	-	-	-	-	-
5. Land Use, Land-Use Change and Forestry (net)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.A. Forest Land	-	-	-	-	-	-	0.0	0.0	0.0
5.B. Cropland	-	-	-	-	-	-	-	-	-
5.C. Grassland	-	-	-	-	-	-	-	-	-
5.D. Wetlands	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.E. Settlements	-	-	-	-	-	-	-	-	-

Continued									
5.F. Other Land	-	-	-	-	-	-	-	-	-
5.G. Other	-	-	-	-	-	-	-	-	-
6. Waste	46.6	47.0	57.5	56.3	35.2	38.4	39.8	50.7	43.1
6.B. Waste-water Handling	6.0	6.2	7.9	6.3	5.6	7.3	5.8	11.9	6.9
6.C. Waste Incineration	-	-	-	-	-	-	-	-	-
6.D. Other	40.6	40.8	49.7	50.0	29.6	31.2	34.0	38.8	36.2

Table 10.5 Recalculation for HFCs, PFCs and SF_6 performed in the 2011 submission for 1990-2008. Differences in Gg CO_2-eqv. between this and the October 2010 submission for DK. Excluding Greenland and Faroe Islands.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
HFC	-	-	-	-	-	-	-	-	-	-
PFC	-	-	-	-	-	-	-	-	-	-
SF_6	-	-	-	-	-	-	-	-	-	-
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	
HFC	-	-	-	-	-	-	-	-	-	-
PFC	-	-	-	-	-	-	-	-	-	-
SF_6	-	-	-	-	-	-	-	-	-	-

10.4 Recalculations, including those in response to the review process, and planned improvements to the inventory (e.g. institutional arrangements. inventory preparations)

The review on the submissions in 2007 and 2008 was finalised and the report was published April 15, 2009. For the 2009 submission the review report was finalised and published April 15 2010.

The draft review report for the review of the 2010 submission was available December 24, 2010, to the extent possible the recommendations have been included in this submission. However, full implementation of all recommendations and suggestions of the reviewers in the main findings etc. was not possible in the time available between publication of the final review report and the deadline for preparation of the NIR. The main recommendations from the reviews of the 2008, 2009 and 2010 submissions are listed in Table 10.6.

CRF	ERT Comment	Denmark's response	Reference
2008 submission (Review report: http://unfccc.int/resource/docs/2009/arr/dnk.pdf)			
General – Paragraph 26	Report emissions from Greenland under the relevant sectors instead of under the category other.	Denmark has since the 2010 submission provided complete CRF's for all three reportings, i.e. Denmark (EU), Denmark & Greenland (KP) and Denmark, Greenland & the Faroe Islands (UNFCCC).	
General – Paragraph 26	The incorporation of emissions from Greenland into the respective category discussions in the NIR and under the respective cross-cutting issues and procedures (e.g. key category analysis, uncertainty, QA/QC and recalculations);	We have some problems implementing this recommendation. Denmark has 3 different reporting obligations under the Convention, Kyoto Protocol and the European Union. This recommendation suggests that Denmark should provide 3 different National Inventory Reports for the different submissions complete with 3 editions of each table and figure in the entire report. This would be very time consuming and would not be an efficient way to use resources. Additionally the emission inventory for Greenland and Denmark are independent, there are no common data suppliers, and the methods and emission factors used are different from Denmark, therefore we believe that reporting on the methods and emission factors for Greenland separately increases transparency of the inventory. Denmark has provided an annex to the NIR (Annex 10) describing the trend, recalculations, QA/QC, KCA and uncertainties of the Denmark & Greenland submission.	Annex 10
General – Paragraph 26	Strengthen its national system to ensure adherence to decision 15/CMP.1 with respect to having a single national entity responsible for the national inventory of Denmark (Including Greenland)	Denmark has strengthened the National System by establishing an agreement with the Government of Greenland.	
General – Paragraph 26	Provide tier 2 uncertainty estimates in order to identify where improvements to the inventory should be focused.	Tier 2 uncertainties have been estimated at the sectoral level and for the overall emission estimates excluding LULUCF.	See sectoral chapters on uncertainties and Chapter 1.7.
General – Paragraph 26	Undertake a tier 2 key category analysis.	A tier 2 key category analysis has been performed.	Annex 1.
Energy, feedstocks and non-energy use of fuels – Paragraph 38	To improve accuracy and completeness, the ERT recommends that Denmark estimate and report emissions from the non-energy use of bitumen, lubricants and white spirit in future annual submissions.	Denmark has estimated and reported emissions from these sources. White spirit is included in CRF sector 3, while bitumen and lubricants are included in CRF sector 2.	Chapter 4.8 and 5.5.
Energy, public electricity and heat production – Paragraph 39	Denmark has included EU ETS data causing a decrease in IEF. To improve accuracy and transparency and to ensure conformity with the Revised 1996 IPCC Guidelines and the IPCC good practice guidance, the ERT recommends that Denmark: (a) Provide sufficient background information	Denmark has expanded and improved the documentation for the use of EU ETS data in the energy sector. Improved emission factor time-series (1990-2005) for coal and residual oil have been implemented based on the EU ETS data for 2006-2009.	Chapter 3.2.5 and Chapter 1.4.10

CRF	ERT Comment	Denmark's response	Reference
	on plant-specific data such as the methods used by the plants to estimate the carbon content, oxidation factor and calorific value of the fuel, the origin of the coal used and the corresponding physical properties, and if possible cross-checks of the information reported by the plant with that obtained from the fuel supplier; (b) Assess time-series consistency and explain the reason for the recent variability of CO2 EFs; (c) Verify the information provided by the plants as more data become available.		
Energy, stationary combustion – Paragraph 40	Emissions from the use of town gas are estimated using the EF for natural gas. The ERT reiterates previous recommendations that Denmark improve the background documentation, particularly by providing the average composition profile of town gas.	Denmark improved the documentation in the 2009 NIR.	Chapter 3.2.5
Energy, road transport – Paragraph 41	The change of non-CO_2 EFs associated with the use of bioethanol in gasoline blends has not been taken into account when estimating the corresponding emissions. The ERT suggests that Denmark assess probable changes to these EFs in its next annual submission.	No data has previously been available indicating different CH_4 and N_2O emission factors for blends of fossil and biogenic fuels. This issue is being followed in case new research indicates otherwise.	Chapter 3.3.2.
Industrial Processes, cement production – Paragraph 47	The ERT noted that the methods used by Denmark to estimate CO_2 emissions from cement production for 1990–1998, 1999–2005 and 2006 are not identical. The ERT therefore strongly recommends that Denmark report correct emissions estimates, make efforts to analyse the causes of the decrease in the IEF in recent years and provide an explanation in the NIR in its next annual submission.	The EF depends on the ratio: white/grey cement and the ratio: GKL-clinker/FHK-clinker/SKL-RKL-clinker. The ratio white/grey cement is known from 1990-1997 with maximum in 1990 and thereafter decreasing. The ratio: GKL-clinker/FHK-clinker/SKL-RKL-clinker is known from 1990-1997. The individual EF for the different clinker types are respectively: 0,477, 0,459, and 0,610 ton CO_2/ton. Production of SKL-RKL-clinker peaks in 1991 and decrease hereafter. FKH-clinker is introduced in 1992 and increase to 35% in 1997. When estimating the activity for 1990-1997 the amount of white cement is summed with the amount of clinker. Information on the total production of clinker from 1998-2008 has been provided by the company recently. The company has at the same time stated that data until 1997 can not	Chapter 4.2.

CRF	ERT Comment	Denmark's response	Reference
		be improved as they are not available anymore.	
Industrial Processes, iron and steel production – Paragraph 51	CO_2 emissions from iron and steel production in 2002, 2003, 2004 and 2006 are reported as "NA, NO" in the CRF. Denmark explained in the NIR that this is due to the ceasing of electro-steelwork operations. However, the ERT found that "NE" should be also used for this category, because Denmark stated in the NIR that the CO_2 emissions from iron foundries have not yet been included and that it hopes to investigate and include them in the future.	Denmark has revised the notation keys for 2C. The emission estimates for CO_2 from iron foundries is still under development.	
Industrial Processes, consumption of halocarbons and SF6 – Paragraph 49	Denmark explained in the NIR that the slowing of the rate of emissions in recent years seems to be due to regulations restricting the use of F-gases that have been in place since 1 March 2001 in the form of taxation and a ban on the use of these gases in new installations. The ERT encourages Denmark to further analyse the cause of the overall trend and inter-annual changes in emissions from each subcategory in this category, and to provide further explanation of this in the NIR in its next annual submission.	The trend discussion has been considerably enlarged and improved as compared to the previous NIR with explanations on the trends occurring in relation to the existing regulations.	Chapter 4.6.
Industrial Processes, consumption of halocarbons and SF6 – Paragraph 49	According to the NIR, a comparison of potential and actual emissions was only carried out in 1995–1997 and, for all three years, the potential emissions are approximately higher than actual emissions by a factor of 3. However, there is no further explanation in the NIR of the difference between potential and actual emissions. The ERT encourages Denmark to compare potential and actual emissions for the whole time-series and to analyse the reason for any differences, with a view to improving its determination of EFs over time.	Since potential emission calculation is in fact a tier 1 methodology, comparison to the tier 2 model methodology is not paid much attention since it is two very different methodologies.	
Solvent and other product use, use of N_2O – Paragraph 52	For N_2O from fire extinguishers, aerosol cans and other uses, emissions are reported as "NA" in the CRF. However, AD for these subcategories are reported as "NE", which implies that emissions should also have been reported as "NE". The ERT encourages Denmark to	Denmark has corrected the notation keys, and provided an explanation for the sources that are reported as not estimated.	CRF and NIR Chapter 5.

CRF	ERT Comment	Denmark's response	Reference
	collect data on AD (e.g. sales data) for these subcategories and to estimate and report N2O emissions. Otherwise, "NA" should be corrected to "NE" and a clear explanation should be provided in the NIR in the next annual submission as to why these emissions have not been estimated.		
Agriculture, enteric fermentation – Paragraph 57	To provide an ongoing QC check of the results obtained using the country-specific model, the ERT recommends that Denmark also prepare estimates using the tier 2 method described in the IPCC good practice guidance and that the Party report on the results in future NIRs.	As recommended by ERT a Tier 2 estimate has been provided and reported in NIR 2010 I order to QC check the country specific model. The result shows a good correlation by using the country specific methodology.	Chapter 6.2.4
Agriculture, enteric fermentation – Paragraph 59	The ERT recommends that Denmark include a summary of the data used to estimate Ym and that it consider providing a comparison with similar data published by Statistics Denmark in the NIR in its next annual submission.	As recommended by the ERT a more detailed description of the key model parameters used to calculate the national Ym value are given in NIR 2009. Furthermore data from Statistics Denmark covering the area of cultivated maize and sugar beet for feeding is given in table in Annex.	Chapter 6.2.2 and Annex 3D table 3b (area of sugar beet for feeding and maize)
Agriculture, manure management – Paragraph 60	CH_4 emissions from manure management were estimated using tier 2 methodologies where appropriate, country-specific volatile solid excretion rate (VS), IPCC default values for CH_4-producing capacity (Bo) and a CH_4 correction factor. For liquid slurries, however, Denmark does not use the default CH_4 correction factor provided by the IPCC good practice guidance, which it argues is not appropriate for Danish conditions. Instead, Denmark uses a factor taken from the Revised 1996 IPCC Guidelines on the basis of two laboratory studies, the application of which, Denmark acknowledges, is not representative. To ensure consistency with the IPCC good practice guidance, the ERT recommends that the Party review the latest international literature and country studies, and consider whether the CH_4 correction factor currently selected could be justified more strongly in the NIR or, alternatively, whether the factor should be revised in its next annual submission.	DK has decided to maintain the use a methane correction factor MCF for liquid manure by 10% as given in the Reference Manual 1996. In GPG the MCF was changed to 39% without any scientific arguments. Most of the slurry in DK is stored under cold conditions (>5-10 degrees) and the CH4 formation merely stops at 4 degrees. That is the main reason why we se no plausible arguments to use 39% under Danish conditions. Review of other countries with comparable climate conditions indicates that the 10% better reflects the Danish conditions than the 39% given in the GPG. Sweden, Finland, Norway, Belgium, Netherlands and Germany all use a MCF factor between 10% and 15%.	

CRF	ERT Comment	Denmark's response	Reference
Agriculture, manure management – Paragraph 61	Denmark uses the IPCC methods and default factors for this category. However, the IEF declines slightly over time as a result of a small reduction in emissions due to the treatment of slurries for biogas. Given that this process is not described in the IPCC good practice guidance, the ERT recommends that Denmark include information from supporting studies on key model parameters in the NIR to enhance transparency and understanding of the methods used in its next annual submission.	As recommended by the ERT further information is supplied in NIR 2009. In annex 3D is given a overview of all key model parameters	Chapter 6.3.2 and Annex 3D table 8
Agriculture, agricultural soils – Paragraph 63	Indirect emissions from agricultural soils have declined by 41.4 per cent since 1990, owing to the decline in the use of synthetic fertilizer and a decline of 13.9 per cent since 1990 in the FracLEACH value. The decline in FracLEACH was calculated from the application of two models reported in a paper only available in Danish. Consequently, the ERT recommends that Denmark include details of key model parameters from supporting studies in its next annual submission to enhance transparency and understanding of the models used.	As recommended by the ERT further information about the model used to calculate the nitrogen leaching on national scale is provided in NIR 2009	Chapter 6.4.2 – Nitrogen leaching and Runn-off and Annex 3D 1.4
Waste, solid waste disposal on land – Paragraph 82	To estimate emissions from solid waste disposal on land, Denmark applied the IPCC tier 2 method with country-specific EFs by waste type and CH_4 generation constant (k). The ERT encourages Denmark to obtain more suitable waste composition data reflecting the current situation and to explain how the specific k value of 0.693 per year was arrived at.	The CH_4 generation constant was varied according to waste type only for a sensitivity analyses, showing a rather limited influence on the output (the CH_4 emission). Also the influence on the output of the waste composition was shown in a sensitivity test and as a study prior to investigation of waste composition. For the 2010 submission the half-life time was changed from 10 to IPCC default value of 14 years.	Chapter 8.2.
2009 submission (Review report: http://unfccc.int/resource/docs/2010/arr/dnk.pdf)			
CRF	ERT Comment	Denmark's response	Reference
General, Paragraph – 27-29	The ERT strongly recommends that Denmark make the agreement effective and implement the necessary improvements to the national system, ensuring that the emissions of Greenland are fully integrated into the CRF tables and the NIR of the next and subsequent submissions.	Denmark submitted in 2010 a CRF with data from Greenland integrated at the most detailed CRF level. Additionally documentation for the Greenlandic greenhouse gas inventory and the aggregated submission was provided in annexes to the NIR.	Annex 9 and 10. (In the 2011 submissions this information has been expanded and at the request of the ERT moved to the main part of the NIR as Chapter 16 & 17)

CRF	ERT Comment	Denmark's response	Reference
General, Paragraph – 30 & 31	Denmark has reported a key category tier 1 analysis, both level (base year and 2007) and trend assessment, as part of its 2009 submission. Denmark has included the LULUCF sector in its key category analysis. However, the ERT noted that the Party did not report the results of the key category analysis excluding LULUCF in its NIR. The ERT recommends that Denmark also report on the results of the analysis excluding LULUCF in the NIR of its next annual submission. The ERT also reiterates the recommendations in the previous review report6 that Denmark reports a tier 2 analysis in its next annual submission.	Denmark has since the 2010 submission reported the KCA both including and excluding LULUCF. Also a tier 2 KCA has been performed and reported in the NIR. A tier 1 KCA for the aggregated submission of Denmark and Greenland has been performed and reported since 2010.	Chapter 1.5 and Annex 1. The information on Denmark and Greenland is included in Annex 10. (In the 2011 submissions this information has been moved at the request of the ERT to the main part of the NIR as Chapter 17)
General, Paragraph – 38	The NIR does not include information on the QA/QC procedures applied to the inventory of Greenland. The ERT reiterates the recommendations from the previous review that the Party implement the plan for the next annual submission. It also recommends that the Party include a description of the full QA/QC system in the NIR for the next annual submission.	Denmark included information on the QA/QC procedures for the Greenlandic inventory in the 2010 submission.	Annex 9. (In the 2011 submissions this information has been expanded and at the request of the ERT moved to the main part of the NIR as Chapter 16)
General, Paragraph – 39	The ERT considers that the NIR of Denmark is generally prepared in a transparent manner and the Party has made significant improvements since last year's submission. In particular, the ERT welcomes the inclusion of methodological information for Greenland in the NIR, as recommended in previous reviews. However, the ERT noted that this information is still included as an annex (annex 6.2) and not in the sectoral discussion in the main body of the NIR. Therefore, the ERT recommends that the Party extend and incorporate this information in the main chapters of the NIR.	Denmark has repeatedly explained the difficulties in honouring this recommendation. During the in-country review of the 2010 submission, Denmark agreed with the ERT to include the information in chapters in the main NIR (instead of in annexes). However, no full incorporation in the sectoral chapters was required.	Chapter 16 and 17.
General, Paragraph – 40	Denmark reports the emissions of Greenland as the total of emissions in the sector other rather than reported in the appropriate categories and sectors. Accordingly, the CRF sectoral background tables for each sector do not refer to AD, IEFs and emissions for the total territory	Denmark submitted in 2010 a CRF with data from Greenland integrated at the most detailed CRF level	CRF tables.

CRF	ERT Comment	Denmark's response	Reference
	(Denmark and Greenland) under the Kyoto Protocol. The ERT considers that this way of reporting reduces the transparency and impairs comparability with the other Parties. The ERT strongly recommends that Denmark report on emissions in Greenland by integrating the activities in Greenland into the categories included in Annex A to the Kyoto Protocol for the next annual submission.		
Energy, use of EU ETS data - Paragraph 49	The ERT recommends that Denmark recalculate the whole time-series by applying the EFs from the EU ETS data, which are more representative and more accurate for the coal and residual oil fired power plants in Denmark, and ensuring that the use of EU ETS data ensure that the use of EU ETS data is followed by appropriate actions in accordance with the IPCC good practice guidance in order to maintain the consistency of the time-series for which these data are used.	Denmark has expanded and improved the documentation for the use of EU ETS data in the energy sector. Improved emission factor time-series (1990-2005) for coal and residual oil have been implemented based on the EU ETS data for 2006-2009.	Chapter 3.2.5 and Chapter 1.4.10
Energy, use of EU ETS data - Paragraph 49	The ERT also recommends that the Party provide more background information to explain the reasons for the variability of the IEF for the most recent years.	Denmark has expanded and improved the documentation for the use of EU ETS data in the energy sector. Emission factor time-series, min and max values are shown.	Chapter 3.2.5 and Chapter 1.4.10 Annex 3A.10
Energy, use of EU ETS data - Paragraph 49	Further, the ERT recommends that Denmark provide information showing that the methodologies used to establish the emission estimates under the EU ETS are in accordance with the Revised 1996 IPCC Guidelines and the IPCC good practice guidance for each category where they are used.	Denmark has expanded and improved the documentation for the use of EU ETS data in the energy sector.	Chapter 3.2.5 and Chapter 1.4.10
Energy, bunker fuels – Paragraph 53	The ERT noted that the allocation procedures used by Denmark to identify fuel sales to domestic navigation and international maritime bunkers, and the inclusion of fuel sales to the fishing industry, is not in agreement with the IPCC good practice guidance, and recommends that the Party revise the methodology it uses to prepare such allocations for the next annual submission.	Denmark has included fuel consumption and emissions from navigation between Denmark, Greenland and the Faroe Islands under national navigation in accordance with the IPCC good practice guidance.	Chapter 3.3.4 and CRF

CRF	ERT Comment	Denmark's response	Reference
Energy, stationary combustion – Paragraph 55	The ERT considers that although total CO2 emissions are correctly estimated and allocated in accordance with the IPCC good practice guidance, the IEFs reported in the CRF tables for biomass and other fuels are not correct and transparently reported, and they are not comparable to the IEFs reported by other Parties. Therefore, the ERT recommends that Denmark split the AD for waste incineration into biomass and plastic fractions, and allocate the energy values to biomass and other fuels, respectively, to improve transparency for the next annual submission.	Both fuel consumption and emissions are split into biomass and other fuel as recommended.	Chapter 3.2.5 and CRF
Energy, manufacturing industries and construction – Paragraph 56	The CO2 IEFs for biomass for pulp, paper and print industry and for food processing, beverages and tobacco range generally between 93.89 t/TJ and 101.99 t/TJ for all years reported in the period 1990–2007. However, the ERT noted that Denmark reports unusually low values from 2000 to 2003 (between 13.18 t/TJ and 21.57 t/TJ). The ERT recommends that Denmark corrects this mistake and enhances the QA/QC procedures it applies to check IEFs and their trends for the next annual submission.	The allocation error has been corrected and control of IEF time-series implemented as part of the QA/QC procedure.	CRF
Energy, road transportation – Paragraph 57	Therefore the ERT recommends that the Party separate the energy component associated with ethanol, which should be reported under biomass, from gasoline for the next annual submission. The ERT also recommends that the Party make efforts to report the part of CH4 and N2O emissions from the use of ethanol under biomass.	Denmark now reports the consumption and associated emissions under biomass in the CRF.	CRF
Industrial Processes, use of EU ETS data – Paragraph 60	The ERT recommends that Denmark ensure that the use of EU ETS data is followed by appropriate actions in accordance with the IPCC good practice guidance in order to maintain the consistency of the time-series and the completeness of emission estimates for the categories for which these data are used. The ERT also recommends that the Party	See response to the ERT questions to the 2010 submission.	

CRF	ERT Comment	Denmark's response	Reference
	provide in the NIR more background information to explain the reasons for the recent variability of the IEFs (e.g. by comparing the estimates using both the previous methodology and the revised methodology using EU ETS data, including assessments explaining the nature of the differences as either accidental or systematic, and explaining the rationale for selection of the new EF). Further, the ERT recommends that Denmark provide information showing that the methodologies used to establish the emission estimates under the EU ETS are in accordance with the Revised 1996 IPCC Guidelines and the IPCC good practice guidance for each category where they are used. Finally, the ERT recommends that Denmark provide information for this year's recalculation in cement production in future annual submissions.		
Industrial Processes, cement production – Paragraph 61	The NIR states that all IEFs are based on measurements using the 'loss of ignition' method, which estimates CO2 emissions by calculating the weight loss during the reactions to form clinker and cement and which result from loss of CO2 from carbonates. During the centralized review, the Party provided sufficient explanation for the 1990–1997 period that the recent decreases in the IEF may be the result of changes in stock of clinker or changes in the product mix and raw materials consumption, but no quantitative supporting information was provided. The ERT noted that the information provided by Denmark is not sufficient to explain the changes in the EFs since 1998 and that the emission estimates for 2005–2007 are not underestimated, and recommends that Denmark provide more detailed information in the NIR, in the next annual submission, about the different sources of EFs, methodologies used for each period, more detailed information used to calculate the EFs by the 'loss of ignition' method (e.g. the quantity of raw materials used	The inventory group has established a dialogue with the company in order to get better data.	

CRF	ERT Comment	Denmark's response	Reference
	and their carbonate content) and on how the consistency was ensured and compliance with the IPCC good practice guidance is achieved.		
Industrial Processes, limestone and dolomite use – Paragraph 62	The ERT noted that estimates for more recent years could be underestimated in comparison to previous years in the time-series, and the full time-series may not be consistent. Besides, the ERT also found some potential inconsistencies in the time-series of AD: an increase of 28.1 per cent in 2005–2006 and a 28.8 per cent decrease in 2006–2007.The ERT recommends that Denmark provide in the NIR of its next annual submission information on the specific procedures and verifications the Party used.	The sector (2A3) comprises a number of different processes: consumption of $CaCO_3$ to flue gas cleaning at power plants and waste incineration plants, production of mineral wool and refining of sugar. The activity data are not comparable or even confidential or lacking for part of the period. The inventory team are working on improvement of the documentation of AD.	
Industrial Processes, other mineral products – Paragraph 63	Despite these differences the Party has decided to use the emissions reported to the EU ETS in the inventory for the last two years, but did not provide reasons for the different EF for the last two years and did not assess or explain how it has ensured consistency with the previous years in the time-series in accordance with the IPCC good practice guidance. The ERT recommends that Denmark provide in the next NIR sufficient information to assess that consistency in the time-series was maintained, or revise the time-series to ensure consistency.	See the answer below regarding the same issue in the review of the 2010 submission.	
Solvent and other product use, use of N_2O – Paragraph 64	The ERT encourages the Party to provide estimates of emissions of N2O from use as anaesthesia for the period 1990–2004 in order to complete the time-series.	The producers and distributors of N2O will be contacted again and if data cannot be given for 1990-2004 this will be clearly explained in the report.	
Agriculture	The ERT recommends that Denmark implement the additional quality checking of all outputs from this database in its next annual submission, and document these quality checks in its NIR and ensure the CRF tables are completed without errors for the next annual submission.	The new database system is implemented and this first year some problems concerning the data extensions turned up. As recommended by ERT a quality procedure are provided which include a first step for annually check for all activity data, emission factor, IEF and other important key parameters used in the emission calculations.	
Agriculture, enteric fermentation – Paragraph 70 & 71	The ERT recommends that Denmark revise GE values and improve time-series consistency in accordance with the IPCC good practice guidance in its next annual submission.	As recommended the GE is interpolated to improve the series consistency. GE concerning heifer is interpolated for the years 2005 and 2006 and GE for piglets and slaughtering pigs is interpolated for the years 1991 – 1993.	

CRF	ERT Comment	Denmark's response	Reference
Agriculture, manure management – Paragraph 72	Denmark uses a methane conversion factor (MCF) for liquid/slurry of 10 per cent, which is from the Revised 1996 IPCC Guidelines, instead of a MCF value of 39 per cent in accordance with the revised default values in the IPCC good practice guidance (table 4.10). The ERT reiterates the recommendation that Denmark review this factor and justify its appropriateness in its next annual submission as planned. In response to the draft review, Denmark provided additional documentation. The ERT recommends that Denmark include this information in its NIR in the 2010 submission.	Denmark has added further explanation and documentation in the 2010 submission. Considering the agricultural conditions in Denmark and the present scientific knowledge as described above a MCF of 10 % for liquid/slurry is more appropriate under the Danish conditions. The Danish decision of using a MCF of 10% is as demonstrated above backed by several scientific papers as well as both the revised 1996 IPCC Guidelines and the IPCC 2006 Guidelines.	
Agriculture, manure management – Paragraph 73	The ERT noted that the allocations of swine manure to each animal manure management system (AWMS) in CRF table 4.B(b) do not match the allocation percentages in CRF table 4.B(a). The ERT recommends that Denmark fix these errors in its next annual submission and ensure adequate QC checking takes place on the completed CRF tables before submission.	The AWMS distribution of swine manure in CRF Table 4.B(a) is corrected. An improvement I QC checking is provided to avoid a similar situation.	
Agriculture, manure management – Paragraph 74	Denmark treats some of its animal slurries in biogas plants, capturing the CH4 generated and using it for electricity and CHP production. In response to a question from the ERT, Denmark stated that some of the information in table 6.12 of the NIR might be misleading with regard to the energy production values expressed in TJ, as they are not directly related to the estimation of CH4 captured, but rather were obtained independently from the Danish Energy Agency. The ERT recommends that the Party report estimates of energy production and CH4 recovery in a consistent way, and correct table 6.12 in the next annual submission. The ERT recommends that Denmark, for the sake of improving transparency, provide plant-specific data regarding energy output and quantities of slurry treated from one or more of	DK agree that the information on the energy production can be misleading. The calculation of the lower CH_4 emission as a consequence of biogas treatment is based on the amount of biogas treated slurry, which is received from the Danish Energy Agency. Table 6.1 includes data concerning the amount of slurry, the VS content in the treated slurry and the reduced emission. DK has planned to improve the possibilities to verify the calculation of the reduced emission from biogas treated slurry. This could be done by contacting a biogas plant in preparation for potential data based on measurement from slurry.	

CRF	ERT Comment	Denmark's response	Reference
	the larger biogas plants. The ERT also recommends that Denmark use the energy output from plants to assess the validity of the CH4 reduction potentials for cattle and swine slurry as an additional QC check.		
Agriculture, manure management – Paragraph 75	Denmark uses the IPCC method and default EFs to estimate emissions from this category. The ERT found that the N2O IEF for liquid systems declines over time as a result of reductions in emissions due to the treatment of slurries for biogas production. According to the NIR, the Party assumes reduction potential factors of 36 per cent for cattle slurry and 40 per cent for swine slurry. The ERT noted that the subtraction of emissions is based on country-specific studies, and that neither the Revised 1996 IPCC Guidelines nor the IPCC good practice guidance provide any guidance on reduction of N_2O emissions by energy use of biogas. The ERT reiterates the recommendation of the previous review that Denmark include additional information in the NIR of the next annual submission with supporting studies that the reduction of emissions does indeed occur, by providing detailed information about the country-specific method it has used, and better documenting the stated reduction potential factors for cattle and swine slurry, to enhance transparency and understanding of the methods used.	Some improvements have taken place. More information concerning all background data for estimating the lower emission from biogas treated slurry is provided in Annex Table 3D.7. Some work has to be done to improve the description and documentation in NIR.	
Agriculture, agricultural soils - Paragraph 76	The ERT noted that, in accordance with data provided in table 6.24 of the NIR, there was a significant increase in the quantity of nitrogen excretion (6.9 per cent) and nitrogen volatized as ammonia (36.1 per cent) from 2006 to 2007. The ERT recommends that Denmark implement additional quality checking and trend analysis of all outputs from this database in its next annual submission, and ensure the CRF tables are completed without errors.	The ammonia emission shown in table 6.24 in 2007 was over estimated due to an error in the new Danish database system. This is corrected – see submission 2009 NIR table 6.29. As recommended by ERT a quality procedure are provided which include a first step for annually check for all activity data, emission factor, IEF and other important key parameters used in the emission calculations.	
Waste, general – Paragraph 88	The ERT found some errors in the naming of	An improved methodology and correct naming of processes contribu-	Chapter 8

CRF	ERT Comment	Denmark's response	Reference
	tables in the NIR, and this makes it difficult to assess the inventory. For example, the title of table 8.17 in the NIR indicates CH4 could be recovered and flared in wastewater treatment plants despite the fact that no flaring is conducted in Danish wastewater treatment plants. Denmark is encouraged to improve QC procedures to improve the transparency of the NIR. The ERT also recommends that Denmark provide a table showing different waste types disposed of as municipal solid waste or incinerated, together with their main characteristics, to increase the transparency.	tion to the methane emission has been implemented Yearly deposited waste types are reported QA/QC procedures have been improved for all categories	
Waste, solid waste disposal on land – Paragraph 90	Denmark uses an IPCC tier 2 country-specific first order decay method and country-specific data for the degradable organic carbon (DOC) fractions. Although the values of the parameters used in the calculations are only slightly different from the IPCC defaults, the NIR does not provide sufficient explanations of how the parameters were determined, and the ERT cannot assess whether they were selected in accordance with the IPCC good practice guidance. To improve transparency, the ERT recommends that Denmark improve explanations and documentation of the parameters in its next annual submission.	Improvements as recommended has been implemented as presented	Chapter 8.2
Waste, solid waste disposal on land – Paragraph 91	The carbon content of plastics has been taken into account as DOC, which the ERT considers not to be correct. During the centralized review and responding to the ERT, Denmark made preliminary estimates showing that emissions for the most recent years could be reduced by about 12–13 per cent if a correction was made. Denmark is planning to revise those parameters in the next annual submission and the ERT encourages the Party to do so.	The DOC content of Plastics has been changes from 85 to 0 %. This was an error in the previous model formulation.	Chapter 8.2
Waste, solid waste disposal on land – Paragraph 92	Denmark uses a half-life time of 10 years (k equal to 0.0693) based on expert judgement as a bulk value for all waste types. However, the Party in the NIR also includes an independent	The half year time has been changes from 10 to 14 years according to the default value in the GPG. This change in itself lowered the time-series of emissions from 15.0 (1990) to 4.2 % (2007) as compared to the 2009 submission.	Chapter 8.2

CRF	ERT Comment	Denmark's response	Reference
	estimate using different k values for different waste types, and the results of this analysis indicate that emission estimates could be significantly different. Considering that the composition of waste may change in the coming years, the ERT encourages Denmark to develop k values by waste type to improve the accuracy.	Improvement of waste characterisation and parameters has been initiated.	
Waste, solid waste disposal on land – Paragraph 93	Denmark estimates the amount of CH4 recovery from the Danish energy statistics on energy obtained and considers the net calorific value to estimate biogas volumes. The ERT recommends that Denmark improve the explanation of the methodology and assumptions it uses to estimate CH4 recovery, together with the volumes of biogas recovered and used in energy production for the next annual submission.	Access to the Danish sludge database have resulted in correction of the amount of sludge used for biogas production	Chapter 8.3
Waste, waste-water handling - Paragraph 94	Emissions from domestic wastewater and industrial wastewater are aggregated together. Denmark uses a country-specific total organic waste (TOW) that does not differentiate between industrial and municipal sewage sludge. Recognizing that the increase of total industrial biochemical oxygen demand is a key driver of the trend of emissions from this category (before the recovered CH4 is subtracted), and following the recommendation by the previous review, the Party is planning to collect plant-specific monitoring data to develop average maximum methane production capacity and to use it to prepare the next annual submission. The ERT encourages Denmark to implement its plans and to report on them in the next annual submission.	Plant-specific data for the municipal WWTPs have been obtained. Data still needs quality assurance with reference to the data reported in the national statistics. No data on plant-specific industrial WWT are available so far. Only reported data on the industrial contribution to the influent wastewater reported by the Danish Ministry of Environment. Ongoing work is in place regarding an improved national database including the needed parameters as asked for by the ERT.	Chapter 8.3.4
Waste, waste incineration - Paragraph 95	Emissions from waste incineration are reported under the energy sector. AD are presented in CRF table 6.C with a reference to the category public electricity and heat production in the energy sector in the documentation box. However, the ERT found in the NIR reference to the fact that also the categories manufacturing	The CRF documentation box for table 6.C has been corrected to improve transparency.	

CRF	ERT Comment	Denmark's response	Reference
	industries and construction and other sectors in the energy sector include emissions from municipal solid waste. Denmark is encouraged to clarify this in the next annual submission to improve transparency.		
2010 submission (Review report: http://unfccc.int/resource/docs/2011/arr/dnk.pdf)			
General – Paragraph 25	The process for the official approval of the inventory was not described in the NIR. However, during the review, Denmark provided this information, indicating that the inventory was finalised by 15 March 2010 and sent for official approval to the Ministry of Climate and Energy. The ERT recommends that the Party provide this information in the NIR of the next annual submission.	Denmark has included a description of the procedure for official approval in the NIR.	Chapter 1.2
General – Paragraph 26	The ERT recommends that Denmark include the information concerning the emissions from Greenland at least as a separate chapter in the NIR instead of as an annex, as this is a substantial part of the submission.	Denmark has included the documentation for the Greenlandic greenhouse gas emissions in Chapter 16 of the NIR.	Chapter 16
General – Paragraph 26	Denmark also informed the ERT that, in the 2011 submission, it will expand the information in the NIR to also include information on recalculations and quality assurance/quality control (QA/QC) of the integrated emissions of mainland Denmark and Greenland under the Kyoto protocol. The ERT welcomes these plans, encourages their timely implementation and recommends that this chapter include a discussion on the procedures used by NERI to integrate both inventories, particularly those aspects that are not solved by merely adding figures, such as the treatment required for part of the data reported in the CRF sectoral background tables.	Denmark has as indicated during the review included information on recalculations and QA/QC procedures for the aggregated submission of Denmark and Greenland. Additionally at the request of the ERT, Denmark has included a technical description of the aggregation process.	Chapters 17.5-17.7
General – Paragraph 28	The NIR lacks a unifying discussion of the approach employed by the Party regarding the use of these data (EU ETS). To improve transparency, the ERT recommends that Denmark include a brief discussion about this approach	Denmark has included a general description of the use of EU ETS data including the quality of the available data and how this is in accordance with the IPCC good practice guidance.	Chapter 1.4.10

CRF	ERT Comment	Denmark's response	Reference
	in the NIR (e.g. under the section presenting the general description of methodologies and data sources used) focusing on those aspects associated with the IPCC good practice guidance requirements.		
General – Paragraph 37	The ERT recommends that Greenland completes the QA/QC plan and implement it in the next annual submission and that Denmark document the QC checks performed during the integration of the Greenlandic inventory into the NIR.	The QA/QC plan for the Greenlandic greenhouse gas inventory is described in Chapter 16 of the NIR. The QC checks performed on the aggregated inventory of Denmark and Greenland are described in Chapter 17.	Chapter 16 & 17
Energy, Use of EU ETS data – Paragraph 46	It is recommended that Denmark discuss more clearly the selection of those plants that are taken from the database under the EU ETS and the QC checks performed to allow the input of these data.	The documentation in NIR has been improved.	Chapter 3.2.5
Energy, Country-specific issues – Paragraph 55	To improve accuracy, the ERT recommends that Denmark make efforts to estimate CO_2 emissions from gas oil used in Greenland by using country-specific EFs that are already available.	This issue will be investigated further with the aim of revising the CO_2 emissions factor for gas oil combusted in Greenland in the 2012 submission.	
Energy, Use of EU ETS data – Paragraph 57	The ERT recommends that Denmark improve the discussion of the use of plant-specific information under EU ETS by providing a more transparent and self-contained explanation about the scope of tier 3 methods for stationary combustion within this framework in such a way that the reader is not forced to consult the EU decision document to understand the implications in the selection of these data.	The documentation in NIR has been improved and reference to tiers and standards included.	Chapter 1.4.10 and Chapter 3.2.5
Energy, Use of EU ETS data – Paragraph 58 & 59	The ERT recommends that, through DEA, Denmark corroborate the accuracy of the reported NCV. After having confirmed the validity of the NCV reported by DEA, the ERT recommends that Denmark: (a) Include a QC check for the data reported under the EU ETS that uses the NCV of the fuel to detect the possible existence of unusual values and bias; (b) Explore the possibility of obtaining a corre-	The correspondence between NCV and CO_2 emission factor in the applied EU ETS data for coal has been analysed. The analysis and discussions with the Danish Energy Agency and power plant owners will continue in 2011. An improved CO_2 emission factor time-series (1990-2005) have been implemented. The QC check for outliers performed by NERI is now mentioned in NIR.	Chapter 1.4.10 and Chapter 3.2.5 and Annex 3A.10

CRF	ERT Comment	Denmark's response	Reference
	lation between the carbon content and the NCV of coal reported by the selected facilities that have used tier 3 methods under the EU ETS, taking into account the recent scientific literature (e.g. Fott, 1999; Mazumdar, 2000; Mesroghli et al., 2009) If a satisfactory correlation is obtained, the ERT further recommends that Denmark use this correlation to generate the time-series 1990–2005 of CO_2 EFs and recalculate the corresponding emissions.		
Energy, Use of EU ETS data – Paragraph 60	The ERT recommends that Denmark explore the relationship between the CO_2 EFs for residual fuel oil and gas oil reported under the EU ETS and the corresponding NCV reported by DEA. The ERT also notes that the recommendations for coal-fired power plants provided in para. 59 above apply to liquid fuels.	This will be included in the future discussions with DEA. Improved emission factor time-series for source sector 1A1a based on EU ETS data have been implemented for residual oil. The emission factor for other sectors now refers to IPCC (1996).	Chapter 3.2.5
Energy, Stationary combustion – Paragraph 63	To improve transparency, the ERT recommends that Denmark provide background information in the next NIR on the incineration of medical and hazardous wastes for energy purposes.	This information is now provided in the NIR.	Chapter 3.2.5
Energy, Stationary combustion – Paragraph 64	The emissions arising from fuels used in cement production are reported under the subcategory other (manufacturing industries and construction). The ERT recommends that Denmark revise the variability of CO2 EFs, particularly before and after the introduction of plant-specific data under the EU ETS. To improve transparency, the ERT recommends that Denmark include in the NIR an explanation of the different fuels covered under other fuels.	A description of the "Other fuels" will be included in the NIR.	Chapter 4.2.2
Energy, Navigation – Paragraph 66	Journeys between ports in mainland Denmark and Greenland and between ports in mainland Denmark and the Faroe Islands are reported under international marine transport. During the review, Denmark informed the ERT that the inventory team has contacted the shipping companies operating the routes from mainland	Denmark has included fuel consumption and emissions from navigation between Denmark, Greenland and the Faroe Islands under national navigation in accordance with the IPCC good practice guidance.	Chapter 3.3.4 and CRF

CRF	ERT Comment	Denmark's response	Reference
	Denmark to Greenland and the Faroe Islands to collect the necessary data to estimate the AD for these journeys. The ERT welcomes these efforts, which will improve accuracy and completeness, and encourages their prompt implementation.		
Energy, Oil and natural gas - Paragraph 67	CO_2 emissions from flaring in refineries, offshore installations and natural gas plants were estimated using plant-specific CO_2 EF data available under the EU ETS. To improve transparency, the ERT recommends that Denmark provide brief background information about the nature of the estimation of these CO_2 EFs under the EU ETS, focusing on their adequacy in relation to the IPCC good practice guidance.	A general description of the EU ETS data is included in chapter 1.4.10 in the 2011 NIR. Chapter 3.5.2 in the NIR 2011 include a short description of the methodologies behind the EU ETS data for fugitive emissions. As only EU ETS data on higher Tiers are applied in the national emission inventory data are found highly adequate in relation to the IPCC Good Practice Guidance.	Chapter 3.5.2
Energy, Oil and natural gas - Paragraph 70	Denmark has updated CH_4 and N_2O EFs from flaring in refineries. The NIR reports that N_2O EFs were adopted from the recently published reference by the European Environment Agency. However, the ERT noted that this reference does not provide EF values for N_2O from flaring in oil refineries. To improve transparency, the ERT recommends that Denmark provide sufficient and accurate background information for the selection of these EFs.	The correct reference for the N_2O emissions factor is EMEP/CORINAIR, 2007: Emission Inventory Guidebook, prepared by the UNECE/EMEP Task Force on Emissions Inventories and Projections, 2007 update. The emission factor refers to flaring offshore as no emission factor is given in the reference for flaring in refineries.	Chapter 3.5.4
Industrial processes, Cement production – Paragraph 77	On the basis of the information provided in the EU ETS reports, the ERT recommends that Denmark derive a country-specific EF that could be used throughout the whole time-series. In order to allow comparability among Parties, it is essential that AD for clinker production be investigated more deeply, as well as providing information on the calcium oxide content of the clinker. The ERT also recommends that a qualitative explanation be included in the NIR regarding the changing nature of the raw materials or the products, wherever decreasing trends are found in the implied EF.	The EF varies as a consequence of variation in product mix. Therefore, it makes no sense to use one national EF during the time period. In the NIR the possibilities for getting more precise clinker data back in time has been described. The inventory team has established a dialogue with the cement factory in order to improve the data for the recent years as well as establishing a qualitative explanation on the decreasing trend in IEF during the last 5 years.	Chapter 4.2.2
Industrial processes, Consumption of HFCs – Paragraph 78	Emissions are estimated using a complex model that was made available to the ERT	The work is ongoing.	

CRF	ERT Comment	Denmark's response	Reference
	during the review. The NIR does not provide sufficient information regarding AD, EFs, quantity of gas in equipment, and basic assumptions. This information, which is needed to understand the input data to the model, is only provided in the report by PlanMiljø. The ERT recommends that Denmark improve the background information for this model in future NIRs.		
Industrial processes, Consumption of HFCs – Paragraph 79	The F-gases report indicates that the comparison between potential and actual emission estimates has been only partly completed. The ERT recommends that the Party improve transparency with regard to this particular key category, as well as for the F-gases in general, by providing more detailed information in the NIR and completing the documentation of the model.	The inventory group has prioritised improvement of the estimate of actual emissions and do not consider the comparison between potential and actual emissions to be relevant.	
Industrial processes, Consumption of HFCs – Paragraph 80	According to the F-gases report, no QA/QC plan specific for the F-gas calculation has been developed, although some QC procedures are carried out in the model. The ERT recommends that Denmark improve QA/QC for F-gases.	The work is ongoing.	
Industrial processes, Consumption of HFCs – Paragraph 82	Figures in the NIR (table 4.16) do not reflect those in the CRF tables from the 2010 submission, except for the year 2008. The ERT recommends that Denmark check its reporting in the NIR and CRF tables for consistency in the next submission.	The tables in the NIR (Chapter 4) are based on the CRF for Denmark (excluding Greenland and the Faroe Islands).	
Industrial processes, Limestone and dolomite use – Paragraph 84	Completely different time-series for AD and EFs were presented in the 2010 submission compared with the 2009 submission, with no explanation regarding the recalculation. The ERT recommends that, in the NIR, the Party explain the changes in assumptions and provide the description of the AD in sectoral background CRF table 2(I).A-G. The ERT also recommends that Denmark ensure time-series consistency, because a different method has been used for the last three years.	The activity: consumption of $CaCO_3$ for refining of sugar was transferred from 2A to 2D. This change was only mentioned in section 4.5.4 Recalculations (in sector 2D) and unfortunately not in section 4.2.5 Recalculations (in sector 2A).	

CRF	ERT Comment	Denmark's response	Reference
Industrial processes, Other mineral products – Paragraph 85	Emissions from the production of yellow bricks and expanded clay products are estimated and reported under this category. Both of the emission time-series are inconsistent because the tier 1 method has been used for the period 1990–2005, while plant specific data reported under the EU ETS have been used for 2006–2008. The ERT recommends that Denmark use this plant-specific information under the EU ETS as a basis for deriving country-specific EFs to be applied for the whole time-series.	Yellow bricks: The EF applied from 1990-2005 is based on an assumption on a fixed average $CaCO_3$ content of the clay used for yellow bricks. Regarding AD no information on share of yellow bricks or the actual yellow colours is available. The NIR present two scenarios: 1) the methodology applied so far and 2) the recommended methodology.	Chapter 4.2.4
Industrial processes, Other mineral products – Paragraph 86	The production of yellow bricks is not well documented and the total production of bricks is not reported in the NIR. The ERT recommends that Denmark improve transparency in this regard.	Table 4.6 will be elaborated. The basic statistical information on consumption of bricks as well as assumptions and the estimated consumption of yellow bricks will be presented in the NIR	Chapter 4.2.2
Industrial processes, Solvent and other product use – Paragraph 87	Emissions are estimated using a model that crosschecks two sources of data: SPIN (Substances in Preparations in Nordic Countries), for bottom-up approach, and Statistics Denmark, for top-down approach, using a mass balance method for consumption of species and EFs for four categories of solvents. Estimations for total emissions before 1995 are not well documented. The ERT recommends that the Party work on the assumptions needed for completing the time-series using consistent methodologies.	Production, import and export data for 1990 -1994 will be compiled for next reporting. At present the completeness of data for the period is not known so there may be data gaps for some chemicals and/or products.	
Agriculture, General – Paragraph 93	The ERT noted that most of the AD (including the number of animals by subcategory, the amount of feed and manure, area and productivity of crops) are not provided in the NIR. The ERT recommends that Denmark provide all the data used for the emissions calculations, at least for the latest year of reporting, in its next NIR. The ERT further noted that constant values of average weights of animals are indicated in the CRF tables for all years. In order to increase the transparency of emission trends, the ERT recommends that Denmark provide actual annual data on average weight	An improvement of information concerning AD is provided. Submission 2011 in NIR Annex includes table 3E Table 2 covering number of animal on subcategory level. In Annex 3E Table 5 is provided data feed intake given in Feed Units (FU) for all subcategories. More information on crops is provided in Table 6.35 and Annex Table 3E Table 13. Annual weight is provided for fattening pigs 1990-2009 – see CRF table 4B(a). Data of the animal weight is not used in the estimation of CH4 from manure management, because the calculation is based on the manure production. However, it is planned to search for data covering the annual average weight for the other animal categories.	Chapter 6.1.1 & 6.2.2 Annex 3E

CRF	ERT Comment	Denmark's response	Reference
	of animal categories. Methodologies for estimating gross energy (GE) values, volatile solids (VS) production, nitrogen excretion (Nex), N losses during housing and storage are not clear from the NIR. The ERT recommends that the Party improve transparency related to the estimation of these parameters in the next annual submission.	Improvements in description of estimation of GE I submission NIR 2011 Table 6.2.2 The transparency for estimation of GE (Chapter 6.2.2), VS, Nex (Chapter 6.1.1) and N losses from housing and storage is provided in Annex 3E Table 3 and4.	
Agriculture, General – Paragraph 94	The ERT recommends that the Party provide more explanatory information for trends of key parameters and emissions in the NIR of the next annual submission	Improvements in information for trends of key parameters are provided. Improvements in explanation of the correlation between IEF and e.g GE, VS, weight and Nex.	Chapter 6.2 & 6.3
Agriculture, General – Paragraph 97	The ERT recommends that the Party include the recommendations made by reviewers and actions undertaken to address these in the next NIR.	In submission 2011 NIR section 6.1.2 the text are supplemented with description of reviewer's most important comments and recommendations.	Chapter 6.1.2
Agriculture, Enteric fermentation – Paragraph 99	In the course of the review, Denmark provided the ERT with AD on feed unit intake by animal subcategories. The ERT noted that, for heifers, feed intake increased by 50 per cent for years in the period 1990–2008. However, the corresponding GE values increased by only 20 per cent. The ERT recommends that Denmark remove any inconsistencies in the estimation of emissions from heifers for 1990–2002 in the next annual submission.	The data of feed intake provided during the review was unfortunately not correct. In submission 2011 Annex 3E Table 5 is provided data for feed intake given as feed unit and in Annex 3ETable 8b is listed estimates of GE. These data shows a good correlation in trends for feed intake and GE from 1990 to 2009. Feed intake and GE has been increased by 19% and 21%, respectively.	Annex 3E
Agriculture, Manure management – Paragraph 103	The ERT noted that the IEF for N_2O emissions from liquid MMS is decreasing within the period. During the review, Denmark clarified that the reduction of N_2O emissions from the application of biogas-treated slurry in agricultural soils is considered within this category. The ERT recommends that Denmark provide more explanatory information on the nature of the reduction in N_2O emissions from treated slurry in the next annual submission, and encourages the Party in its intention to further verify the rates of N_2O reduction in different environmental conditions. The ERT recommends that Denmark includes uncertainty of scientific knowledge concerning the calculation of re-	A better description and explanation of the lower N_2O emission from biogas treated slurry is provided in submission 2011 NIR chapter 6.3.2 – section "A lower N2O emission from biogas treated slurry". The estimate concerning the lower N2O emission are subject to a relatively high uncertainty, which is taken into account in the overall uncertainty calculation of the agricultural sector (NIR chapter 6.7). CRF Table 4.B(b) is corrected. The Nex and AD covering the sum data from Denmark and Greenland.	Chapter 6.7

CRF	ERT Comment	Denmark's response	Reference
	duced N_2O emission from biogas treated slurry. The ERT further noted that the Nex rates of animals reported in table 4.B(b) represent data for mainland Denmark only; however, AD and emissions are reported for mainland Denmark and Greenland. The ERT recommends that Denmark correct its reporting in the CRF tables in the next annual submission.		
Agriculture, Agricultural soils - Paragraph 104	The ERT further noted that Denmark applied an additional country-specific parameter on ploughing frequency for the estimation of N in crop residues, which may lead to an underestimation of N_2O emissions. During the review, Denmark clarified that AD used for this category are not annual and represent total N input from aboveground biomass during the production cycle. The ERT recommends that the Party provide explanatory information on this issue in the next annual submission.	Previous, the N content for perennial crops where provided for a production cycles and incorporated in the estimation with a variable called ploughing frequency. This is now changed and the N content for all crops represent annual estimates (submission 2010, NIR annex 3E Table13).	Annex 3E
LULUCF, General – Paragraph 110	For the LULUCF sector, Denmark has used various tier 3 methods involving the use of models and inventory-based approaches. Although the NIR generally contains transparent information on these models and inventories, it lacks transparent information on the model outputs and their relationship with the entries in the CRF tables. The ERT recommends that Denmark provide transparent information in the NIR on the model outputs and their relationship with the entries in the CRF tables in the next annual submission.	Documentation has been improved in the NIR for the 2011 submission.	Chapter 7
LULUCF, General – Paragraph 111	The use of notation keys was found to be incorrect and misleading in many places in the CRF tables, leading to lack of transparency. The ERT recommends that Denmark report using the correct notation keys in the CRF tables in the next submission.	In the 2011 submission, Denmark has considered the notation keys used in the LULUCF reporting and corrected and harmonised the use of notation keys.	CRF
LULUCF, General – Paragraph 114	Denmark has performed a key category analysis at tier 1 and 2 levels using both trend and level assessments. However, only the tier 1 level assessment has been used for identifying	Denmark has from the 2011 submission considered key sources identified due to both level and trend.	

CRF	ERT Comment	Denmark's response	Reference
	the key categories and guiding methodological choice. The ERT recommends that Denmark use the results of both level and trend key category analysis in identifying key categories and guiding methodological choice in the next annual submission.		
LULUCF, General – Paragraph 115	The ERT found many errors and discrepancies in the CRF tables for the LULUCF sector submitted by Denmark. This indicates that there are problems with the QA/QC procedures for the LULUCF sector in the Danish national inventory system. For example, the ERT found that in the Danish national inventory system, the inventory compilation for forestland is done separately by the Centre of Landscape and Planning, University of Copenhagen and the data are transmitted to NERI (Aarhus University), the main body responsible for compiling the national inventory, where it is integrated with the rest of the LULUCF sector. The ERT noted that there may be issues with QA/QC procedures used in the transfer of data between these organizations. The ERT strongly recommends that Denmark improve the QA/QC processes for the LULUCF sector in order to eliminate such inconsistencies in its reporting in the next annual submission.	An intensive and improved QA/QC has been performed. This includes that all data transfers are checked by a person not directly involved with the preparation of the LULUCF inventory.	Chapter 7. Included under all activities.
LULUCF, Cropland remaining cropland – Paragraph 120	Denmark uses a tier 3 model (C-TOOL) based on modelled dynamics for carbon turnover in soil to estimate carbon stock changes in mineral soils in cropland. The model operates with three different pools: FOM (fresh organic matter), HUM (humified organic matter) and ROM (resilient organic matter). In the course of the review, in response to a recommendation from the ERT, Denmark provided revised estimates for carbon stocks in mineral soils in cropland using a new approach – ignoring the FOM pool and taking into account only the changes in HUM and ROM pools. The ERT recommends that Denmark provide information on validation of the model predictions using this new ap-	All pools are dynamical modelled/estimated. The FOM pool consist of only app. 1% of the total C-stock and are responsible for the large interannuel variability but not the long term development in the C-stock. The estimated long term loss from 1990 to 2009 is app. 0.75% of the total C-stock in the mineral soils. Independent verification by soil sampling for > 600 paired plots taken in 1987 and resampled in 2009 been performed. Despite the well-known large variability in results from soil sampling, the data shows that no or almost no changes in the C-stock in soil have taken place. We therefore conclude that the modelled results are in line what can be measured. As FOM, HUM and ROM are dynamical modelled, and especially for	Chapter 7.3.

CRF	ERT Comment	Denmark's response	Reference
	proach with field measurements of changes in HUM and ROM pools in the next annual submission.	the FOM pool has a very large variability and based on long term experiments (>100 years) combined with the large variation in soil sampling it is not possible to measure these fractions.	
LULUCF, Land converted to cropland – Paragraph 123	For land converted to cropland, net carbon stock change of mineral and organic soils is reported as "IE" for many conversions. During the review, Denmark explained that these have been included in cropland remaining cropland. To improve transparency, the ERT recommends that Denmark report net carbon stock change of mineral and organic soils separately under cropland remaining cropland and land converted to cropland in the next annual submission.	The recommendation from the ERT is difficult to follow. Although we have very detailed information on the individual fields it will be a very time consuming task with little effect. The area with soil in agricultural use is based on the detailed information on the position of the field and the actual crop grown in that field. The minor areas which is converted to cropland and its use is included in the modelling with C-TOOL and for the organic soils we use an overlay of the current used fields to see their position in relation to the organic soil map.	
Waste, General – Paragraph 131	QC procedures have been developed and performed for all categories, except for waste incineration; and are described in the NIR. Verification of CH_4 emissions from solid waste disposal on land has been performed as a QA procedure. No other QA procedures have been performed for the sector, regardless changes in methodologies and/or data in assessment of all the categories of the sector. The ERT recommends that Denmark extends its QA/QC procedures to all categories and ensure the relevant level of rigour of QA/QC procedures for categories where they are required, according to the IPCC good practice guidance.	QA/QC procedures to all categories have been implemented and documented in the NIR	Chapter 8
Waste, Solid waste disposal on land – Paragraph 136	Denmark has made some changes in the parameters used in the FOD model (oxidation factor, half-life time, fraction CH_4 in emitted gas, degradable organic carbon content for plastics, fraction of degradable organic carbon dissimilated) according to previous recommendations. The ERT considers that some of these changes need further justification and/or investigation. For example, the value for the oxidation factor set to 0.1 requires further justification than that solid waste disposal to land is being well managed. The ERT reiterates the previous recommendations that Denmark	Updated documentation of the Danish solid waste disposal on land being well managed has been implemented in the NIR to support the value for the oxidation factor as set to 0.1. However, an in dept investigation of the individual landfill practices have not yet been realised – improvements at this level are ongoing.	Chapter 8.2

CRF	ERT Comment	Denmark's response	Reference
	further investigate landfill practices and choose the value for the oxidation factor parameter according to recent scientific literature.		
Waste, Solid waste disposal on land – Paragraph 138	The ERT was unable to follow the logic of the calculations and assessments of CH_4 emissions from solid waste disposal on land as presented in the NIR. The ERT reiterates the recommendation from the previous review that the Party provide a table in the NIR showing the different waste types disposed of as municipal solid waste or incinerated, together with their main characteristics, to increase transparency. The ERT appreciates Denmark's efforts in using a tier 2 uncertainty analysis. However, due to the complexity of the FOD estimation method for CH4 emissions, the ERT encourages the Party to further investigate relevant distributions for different parameters in order to increase accuracy.	The methodology and activity data has been described and provided at a more detailed level that should increase the transparency and ability for the ERT to follow stepwise the calculation procedure and results. An extended version of the Tier 2 uncertainty analysis has been performed applying defined uncertainty ranges for all input parameters. Details are shown in the NIR.	Chapter 8.2
Waste, Wastewater handling – Paragraph 140	There is a considerable discrepancy between the final CH_4 recovered for energy purposes and the corresponding value in the statistical database (DEA, 2009). Data on the sludge fraction treated anaerobically have been verified with sludge database values contained in (DEA, 2009), and the Party is planning to reflect the difference and to use an updated (increased) value for the fraction of anaerobically treated sludge in the next annual submission. The ERT encourages the Party to do so and to make recalculations with the new EF. Further the ERT recommends to improve the description of the EF for calculating CH_4 emissions in the NIR, correct the formula used and the corresponding text in order to give a clear explanation of its components and their values, and thus to make possible to follow the logic of calculations.	Yearly emission factors for the anaerobic treatment processes have been calculated based on the Danish Sludge Database, which have resulted in an increase in the EF ranging from 15-63%. Recalculation for the EF for anaerobic processes is presented in the NIR. The above improvement has resulted in a discrepancy between the amount of recovered methane calculated based on the National Sludge statistics and the DEA statistical database corresponding to an average of 22%.	Chapter 8.3
Waste, Waste incineration – Paragraph 142	Hazardous waste is not mentioned in the NIR, during the review Denmark informed the ERT that incineration of hazardous waste is done	It has been specified in the waste incineration section that hazardous waste is included in the energy section.	2011 NIR section 8.4

CRF	ERT Comment	Denmark’s response	Reference
	with energy recovery and that emissions therefore are reported in the energy sector. The ERT appreciates Denmark’s efforts in obtaining data and assessing the emissions from this category to such a disaggregated level, but recommends that the Party to improve transparency includes a description on hazardous waste incineration in the next annual submission.		
Waste, Waste incineration – Paragraph 143	The documentation box of CRF table 6.C references particular categories of the energy sector where the recovered emissions are reported. However, the values reported in the referenced categories of the energy sector (public electricity and heat production, manufacturing industries and construction, and commercial/institutional, amounting to 16,937.56 TJ) differ from the figure from DEA for energy consumption from incinerated waste (16,501 TJ). Denmark is recommended to double-check the figures in the CRF tables for the energy sector with the data from energy statistics for the next annual submission.	This inconsistency has been corrected in the 2011 NIR	

More information on the specific responses to the review has been given in the sectoral chapters of this report.

10.5 Explanations, justifications and implications of recalculations for KP-LULUCF inventory

10.5.1 Recalculations

Almost all sectors in the KP-LULUCF have been recalculated.

This is due to:

- small changes in Land Use Matrix which affect the land use conversions,
- updated data from the Danish NFI for C-stock changes in above-, belowground, dead wood and litter,
- a new soil map for organic soils (Figure 7.14),
- a new R:S factor for vegetation in grassland (Table 7.20),
- new emission factors for organic soils (Table 7.25),
- new data on C-stock in mineral soils from our research (0-100 cm dept compared to 0-50 cm / 0-30 cm in the previous submission to be used when land use change takes place (Table 7.19),
- correction of errors in the previous reporting.

The major changes in A/R are corrections of errors in the previous submission and changed methodology for estimation of C accumulation in litter as recommended by the previous ERT.

For D the main reason is a small change in living biomass and updated values on C-stock in mineral soils.

For FM the major change is due to updated values from the NFI on C-stocks in living biomass.

For CM and GM the changes are primarily due to the new soil map for organic soils and the new emission factors for organic soils. The analysis has shown that a large part of the area should be classified as GL and not as CL. Consequently has there been a reduction of 150-200 Gg CO_2-eqvivalents in the emissions from CM and a similar increase in the emission from GM.

Table 10.7 Effect of the recalculations in the KP-LULCUF sector for 1990 and 2008, Net CO_2-eqv.

	Net CO_2 equivalent emissions/removals					
	1990			2008		
GREENHOUSE GAS SOURCE AND SINK ACTIVITIES	2008 submission	2009 submission	Change, %	2008 submission	2009 submission	Change, %
A. Article 3.3 activities	259.2	251.6	-3.0	-206.8	-12.6	-93.9
A.1. Afforestation and Reforestation	13.2	10.5	-20.3	-230.1	-45.1	-80.4
A.2. Deforestation	246.0	241.0	-2.0	23.3	32.4	39.2
B. Article 3.4 activities	2.593.2	2.793.0	7.7	3.042.8	-2.102.3	-169.1
B.1. Forest Management	-809.2	-709.3	-12.4	264.7	-4.816.9	-1919.5
B.2. Cropland Management	3.377.9	3.188.6	-5.6	2.759.6	2.530.1	-8.3
B.3. Grazing Land Management	24.5	313.6	1179.0	18.4	184.5	901.7%

10.5.2 Review recommendations

The main recommendations for KP-LULUCF are included in Table 10.8.

Table 10.8 Recommendations from the UNFCCC review process concerning KP-LULUCF.

CRF	ERT Comment	Denmark's response	Reference
2010 submission (Review report: http://unfccc.int/resource/docs/2011/arr/dnk.pdf)			
KP-LULUCF, General – Paragraph 176	The ERT strongly recommends that Denmark increase the transparency of the inventory by further documenting the relationship between convention reporting and Kyoto accounting in the next annual submission.	The NIR has been updated with more information.	Chapter 11
KP-LULUCF, General – Paragraph 177	The ERT notes that Denmark's has used consistent, complete remote sensing to identify areas of forest and forest change. This is a significant achievement and the ERT commends Denmark's efforts in this area, but recommends that the Party provides further detail on the programme in the next annual submission. In particular, issues such as how Denmark ensures that the minimum mapping unit derived from the remote sensing data meets the 0.5 ha minimum forest area criteria applied by Denmark for classifying forests under the Kyoto Protocol need to be addressed.	The NIR has been updated with more information.	Chapter 7.1.2
KP-LULUCF, Afforestation/reforestation – Paragraph 179	The ERT notes that Denmark does not currently identify areas of afforestation which have been subject to harvest. During the review Denmark explained to the ERT that this is because the majority of areas subject to afforestation are on long rotations (>50 years) and therefore will not be harvested during the commitment period. The ERT recommends that Denmark provide further information to explain this in the next annual submission, or provide estimates of the harvested areas and the associated emissions and removals.	The NIR has been updated with more information.	Chapter 11.3.2
KP-LULUCF, Afforestation/reforestation – Paragraph 180	The ERT noted inconsistencies between the living biomass pools reported under the Convention reporting and the above- and belowground biomass pools reported for afforestation and reforestation. During the review Denmark provided revised estimates. However, the ERT found that the revised carbon stock change numbers for living biomass (Convention) and afforestation and reforestation still differed by 0.09 Gg C. The ERT therefore strongly recommends that QC procedures be strengthened in future annual submissions to ensure consistency in reported numbers. The ERT also strongly recommends that Denmark transparently document the improved QC procedures in the	A thorough QA/QC procedure has been implemented and several errors have been corrected. We have found no further discrepancies between the UNFCCC and the KP reporting. A more intensive cooperation with Inst. of Forest and Landscape which is responsible for the Forest data and NERI, who is responsible for the other parts of the inventory as well as the reporting to UNFCCC, has been carried out throughout the year.	

CRF	ERT Comment	Denmark's response	Reference
	next annual submission.		
KP-LULUCF, Deforestation – Paragraph 182	During the review the ERT found a lack of consistency between the emission estimates reported under deforestation and the equivalent LULUCF conversion categories for mineral soil, organic soil and dead organic matter (DOM). During the review, Denmark provided the ERT with a revised estimate for deforestation. However, the ERT noted that the results were still inconsistent in both dead organic matter (1.55 Gg C) and mineral soil (0.33 Gg C). The ERT strongly recommends that Denmark improve its QC procedures on data entry and checking of the CRF tables prior to the next annual submission and that the Party provide information on these procedures in the next annual submission.	A thorough QA/QC procedure has been implemented and several errors have been corrected. We have found no further discrepancies between the UNFCCC and the KP reporting. A more intensive cooperation with Inst. of Forest and Landscape which is responsible for the Forest data and NERI, who is responsible for the other parts of the inventory as well as the reporting to UNFCCC, has been carried out throughout the year.	
KP-LULUCF, Forest management – Paragraph 183	The ERT found a lack of consistency between the emission estimates reported under forest land remaining forest land and forest management. During the review Denmark provided the ERT with revised estimates for forest management. However, the ERT found that the revised estimates of carbon fluxes were still inconsistent. In particular, the forest management emission estimates include 1.4 Gg C loss in litter that is not included under forest land remaining forest land. While this does not represent a potential underestimate of emissions in forest management, the ERT strongly recommends that Denmark implement further QC checks and document these checks in the next annual submission.	A thorough QA/QC procedure has been implemented and several errors have been corrected. We have found no further discrepancies between the UNFCCC and the KP reporting. A more intensive cooperation with Inst. of Forest and Landscape which is responsible for the Forest data and NERI, who is responsible for the other parts of the inventory as well as the reporting to UNFCCC, has been carried out throughout the year.	
KP-LULUCF, Cropland management – Paragraph 184	Denmark has used the tier 3 model C-TOOL to estimate emissions from mineral soils under cropland management. To establish the 1990 base for cropland management for the purposes of net-net accounting Denmark applied a five-year average of emissions from mineral soils from 1988 to 1992. While the use of a five-year average to remove the effect of climate variability is consistent with the IPCC good practice guidance for LULUCF, the ERT noted that this period also included a significant change in management practice. During the review Denmark proposed a new method to reduce variability while still including man-	The emission from mineral soils under cropland is estimated with a tier 3 model, C-TOOLs. The reported emissions are in accordance with the methodology accepted by the ERT in 2010. Further descriptions on the model calculations are given in the NIR. C-TOOL is a three pooled model called: FOM (Fresh Organic Matter), HUM (Humified Organic Matter) and ROM (Resilient Organic Matter). The two latter accounts for 99 % of the total carbon stock in agricultural soils. The FOM pool consists of newly incorporated straw, thin roots, fungi, bacteria etc. having a half-life in the soil of 6-7 months. This pool is responsible for the high variability between years.	Figure 7.12 and Table 7.24

CRF	ERT Comment	Denmark's response	Reference
	agement effects that excluded the fast turnover pools from the reporting. The ERT accepted the proposed method and recommends that Denmark provide additional information on this method in the next annual submission, including data on the change in each pool within the C-TOOL model.	Table 7.24 in the NIR gives the total amount of all three pools and the two slow reacting pools (HUM and ROM).	
KP-LULUCF, Cropland management – Paragraph 185	During the review, Denmark provided the ERT with revised estimates for cropland management. In these revised estimates the areas reported under cropland management and the relevant Convention subcategories no longer match. There is also a difference in the emissions estimates for living biomass (0.18 Gg C) and soil (89.96 Gg C). The ERT strongly recommends that Denmark improve its QC procedures on data entry and checking of the CRF tables prior to the next annual submission and that the Party provide information on these procedures in the next annual submission.	A thorough QA/QC procedure has been implemented and several errors have been corrected. We have found no further discrepancies between the UNFCCC and the KP reporting. A more intensive cooperation with Inst. of Forest and Landscape which is responsible for the Forest data and NERI, who is responsible for the other parts of the inventory as well as the reporting to UNFCCC, has been carried out throughout the year.	
KP-LULUCF, Cropland management – Paragraph 186	During the review, Denmark provided the ERT with additional information on the Convention subcategories which correspond to the activities under Article 3, paragraphs 3 and 4. Upon reviewing this information and the related CRF submission, the ERT noted that some areas and emissions may have been double counted. In particular, the forest land converted to cropland area appears to have been included in the deforestation reporting as well as in the cropland management reporting. The ERT recommends that Denmark review the inclusion of each relevant Convention subcategory to activities under Article 3, paragraphs 3 and 4, to ensure that there is no double counting of emissions and to ensure the consistent representation of lands as per the IPCC good practice guidance for LULUCF, in the next annual submission. In particular, the ERT strongly recommends that Denmark provide a detailed land area matrix that clearly shows the land-areas and the transfers between categories under the Convention and relation of those to land accounted under the Kyoto Protocol.	A thorough QA/QC procedure has been implemented and several errors have been corrected. We have found no further discrepancies between the UNFCCC and the KP reporting. A more intensive cooperation with Inst. of Forest and Landscape which is responsible for the Forest data and NERI, who is responsible for the other parts of the inventory as well as the reporting to UNFCCC, has been carried out throughout the year. We have not found any double counting in the 2011 submission.	
KP-LULUCF, Grazing land manage-	Denmark provided the ERT, during the review, with	A thorough QA/QC procedure has been implemented and several errors	

CRF	ERT Comment	Denmark's response	Reference
ment – Paragraph 187	revised estimates for grazing land management. In these revised estimates, the areas reported under grazing land management and the relevant Convention sub-categories do not match. There is also a difference in the emission estimates for living biomass (14.99 Gg C) and soil (0.05 Gg C). The ERT strongly recommends that Denmark improve its QC procedures on data entry and checking of the CRF tables prior to the next annual submission and that the Party provide information on these procedures in the next annual submission.	have been corrected. We have found no further discrepancies between the UNFCCC and the KP reporting. A more intensive cooperation with Inst. of Forest and Landscape which is responsible for the Forest data and NERI, who is responsible for the other parts of the inventory as well as the reporting to UNFCCC, has been carried out throughout the year.	
KP-LULUCF, Grazing land management – Paragraph 188	During the review, Denmark provided the ERT with additional information on the Convention subcategories which correspond to the activities under Article 3, paragraphs 3 and 4. Upon reviewing this information and the related CRF submission, the ERT noted that some areas and emissions may have been double counted. In particular, the forest land converted to grassland area appears to have been included in the deforestation reporting as well as the grazing land management reporting. The ERT recommends that Denmark review the inclusion of each relevant Convention subcategory to activities under Article 3, paragraphs 3 and 4, to ensure that there is no double counting of emissions and to ensure the consistent representation of lands as per the IPCC good practice guidance for LULUCF in the next annual submission. In particular, the ERT strongly recommends that Denmark provide a detailed land-area matrix that clearly shows the land areas within each category and the transfers between categories.	A thorough QA/QC procedure has been implemented and several errors have been corrected. We have found no further discrepancies between the UNFCCC and the KP reporting. A more intensive cooperation with Inst. of Forest and Landscape which is responsible for the Forest data and NERI, who is responsible for the other parts of the inventory as well as the reporting to UNFCCC, has been carried out throughout the year. We have not found any double counting in the 2011 submission.	

11 KP-LULUCF

11.1 General information

In the following text the abbreviations is used in accordance with definitions in the IPCC guidelines:

A:	Afforestation
R:	Reforestation
D:	Deforestation
FF:	Forest remaining Forest, areas remaining forest after 1990
FL:	Forest Land meeting the Danish definition of forests
CL:	Cropland
GL:	Grassland
SE:	Settlements
OL:	Other land, unclassified land
FM:	Forest Management, areas managed under article 3.4
CM:	Cropland Management, areas managed under article 3.4
GM:	Grazing land Management, areas managed under article 3.4

11.1.1 Definition of forest and any other criteria

For the estimation of anthropogenic emissions by sources and removals by sinks associated with afforestation (A), reforestation (R) and deforestation (D) since 1990 under Article 3.3 and forest management (FM) under Article 3.4 of the Kyoto Protocol, the following forest definition will be applied:

- Minimum values for tree crown cover: 10 % tree crown cover for forests.
- Minimum values for land area: 0.5 ha.
- Minimum value for tree height: trees must be able to reach a minimum height of 5 m in the site.

In addition, the forest area includes temporarily unstocked areas, smaller open areas in the forest needed for management purposes and fire breaks. Forests in national parks, reserves, or areas under special protection are included. Windbreaks and groves covering more than 0.5 ha and with a minimum width of 20 m are also considered as forests. Farmlands, fruit plantations for commercial purposes, orchards, gardens (houses and summer houses) are NOT included in the forest area. Willow plantations on agricultural soils for bioenergy purposes are included in Cropland (CL).

11.1.2 Elected activities under Article 3, paragraph 4, of the Kyoto Protocol

As regards the possibility of including in the first commitment period emissions and removals associated with land use, land-use change and forestry activities under Article 3.4 of the Kyoto Protocol, it has been decided to include emissions and removals from forest management (FM), cropland management (CM) and grazing land management (GM).

The national system has identified land areas associated with the activities under Article 3.4 of the Kyoto Protocol in accordance with definitions, modalities, rules and guidelines relating to land use, land-use change and forestry activities under the protocol by satellite monitoring, use of EU Land Parcel Information System (LPIS), detailed crop information data on field level, soil mapping and sample plots from the national forest inventory (NFI).

Inventories of emissions and removals under Article 3.3 and Article 3.4 are prepared for 2009, and reported annually in 2010 together with the other greenhouse gas inventory information.

11.1.3 Description of how the definitions of each activity under Article 3.3 and each elected activity under Article 3.4 have been implemented and applied consistently over time

The definition of afforestation, reforestation and deforestation is in accordance with the GPG (IPCC 2003).

Afforestation or reforestation is identified when areas have wooded tree-cover and fulfils the forest definition given above. The time of the A is given by the time of action - e.i. planting of trees. For R the time is given by the first spontaneous regeneration of tress, typically either by absence of management or by management inducing natural regeneration. All types of establishment of forest (A or R) is considered human induced, as all land area of Denmark is under management or as minimum specifically left for spontaneous revegetation. Regulations and support for A and R include natural revegetation as a specific method, often supplementing already existing forest areas. (Danish Forest and Nature Agency, Support for Sustainable Forestry - active until 2010. http://www.skovognatur.dk/Skov/Privat/Tilskud/Baeredygtig/)

Deforestation is identified where areas in 1990 were covered by forest and where subsequent information (through remote sensing or NFI) is recorded to have another land use. Deforestation occurs for a number of reasons, e.g. nature restoration which in the period 1990 - 2008 have been the predominant reason. Other reasons can be urban or infrastructure development.

Temporarily unstocked areas - as integral part of forest management or as result of windthrow - which is expected to continue in forest management is not considered deforestation.

As for the forest management (Article 3.4) - the forest areas fulfilling the definition given above are included under this activity. All forest areas are considered managed due to the intense utilisation of the land area of Denmark. All inventories apply this approach. The Forest Act in Denmark gives the frame for most of the forest area ('Fredskov') - thereby ensuring continued forest cover - or by deforestation at least afforestation of a similar area or in most cases the double area. As described in Chapter 7 the changes in forest floor and mineral soils pools are not significant in the period observed (1990-2009) and are hence not considered being a source of emissions.

For Cropland and Grassland the area accounted for under Art. 3.4 has been estimated with the EO mapping combined with agricultural data from Statistics Denmark and the EU agricultural subsidiary system. Only areas which are reported as CL and GL are included in the accounted area.

11.1.4 Description of precedence conditions and/or hierarchy among article 3.4 activities and how they have been consistently applied in determining how land was classified

All Forest activities have precedence, after this Cropland activities and then Grassland activities.

Afforestation has precedence. All land converted to forest are included as afforested area. Deforestated areas are reported under D. The following categories in the Convention reporting are included under afforestation:

- 5A21 CL to A
- 5A22 GL to A
- 5A23 WE to A
- 5A24 SE to A
- 5A25 OL to A

Deforestation is estimated as:
- 5B21 to CL
- 5C21 to GL
- 5D21 to WE
- 5E21 to SE
- 5F21 to OL

FM activities are only related to:
- 5A1 Forest remaining Forest

CM activities are related to:
- 5B1 CL remaining CL
- 5B22 GL to CL
- 5B23 WE to CL (not occurring)
- 5B24 SE to CL
- 5B25 OL to CL
- 5D22 CL to WE
- 5E22 CL to SE
- 5F22 CL to OL (not occurring)

GM activities are related to:
- 5C1 GL remaining GL
- 5C22 CL to GL
- 5C23 WE to GL (not occurring)
- 5C24 SE to GL
- 5C25 OL to GL
- 5D23 GL to WE
- 5E23 GL to SE
- 5F23 GL to OL (not occurring)

No elected land has left land, which is accounted for. Land conversion between elected activities (FM, CM and GM) has been allowed. FL, CL and GM, which has been converted to WE and SE is still included in the accounted area. No land elected under 3.4 activities has been converted to Other Land. Other land converted to elected activities is included in the respective category. As a consequence there has been a steady increase in land, which is accounted for under Art. 3.3 and Art. 3.4 (Table 11.1) with 24 259 hectares from 1990 to 2009.

Table 11.1 The development in the different land areas which is included in the accounting.

	1990	1995	2000	2005	2006	2007	2008	2009
AF	711	9795	21590	31393	34394	36577	39998	43420
D	884	2557	4745	6353	6467	6581	6694	6808
FM	538903	537231	535043	533435	533321	533207	533093	532979
CM	2920903	2906334	2890202	2875219	2871601	2867734	2863868	2860001
GM	119373	130561	141666	152831	155080	157329	159577	161826
Total area, Hectares	3580775	3586478	3593245	3599231	3600863	3601428	3603231	3605034

The Land Use matrix developed for the purpose of reporting Art. 3.3 and 3.4 activities for 2008 are shown in Table 11.2.

Table 11.2 Land Use matrix for art. 3.3 and 3.4 activities in 2009.

From previous inventory year / To current inventory year		Article 3.3 activities		Article 3.4 activities				
		Afforestation and Reforestation	Deforestation	Forest Management (if elected)	Cropland Management (if elected)	Grazing Land Management (if elected)	Revegetation (if elected)	Other (5)
		(kha)						
Article 3.3 activities	Afforestation and Reforestation	40,00	NO					
	Deforestation		6,69					
Article 3.4 activities	Forest Management (if elected)		0,11	532,98				
	Cropland Management(4) (if elected)	2,00	NO		2.859,54	2,33	NA	
	Grazing Land Management(4) (if elected)	0,05	NO		0,30	159,23	NA	
	Revegetation(4) (if elected)	NA			NA	NA	NA	
Other (5)		1,38	NO	NO	0,17	0,26	NA	704,77
Total area at the end of the current inventory year		43,42	6,81	532,98	2.860,00	161,83	NA	704,77

11.2 Land-related information

11.2.1 Spatial assessment unit used for determining the areas of the units of land under Article 3.3

Afforestation and reforestation is identified where areas in 1990 not were covered by forest and where subsequent information (through remote sensing or NFI) is recorded to have forest cover fulfilling the forest definition. Even though the definition for A and R refers to the time of establishment, there may be a slight time delay in the actual recording of the A/AR. This will be improved through more frequent land use mapping and improved methods for mapping in the coming years.

Deforestation is identified where areas at the beginning of the commitment period were covered by forest and where subsequent information (through remote sensing or NFI) is recorded to have another land use. The identification of the areas is in most cases supported by reports on e.g. nature restoration or establishment of settlements.

11.2.2 Methodology used to develop the land transition matrix

A land use/land cover map was produced for the Kyoto reference year 1990 and for the year 2005 based on EO data (23 August 1990) and other data produced from 1992-2005. The primary data used is Landsat imagery mainly Landsat 5 (TM) and 7 (ETM+) data to classify and estimate the area. These data has been combined with different vector layers such as cadastral maps, road maps, wetland areas, agricultural land use data, vector layers of established wetlands, gravel maps etc. as well as aerial photos. Portions of seven scenes covering the whole country were classified into forest and non-forest classes. The approach involved the integration of sampling, image processing, and estimation. The product is specified by a Minimum Mapping Unit (MMU) of 0.5 ha, a geometric accuracy of < 15 m RMS and a thematic accuracy of 90% +/- 5% for the six major Kyoto classes: Forest, Cropland, Grassland, Wetland, Settlements, and Other. Forest has a 0.5 ha MMU.

In Chapter 7, Table 7.1 shows the overall development from 1990 to 2009. The preliminary result is an increase in the afforested area of 43,420 hectares, but also that deforestation has taken place of approximately 6,808 ha. Afforestation is mainly taking place on CL and OL not previous classified as forest. Areas, which is deforestated is mainly converted to GL and to a less extend into CL. Since 1990 almost 67,000 hectares has been changed into SE and other infra structures. No FF, CL and GL are converted into OL by definition.

Based upon the combination of the satellite image classified land use map and the combined vector layer of know information a full land use map for 1990 and 2005 was produced. The maps were transformed into a pixel based relational data base - SINKPIX - with each of the 25 x 25 m pixels giving a full dataset for the entire Danish land area in 1990 and 2005. Based upon this database the extraction of the land use matrix and the land use changes could be performed.

11.2.3 Maps and/or database to identify the geographical locations, and the system of identification codes for the geographical locations

The entire Danish territory except the Faroe Islands is included. This chapter includes only the territory of Denmark without Greenland. Denmark is reported as one unit and no sub-geographical locations are used.

Greenland is submitting a full separate NIR and CRF to be included in the submission to UNFCCC (Chapter 16).

11.3 Afforestation, Reforestation & Deforestation (ARD)

11.3.1 Methods for carbon stock change and GHG emission and removal estimates

For afforestation the carbon stock change in the period 1990 - 2008 is based both on the area of afforestation, the information on species composition from the Forest Census 2000 and from the NFI.

In the afforestation a steady increase in carbon stock is found. The species composition is based on the information from the 2000 Forest Census for the period 1990-2000. Subsequently the NFI provides information on the afforestation area and the carbon pools in these areas - up till 2007. The estimates for the carbon pools in the afforestation are similar to previous estimates, with a slight increase due to the new knowledge on species composition and average carbon stock in those areas based on the NFI data.

Carbon stock change caused by deforestation is estimated based on the deforestated area and the mean values of carbon stock in the total forest area. This is due to the fact that no specific knowledge is available on the carbon pools of the deforested areas.

Further details are available in Johannsen et al. 2009.

11.3.2 Description of the methodologies and the underlying assumptions used

The climate in Denmark is cold and wet, which gives limitations to the growth of the forests and therefore afforestation in Denmark are on long rotations (>50 years) to give a reasonable amount of wood and wood products. Furthermore, the afforested areas are in many cases protected against deforestation. Therefore afforested areas under article 3.3. will not be harvested during the commitment period.

As a consequence no estimates for "Units of land harvested since the beginning of the commitment period" in table 5(KP-I)A.1.2 is given. In the current submission it is, by error, stated as IE and not as NO.

11.3.3 Justification when omitting any carbon pool or GHG emissions/removals from ARD

When deforestation occurs it is assumed that all dead organic matter will be cleared. The actual amount depends on which type of forest is converted.

11.3.4 Information on whether or not indirect and natural GHG emissions and removals have been factored out

No factoring out has been performed in the emission and removal estimates.

11.3.5 Changes in data and methods since the previous submission (recalculations)

Some recalculations have been made as updated values from the NFI and has become available; also minor changes in the Land Use Matrix has occurred.

11.3.6 Uncertainty estimates

The uncertainty has been estimated based on the net changes in the different carbon stock with the IPCC Tier 1 methodology, Table 11.3 and Table 11.4.

The uncertainty in 2009 for Afforestation has been estimated to ± 38.4 Gg CO_2-eqv., and for Deforestation to ± 10.4 Gg CO_2-eqv.

Table 11.3 Uncertainty assessment for Afforestation.

KP A.1.1 Afforestation and Reforestation	Emission	Activity data, %	Emission factor, %	Combined uncertainty	Total uncertainty, %	Uncertainty 95 %, Gg CO_2-eqv.
Area subject to the activity, Kha	43.4					
Area of organic soils, Kha	1.7					
Net CO_2 emissions/ removals	-145.3				26.4	38.4
Carbon stock change in above-ground biomass	19.9	15	50	52.2	52.2	10.4
Carbon stock change in below-ground biomass	5.6	15	50	52.2	52.2	2.9
Net carbon stock change in litter	5.8	15	50	52.2	52.2	3.0
Net carbon stock change in dead wood	15.4	15	50	52.2	52.2	8.0
Net carbon stock change in soils, mineral soils	-6.5	15	50	52.2	52.2	3.4
Net carbon stock change in soils, organic soils	-0.6	15	90	91.2	91.2	0.5

Table 11.4 Uncertainty assessment for Deforestation.

KP A.2 Deforestation	Emission	Activity data, %	Emission factor, %	Combined uncertainty	Total uncertainty, %	Uncertainty 95 %, Gg CO_2-eqv.
Area subject to the activity, Kha	6.8					
Area of organic soils, Kha	0.3					
Net CO_2 emissions/ removals	33.1				32.7	10.8
Carbon stock change in above-ground biomass	-6.3	15	50	52.2	52.2	3.3
Carbon stock change in below-ground biomass	-1.3	15	50	52.2	52.2	0.7
Net carbon stock change in litter	-1.5	15	50	52.2	52.2	0.8
Net carbon stock change in dead wood	-0.1	15	50	52.2	52.2	0.1
Net carbon stock change in soils, mineral soils	0.9	15	50	52.2	52.2	0.5
Net carbon stock change in soils, organic soils	-0.7	15	90	91.2	91.2	0.6

11.3.7 Information on other methodological issues

See Chapter 7.

11.3.8 The year of the onset of an activity, if after 2008

Not applicable.

11.4 Forest Management (FM)

11.4.1 Methods for carbon stock change and GHG emission and removal estimates

See Chapter 7 in LULUCF on "Forest remaining forest (5.A.1)".

11.4.2 Methodologies and the underlying assumptions

See Chapter 7 in LULUCF on "Forest remaining forest (5.A.1)".

11.4.3 Omission of pools from FM

No pools omitted.

11.4.4 Factoring out

No factoring out has been made.

11.4.5 Recalculations

Some recalculations has been made due to updated values from the NFI on carbon stocks.

11.4.6 Uncertainty estimates

The uncertainty has been estimated based on the net changes in the different carbon stock with the IPCC Tier 1 methodology. The uncertainty in 2009 for Forest Management has been estimated to ± 903.8 Gg CO_2-eqv. and ± 12.6 Gg CO_2-eqv. from drainage of organic soils in the forest.

Table 11.5 Uncertainty assessment for Forest Management.

KP B.1 Forest Management	Emission	Activity data, %	Emission factor, %	Combined uncertainty	Total uncertainty, %	Uncertainty 95%, Gg CO_2-eqv.
Area subject to the activity, Kha	533.0					
Area of organic soils, Kha	26.7					
Net CO_2 emissions/ removals	-2591.1				34.9	903.8
Carbon stock change in above-ground biomass	441.0	15	50	52.2	52.2	230.2
Carbon stock change in below-ground biomass	89.3	15	50	52.2	52.2	46.6
Net carbon stock change in litter	178.2	15	50	52.2	52.2	93.0
Net carbon stock change in dead wood	7.3	15	50	52.2	52.2	3.8
Net carbon stock change in soils, mineral soils	NO	15	50	52.2	-	-
Net carbon stock change in soils, organic soils	-9.1	30	90	94.9	94.9	8.6

Table 11.6 Uncertainty assessment associated with drainage of forest soils.

KP-II 2 N2O from drainage of soils	Emission	Activity data, %	Emission factor, %	Combined uncertainty	Total uncertainty, %	Uncertainty 95%, Gg CO_2-eqv.
Area of drained soils, Kha	353.6					
Emission	15.7				80.8	12.6
N_2O, Gg CO_2-eqv.	15.7	30	75	80.8	80.8	12.6

11.4.7 Information on other methodological issues

See Chapter 7 in LULUCF on "Forest remaining forest (5.A.1)".

11.4.8 The year of the onset of an activity, if after 2008

Not applicable.

11.5 Cropland Management (CM)

11.5.1 Methods for carbon stock change and GHG emission and removal estimates

CL is subdivided in four classes: agricultural CL, wooded perennial fruit plantations, hedgerows and “other agricultural CL”.

11.5.2 Methodologies and the underlying assumptions used

The area with agricultural CL are given as the agricultural area in Statistics Denmark for cereals, fodder crops, grass for seed, sugar beets, potatoes and other root crops.

Land converted from other Land use categories to CL is included under CL. Land converted to forest is reported under forest (AR). Land which according to the land use matrix is converted to WE and SE are still included in CM. Land conversion to OL is not allowed.

The same methodology as used in the Convention reporting, is used in the KP reporting.

11.5.3 Omission of pool from CM

Aboveground and belowground living biomass, litter and dead organic are only reported for perennial woody crops in accordance with IPCC GPG 2003. No litter and dead organic matter are reported under CL as this is seen as not occurring or as very insignificant as it is only related to the small area with fruit plantations and hedges. Only above- and belowground living biomasses for perennial fruit plantations, hedgerows and willow plantations for bioenergy purposes on agricultural land are therefore reported under cropland. Christmas trees are reported under FL.

11.5.4 Factoring out

The dramatic increase in the temperature in the latter years results in a higher turn-over rate of organic matter in soils leading to an increased emission from soils compared to pre 1990. For agricultural soils Denmark is using a dynamical temperature dependent model (Tier 3), which is expected to give the best estimate of the actual emission from soils compared to most other methods. If Denmark has used the default IPCC Tier 1 or 2 there would likely have been a *negative* factoring out, because the EF in these methods are based on long-term scientific data and thus not having the recent increase in temperatures included. Therefore by using the actual temperature in the Tier 3 no factoring out has been made, on the contrary the opposite.

11.5.5 Recalculations

Some recalculations has been made due to an updated Land Use Matrix.

11.5.6 Uncertainty estimates

The uncertainty has been estimated based on the net changes in the different carbon stock with the IPCC Tier 1 methodology. The uncertainty in 2009 for Cropland Management has been estimated to ± 865.9 Gg CO_2-eqv., ± 0.3 Gg CO_2-eqv. associated with disturbance from land use change and ± 93.6 Gg CO_2-eqv. from lime application, Table 11.7, 11.8 and 11.9, respectively.

Table 11.7 Uncertainty assessment for Cropland Management.

KP B.2 Cropland Management	Emission	Activity data, %	Emission factor, %	Combined uncertainty	Total uncertainty, %	Uncertainty 95%, Gg CO_2-eqv.
Area subject to the activity, Kha	2860.0					
Area of organic soils, Kha	42.8					
Net CO_2 emissions/ removals	1183.0				73.2	865.8
Carbon stock change in above-ground biomass	-30.5	10	50	51.0	51.0	15.6
Carbon stock change in below-ground biomass	IE	10	50	51.0	-	-
Net carbon stock change in soils. mineral soils	56.7	10	75	75.7	75.7	42.9
Net carbon stock change in soils. organic soils	-348.9	10	90	90.6	90.6	315.9

Table 11.8 Uncertainty assessment for N_2O associated with land use conversion.

KP-II 3 N_2O associated from disturbance of land use change	Emission	Activity data, %	Emission factor, %	Combined uncertainty	Total uncertainty, %	Uncertainty 95%. Gg CO_2-eqv.
Land area converted, Kha	6.8					
Emission	0.4				76.5	0.3
N_2O Gg CO_2-eqv	0.4	15	75	76.5	76.5	0.3

Table 11.9 Uncertainty assessment for lime consumption.

KP-II 4 Lime consumption	Emission	Activity data, %	Emission factor, %	Combined uncertainty	Total uncertainty, %	Uncertainty 95%. Gg CO_2-eqv.
Total amount of lime applied	423550.7					
Emission	186.2				50.2	93.6
CO_2	186.2	5	50	50.2	50.2	93.6

11.5.7 Information on other methodological issues

None.

11.5.8 The year of the onset of an activity. if after 2008

Not applicable.

11.6 Grazing land management (GM)

11.6.1 Methods for carbon stock change and GHG emission and removal estimates

Grazing land is defined as land used for permanent grazing as well as dry land not meeting the definitions for FF. CL. WE or SE. GL is subdivided into two types: Land strictly used for grazing and other grassland. Land used for grazing has no wooden vegetation whereas other grassland may have some wooden vegetation that does not meet the forest definition. The area with strict grazing land is given as the area recorded as “common grassland” in the EU agricultural subsidiary system. Other grassland is estimated as the difference between the grazing land and the area classified as Grassland with remote sensing.

11.6.2 Description of the methodologies and the underlying assumptions used

As all the grazed grassland is more or less unimproved without fertiliser no changes in management practice has been applied. This is in accordance with IPCC GPG 2003 (3.4.1.2.1.2).

For land converted to GL and not purely free of wooden trees/bushes it is assumed that there is a living biomass of 2.200 kg DM per ha in above ground biomass and 6.160 kg DM per ha in below ground biomass (IPCC. 2003). In Grassland it is assumed that no changes in soil carbon stock in mineral soils are occurring. For organic soils is assumed an emission as reported in Section 7.

11.6.3 Factoring out

No factoring out has been made.

11.6.4 Recalculations

A recalculation has been made due to an updated Land Use Matrix. the new soil map of organic soils and a change in the factor for below-ground carbon in living biomass and carbon stock in mineral soils (Table 7.19 and 7.20).

11.6.5 Uncertainty estimates

The uncertainty has been estimated based on the net changes in the different carbon stock with the IPCC Tier 1 methodology. The uncertainty in 2009 for Grassland Management has been estimated to ± 125.5 Gg CO_2-eqv.

Table 11.10 Uncertainty assessment for Grassland Management.

KP B.3 Grassland Management	Emission	Activity data. %	Emission factor. %	Combined uncertainty	Total uncertainty. %	Uncertainty 95 %. Gg CO_2-eqv.
Area subject to the activity, Kha	161.8					
Area of organic soils, Kha	29.9					
Net CO_2 emissions/ removals	185.6				67.6	125.5
Carbon stock change in above-ground biomass	-6.2	10	50	51.0	51.0	3.2
Carbon stock change in below-ground biomass	IE	10	50	51.0	-	-
Net carbon stock change in soils. mineral soils	-7.3	10	75	75.7	75.7	5.5
Net carbon stock change in soils. organic soils	-37.2	10	90	90.6	90.6	33.6

11.6.6 Information on other methodological issues

None.

11.6.7 The year of the onset of an activity, if after 2008

Not applicable.

11.7 Article 3.3

11.7.1 Information that demonstrates that activities under Article 3.3 began on or after 1 January 1990 and before 31 December 2012 and are direct human-induced

The land use mapping in 1990, 2005 and again at the end of the period 2012 is the documentation that activities under Article 3.3 began after 1.1.1990. As all land area is under management all changes are evaluated as direct human induced. This also includes A and R, which are based on approved methods of establishing new forest - both planting and natural revegetation. In some cases the absence of removal of tree growth is an easy and cheap method for establishing new forest. Hence this method has also been supported through public support for establishment of new forest areas.

11.7.2 Information on how harvesting or forest disturbance that is followed by the re-establishment of forest is distinguished from deforestation

Deforestation is detected by analysis of satellite images. Furthermore deforestation of larger areas is confirmed by e.g. projects on nature restoration. Temporarily unstocked areas are typically located within larger forest areas and will in most cases be reforestated within a period of 10 years as according to the Forest Act of Denmark, which applies to all Legal Forest Reserves (Fredsskov) and equals approximately 75 % of the total forest area. Clearcuts outside forests - e.g. small plantations of conifers on former cropland - is considered deforestation.

Most forest areas - including new forest areas - are subject to intermediate thinnings - harvesting of small trees. This is done with the purpose of reducing stem number and often to produce firewood or wood chips. Clearcuts of new forest areas occours in most cases first at maturity of the stand – after 50-100 years. A subset of the new forest area are managed as coppice like management. e.g. for production of christimas trees.

11.7.3 Information on the size and geographical location of forest areas that have lost forest cover but which are not yet classified as deforested

This information will be available after the QA/QC analysis of the land use maps of 1990 and 2005, which will be performed during 2011.

11.7.4 Uncertainty on article 3.3 activities

An Tier 1 uncertainty analysis has been performed for Article 3.3 activities according to the GPG 2000. In total, the overall uncertainty in the year has been estimated to 69.57 % and the trend uncertainty to 41.06%.

Table 11.11 Uncertainty assessment for Article 3.3. activities inclusive trend uncertainty.

	Base year 1990 emission	Year 2009 emission	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
	Gg CO_2 eq	Gg CO_2 eq	%	%	%
A. Article 3.3 activities	251.55	-111.83			
KP A.1.1 Afforestation and Reforestation	10.51	-145.31	-27.94	-12.25	30,51
KP A.2 Deforestation	237.86	33.07	27.33	2.79	27,47
Total uncertainties	Overall uncertainty in the year (%):				69.57
	Trend uncertainty (%):				41.06

11.8 Article 3.4

11.8.1 Information that demonstrates that activities under Article 3.4 have occurred since 1 January 1990 and are human-induced

Forest Management

In FM all forest area is under management and changes in carbon stock are hence seen as human induced. The baseline for 1990 is estimated as documented in Johannsen et al. 2009.

Cropland Management

Since 1990 major changes in Danish Agriculture has taken place. Due to environmental demands for “green crops during winter” the previous major crop, spring barley, has been replaced by primarily winter wheat. Furthermore, a ban on field burning was implemented in January 1990 (Executive order NO. 142 of 08/03/1989). This has reduced the burning of field residues, which were widely occurring until then. Furthermore, as part of reducing the leaching of nitrogen, executive order NO. 624 of 15/07/1997 demands of the farmers that a certain percentage of the area shall be grown with an extra crop after harvest of annual crops. Currently about eight percent of the agricultural area is having an extra crop. From 2003 agricultural areas has been taken out of rotation due to demanded borders along watersheds to protect the watersheds.

Grassland Management

No specific activities have taken place in Grassland to increase or decrease the C-stock. GM was elected so that all human induced activities affecting the C-stock in the landscape are included in the Danish commitments under the Kyoto Protocol. Furthermore, it is very difficult to distinguish between activities in CM and GM in the heterogenic patchy Danish landscape.

11.8.2 Information relating to Cropland Management. Grazing Land Management and Revegetation, if elected, for the base year

No further information is available.

11.8.3 Information relating to Forest Management

No further information is available.

11.8.4 Uncertainty on article 3.4 activities

An Tier 1 uncertainty analysis has been performed for Article 3.3 activities according to the GPG 2000. In total the overall uncertainty in the year has been estimated to 159.23 % and the trend uncertainty to 79.80%.

Table 11.12 Uncertainty assessment for Article 3.4. activities inclusive trend uncertainty.

	Base year 1990 emission	Year 2009 emission	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
	Gg CO_2 eq	Gg CO_2 eq	%	%	%
B. Article 3.4 activities	2.793,00	-1.024,17			
KP B.1 Forest Management	-724,92	-2.591,13	-51,28	-19,68	54,92
KP B.2 Cropland Management	2.565,70	1.183,05	56,51	5,99	56,83
KP B.3 Grassland Management	313,65	185,64	8,06	0,94	8,12
KP-II 2 N_2O from drainage of soils	15,66	12,04	0,48	0,18	0,51
KP-II 3 N_2O associated from disturbance of land use change	3,19	0,41	0,04	0,00	0,04
KP-II 4 Lime consumption	622,92	186,24	7,41	0,47	7,42
Total uncertainties	Overall uncertainty in the year (%):				159,23
	Trend uncertainty (%):				79,80

11.9 Other information

11.9.1 Key category analysis for Article 3.3 activities and any elected activities under Article 3.4

According to the IPCC Good Practice Guidance for LULUCF a category that is identified as key in the UNFCCC inventory should also be considered key under the Kyoto Protocol (IPCC GPG. 2003).

The following LULUCF categories were identified as key categories in the UNFCCC reporting:

- Cropland remaining cropland – organic soils.
- Cropland remaining cropland – mineral soils.
- Cropland converted to forest land – conifers.
- Cropland converted to forest land – broadleaves.
- Forest land remaining forest land.

According to Table 5.4.4 in the IPCC GPG for LULUCF this means that the following Kyoto Protocol activities are initially considered key.

Table 11.13 Relationship between activities in the UNFCCC LULUCF and the KP-LULUCF.

LULUCF activity	KP-LULUCF activities
Forest land remaining forest land	FM, GM, CM
Land converted to forest land	AR
Cropland remaining cropland	CM
Grassland remaining grassland	GM

For Denmark the relevant KP-LULUCF activity corresponding to forest land remaining forest land identified as being a key category in the UNFCCC reporting is FM. For land converted to forest afforestation/reforestation is a key category. For cropland remaining cropland the relevant KP-LULUCF activity is CM. For grassland remaining grassland the relevant KP-LULUCF activity is GM.

Therefore AR, FM, CM and GM are considered key categories in the Danish KP-LULUCF inventory.

For the full list of identified key categories please refer to Annex 1.

11.10 Information relating to Article 6

There are no Article 6 projects (Joint Implementation) on the Danish territory.

12 Information on accounting of Kyoto units

Referring to Decision 15/CMP.1 on Guidelines for the preparation of the information required under Articles 7 of the Kyoto Protocol (UNFCCC, 2006), this chapter and chapters 14 and 15 include information and references to Denmark's and Greenland's annual non-inventory information under the Kyoto Protocol.

12.1 Background information

In accordance with paragraph 10 of the annex to Decision 15/CMP.1 information on emission reduction units, certified emission reductions, temporary certified emission reductions, long-term certified emission reductions, assigned amount units and removal units will be reported for the first calendar year in which these units will be transferred or acquired.

12.2 Summary of information reported in the SEF tables

The information required is contained in the UNFCCC Standard Electronic Format (SEF) application version 1.2.1. Since the last submission the interpretation of the EU Registry Regulation has changed and Denmark now allows for the full set of SEF tables to be published. The decision to submit the full SEF report was taken after consultation with the EU Commission. The decision used the argument that the SEF report contains aggregated data which is not regulated under EU law.

12.3 Discrepancies and notifications

Annex 1 parties are also required to submit four reports according to paragraphs 12 to 16 of the annex to decision 15/CMP.1. These reports are:

- Paragraph 12 – List of discrepancies identified by the ITL.
- Paragraph 13/14 – List of notifications from the CDM Executive Board regarding lCERs.
- Paragraph 15 – List of non-replacement identified by the ITL.
- Paragraph 16 – List of invalid Kyoto units.

The list described in paragraph 12 is contained in Annex 6 as "Report – List of discrepancies identified by the ITL according to paragraph 12 of the annex to decision 15/CMP.1".

The lists described in paragraph 13-15 are not included in this NIR, as there are no tCERs or lCERs in the Danish Registry. For paragraph 16, the Danish Registry has yet to receive invalid Kyoto units. This also renders this list unnecessary to submit. The discrepancies have been found in the daily reconciliation and have all been solved by manual intervention by either the Danish Registry or the CITL/ITL depending on which stage the transaction was in.

12.4 Publicly accessible information

Information to be publically available from the SEF is included in Annex 6 (SEF 2011 Denmark). The SEF report that is attached in Annex 6 will also be publically available on the Danish Energy Agency website (http://www.ens.dk/en-US/ClimateAndCO2/emissiontradingscheme/DETR/Sider/Forside.aspx).

Other information that is required to be publically available can be found on the Danish Energy Agency's registry website: https://www.kvoteregister.dk/

This information includes information on each account as required in paragraph 45 of the annex to Decision 13/CMP.1. Please note that the contact information (paragraph 45 (e)) requires the consent of the account holder according to EU law. Thus, all of this information is not publically available.

Information on article 6 projects is not available as the Denmark to this date has not approved any Joint Implementation projects in Denmark.

12.5 Calculation of the commitment period reserve

The calculation of the Commitment Period Reserve (CPR) is based on the assigned amount of 276,838,955 tonnes of CO_2 equivalents. Subsequently, the CPR calculated as 90 % of the assigned amount is 249,155,060 tonnes CO_2 equivalent, during the commitment period and has not changed since the Report of the review of the initial report of Denmark published on 2 November 2007. The commitment period reserve has not changed since the previous submission, as 100 % times the most recent inventory times five would amount to a higher value.

The software still checks if the CPR is respected before a transaction from the Danish Registry can be carried out.

The CR Software that the Danish Emission Trading Registry is using as registry software was approved by the UNFCCC in the Independent Assessment Report the 16th of October 2007. Changes in the software have not been of a significance that has required a new Independent Assessment Report and software testing since then.

12.6 KP-LULUCF accounting

At the time of preparation for this report Denmark had not issued RMUs. According to the ARR for Denmark's 2010 submission 288,245 RMUs shall be issued. Denmark has recalculated the inventory for 2008 in the 2011 submission.

Referring to the KP-LULUCF inventory (Denmark and Greenland) the accounting quantity is 3,776,790 tonnes CO_2 equivalent as RMUs on the basis of activities in 2008 and 2009 under Articles 3.3 and 3.4 of the Kyoto Protocol.

The accounting of RMUs based on the 2011 submission will not begin until after publication of the review report from the review of the NIR 2011.

Table 12.1 Information on accounting for activities under articles 3.3 and 3.4 of the Kyoto Protocol.

Greenhouse gas source and sink activities	Base year	Net emissions/-removals 2008	2009	Total	Accounting Parameters	Accounting Quantity
		(Gg CO_2 equivalent)				
A. Article 3.3 activities						
A.1. Afforestation and Reforestation						-190.38
A.1.1. Units of land not harvested since the beginning of the commitment period		-45.07	-145.31	-190.38		-190.38
A.1.2. Units of land harvested since the beginning of the commitment period						IE.NO
Denmark		IE. NO	IE. NO	IE.NO		IE.NO
A.2. Deforestation		32.44	33.48	65.92		65.92
B. Article 3.4 activities						
B.1. Forest Management		-4816.98	-2579.13	-7396.11		-916.67
3.3 offset					0.00	0.00
FM cap					916.67	-916.67
B.2. Cropland Management	3188.62	2530.16	1369.30	3899.46	6377.23	-2477.77
B.3. Grazing Land Management	313.20	184.35	184.17	368.52	626.41	-257.89
Total[1]		-1716.61	-2060.18			-3776.79

[1] The FM cap is fully accounted in 2008.

Table 12.2 shows the average accounting quantity for 2008 and 2009.

Table 12.2 Annual average accounting quantity, Gg CO_2 equivalent.

	Average for 2008-2009
Afforestation and Reforestation	-95,19
Deforestation	32,96
Forest Management	-183,33[1]
Cropland Management	-1238,89
Grazing Land Management	-128,95
Total	-1613,39

[1] Calculated as the FM cap divided by five.

References

EC, 2004: COMMISSION REGULATION (EC) No 2216/2004 of 21 December 2004 for a standardised and secured system of registries pursu-

ant to Directive 2003/87/EC of the European Parliament and of the Council and Decision No 280/2004/EC of the European Parliament and of the Council. Available at:
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:386:0001:0077:EN:PDF

DEA, 2010: Publically available information on the Danish Energy Agency's Registry website. Available at:
https://www.kvoteregister.dk/reportTransactionInformation.do

DEA, 2010: Publically available information on the on the Danish Energy Agency's general website. Available at:
http://www.ens.dk/en-US/ClimateAndCO2/emissiontradingscheme/DKemissiontradingagency/Sider/Forside.aspx

UNFCCC, 2006: Report of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol on its first session, held at Montreal from 28 November to 10 December 2005. Available at:
http://unfccc.int/resource/docs/2005/cmp1/eng/08a02.pdf

UNFCCC, 2007: Report of the review of the initial report of Denmark. Available at: http://unfccc.int/resource/docs/2007/irr/dnk.pdf

13 Information on changes in the national system

Since the previous submission (NIR2010) there have been two changes to the national system.

A new updated data delivery agreement with the Danish Energy Agency has been signed. This agreement ensures NERI timely access to the necessary data to estimate emissions from the energy sector.

During the UNFCCC review of Denmark's 2010 submission, a new data agreement was signed between NERI and the Government of Greenland. This agreement ensures NERI receives the relevant data and documentation from the Government of Greenland in order to ensure a timely submission to the UNFCCC.

14 Information on changes in the national registry

Referring to paragraph 22 of the annex to Decision 15/CMP.1, information on any changes that have occurred in the national registry, compared with information reported in the last submission should be included in this report.

The Danish Emission Trading Registry is updated and the software is continuously patched in an ongoing effort to make the registry as safe and secure as possible. One thing of special notice is the work that has been carried out in 2010 on the development of a 2 factor security system in the Registry. The first factor is login via a personal password for each registry user. The second factor is a login via a code, which the registry user has received by sms to a single telephone number which is connected to the user account. This new 2 factor security system was implemented in February 2011.

15 Information on the minimization of adverse impacts in accordance with Article 3, paragraph 14

Referring to paragraph 23 of the annex to Decision 15/CMP.1, information on how Denmark is striving to implement commitments under the Kyoto Protocol in such a way to minimize adverse social, environmental and economic impacts on developing country Parties, particularly those identified in Article 4, paragraphs 8 and 9, of the Convention is included in this chapter.

In connection with Denmark's contribution to international climate efforts, in accordance with the Kyoto Protocol Denmark will endeavour to implement policies and measures under article 3 of the Protocol in such a way that adverse effects in other countries are minimised. However, Denmark does not consider that its contributions to international climate efforts have adverse effects in other countries as, on the contrary, the reduction of emissions of greenhouse gases in Danish commitments under the Protocol will in fact contribute to limiting dangerous climate change in all countries.

If nothing is done to limit emissions of greenhouse gases, climate scenarios from the IPCC indicate that developing countries in particular will experience the greatest changes in climate.

In its international efforts, Denmark will therefore continue to take the greatest possible account of special needs and concerns of developing countries and especially least developed countries. This also applies to adverse effects which can already be ascertained from changes in the climate. The existing strong Danish focus on the special vulnerability of developing countries to climate change underlines this as further described below.

15.1 Assistance to developing country parties particularly vulnerable to climate change

The least developed countries are among the countries that are most vulnerable to climate change. Denmark therefore attaches particular importance to helping these countries adapt to climate change. A natural consequence of this is that Danish programme cooperation countries are among the least developed countries and/or the most vulnerable countries.

The climate screenings performed under the Climate Change and Development Action Programme are important instruments in ensuring that the most vulnerable countries and communities are assisted in an appropriate and integrated manner. The studies were carried out in 17 countries (programme countries and Niger and Cambodia) from December 2005 to June 2008. The 17 studies include critical information about the impact of climate change and constitute a first step to "operationalising climate proofing" of Danish bilateral development assistance. Although this form of "climate proofing" was only one of several elements in the action programme, it is the area that has been most intensively in focus since 2005.

Probably the most important issue emerging from the studies concerns the uncertainty about trends in temperature, rainfall patterns and "extreme events" and the impact of climate change on economic growth and poverty reduction. In this context, the CCS studies emphasised the need to improve knowledge, awareness and information at regional, national and community levels, through enhanced climate data collection and analysis, refined scenarios and "downscaling" climate models to specific countries and regions. There is still a lot to learn and understand about the impact of climate change.

The projects launched based on the screenings were related to capacity building, mainstreaming of climate change, forest management, strengthening the link between climate change adaptation and disaster risk reduction as well as coastal and water resource management. The largest support to till date to a vulnerable country is the climate change adaptation and mitigation programme in Vietnam of 200 Mill. DKK. One third of the grant is allocated to climate change mitigation through energy efficiency and the remaining part is allocated to support the climate change adaptation.

15.2 New initiatives

Starting from 2008 the Danish government has allocated specific climate funds through the so-called Climate Pool. The total amount frame was in 2008 100 Mill.DKK, of which approximately 88 mill. DKK was allocated to specific climate change projects. As shown in Table 15.1 the projects cover issues such as adaptation, mitigation, participation of developing countries in UNFCCC negotiations, civil society capacity building, participation and dialogues as well as climate diplomacy.

Table 15.1: Climate Pool Commitments 2008 (DKK mill.).

Category	Commitment 2008 Million DKK
Climate Change Adaptation	16.0
Climate Change Mitigation, forestry	25.0
Developing countries participation in UNFCCC negotiations	23.7
Greenland Dialog	1.8
Civil society	8.0
Climate Diplomacy	8.0
In total incl. administration	87.7

Source: The Ministry of Foreign Affairs

As part of the financial promises that were given to developing countries at COP15 in Copenhagen in December 2009, the EU has subsequently announced that it would contribute 7.2 billion Euro in the period 2010 - 2012 (out of industrialized countries' total initial funding pledges 30 billion USD for the period 2010-2012). As part of this, Denmark announced as one of the first countries clearly a contribution of 1.2 billion DKK implementation of the accelerated climate financing.

The Danish contribution is financed by funds from the continued Climate Pool and will be balanced for sharing between mitigation and adaptation efforts, as implemented in cooperation with multilateral and bilateral partners. Emphasis is placed on the civil society and the private sector involved and there was planned in 2010 for greater bilateral initiatives for implementation in 2011-12.

At COP16 in December 2010 the Danish minister for climate and energy, on behalf of the Danish government, launched the following projects funded under the Climate Pool:

- support for the federation of Small Island Developing States (SIDS) for the development and implementation of reduction and adaptation efforts;
- support for the implementation of Nationally Appropriate Mitigation Actions (NAMAs) in a number of major developing countries;
- support for the encouragement of private sector investment in energy efficiency and renewable energy in emerging economies among developing countries through a fund deposits with mixed public and the private investor participation; and
- collaboration with the South Korean Global Green Growth Institute (GGGI) implementing various emission reduction projects through sustainable growth plans in selected developing countries.

15.3 EU-wide climate policies and measures

This section provides information on how Denmark through its role as a member state in the EU is also supporting the implementation of the commitments under Article 3, paragraph 14 of the Kyoto Protocol. The EU is well aware of the need to assess impacts, and has built up thorough procedures for EU-wide policies and measures in line with our obligations. This includes bilateral dialogues and different platforms in which the EU interact with third countries, explain new policy initiatives and receive comments from third countries.

Impacts on third countries are mostly indirect and can frequently neither be directly attributed to a specific EU policy, nor directly measured by the EU in developing countries. Therefore, the reported information covers potential adverse social, environmental and economic impacts that result from complex assessments of indirect influences and that are based on accessible data sources in developing countries.

15.3.1 Impact assessment of EU policies

In the EU a wide-ranging impact assessment system accompanying all new policy initiatives has been established. This regulatory impact assessment is a key element in the development of the Commission's legislative proposals. The Commission is required to take the impact assessment reports into account when taking its decisions, while the impact assessments are also presented and discussed during the scrutiny of legislative proposals from the Council and the Parliament. This approach ensures that potential adverse social, environmental and economic impacts on various stakeholders (in the case on developing country Parties) are identified and minimized within the legislative process. In general, impact assessments are required for all legislative proposals, but also other important Commission initiatives which are likely to have far-reaching impacts. Below the impact assessment process implemented in the EU policy making is explained in more detail in order to better demonstrate how the EU is striving for all strategies and policies to minimize their adverse impacts. Specific guidelines for the impact assessment have been adopted (European Commission 2009).

The Impact Assessment Guidelines specifically address impacts on third countries and also issues related to international relations. In this area the following questions have to be assessed:

- Trade relations with third countries: some policies may affect trade or investment flows between the EU and third countries; the impact assessment should analyse how different groups (foreign and domestic businesses and consumers) are affected, and help to identify options which do not create unnecessary trade barriers.
- Impact on WTO obligations: it should be analysed which impact each proposed policy option has on the international obligations of the EU under the WTO Agreement; the impact assessment should examine whether the policy options concern an area in which international standards exist.
- Impacts on developing countries: initiatives that may affect developing countries should be analysed for their coherence with the objectives of the EU development policy. This includes an analysis of consequences (or spill-overs) in the longer run in areas such as economic, environmental, social or security policies.

Key economic questions to be assessed in relation to third countries are:

- How does the policy initiative affect trade or investment flows between the EU and third countries? How does it affect EU trade policy and its international obligations, including in the WTO?
- Does the option affect specific groups (foreign and domestic businesses and consumers) and if so in what way?
- Does the policy initiative concern an area in which international standards, common regulatory approaches or international regulatory dialogues exist?
- Does it affect EU foreign policy and EU development policy?
- • What are the impacts on third countries with which the EU has preferential trade arrangements?
- Does it affect developing countries at different stages of development (least developed and other low-income and middle income countries) in a different manner?
- Does the option impose adjustment costs on developing countries?
- Does the option affect goods or services that are produced or consumed by developing countries?

Key questions on social impacts in third countries are:

- Does the option have a social impact on third countries that would be relevant for overarching EU policies, such as development policy?
- Does it affect international obligations and commitments of the EU arising from e.g. the ACP-EU Partnership Agreement or the Millennium Development Goals?

- Does it increase poverty in developing countries or have an impact on income of the poorest populations?

Key questions on environmental impacts in relation to third countries are:

- Does the option affect the emission of greenhouse gases (e.g. carbon dioxide, methane etc) into the atmosphere?
- Does the option affect the emission of ozone-depleting substances (CFCs, HCFCs etc)?
- Does the option affect our ability to adapt to climate change?
- Does the option have an impact on the environment in third countries that would be relevant for overarching EU policies, such as development policy?

If third countries are likely to be affected, the impact assessment should analyse in greater detail what the specific impacts may be, how undesired effects can be avoided or minimised, or mitigated, how the policy options compare in this respect and what trade-offs have to be addressed in the final policy choice.

Consulting interested parties is an obligation for every impact assessment and all affected stakeholders should be engaged, using the most appropriate timing, forma and tools to reach them. Appropriate consultation tools can be consultative committees, expert groups, open hearings, ad hoc meetings, consultation via Internet, questionnaires, focus groups or seminars/workshops. Existing international policy dialogues are also be used to keep third countries fully informed of forthcoming initiatives, and as a means of exchanging information, data and results of preparatory studies with partner countries and other external stakeholders.

The EU's recent 5th national communication provides a detailed overview of the European policies and measures to mitigate GHG emissions in all sectors. All key strategies and climate policies have been subject to impact assessments as described above. All impact assessments and all opinions of the Impact Assessment Board are published online (see http://ec.europa.eu/governance/impact/ia_carried_out/cia_2010_en.htm). In addition to the general approach described above to address adverse social, environmental and economic impacts, more specific ways to minimize impacts depend on the respective policies and measures implemented. As the reporting obligation related to Article 3, paragraph 14 does not include an obligation to report on each specific mitigation policy, the EU choses the approach to provide some specific examples for a more complete overview on the ways how the EU is striving to minimize adverse impacts.

Two major EU policies, the Directive on the promotion of the use of renewable energy (Directive 2009/28/EC as well as the extension of the EU emission trading scheme (ETS) to the aviation sector (Directive 2008/101/EC) are presented in more detail as examples in this chaper, because the related impact assessments identified potential impacts on third countries.

Example 1: Directive on the promotion of the use of renewable energy - Promotion of biomass and biofuels

The Directive on renewable energy (Directive 2009/28/EC), a part of the EU's climate and energy package, sets ambitious targets for all Member States, such that the EU will reach a 20% share of energy from renewable sources in the overall energy consumption by 2020 (with indivudal targets for each Member State) and a 10% share of renewable energy specifically in the transport sector, which includes biofuels, biogas, hydrogen and electricity from renewables. Biomass is one of the renewable energy sources promoted by this directive and biofuels will be important for the achievement of the renewable target in the transport sector.

The impact assessments related to enhanced biofuel and biomass use in the EU showed that the cultivation of energy crops have both potential positive and negative impacts. Positively, as the growing of EU demand for bioenergy generates new export revenues and employment opportunities for developing countries and boosts rural economies. Thus there could be clear economic and social benefits. At the same time, the new EU energy crop demand could increase the impact on biodiversity, soil and water resources and can have positive as well as negative effects on air pollutants. The extent of carbon reduction and other environmental effects from the promotion of biofuels can vary according to the feedstock employed, the way the feedstock and the biofuels are produced, how they are transported and how far. Growing future demand for biomass feedstock combined with growing global food consumption could add to the agricultural sector's pressure on land use and result in adverse land use change.

To address the risk of such adverse impacts, Article 17 of the EU's Directive on renewable energy sources creates pioneering "sustainability criteria", applicable to all biofuels (biomass used in the transport sector) and bioliquids. The sustainability criteria adopted are:

- establish a threshold for GHG emission reductions that have to be achieved from the use of biofuels,
- exclude the use of biofuels from land with high biodiversity value (primary forest and wooded land, protected areas or highly biodiverse grasslands),
- exclude the use of biofuels from land with high C stocks, such as wetlands, peatlands or continuously forested areas.

Developing country representatives as well as other stakeholder were extensively consulted during the development of the sustainability criteria and preparation of the directive and the extensive consultation process has been documented.

The Directive also ensures that the Commission will report every two years, in respect to both third countries and Member States which constitute a significant source of biofuels or of raw material for biofuels consumed within the Union, on national measures taken to respect the sustainability criteria for soil, water and air protection.

The criteria pursuant to Article 17 apply to biofuels and bioliquids, not to solid biomass which is also promoted by the Directive. With regard to the energy use of all biomass forms, Article 17, paragraph 9 of the Directive requires the Commission to report on "requirements for a sustainability scheme for energy uses of biomass, other than biofuels and bioliquids, by 31 December 2009." A Commission communication on biomass sustainability including an impact assessment is forthcoming.

The Directive also required the Commission to examine and report on the potential adverse impact of biomass consumption and the need for sustainability criteria. This report and associated impact assessment addresses these issues (http://ec.europa.eu/energy/renewables /transparency_platform/transparency_platform_en.htm) and finds that as the overwhelming bulk of biompass energy is derived from European sources there is no need for sustainability criteria.

The Commission will also report on biofuels' potential indirect land use change effect and the positive and negative impact on social sustainability in the Union and in third countries, including the availability of foodstuffs at affordable prices, in particular for people living in developing countries, and wider development issues. Reports shall address the respect of land-use rights. The first reports will be submitted in 2012.

The EU's biofuel sustainability criteria form the first global initiative to address the climate change and sustainability issues surrounding crop production.

The biofuels scheme, by imposing environmental standards and requiring high greenhouse gas savings (35% rising to 60%), put also pressure on the production of the raw materials used for other purposes. Some examples of voluntary sustainability scheme out of the biofuels field are in the pipeline.

Any negative economic aspects will also be monitored by the Commission. In addition, Article 18(4) of the Directive provides that the Community shall endeavour to conclude bilateral or multilateral agreements with third countries containing provisions on sustainability criteria that correspond to those of this Directive. Where the Community has concluded agreements containing provisions relating to matters covered by the sustainability criteria set out in Article 17(2) to (5), the Commission may decide that those agreements demonstrate that biofuels and bioliquids produced from raw materials cultivated in those countries comply with the sustainability criteria in question.

In addition to the sustainability criteria, several initiatives have been taken to better channel and control biofuel and biomass expansion and thereby mitigate the most serious effects. With respect to palm oil production, the Roundtable on Sustainable Palm Oil (RPSO), an initiative by WWF, producers, traders and other NGOs, has recently announced the adoption of a set of criteria for the responsible production of palm oil, which would allow palm oil production without affecting the sustainability of tropical forests and endangered species. Other similar private and public initiatives will follow for other sectors and regions.

Another way the EU will strive to minimize potential adverse impacts of biomass use is to promote second generation biomass technologies. Within the renewable energy Directive, second generation biofuels are promoted through Article 21, paragraph 2 which establishes that the contribution made by biofuels produced from wastes, residues, non-food cellulosic material, and ligno-cellulosic material shall be considered to be twice that made by other biofuels for the purposes of demonstrating compliance with national renewable energy targets; and EU research also has a major focus on bioenergy technologies. The goal of second generation biofuel processes is to extend the amount of biofuel that can be produced sustainably by using biomass consisting of the residual non-food parts of current crops, such as stems, leaves and husks that are left behind once the food crop has been extracted, as well as other crops that are not used for food purposes (non food crops) and also industry waste such as woodchips, skins and pulp from fruit pressing. Second generation biofuels are expected to expand the biomass feedstock available for biofuel production. Further research and impact assessments in this area are necessary to assess e.g. the long-term effects of the energy use of non-food parts of crops compared to their existing use.

Example 2: Inclusion of aviation in the EU emission trading scheme

In 2005 the Commission adopted a Communication entitled "Reducing the Climate Change Impact of Aviation", which evaluated the policy options available to this end and was accompanied by an impact assessment. The impact assessment concluded that, in view of the likely strong future growth in air traffic emissions, further measures are urgently needed. Therefore, the Commission decided to pursue a new market-based approach at EU level and included aviation activities in the EU's scheme for greenhouse gas emission allowance trading. The finally adopted legislation was the result of an extensive stakeholder consultation including an internet consultation and an Aviation Working Group of experts set up as part of the European Climate Change Programme that identified the integration of aviation in the EU ETS as the lowest cost option to address the challenge of reducing emissions from this sector. The impact assessment also specifically addressed the effects on developing countries (European Commission 2006).

Aircraft operators from developing countries will be affected to the extent they operate on routes covered by the scheme. Data from Eurocontrol on the nationality of operators has been used to make an estimate of the aggregated costs for third country airlines from regions that include developing countries. As operators from third countries generally represent a limited share of emissions covered, the impact is also modest. For example, the total additional operating costs for all operators based in Africa would, at current activity levels, vary from €2 to €35 million per year depending on allowance prices and the share of allowances auctioned. In terms of the economic impacts, a larger proportion of the compliance costs would naturally be borne by carriers from Annex I countries as they generally have a higher market share on the routes covered. However, carriers from developing countries that are able to operate in competition with Annex I carriers on such routes would need to be covered in order to avoid a) distortions of competition and b) discrimination as to nationality in line with the Chicago Convention.

For carriers with relatively old and inefficient fleets the impact may be higher as the effective proportion of allowances acquired for free through benchmarking is lower. However, as third country airlines would generally only have a fraction of their fleet operating in Europe, they may in some cases be able to reduce any negative effects by shifting their most efficient aircraft to operate on routes covered by the scheme.

To the extent that aviation's inclusion in the EU ETS creates additional demand for credits from JI and CDM projects, there will also be indirect positive effects as such projects imply additional investments in clean technologies in developing countries.

Similarly, additional finance for climate change mitigation and adaptation in developing countries should be raised through the auction of emissions allowances by EU Member States. The legislation provides a list of such areas by which the Member State should use the monies raised, and specifically mentions use for adaptation in developing countries.

There are further opportunities for developing countries to increase the demand for both CDM credits and future forms of sectoral mechanisms. The EU ETS legislation anticipates that third countries will take equivalent measures covering all flights departing their territory for the EU. In such circumstances, when equivalent measures are taken, the scope of the EU scheme can be reduced with the exclusion of these flights. Developing countries can thus benefit from additional demand for credits over and above the quantity that is allowed already for compliance by participants in the EU ETS.

15.3.2 Information on how the EU gives priority, in implementing the commitments under Article 3, paragraph 14, to specific actions

The EU reports activities that are related to the actions specified in the subparagraphs (a) to (f) of paragraph 24 of the reporting requirements in the Annex to decision 15/CMP.1. However, no decision was agreed yet that these actions form part of the commitment under Article 3, paragraph 14. For some of the actions specified in the reporting requirements, it seems rather unclear how they relate to the minimization of adverse social, environmental and economic impacts resulting from policies and measures to mitigate GHG emissions, e.g. information related to the cooperation activities requested are activities that help both Annex I and Non-Annex I Parties in reducing emissions from fossil fuel technologies, but they do not directly address the minimization of potential adverse impacts in Annex I Parties.

For the purposes of completeness in reporting, the all subparagraphs specified in the subparagraphs (a) to (f) of paragraph 24 of the reporting requirements in the Annex to decision 15/CMP.1 are addressed below. However the main ways how the EU is striving to minimize adverse impacts are described in the previous section.

a) The progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions and subsidies in all greenhouse-gas-emitting sectors, taking into account the need for energy price reforms to reflect market prices and externalities

The actions addressed in subparagraph a) also form part of the commitment to implement policies and measures requested under Article 2, paragraph 1(a) (v), however Article 2 specifies that Annex I Parties shall "implement and/or further elaborate policies and measures in accordance with national circumstances, such as progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions and subsidies in all greenhouse gas emitting sectors that run counter to the objective of the Convention and application of market instruments.” Subparagraph a) in the reporting requirements lacks such objective and therefore seems somewhat inconsistent with the commitment under Article 2. The promotion of research, demonstration projects, fiscal incentives or carbon taxes is important instrument to advance the objectives of the Convention, e.g. the use of renewable energies. A progressive reduction of all fical incentives or subsidies in all GHG emitting sectors would run counter the objective of the Convention and counter the ability of the EU to meet its commitment under Article 3, paragraph 1 of the Kyoto Protocol. Therfore the EU interprets this reporting requirement in a way consistent with Article 2 paragraph 1(a)(v) that the EU should focus on the progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions and subsidies that run counter the objectives of the Convention and application of market instruments.

The 2009 Review of the EU Sustainable Development Strategy assesses that "the Commission has been mainstreaming the progressive reform of environmentally harmful subsidies into its sectoral policies". For instance, environmental concerns have been gradually incorporated into the EU Common Agricultural Policy, including "decoupled" direct payments which have replaced price support; environmental cross compliance; a substantial increase in budget for rural development. As part of 2008 Common Agriculture Policy Health Check, additional part of direct aid has been shifted to climate change, renewable energy, water management, biodiversity, innovation; - transparency of agricultural subsidies has improved. It is important to note that in the other areas most subsidies are within the competence of the Member States and not of the EU, within the limits established by EU state aid rules.

EU policies aim to address market imperfections and to reflect externalities. For example the EU has made significant efforts to liberalise the internal energy market and to create a genuine internal market for energy as one of its priority objectives. The existence of a competitive internal energy market is a strategic instrument both in terms of giving European consumers a choice between different companies supplying gas and electricity at reasonable prices, but also in terms of making the market accessible for all suppliers, especially the smallest and those investing in renewable forms of energy.

With the implementation of the EU Emissions Trading Scheme, the EU uses a market instrument to implement the objective of the Convention and its commitment under Article 3, paragraph 1 of the Kyoto Protocol which aims at creating the right incentives for forward looking low carbon investment decisions by reinforcing a clear, undistorted and long-term carbon price signal.

With respect to financial support provided by the Member States to undertakings, the EU Treaty pronounces a general prohibition of "State aid". This concept encompasses a broad range of financial support measures adopted at national or sub-national level (i.e. not at EU level), and which can take various forms (subsidies, tax relieves, soft loans…). The

Treaty provides for exceptions to this general prohibition. When State aid measures can contribute in an appropriate manner to the furtherance of objectives of common interest for the EU, and provided that they comply with certain strict conditions, they may be authorised by the Commission. By complementing the fundamental rules through a series of legislative acts and guidelines, the EU has established a worldwide unique system of rules under which State aid is monitored and assessed in the European Union. This legal framework is regularly reviewed to improve its efficiency. EU State aid control is an essential component of competition policy and a necessary safeguard for effective competition and free trade.

State aid reform in the EU aims to redirect aid to objectives of common interest which are related to the EU Lisbon Treaty, such as R&D&I, risk capital measures, training, and environmental protection. Environmental protection, and in particular, the promotion of renewable energy and the fight against climate change, is considered one of the objectives of common interest for the EU which may, under certain circumstances, justify the granting of State aid.

Specific "Community Guidelines on State aid for Environmental Protection"[31] have been established. The Guidelines foresee in particular the possibility to authorise the following types of State aid under certain conditions:

- Aid for undertakings which go beyond EU environmental standards or which increase the level of environmental protection in the absence of EU standards
- Aid for early adaptation to future EU standards
- Aid for energy saving
- Aid for renewable energy sources
- Aid for high-efficient cogeneration
- Aid for energy-efficient district heating (DH).

Directive 2003/96/EC on the taxation of energy products and electricity establishes EU-wide rules for the taxation of energy products used as motor or heating fuel, taxes on energy consumption, and common minimum levels of taxation. Under certain conditions the Directive allows for exemptions or reductions to promote renewable sources of energy. Thus, the tax exemptions allowed under this directive further promote the objectives of the Kyoto Protocol.

b) Removing subsidies associated with the use of environmentally unsound and unsafe technologies

There is no clear definition of environmentally unsound and unsafe technologies. However, in the context of the KyotoProtocol, unsound and unsafe technologies could be interpreted as those increasing GHG emissions.

Council Regulation (EC) No 1407/2002 on State Aid to the Coal Industry lays down rules for granting state aid with the aim of contributing to restructuring of the coal industry. The regulation expires at 31st December 2010. The provision of state aid is limited to the following activities:

[31] Official Journal No C 82, 1.4.2008, p.1

- Aid for reduction of activity where the production units receiving aid from part of a closure plan with a final deadline of 31 December 2007;
- Aid for maintaining access to coal reserves;
- Aid to cover exceptional costs arising from rationalisation and restructuring that are not related to current production such as environmental rehabilitation and social costs.

The authorised aid has to follow a downward trend and for the EU 15 it shall not exceed for any year after 2003 the amount authorised for 2001. A separate baseline of aid authorised in 2004 is set as the ceiling for the ten new Member States. Thus, state aid provided to the coal industry has to be and is being continuously reduced. Where aid is provided under this regulation it must not result in delivered prices for the EU coal being lower than the prices of coal of similar quality from third countries. In this respect the state aid provided will not have adverse economic impacts on developing countries being coal exporters.

The phase-out of subsidies to fossil fuel production and consumption by 2010 was also one of the objectives in the Communication from the Commission "A Sustainable Europe for a Better World: A European Union Strategy for Sustainable Development (Commission's proposal to the Gothenburg European Council, 2001)"[32].

c) Cooperating in the technological development of non-energy uses of fossil fuels, and supporting developing country Parties to this end;

The technological development of non-energy uses of fossil fuels is not a current research priority in the EU, nor a priority of cooperation with developing countries because the EU is not a major producer of oil and gas. Given the long-term depletion of fossil fuel resources and the decline in coal production, the EU's priority in general is the replacement of the use of fossil fuels by renewable resources.

d) Cooperating in the development, diffusion, and transfer of less-greenhouse-gas-emitting advanced fossil-fuel technologies, and/or technologies, relating to fossil fuels, that capture and store greenhouse gases, and encouraging their wider use; and facilitating the participation of the least developed countries and other non-Annex I Parties in this effort;

In March 2005, the EU and China signed an Action Plan on Clean Coal, which included cooperation on carbon capture and storage. The subsequent 2005 EU-China Summit established the EU-China Climate Change Partnership, which includes a political commitment to develop and demonstrate in China and the EU advanced, near-zero emissions coal (NZEC) technology through carbon capture and storage (CCS) by 2020. Phase I of this cooperation will be completed in 2009. Phase II of NZEC will run from 2010-2012. It will examine the site-specific requirements for and define in detail a demonstration plant and accompanying measures. It will include the technical and cost analysis of different options. Based on this analysis, the site of the power plant as well as the combustion technology (pulverised coal or IGCC), the capture technology and the transport and storage concepts will be determined. Phase II shall also include a detailed roadmap for the construction and operation of the dem-

[32] See
http://eur-lex.europa.eu/LexUriServ/site/en/com/2001/com2001_0264en01.pdf

onstration plant as well as an Environmental Impact Assessment of the demonstration power plant and the carbon storage site. Phase III should commence thereafter and will see the construction and operation of a commercial-scale demonstration plant in China.

The Communication from the Commission entitled "Demonstrating Carbon Capture and Geological Storage (CCS) in emerging developing countries: financing the EU-China Near Zero Emissions Coal Plant project" from June 2009 sets out the plan of the European Commission to establish an investment scheme to co-finance the construction and operation of a power plant to demonstrate carbon capture and storage (CCS) technology in China. This investment scheme could serve as a model for other technology cooperation activities between developed countries and emerging/developing countries in the context of a post-2012 climate change agreement.

The EU is also cooperating with other Annex I and Non-Annex I Parties (Brazil, Saudi Arabia, China, Colombia, India, Korea, Mexico and South Africa) in the "Carbon Sequestration Leadership Forum (CSLF)". The CSLF is a Ministerial-level international climate change initiative that is focused on the development of improved cost-effective technologies for the separation and capture of carbon dioxide (CO2) for its transport and long-term safe storage. The mission of the CSLF is to facilitate the development and deployment of such technologies via collaborative efforts that address key technical, economic, and environmental obstacles. The CSLF will also promote awareness and champion legal, regulatory, financial, and institutional environments conducive to such technologies[33].3

e) Strengthening the capacity of developing country Parties identified in Article 4, paragraphs 8 and 9, of the Convention for improving efficiency in upstream and downstream activities relating to fossil fuels, taking into consideration the need to improve the environmental efficiency of these activities

In the oil and gas industry the upstream sector is a term commonly used to refer to the exploration, drilling, recovery and production of crude oil and natural gas. The downstream sector includes the activities of refining, distillation, cracking, reforming, blending storage, mixing and shipping and distribution.

The EU contributes to strengthening of the capacities of fossil fuel exporting countries in the areas of energy efficiency via the work of the Energy Expert Group of the Gulf Cooperation Council (GCC)[34], in particular in the working sub-group on energy efficiency. As part of the EU's research programme, a project called "EUROGULF" was launched with the objective of to analyse EU-GCC relations with respect to oil and gas issues and propose new policy initiatives and approaches to enhance cooperation between the two regional groupings.

The European e-network on clean energy technologies, currently under development as part of the EU's research and development, is also aiming at the objective: promote research and technical development of

[33] See http://www.cslforum.org/ for more specific information.

[34] The Gulf Cooperation Council covers Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates.

clean energy technologies in the GCC countries. The Commission has recently started a project with the specific objective to create and facilitate the operation of an EU-GCC Clean Energy Network during the next three years. The network is to be set up to act as a catalyst and element of coordination for development of cooperation on clean energy.

Energy efficiency activities in the upstream or downstream sector are also candidates for CDM projects. Thus, the development of the CDM under the Kyoto Protocol and the demand of CERs by Annex I Parties under the Kyoto Protocol as well as by operators under the EU ETS have fostered such activities performed by the private sector. Related CDM projects are for example:

- Rang Dong Oil Field Associated Gas Recovery and Utilization Project in Vietnam: The purpose of this project activity is the recovery and utilization of gases produced as a by-product of oil production activities at the Rang Dong oil field in Vietnam with the involvement of ConocoPhillips (UK).
- Recovery of associated gas that would otherwise be flared at Kwale oil-gas processing plant in Nigeria involves the capture and utilisation of the majority of associated gas previously sent to flaring at Kwale OGPP plant. The Kwale OGPP plant receives oil with associated gas from oil fields operated by Eni Nigeria Agip Oil Company.
- Recovery and utilization of associated gas produced as by-product of oil recovery activities at the Al-Shaheen oil field in Qatar.
- Flare gas recovery and utilisation project at Uran oil and gas processing plant in India which is handleing the oil and gas produced in the Mumbai High offshore oil field.
- Flare gas recovery and utilisation project at Hazira gas and condensate processing plant in India.
- Flare gas recovery and utilisation project from Kumchai oil field in India.
- Flare gas recovery and utilisation project at the Ovade-Ogharefe oil field operated by Pan Ocean Oil Corporation in Nigeria.
- Flare gas recovery and utilisation project at Soroosh and Nowrooz offshore oil fields in Iran.
- Leak reduction in aboveground gas distribution equipment in the KazTransgaz-Tbilisi gas distribution system in Georgia where leakages at gate stations, pressure regulator stations, valves, fittings as well at conection points with consumers are reduced.
- There are currently 21 Coal Mine Methane Utilization Project in China which use coalmine methane previously released to the atmosphere.

Improved energy efficiency in the energy and the transport sector in a more general way is one of the priorities in the EU's development assistance as well as for the EIB (European Investment Bank) and the EBRD (European Bank for Reconstruction and Development). Related projects and specific activities can be found for example at http://www.eib.org/projects/topics/environment/renewable-energy/index.htm or http://www.ebrd.com/country/sector/energyef/.

f) Assisting developing country Parties which are highly dependent on the export and consumption of fossil fuels in diversifying their economies.

The EU actively undertakes a large number of activities aiming at reducing dependence on the consumption of fossil fuels, in particular the EU support activities for the promotion of renewable energies and energy efficiency in developing countries contribute to reduction of dependence on fossil fuels, meeting rural electricity needs, and the improvement of air quality. As explained in more detail in chapter 8 of the EU's 5th national communication, there exist several support programmes in this respect. These include:

- *Renewable energy cooperation with the Mediterranean and Gulf countries*
  The major objective of the cooperation between the EU and the Mediterranean and Gulf countries in the field of renewable energy is to contribute to sustainable energy and climate mitigation and to develop an integrated and interconnected 'Green Energy Market'.

  Several initiatives are already being developed by the European Union in cooperation with the partners in the Gulf region to boost energy as well as renewable energy development. This includes the EU-GCC (Gulf Cooperation Council) Energy Expert Group, which started working at the beginning of 1990s' and the EU-GCC Climate Change Expert Group that has met on a regular basis since 2007. In 2009 EU and GCC partners agreed on extending energy cooperation and more specifically on establishing an EU-GCC clean energy network thus bringing together the relevant EU and GCC stakeholders. The European Commission will support the establishment of a network of key actors from public and private sectors in the EU and the GCC with a view to deepening cooperate on clean energy. This network will act as a facilitator and identify projects in fields of common interest, such as solar and other renewable energies.

  Given the importance of research to further development of renewable energy in the GCC region, the Commission is also contributing to the establishment of a specific large-scale platform to foster international R&D cooperation with partners of the Gulf region.

  The expansion and deployment of renewable energy is currently a key element in cooperation between the EU and the Mediterranean countries. The most important initiative is the Mediterranean Solar Plan, endorsed in 2008. The objective is the creation of 20 GW of new generation capacity in solar and other renewable energy sources around the Mediterranean Sea by 2020. The Regional Centre of Excellence for Renewable Energy and Energy Efficiency (RCREEE) facilitates development of renewable energy sources and promotion of energy efficiency measures in the Southern Mediterranean partner countries. Since 2008, when the centre was established in Cairo, the European Union has provided a financial contribution to enable the launch and initial operation of the Centre.

  Bearing in mind the importance of the infrastructures necessary for deployment and exports of green energy, the EU is contributing to the Maghreb Electricity Market Integration Project (IMME). The objective is to create a sub-regional electricity market between Morocco, Tunisia and Algeria and its progressive integration with the EU's electricity market. The Commission has so far provided a support of €5.6 million. These are only some examples from the cooperation with the Mediterranean countries.

- *Africa, Caribbean and the Pacific (ACP-E) Energy Facility*
  The ACP-EU Energy Facility is a contribution under the EU Energy Initiative to increase access to energy services for the poor. The Facility was approved by the joint ACPEU Council of Ministers in June 2005, with an amount of € 220million. The main activity of the Facility is to co-finance projects that deliver energy services to poor rural areas.

  The Energy Facility was mainly implemented through a €198 million Call for Proposals which was launched in June 2006. Out of 307 proposals received, 74 projects have been contracted by the end of 2008 for a total amount of €196 million from the Energy Facility, with a total project cost of €430 million.

  The main activities performed through Energy Facility projects can be classified into three different groups: (1) energy production, transformation and distribution, (2) extension of existing electricity grids and (3) "soft" activities such as governance, capacity building or feasibility studies. The sources of energy used for electricity generation were mainly renewable energies (77 % of the projects). Only one project using exclusively fossil fuels was funded. In total, € 81 million of commitments have been marked as climate change related under the Energy Facility, covering support to enhance use of renewable energies or increase energy efficiency. A replenishment of the ACP-EU Energy Facility has been decided under the 10th European Development Fund for the period of 2009-2013. Endowed with € 200 Million, it will focus on improving access to safe and sustainable energy services in rural and peri-urban areas. The new Energy Facility will also contribute to the fight against climate change by emphasizing the use of renewable energy sources and energy efficiency measures and by taking into account impacts of climate change on energy systems. The new Facility would start being implemented by the end of 2009.

- *Euro-Solar Programme in Latin America*
  The Euro-Solar Programme is aiming to reduce poverty, allowing remote rural communities currently without access to electricity, to benefit from renewable electric energy. Approved in May 2006 and extended in December 2008, the Programme's total budget amounts to € 35.8 million, of which € 6.9 million will be provided by the Programme's eight beneficiary countries.

- *Latin America Investment Facility (LAIF)*
  The European Commission plans to establish the Latin America Investment Facility (LAIF). The LAIF will focus on energy, environment and transport investment, contributing to cleaner transport infrastructure, improved energy efficiency and energy savings, the use of renewable energy, low-carbon production and of climate change adaptation technologies. The LAIF will operate by providing financial non-refundable contributions to support loans to partner countries from the European Investment Bank (EIB) and other European, multilateral and national, development finance institutions and will encourage the

beneficiary governments and public institutions to carry out essential investments in the relevant sectors. The contribution of the Commission to the LAIF will be decided annually. For the year 2009, the Commission will allocate a budget of €10.85 million.

- *Global Energy Efficiency and Renewable Energy Fund (GEEREF)*
  The European Commission has launched an innovative pilot instrument to involve the private sector. The Global Energy Efficiency and Renewable Energy Fund (GEEREF), launched in 2007, is focused on energy efficiency and renewable energy projects in developing countries and economies in transition. GEEREF invests in regionally-orientated investment schemes and prioritizes small investments below €10 million. In December 2008, the GEEREF Investment Committee approved two funds, and the first investments of a total value of € 22.5 million were carried out in 2009 focusing on projects in Sub-Saharan and Southern Africa and in Asia:

  - €12.5 million investment in Berkeley Energy's Renewable Energy Asia Fund (REAF) for operationally and economically mature wind, hydro, solar, biomass, geothermal and methane recovery projects in India, Philippines, Bangladesh and Nepal.

  - €10 million investment in the Evolution One Fund, dedicated to clean energy investment in Southern Africa (SADC countries).

  In the regions where the two funds operate, there is a lack of equity investment available through the market for these types of projects. It is envisaged that GEEREF will invest in regional sub-funds for the African, Caribbean and Pacific (ACP) region, Neighbourhood, Latin America and Asia. Together the European Commission, Germany and Norway have committed about €108 million to the GEEREF over the period 2007-2011, the majority of which is provided by from the EU budget. It is envisaged that further financing from other public and private sources will be forthcoming. In 2007, the EU budget contributed €5 million towards a support facility for the GEEREF and a further €25 million in form of grants.

The EU also supports developing countries in diversifying their economies, however these activities are not limited to fossil fuel exporting countries, but open to all developing countries based on partnership agreements such as the ACP-EU Partnership Agreement. Within this partnership agreement there are five areas of EU intervention for private sector development which are:

1. The creation of enabling environment.
2. The promotion of investment and inter-enterprise co-operation.
3. Investment financing and development of financial markets.
4. Business Development Services.
5. Support for micro-enterprises (especially through the development of an effective microfinance market).

More specific information related to these activities can be obtained at: http://ec.europa.eu/europeaid/where/acp/sector-cooperation/economic-growth/index_en.htm

15.3.3 References

European Commission, 2002: (Directorate General for Energy and transport): Inventory of public aid granted to different energy sources. Working document from the services of the Commission.

European Commission, 2006: Commission staff working document, Accompanying document to the proposal for a Directive of the European Parliament and of the Council amending Directive 2003/87/EC so as to include aviation activities in the scheme for greenhouse gas emission allowance trading within the Community Impact Assessment of the inclusion of aviation activities in the scheme for greenhouse gas emission allowance trading within the Community SEC(2006) 1648, COM(2006) 818 final.

European Commission, 2007a: Commission Report on the Application of Council Regulation (EC) No 1407/2002 on State Aid to the Coal Industry, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, 21.5.2007, SEC(2007) 602, COM(2007) 253 final.

European Commission, 2007b: Commission staff working document, Annex to the Commission Report on the Application of Council Regulation (EC) No 1407/2002 on State Aid to the Coal Industry, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, 21.5.2007, SEC(2007) 602, COM(2007) 253 final.

European Commission, 2009: Impact Assessment Guidelines, 15 January 2009, (SEC(2009)92).

Luciani, G. 2005: EUROGULF: An EU-GCC Dialogue for energy stability and sustainability. Final research report as presented at the conclusing conference in Kuweit, 2-3 April 2005.

16 Methodology applied for the greenhouse gas inventory for Greenland

16.1 Introduction

The following sections contain a report of Greenland's part of the National Inventory Report (NIR) 2011. The structure of the report follows the UNFCCC guidelines on reporting and review (UNFCCC, 2002).

The report is to a far extent structured according to the recommended outline provided by the UNFCCC secretariat.

Previously the greenhouse gas (GHG) inventory and this annex were completed exclusively by The Danish National Environmental Research Institute, Aarhus University (NERI), with input from the Environmental and Nature Protection Agency (APA), Ministry of Domestic Affairs, Nature and Environment.

In 2008 an energy statistic was officially initiated at Statistics Greenland with the intention to "… create an important tool, which in regard to political and economical priorities, can contribute to the identification of efforts on energy matters…" and which "… in regard to environmental aspects will create a basis for assessing the development in regard to Greenland's meetings of the Kyoto protocol …". The first results on the new energy statistics, covering the period 2004-2007, were published in November 2008.

The GHG inventory submitted in April 2011 is completed by Statistics Greenland and the Ministry of Housing, Infrastructure and Transport, Greenland Government, with technical support from NERI. This report on methodology is written by Statistics Greenland with assistance from the Ministry of Housing, Infrastructure and Transport and documental support by NERI.

The annual emission inventories for Greenland for the years 1990-2009, are reported in the full CRF format.

The GHG's reported are:

- Carbon dioxide CO_2
- Methane CH_4
- Nitrous Oxide N_2O
- Hydrofluorocarbons HFCs
- Perfluorocarbons PFCs
- Sulphur hexafluoride SF_6

16.1.1 A description of the institutional arrangement for inventory preparation

The Greenland Ministry of Housing, Infrastructure and Transport is responsible for the annual preparation of the Greenlandic contribution to the National Inventory Report and the GHG inventories in the Common Reporting Format in accordance with the UNFCCC Guidelines. The Greenland Ministry of Housing, Infrastructure and Transport will provide the data to NERI. NERI is responsible for aggregating the Danish and Greenlandic CRF submissions and reporting the aggregated CRF and the National Inventory Report to the UNFCCC.

The inventory for LULUCF and KP-LULUCF is carried out by NERI and the documentation of the inventory (Sections 16.7 and 16.11) is completed by the Danish LULUCF experts.

Formerly, the provision of data was on a voluntary basis, but a formal contract between NERI and the Greenland Government came in place for the 2009 GHG inventory report.

The work concerning the annual GHG emission inventory is carried out in co-operation with other Greenlandic ministries, research institutes, organisations and companies:

Statistics Greenland (Ministry of Finance)
Annual energy statistics in a format suitable for the emission inventory work and fuel-use data for the large combustion plants. Statistical Yearbook. From 2009 annual survey on emissions of F-gases.

Agricultural Advisory Service (Ministry of Fisheries, Hunting and Agriculture)
Background data on cropland and grassland, and statistics on livestock (sheep and reindeer).

Ministry of Domestic Affairs, Nature and Environment
Data on waste and emissions of F-gases. Annual Survey carried out by the Ministry of Domestic Affairs, Nature and Environment until 2008 and by Statistics Greenland from 2009 and onwards.

Ministry of Fisheries, Hunting and Agriculture and the Greenlandic Arboretum
Background data on forestry.

Greenland Airport Authority (Ministry of Housing, Infrastructure and Transport)
Statistics on domestic flights and foreign flights to and from Greenland.

16.1.2 Brief description of the process of inventory preparation - data collection, data processing, data storage

The background data (activity data and emission factors) for estimation of the Greenlandic emission inventories is collected and stored in central databases at Statistics Greenland. The databases are in SAS format and handled with software from the SAS Institute Inc. The SAS programs are designed by Statistics Greenland. The methodologies and data sources used for the different sectors are described briefly in Section 16.1.4 and more in depth in Sections 16.3 to 16.8 and Section 16.11.

The material is placed on servers at Statistics Greenland. The servers are subject to routine backup services. Material, which have been backed up is archived safely.

16.1.3 General description of methodologies and data sources used

The GHG inventory for Greenland includes the following sectors:

- Energy sector
- Industrial processes
- Solvent and other product use
- Agriculture
- Land Use, Land-use Change and Forestry
- Waste
- KP-LULUCF

The applied methodologies follow the IPCC Guidelines and IPCC Good Practice Guidance. In some cases the methodology is identical to the methodology applied in the Danish inventory, however, the availability of data – especially site specific data – do not allow the same methodology to be used for all the sectors. The brief methodological description is included below for the different sectors. More thorough descriptions are included in Sections 16.3-16.8 and 16.11.

Energy sector

Fuel combustion

The Greenlandic emission inventory for fuel combustion has been performed according to the IPCC tier 1 methodology. The inventory is based on activity data from the Greenlandic energy statistics and on emission factors for different fuels, plants and sectors.

Total fuel combustion is based on data from Polaroil, Statoil and Malik Supply A/S. Polaroil imports fuel and distributes fuel in all parts of Greenland. Statoil imports and distributes fuel in Kangerlussuaq. Malik Supply A/S, a Danish company, re-distributes fuel bought from Polaroil to Greenlandic trawlers, ships etc. By using detailed data from Polaroil, Statoil and Malik Supply A/S it is possible to determine total import, total export, total international bunkers and total domestic fuel combustion.

Total domestic fuel combustion is then divided into sectors and private households by using data from a survey on energy consumption, company specific sales data from Polaroil and local fuel distributors, company tax accountings, municipality and the Government of Greenland accountings, and by estimation.

Fuel combustion in private households is estimated using detailed information from a number of local fuel distributors. Fuel deliveries are registered by buildings. In Greenland each building has a unique number registered in the Greenlandic Area Register (NIN). By combining the NIN-register and the GER-register (see above) with statistics on housing and population each building is labelled *private household* or located to a sector describing the main activity in the building. This new building-sector register, completed annually, is used extensively to determine the buyer of fuel delivered by Polaroil or local fuel distributors.

Fuel combustion in road traffic is based on a model designed by Statistics Greenland. The model contains data on the vehicle stock obtained from the Greenland Police Department's register on engine data. The vehicles are divided into broad categories of type i.e. personal car, lorry, taxi, truck, ambulance, motorbike etc. Each category is assigned with ratios on fuel type and mileage. Input data on mileage is derived from a survey among businesses and private road traffic in 2008, 2009 and 2010. Each vehicle is divided in business categories or labelled *private vehicle* according to the owner. For each group the emissions are estimated by combining vehicle and annual mileage numbers with standard emission factors according to the type of fuel. The model does not take cold start or hot engines into account.

For air traffic annual emissions are based on activity data from Air Greenland A/S and sales data from the Greenland Airport Authority. For navigation, ferries and freight, annual emissions are based on activity data from Royal Arctic Line A/S (freight), Royal Arctic Tankers A/S (freight), Royal Arctic Bygdeservice A/S (freight/passengers), and Arctic Umiaq Line A/S (passengers) and the liquidated Assartuivik A/S (passengers).

For further information please refer to Section 16.3.

Fugitive emission

Greenland has no coal mines, no off-shore activities, no oil refineries, no natural gas transmission or distribution. For that reason there are no fugitive emissions from such activities.

However, some fugitive emissions could possibly occur in the distribution of fuel e.g. when refuelling from ships to on-shore tanks, onshore loading of fuel to ships and offshore loading of ships. The fugitive emission from loading/unloading of ships is currently not estimated.

Industrial processes

Mineral products

CO_2 emissions occur from limestone and dolomite use, road paving with asphalt and asphalt roofing. Import statistics of asphalt and limestone are used as activity data for estimating the emissions.

Chemical industry

Greenland has no chemical industry.

Metal production

Greenland has no metal production.

Other production

There are several manufacturers of fish products and one tannery. Emissions of NMVOC are estimated, but there are no emissions of greenhouse gases occurring.

F-gases

Greenland has no production of halocarbons or SF_6. Data on consumption of F-gases (HFCs and SF_6) are obtained from an annual survey on consumption of halocarbons and SF_6 conducted by Statistics Greenland. Information on emission of industrial gases is available from 1995 onwards. Greenland has no consumption of PFCs.

For further information on the methodology for calculating emissions from industrial processes please refer to Section 16.4.

Solvent and other product use

The emission estimates for solvent and other product use are prepared by using import statistics of pure chemicals that fits the criteria for being considered a NMVOC compound. Additionally import statistics are used for products containing NMVOC's. The NMVOC emission is then calculated in to a CO_2 emission by using a standard value for carbon content in the NMVOC's. For further information see Section 16.5.

Agriculture

Enteric Fermentation Manure Management

Agriculture is sparse in Greenland due to climatic conditions. However sheep and reindeer are considered to contribute to emission of greenhouse gases. Enteric fermentation and manure management is assumed to contribute to emission of CH_4, and nitrogen excretion is assumed to contribute to emission of N_2O.

The emissions are given in CRF: Table 4 Sectoral Report for Agriculture and Table 4.A, 4.B(a), 4.B(b) and 4.D Sectoral Background Data for Agriculture. The calculation of emissions from the agricultural sector is based on methods described in the IPCC Guidelines (IPCC, 1996) and the Good Practice Guidance (IPCC, 2000). Activity data for livestock is on a one year average basis from the agriculture statistics published by Statistics Greenland. Data concerning the land use and crop yield is obtained from the Agricultural Advisory Service.

Data concerning the feed consumption and nitrogen excretion from sheep is based on information from the Agricultural Advisory Service supplemented by data on imported feed. Data concerning the feed consumption and nitrogen excretion from reindeer is based on information from the Agricultural Advisory Service and information from an article on reindeer management in Greenland.

Emission of N_2O is closely related to the nitrogen balance. Thus, quite a lot of the activity data is related to the calculation of ammonia emission. National standards are used to estimate the amount of ammonia emission. When estimating the N_2O emission the IPCC standard value is used for all emission sources. The emission of CO_2 from Agricultural Soils is included in the LULUCF sector.

For a more thorough description of the methodology for the agricultural sector please refer to Section 16.6.

Land use, land-use change and forestry

Greenland is the world's largest non-continental island on the northern American continent between the Arctic Ocean and the North Atlantic Ocean, northeast of Canada. The northernmost point of Greenland, Cape Morris Jesup, is only 740 km from then North Pole. The southernmost point is Cape Farewell, which lies at about the same latitude as Oslo in Norway. Greenland is covering app. 2,166,086 km^2. It has been estimated that 81% is covered permanently with ice leaving only 410,449 km^2 ice free. The climate is Arctic to sub arctic with cool winters and cold summers. The capitol Nuuk is having an average temperature of 1.4°C.

Due to its cold climate is the LULUCF sector of minor importance in relation to the emission of green house gases. Only a very minor area is covered by forest of which the major part has been planted within the last 40 years. Cropland was introduced in year 2000 and grassland management within the last 30 years. The cold climate slows down the biological processes making all growth rates very low.

In total has the emission from the LULUC sector been estimated to a sink of 0.89 Gg CO_2-eqv or 0.14% of the total Greenlandic emission.

Forest land

Greenland has a few forests, which may qualify to the FAO criteria of forest definitions. The major forest areas are:

A natural forest in the Qinngua valley of 45 ha consisting mainly of *Betula Pubescens ssp. czerepanovii* which in the period 1990 to 2009 has had an average height of six meters and app. 100 trees pr ha. It is thus assumed that it has had the same biomass for the whole period.

187 ha other planted forest. The largest of this is an arboretum (a research area) where different species and origins of trees are investigated which are adaptable to the harsh climate.

Cropland

In 1990 no annual crops were grown in Greenland. In 2009 6.5 ha of cropland was used for annual crops. The primary production is potatoes. Potato fields are mainly managed by hand and primarily fens with a high content of organic matter which is used for this purpose. It is thus assumed that the IPCC standard emission factor for boreal/cold areas of five tonnes C pr ha can be used although it is probably an overestimation due to the cold climate and the current management practice.

Grassland

In total is 242.000 hectare reported as grassland. The grassland is located in mountainous areas used for grazing of sheep. Due to the global warming are there some smaller areas which has become improved fertilised grassland. The total area with improved grassland has increased from 490 ha in 1990 to 1089 ha in 2008.

Wetlands

Reported area with wetlands consists only of water-reservoirs. Due to lack of methodology for methane emissions under arctic conditions has no emission estimates has been made which is in accordance with the IPCC GPG 2003 guidelines.

Settlements

The few settlements are mainly built on cliffs with very sparse vegetation. Hence it is assumed that no changes in C stock is occurring.

Other land

No emission estimates has been made since no data is available which is in accordance with IPCC GPG 2003 guidelines.

For a more thorough description of the methodology applied for LULUCF and KP-LULUCF please refer to Section 16.7 and 16.11.

Waste

Solid waste management

The solid waste management in Greenland can be divided in the following processes:

- Managed waste disposal combined with open burning.
- Unmanaged waste disposal combined with open burning.
- Wastewater handling.
- Waste incineration with energy recovery.
- Waste incineration without energy recovery.

Waste incineration with energy recovery is according to IPCC Guidelines included under the energy sector.

Information on amount of waste produced pr year, amount of waste treated in the different processes, distribution between household and commercial waste, composition of the household waste and commercial waste, respectively, are provided by the Ministry of Domestic Affairs, Nature and Environment.

Wastewater handling

N_2O emission from human sewage is estimated. The calculation of the N_2O emission uses population data from Statistics Greenland and an estimate for average protein consumption combined with default values from the IPCC Guidelines. No emissions of CH_4 are assumed to occur.

For more information please refer to Section 16.8.

Memo Items

International Aviation Bunkers

Emissions from international aviation bunkers are considered to be of neglible importance. The Greenland Airport Authority has reported the annual amount of jet fuel loaded into foreign aircrafts including Danish aircrafts. However, it is not possible to distinguish between Danish aircrafts and other aircrafts. Since most foreign aircrafts by far are Danish the annual amount of jet fuel loaded into foreign aircrafts are therefore included as part of the IPCC category 1A3a Civil aviation.

International Marine Bunkers

Emissions from international marine bunkers are included from 2004 and onwards. Before 2004 international marine bunkers are considered to be of negligible importance.

KP-LULUCF

Regarding the possibility of including in the first commitment period emissions and removals associated with land use, land-use change and forestry activities under Article 3.4 of the Kyoto Protocol, Greenland as part of the Kingdom of Denmark has included emissions and removals from forest management (FM), cropland management (CM) and grazing land management (GM).

The national system has identified land areas associated with the activities under Article 3.4 of the Kyoto Protocol in accordance with definitions, modalities, rules and guidelines relating to land use, land-use change and forestry activities under the protocol. All land converted from other activities into Cropland and Grassland is accounted for. No land has been allowed to leave elected areas under art. 3.4.

Please see Section 16.11 for further details.

16.1.4 Brief description of key categories

A key category analysis (KCA) for year 1990 and 2009 has been carried out in accordance with the IPCC Good Practice Guidance. This is the second KCA done for the Greenlandic inventory. The first KCA was accomplished in the Greenlandic 2010 inventory submission.

The categorisation used results in a total of 33 categories. In the level KCA for the inventory for 1990, 5 key categories were identified. For the KCA for 2009, 6 categories were identified as key categories due to both level and trend. Four further categories were key categories due to the trend.

Of the six key sources due to level for the reporting year 2009 four are in the energy sector, of which CO_2 from liquid fuels excluding transport in the analysis contributes most with 75.7% of the national total (this contribution and the percentage contributions in the following are results from the level KCA based on the absolute values of the emissions; this contribution as percentages may differ somewhat from the percentage used in the sectoral chapters). The remaining level key categories in the energy sector are all CO_2 from the transport sector. Civil aviation, road transportation and domestic navigation comprise respectively 7.1%, 5.4% and 4.1% of the national total. The last key category is N_2O from wastewater handling.

The trend assessment shows that consumption of HFCs, N_2O from waste water handling, direct N_2O emissions from agricultural soils, CO_2 removal from grassland remaining grassland and CH_4 emission from waste incineration are key categories due to the trend.

The categorisation used, results, etc. are included in Section 16.12 (Annex 1).

16.1.5 Information on QA/QC plan including verification

A number of measures are in place to ensure the quality of the Greenlandic greenhouse gas inventory.

The general QC activities include:

- Check that data are correctly moved between data processing steps, e.g. it is ensured that the data are imported correctly from the emission spreadsheets/databases to the CRF Reporter.
- The time series are analysed. Any large fluctuations are investigated and explained/corrected.
- The recalculations are analysed and the consistency of the emission estimates are verified.
- The completeness of the inventory is checked utilising the completeness checker incorporated in the CRF Reporter as well as expert knowledge from the inventory compilers.

- All references are checked and it is ensured that the citations are correct.

These types of QC checks are recommended as tier 1 QC checks in the IPCC Good Practice Guidance (IPCC, 2000).

The Greenlandic emission inventory is reviewed by Danish emission experts, who provide input to the Greenlandic inventory compilers on necessary improvements etc. This is done as a QA procedure. When the emission estimates are transferred to NERI, the quality control system of the Danish emission inventory is applied to the Greenlandic data.

All information related to the Greenlandic emission estimates are documented and archived securely annually. This is done in order to ensure that any part of the inventory can be reproduced at a later stage if necessary.

In addition source specific QA/QC activities are carried out, please see the associated paragraphs in the sectoral chapters.

16.1.6 General uncertainty evaluation

The uncertainty estimates are based on the Tier 1 methodology in the IPCC Good Practice Guidance (GPG) (IPCC, 2000). Uncertainty estimates for the following sectors are included in the current year: fuel combustion, industrial processes, solid waste, wastewater treatment and waste incineration, solvents and other product use, agriculture and LULUCF.

The uncertainties for the activity rates and emission factors are shown in Table 16.1.4. The estimated uncertainties for total GHG and for CO_2, CH_4, N_2O and F-gases are shown in Table 16.1.3. The base year for F-gases is 1995 and for all other sources the base year is 1990. The total Greenlandic GHG emission is estimated with an uncertainty of ±5.7% and the trend in GHG emission since 1990 has been estimated to be -4.0% ± 2.7%-age points. The GHG uncertainty estimates do not take into account the uncertainty of the GWP factors.

The uncertainty on CO_2 from liquid fuels in fuel combustion, N_2O emission waste water treatment and CH_4 emission from enteric fermentation are the largest sources of uncertainty for the Greenlandic GHG inventory. The result is skewed by the fact that more than 90% of the Greenlandic Greenhouse gas emission is from fuel combustion of liquid fuels.

Table 16.1.3 Uncertainties 1990-2009.

	Uncertainty [%]	Trend [%]	Uncertainty in trend [%-age points]
GHG	5.7	-4.0	± 2.7
CO_2	5.3	-5.0	± 2.7
CH_4	56	-7.2	± 9.0
N_2O	80	-3.9	± 28
F-gases	51	+10 785	± 4 798

Table 16.1.4 Uncertainty rates for each emission source.

IPCC Source category	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty
		Gg CO_2 eq	Gg CO_2 eq	%	%
1A, Liquid fuels	CO_2	621	586	2	5
1A, Municipal waste	CO_2	1	6	2	25
1A, Liquid fuels	CH_4	1	1	2	100
1A, Municipal waste	CH_4	0	0	2	100
1A, Biomass	CH_4	0	0	2	100
1A, Liquid fuels	N_2O	2	2	2	500
1A, Municipal waste	N_2O	0	0	2	500
1A, Biomass	N_2O	0	0	2	200
2A3 Limestone and dolomite use	CO_2	0	0	5	5
2A5 Asphalt roofing	CO_2	0	0	5	25
2A6 Road paving with asphalt	CO_2	0	0	5	25
2F Consumption of HFC	HFC	0	7	10	50
2F Consumption of SF6	SF_6	0	0	10	50
3A Paint application	CO_2	0	0	10	15
3B Degreasing and dry cleaning	CO_2	0	0	10	15
3C Chemical products, manufacturing and processing	CO_2	0	0	10	15
3D5 Other	CO_2	0	0	10	20
4A Enteric Fermentation	CH_4	6	5	10	100
4B Manure Management	CH_4	0	0	10	100
4.B Manure Management	N_2O	1	1	10	100
4D1 Direct N2O emissions from agricultural soils	N_2O	1	2	20	50
4D2 Pasture range and paddock	N_2O	1	1	20	25
4D3 Indirect N2O emissions from agricultural soils	N_2O	1	1	20	50
5A Forest	CO_2	0	0	5	50
5B Cropland	CO_2	0	0	5	50
5.C Grassland	CO_2	0	-1	5	50
6A Solid Waste Disposal on Land	CH_4	4	4	10	100
6B Wastewater Handling	N_2O	15	13	30	100
6C Waste incineration	CO_2	3	3	10	25
6C Waste incineration	CH_4	2	2	10	50
6C Waste incineration	N_2O	1	1	10	100

16.1.7 General assessment of completeness

The present Greenlandic greenhouse gas emission inventory includes all major sources identified by the Revised IPPC Guidelines.

16.1.8 References

Ministry of Domestic Affairs, Nature and Environment: Data on waste and ozone depleting substances and greenhouse gases HFCs, PFCs and SF_6.

Agricultural Advisory Service: Statistics on livestock (sheep and reindeer) and background data on land use (cropland and grassland).

Ministry of Fisheries, Hunting and Agriculture: Background data for Forestry.

IPCC, 1997: Revised 1996 IPCC Guidelines for National Greenhouse Gas inventories. Available at: http://www.ipcc-nggip.iges.or.jp/public/gl/invs6.htm (15-04-2007).

IPCC, 2000: Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. Available at: http://www.ipcc-nggip.iges.or.jp/public/gp/english/(15-04-2007).

IPCC, 2006: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan. Available at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

Rasmussen, H.E., 1992: Reindeer Management in Southern Greenland (1992). Published in Danish as "Den sydgrønlandske rendrift" (1992)

Statistics Greenland: Energy Consumption in Greenland 2004-2009 published in Danish. Available at: http://www.stat.gl/Statistik/MiljoogEnergi/tabid/92/language/da-DK/Default.aspx as "Grønlands energiforbrug 2009" (29-11-2010).

Statistics Greenland, 2010: The Greenlandic energy statistics aggregated to SINK categories. Not published.

16.2 Trends in Greenhouse Gas Emissions

16.2.1 Description and interpretation of emission trends for aggregated greenhouse gas emission

The GHG emissions are estimated according to the IPCC guidelines and are aggregated into seven main sectors; Energy incl. Transport, Industrial Processes, Solvent and Other Product Use, Agriculture, LULUCF, and Waste. In Figure 16.2.3 and Figure 16.2.4 CO_2 emissions from fuel combustion in the Energy Sector is split into several sub-categories i.e. Energy Industries, Manufacturing Industries and Construction, Commercial and Institutional, Transport, Residential, Agriculture and Fishing.

The greenhouse gases include CO_2, CH_4, N_2O, HFCs, PFCs and SF_6. However, Greenland has no consumption of PFC. In 2009 total emission of greenhouse gases excluding LULUCF was 633.7 Gg CO_2-equivalent, and including LULUCF 632.8 Gg CO_2-equivalent.

Figure 16.2.1 shows total greenhouse gas emission in CO_2 equivalents from 1990 to 2009. The emissions are not corrected for temperature variations. CO_2 is the most important greenhouse gas. In 2009 CO_2 contributed to the total emission in CO_2 equivalent excluding LULUCF (Land Use and Land-Use Change and Forestry) with 93.8%, followed by N_2O with 3.2%, CH_4 1.9% and F-gases (HFCs and SF_6) with 1.0%. Since 1990 these percentages have been increasing for F-gases, almost constant for N_2O and falling for CO_2 and CH_4.

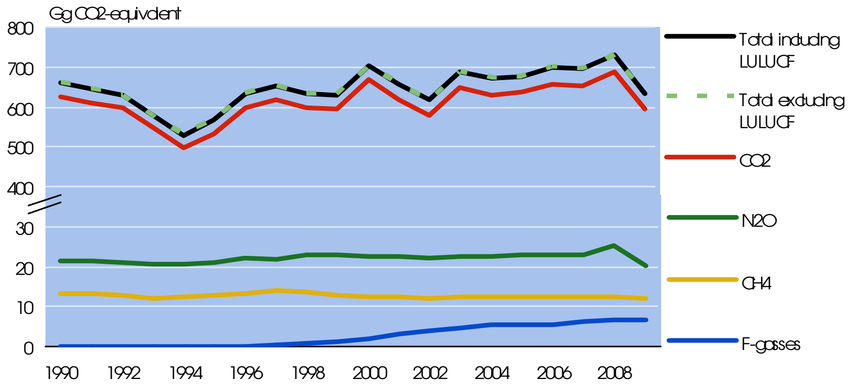


Figure 16.2.1 Greenhouse gas emission in CO_2 equivalents, time-series 1990-2009.

Stationary combustion plants and transport represent the largest categories. Energy excluding transport contributed to the total emission in CO_2 equivalents excluding LULUCF with 77% in 2009, see Figure 16.2.2. Transport contributed with 17%. Industrial processes, solvent and other products use, agriculture and waste contributed to the total emission in CO_2 equivalents with 6%.

The net CO_2 removal by forestry is 0.14% of the total emission in CO_2 equivalents in 2009. The total GHG emission in CO_2 equivalents excluding LULUCF has decreased by 3.9% from 1990 to 2009 and decreased 4% including LULUCF. Comments on the overall trends etc. seen in Figure 16.2.1 and Figure 16.2.2 are given in the sections below on the individual greenhouse gases.

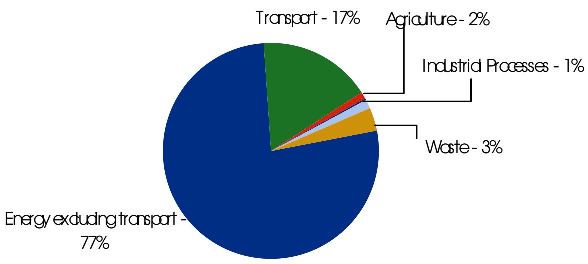


Figure 16.2.2 Greenhouse gas emission in CO_2 equivalents distributed on main sectors for 2009.

16.2.2 Description and interpretation of emission trends by gas

Carbon Dioxide

In Figure 16.2.3 and Figure 16.2.4 CO_2 emissions from fuel combustion in the Energy Sector is split into several sub-categories i.e. Energy Industries, Manufacturing Industries and Construction, Transport, Commercial and Institutional, Residential, Agriculture and Fishing.

The largest source to the emission of CO_2 is the energy sector. This sector includes combustion of fossil fuels like gas oil, gasoline, jet kerosene etc. From this sector Agriculture and Fishing (AFF) contributes with 22% making AFF the largest contributor in 2009 followed by Energy Industries and Residential each contributing with 21% of the total CO_2 emission in 2009. Before 2009 Energy Industries was the largest contributor to CO_2 emission. However, because of massive investments in hydro power plants an increasing share of energy is produced by electricity from hydro power plants reducing CO_2 emission from Energy Industries.

Transport contributes with 18% of the total CO_2 emission. Manufacturing Industries and Construction with 7%. Commercial and Institutions with 11%. The category *Other* contributes with 1% of the emissions.

CO_2 emission excluding LULUCF decreased by approximately 13.2% from 2008 to 2009. The main reason for this decrease was a substantial increase of hydro power used in Energy Industries substituting a larger amount of fossil fuels. A relatively warmer 2009-spring compared to a relative cold 2008-winter extended the decrease in the consumption of fuel in Energy Industries. In 2009, the actual CO_2 emission was 4% lower than the emission in 1990.

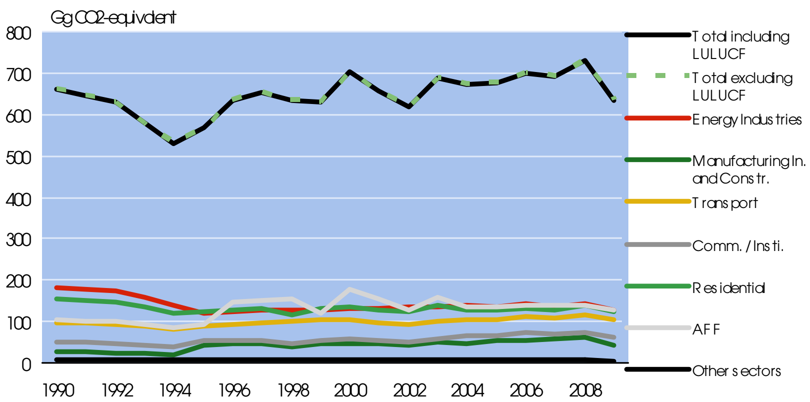


Figure 16.2.3 CO_2 emissions, time-series for 1990-2009.

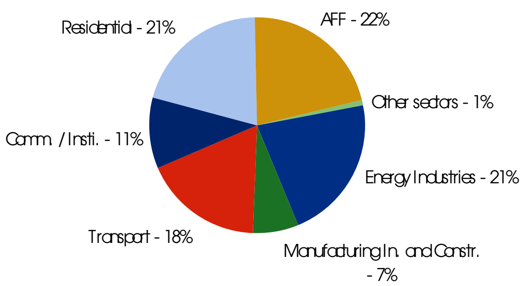


Figure 16.2.4 CO_2 emissions, distribution according to the main sectors for 2009.

Nitrous oxide

Waste, particularly waste water handling is the most important N_2O emission source in 2009 contributing 67% to the total N_2O emissions, see Figure 16.2.6. Emission of N_2O from agricultural contributed 23% to the total N_2O emissions in 2009. Fuel combustion including transport contributed 10%. Since 1990 total emission of N_2O has increased by 3.9%.

The N_2O emission from agriculture decreased during the early nineties due to a decrease in reindeer livestock from 1990 to 1994. Since 1995 the emission of N_2O has increased and decreased for shorter periods depending on changes in the livestock and the use of fertiliser. From 2002 until 2008 the N_2O emission has increased. In 2008, the actual N_2O emission was double than the emission in 1990, see Figure 16.2.5. The cause of this was a significant increase in the use of fertilisers in 2008. In 2009 N_2O emission was reduced by 19.4% due to a fall in the amount of waste water handling from industrial fishing plants.

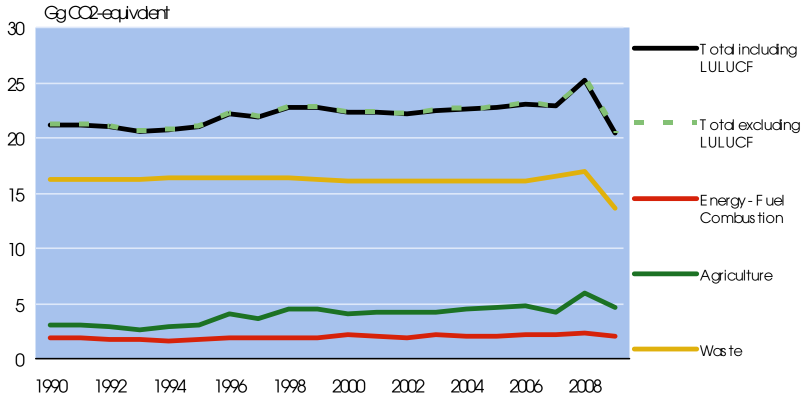


Figure 16.2.5 N2O emissions, time-series for 1990-2009.

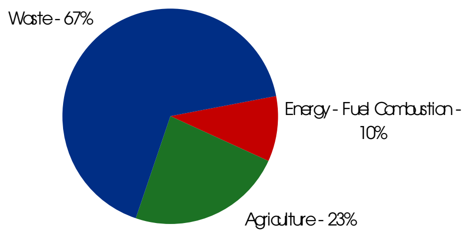


Figure 16.2.6 N_2O emissions, distribution according to the main sectors in 2009.

Methane

The largest sources of anthropogenic CH_4 emissions are agricultural activities and waste handling, each contributing in 2009 with 45 % of total CH_4 emissions, see Figure 16.2.8. The energy sector contributes with 9 %. The emission from agriculture derives from enteric fermentation (98 %) and management of animal manure (2 %).

Since 1990 the overall number of sheep has increased, while the overall number of reindeer has decreased. From 1990 to 2009 the emission of CH_4 from agricultural activities has decreased by 10.4 %.

The emission of CH_4 from waste derives from solid waste disposal (71 %) and waste incineration (29 %). From 1990 to 2009 the emission of CH_4 from solid waste disposal has increased by 8.4 %, while emissions from waste incineration have decreased by 30.3 %. Overall emission of CH_4 from waste handling has decreased by 7.2 % from 1990 to 2009.

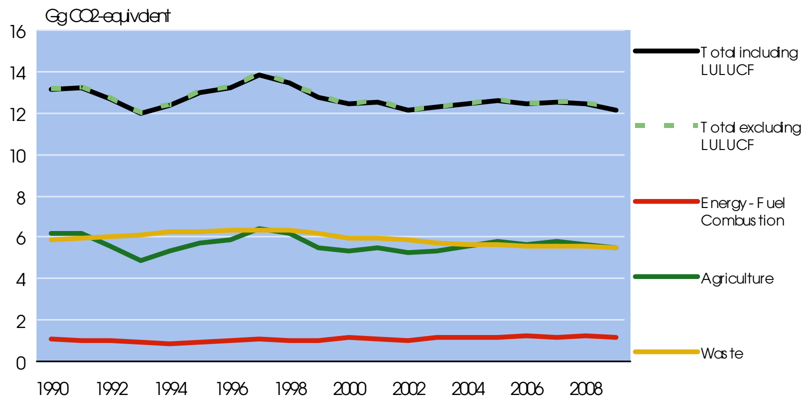


Figure 16.2.7 CH_4 emissions, time-series for 1990-2009.

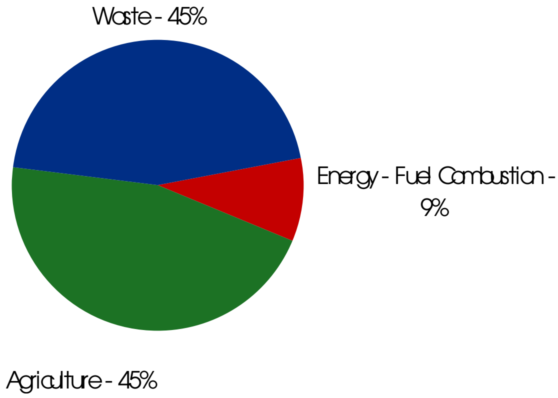


Figure 16.2.8 CH_4 emissions, distribution according to the main sectors in 2009.

HFCs, PFCs and SF_6

This part of the Greenlandic inventory only comprises a full data set for HFCs and SF_6 from 1995. Greenland has no consumption that leads to emission of PFCs. From 1995 to 2008 there has been a continuous and substantial increase in the contribution from F-gases calculated as the sum of emissions in CO_2 equivalents, see Figure 16.2.9. This increase is caused by and simultaneous with an increase in the emission of HFCs. For the time-series 2004-2009 the increase is lower than for the years 1995 to 2004. The increase from 1995 to 2004 is 8,892 %. From 2004 to 2009 total emission increased by 21.1 %. SF_6 contributed to the F-gas sum in 1995 with 59 %. Environmental awareness and regulation of this gas under Danish law has reduced its use considerably since 1995. In 2009 the contribution from SF_6 to the emission of F-gases was only 0.05 %.

The use of HFCs has increased to a great extent. Today HFCs are by far the dominant F-gas, comprising 41 % in 1995, but 99.95 % in 2009. HFCs are mainly used as a refrigerant.

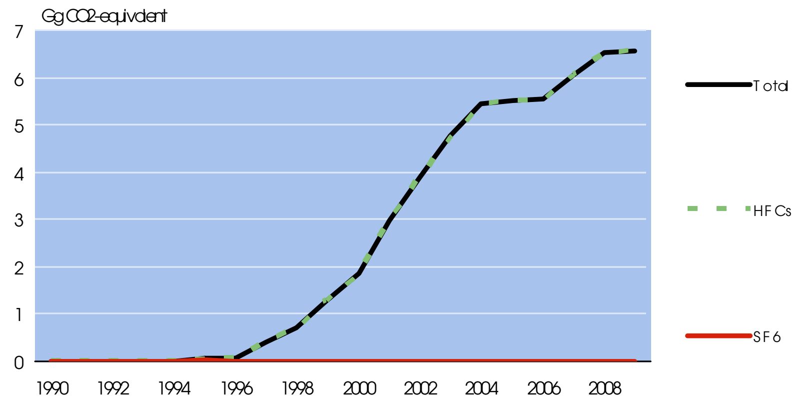


Figure 16.2.9 F-gas emissions, time-series for 1990-2009.

16.2.3 Description and interpretation of emission trends by category

Energy

The emission of CO_2 from fuel combustion has decreased by 5 % from 1990 to 2009. Combustion of fuel was decreasing from 1990 until 1994 due to the implementation of the first hydro power plant. However, since 1994 combustion of fuel has increased continuously until 2009. The reason for this increase is primarily higher demand for transportation and heating. Combustion of fuel may decrease in certain years due to milder temperatures. In 2009 combustion of fuel was reduced heavily due to a significant increase in hydro power, which caused CO_2 emission from energy combustion to fall by 13.3 % from 2008 to 2009. In 2011 four hydro power plants are currently operating and a fifth is under construction.

Emission of CH_4 has increased by 6.7 % from 1990 to 2009 primarily due to an increase in the use of fuel for transportation. The CH_4 emission from the transport sector has increased by 59.9 % from 1990 to 2009, mainly due to increasing domestic aviation.

Emission of N_2O has increased by 6.3 % from 1990 to 2009.

Industrial processes

Emissions from industrial processes (consumption of halocarbons and SF_6) other than fuel combustion amount to 1% of the total emission in CO_2 equivalents excluding LULUCF in 2009. The main source is consumptions of HFCs. Emission of F-gases have increased considerable since 1990.

Agriculture

The agricultural sector contributes with 1.6% of the total greenhouse gas emissions in 2009, 45% of the total CH_4 emission and 23% of the total N_2O emission. The total emission from the sector has increased by 11.2% from 1990 to 2009. This increase is due to an increase in the use of fertilisers. The number of reindeer has decreased from 6,000 heads in 1990 to 3,000 heads in 2009. The number of sheep has increased from 19,929 heads in 1990 to 20,139 heads in 2009. The N_2O emission has increased by 54.9% from 1990 to 2009 due to a significantly increased in the use of fertilisers, while the CH_4 emission decreased by 10.4% during the same period.

LULUCF

Emissions from the LULUCF sector amount to just 0.14 % of the total emission in CO_2 equivalents in 2009. Forests are assumed to be a sink for the whole period increasing from approximately zero in 1990 to 30.4 tonnes CO_2 in 2009. The emission from cropland is estimated to zero in 1990 as there were no cropland in Greenland in 1990 and a net source in 2009 of 16.0 tonnes CO_2 pr year. The emission removal from grassland has been estimated to 246.4 tonnes CO_2 in 1990 increasing to 874.2 tonnes CO_2 in 2009.

Waste

The waste sector contributes with 3.5 % of the total greenhouse gas emissions in 2009, 45.4 % of the total CH_4 emission and 67.1 % of the total N_2O emission. The total emission from the sector has decreased by 10.6 % from 1990 to 2009. This decrease is caused by a decrease in the CH_4 emission from waste incineration by 30.3 %, and a decrease in N_2O emission from waste water handling by 15.3 %. Total GHG emission from waste incineration without energy recovery has decreased by 10.6 % from 1990 to 2009 due to an increasing amount of waste incineration with energy recovery and a decrease in waste water handling from industrial fishing plants in 2009. Emission from incinerated waste used for heat production is included in the 1A1 IPCC category Energy Industries.

16.2.4 Description and interpretation of emission trends for indirect greenhouse gases and SO_2

NO_X

The largest sources to emission of NOx are AFF (Agriculture, Forestry and Fisheries) followed by Transport and combustion in Energy Industries (public power and district heating plants). The AFF-sector is the most contributing the most to the emission of NO_X. In 2009, 52 % of the Greenlandic emission of NO_X came from AFF-related activities.

The emission of NO_X from AFF varies from year to year. In recent years emission of NO_X from AFF has been relatively stabile with a slightly increasing tendency since 2000.

The emissions from transport obtain 27 % of total emissions in 2009. From 1990 to 2009 emission of NO_X from transport has decreased by 8.6 %. In the same period total emission of NO_X has increased by 7 %.

The emissions from energy industries obtain 9 % of total emission in 2009. The emission from energy industries have decreased by 30.9 % from 1990 to 2009. The reduction is due to the increasing use of renewable energy primarily hydro power, which has caused a reduction in the use of fossil fuel in power and district heating plants.

Emission of NO_X from waste handling obtains 1 % of total emission, see Figure 16.2.10.

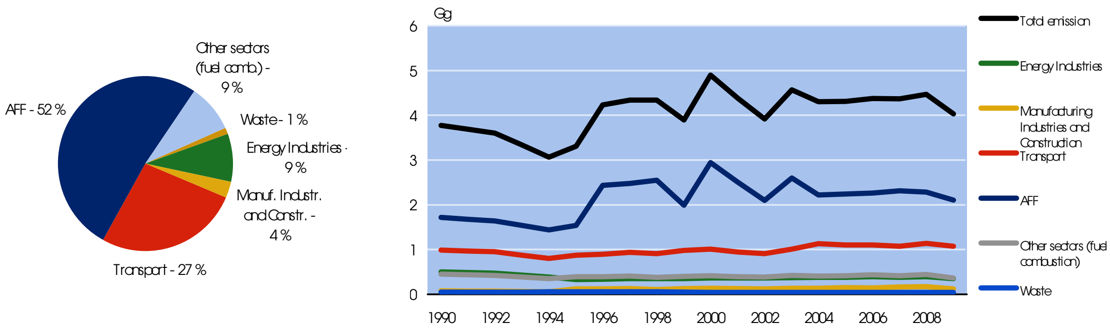


Figure 16.2.10 NO_X emissions. Distribution according to the main sectors (2009), and time-series (1990-2009).

CO

Mobile sources like transport and AFF (agriculture, forestry and fisheries) contribute significantly to the total emission of this pollutant. Transport is the largest contributor to the total CO emission, see Figure 16.2.11.

Total CO emission has increased by 42.2 % from 1990 to 2009, largely due to increasing emissions from road transportation and civil aviation. Emissions from transport have more than doubled from 1990 to 2009.

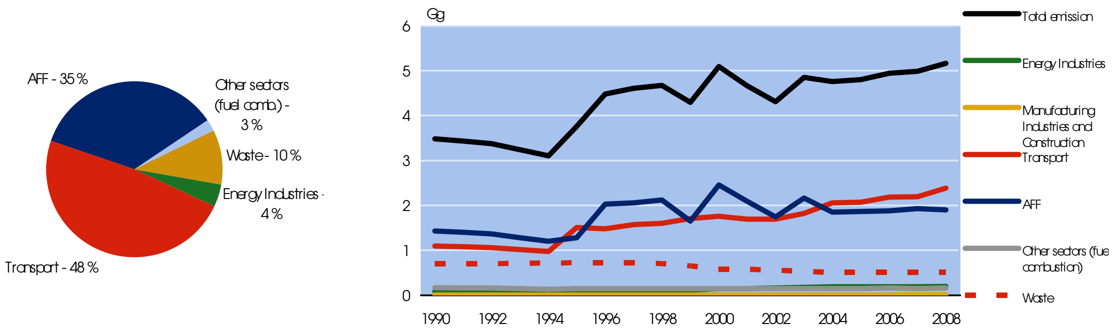


Figure 16.2.11 CO emissions. Distribution according to the main sectors (2009), and time-series (1990-2009).

NMVOC

The emissions of NMVOC originate from many different sources and can be divided into two main groups: incomplete combustion and evaporation. Road vehicles and other mobile sources such as national navigation vessels fishing vessels and off-road machinery are the main sources of NMVOC emissions from incomplete combustion processes. Road transportation and fishing vessels are the main contributors to this pollutant. Road transportation is included under transportation, which obtain 40 % of the total NMVOC emission in 2009. Fishing vessels are included under AFF (agriculture, forestry and fisheries), which obtain 30 % of total NMVOC emission in 2009, see Figure 16.2.12.

The evaporative emissions mainly originate from the use of solvents and the extraction, handling and storage of oil. Emissions from solvents and other product use have decreased by 15.1 % from 1990 to 2009.

The total anthropogenic emissions have increased by 25.8 % from 1990 to 2009, largely due to the increase in road transportation and AFF activities.

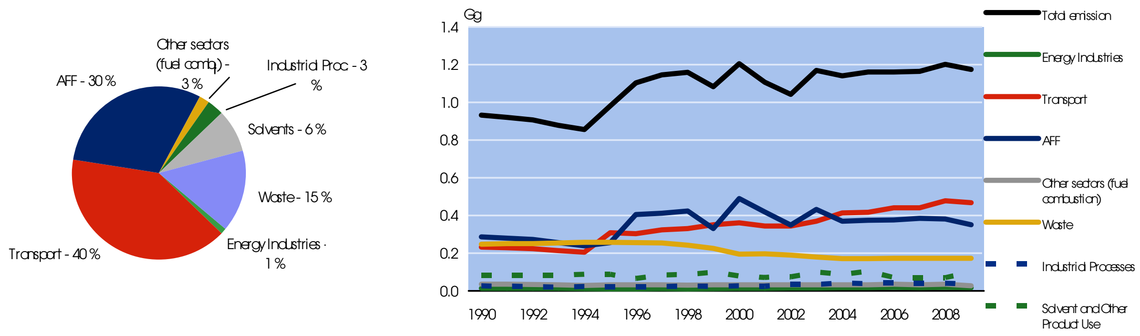


Figure 16.2.12 NMVOC emissions. Distribution according to the main sectors (2009), and time-series (1990-2009).

SO_2

The main part of the SO_2 emission originates from the combustion of fossil fuels mainly gas oil in public power and district heating plants. From 1990 to 2009, total emission of SO_2 decreased by 11.2 %.

Emissions from Energy Industries and AFF (agriculture, forestry and fisheries) each obtain 23 % of total SO_2 emission in 2009. Also emissions from other industrial combustion plants, non-industrial combustion plants and mobile sources are important. Transport contributed with 10 % of total SO_2 emission in 2009.

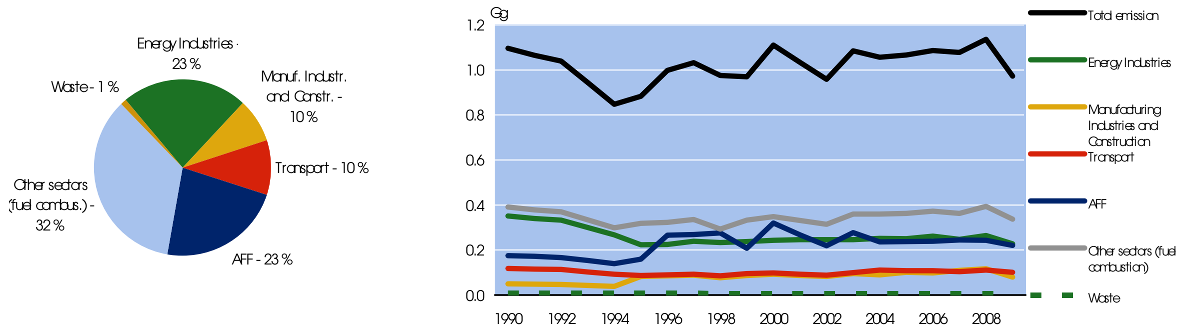


Figure 16.2.13 SO_2 emissions. Distribution according to the main sectors (2009), and time-series (1990-2009).

16.3 Energy (CRF sector 1)

16.3.1 Overview of sector

The emission of greenhouse gases from energy activities includes CO_2, CH_4 and N_2O emission from fuel combustion. The emissions are reported in CRF Tables 1.A(a), 1.A(b), 1.A(c), 1.A(d) and 1.B. Furthermore, the emission of non-methane volatile organic compounds (NMVOC), NO_X, CO and SO_2 from fuel combustion is given in CRF Table 1.

Summary tables for the energy sector are shown below.

Table 16.3.1 CO_2 emission from the energy sector.

Greenhouse gas source and sink categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
					Gg					
1. Energy	622.2	607.4	593.3	543.2	492.9	530.9	593.8	614.4	592.9	590.8
A. Fuel Combustion (Sectoral Approach)	622.2	607.4	593.3	543.2	492.9	530.9	593.8	614.4	592.9	590.8
1 . Energy Industries	182.5	177.3	173.2	156.7	140.1	120.8	121.8	128.8	126.7	128.7
2 . Manufacturing Industries and Construction	26.4	25.6	25.0	22.5	20.1	43.8	44.5	46.2	40.0	45.9
3 . Transport	95.9	95.4	93.4	87.0	80.6	88.4	92.3	96.3	100.6	104.0
4 . Other Sectors	309.1	301.1	293.9	269.8	245.7	270.5	327.9	335.9	318.4	304.9
5 . Other	8.2	8.0	7.8	7.0	6.3	7.3	7.3	7.3	7.3	7.3
B . Fugitive Emissions from Fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1. Energy	664.3	614.8	576.3	646.5	627.8	632.2	654.0	648.9	682.4	591.4
A. Fuel Combustion (Sectoral Approach)	664.3	614.8	576.3	646.5	627.8	632.2	654.0	648.9	682.4	591.4
1 . Energy Industries	132.1	133.2	133.8	134.3	137.9	136.5	143.3	135.8	144.4	125.7
2 . Manufacturing Industries and Construction	48.2	45.8	43.3	49.9	47.9	53.3	52.3	58.4	62.1	42.4
3 . Transport	105.4	95.7	92.0	100.9	105.1	105.8	110.4	109.3	116.8	105.4
4 . Other Sectors	371.3	332.9	299.9	354.1	330.2	329.4	340.3	338.3	351.6	312.6
5 . Other	7.3	7.3	7.3	7.3	6.7	7.2	7.7	7.0	7.5	5.2
B . Fugitive Emissions from Fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 16.3.2 CH_4 emission from the energy sector.

Greenhouse gas source and sink categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
					Gg					
1. Energy	0.05	0.05	0.05	0.04	0.04	0.04	0.05	0.05	0.05	0.05
A. Fuel Combustion (Sectoral Approach)	0.05	0.05	0.05	0.04	0.04	0.04	0.05	0.05	0.05	0.05
1 . Energy Industries	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
2 . Manufacturing Industries and Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3 . Transport	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
4 . Other Sectors	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.03
5 . Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B . Fugitive Emissions from Fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1. Energy	0.06	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.05
A. Fuel Combustion (Sectoral Approach)	0.06	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.05
1 . Energy Industries	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
2 . Manufacturing Industries and Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3 . Transport	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
4 . Other Sectors	0.04	0.04	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.03
5 . Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B . Fugitive Emissions from Fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 16.3.3 N_2O emission from the energy sector.

Greenhouse gas source and sink categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
					Gg					
1. Energy	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01
A. Fuel Combustion (Sectoral Approach)	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01
1 . Energy Industries	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 . Manufacturing Industries and Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3 . Transport	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4 . Other Sectors	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5 . Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B . Fugitive Emissions from Fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1. Energy	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
A. Fuel Combustion (Sectoral Approach)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1 . Energy Industries	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 . Manufacturing Industries and Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3 . Transport	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4 . Other Sectors	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5 . Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B . Fugitive Emissions from Fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

16.3.2 Source category description

In this section emission source categories, fuel consumption data and emission data are presented.

Activity data on fuel consumption is based on annual statistics on energy published by Statistics Greenland, and information on waste incineration with energy recovery. The annual statistics on energy is divided into sectors according to the Greenlandic Business Register (GB2000). The register comprises 577 business categories. The official statistics on energy is published by aggregation into 34 categories.

In the Greenlandic emission database, all activity rates and emissions are based on the official statistics on energy. However, in order to fit the CRF format fuel consumption from the official statistics on energy is further aggregated into 15 sectors.

Fuel combustion

In 2009, total fuel combustion was 8,231 TJ of which 8.047 TJ was fossil fuels.

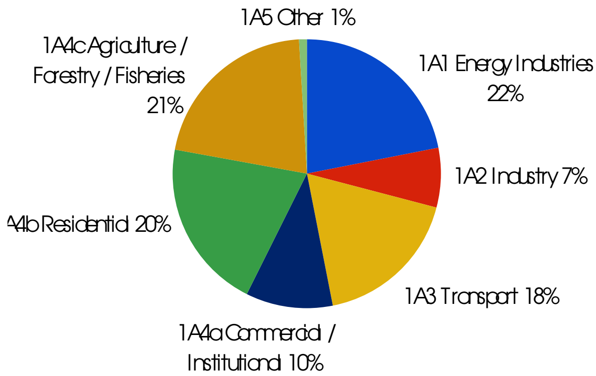


Figure 16.3.1   Fuel combustion rate, fossil fuels 2009 (Statistics Greenland).

In Greenland gas oil, kerosene and gasoline are used in fuel combustion. Gas oil and kerosene are the most utilised fuels. Gas oil is used in power plants to produce electricity and heat, as well as in district heating, private households, industries and for transportation.

Kerosene is primarily used in aviation, but also for heating in smaller settlements.

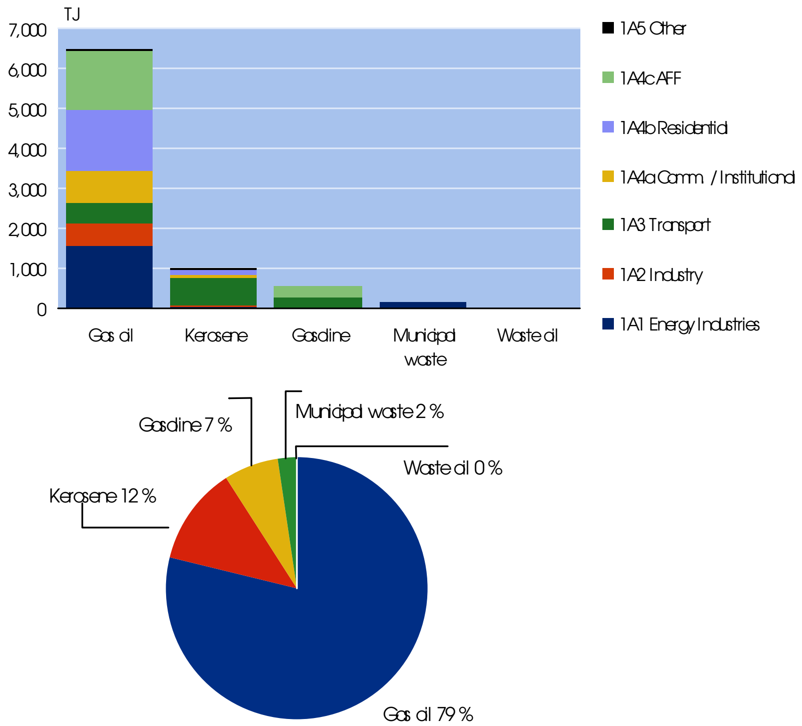


Figure 16.3.2   Fuel combustion, 2009 (Statistics Greenland).

Time-series on fuel consumption are presented in Figure 16.3.3. Total fuel consumption has decreased by 3.8% from 1990 to 2009. Fossil fuel consumption has decreased by 5.4%. Consumption of renewable energy has increased since 1990.

Fuel consumption is dominated by liquid fuels e.g. gas oil, kerosene and gasoline. In 2009 total fuel consumption consists of 98% liquid fuels, 1% solid fuels and 1% biomass.

In 2009 Energy Industries accounted for 22% of total fuel consumption. From 1990 to 1995 fuel consumption in Energy Industries decreased significantly due to the introduction of the first hydro power plant in 1993, and the introduction of burning waste to produce heat for district heating networks in 1989. Dependence on gas oil conversion decreased immediately. Nevertheless, from 1995 an onwards consumption of gas oil once again increased due to the general economic development. In 2007 fuel consumption in Energy Industries decreased due to a relatively warm winter. Contrary to this, the winter in 2008 was relatively colder, which increased fuel consumption to produce heat. In 2009 hydro power productions increased further when a fourth plant was opened. Together with a relatively warm 2009 winter fuel consumption in Energy Industries decreased additionally.

Fuel consumption in Agriculture, Forestry and Fisheries accounted for 21% of total fuel consumption in 2009. Fuel consumption in this sector has decreased since 2007. Before 2004, annual fuel combustion in this sector varied a great deal due to fluctuations in fishing activities from year to year. However, some uncertainty is expected in the 1990-2003 time-series on fuel consumption in Agriculture, Forestry and Fisheries.

Residential fuel consumption accounted for 20% of total fuel consumption in 2009. Fluctuations in fuel consumption are largely a result of variation in outdoor temperatures from year to year, which also causes fluctuations in fuel consumption in Energy Industries.

For 2004-2009 Statistics Greenland has conducted statistics on energy including detailed information on fuel consumption divided into 33 business categories and private households, see Section 16.3.3.1. Compared to the new statistics on energy the historic construction of time-series on fuel consumption in 1990-2003 was based on a much simpler method. Some uncertainty is therefore to be expected in the 1990-2003 time-series on sector-divided fuel consumption.

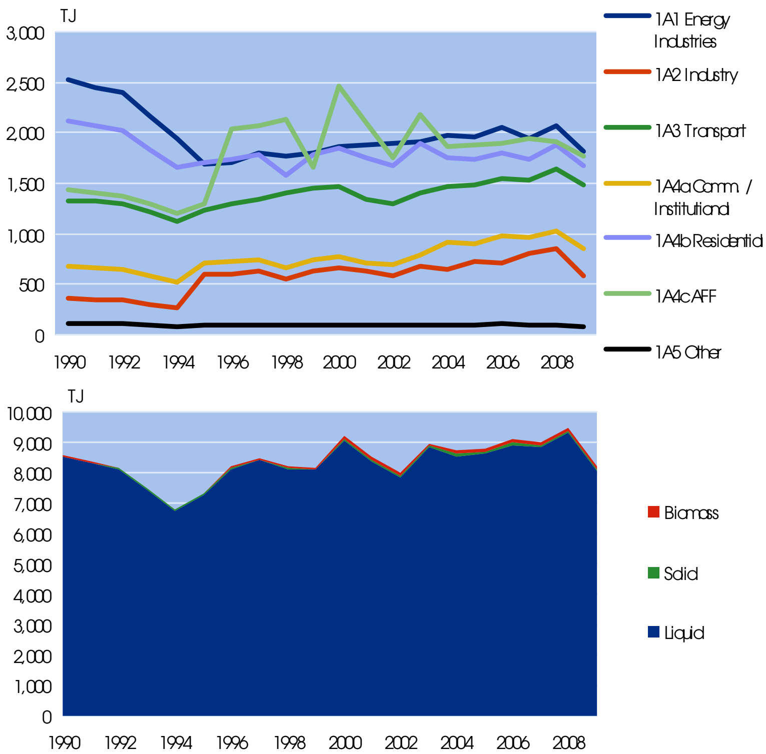


Figure 16.3.3 Fuel consumption time-series 1990-2009 (Statistics Greenland).

Fugitive emissions from fuels

Greenland has no coal mines, no off-shore activities, no oil refineries, no natural gas transmission or distribution. For that reason there are no fugitive emissions from such activities.

However, some fugitive emission occurs in the distribution of fuel e.g. when refuelling from ships to on-shore tanks, onshore loading of fuel to ships and offshore loading of ships. The emission would only be in the form of NMVOC. The fugitive emission from loading/unloading of ships is currently not estimated.

International bunker fuels

International Aviation Bunkers

Emissions from international aviation bunkers are considered to be of neglible importance. The Greenland Airport Authority has reported the annual amount of jet fuel loaded into foreign aircrafts including Danish aircrafts. However, it is not possible to distinguish between Danish aircrafts and other aircrafts. Since most foreign aircrafts by far are Danish the annual amount of jet fuel loaded into foreign aircrafts are therefore included as part of the IPCC category 1A3a Civil aviation.

International Marine Bunkers

Emission from international marine bunkers is included from 2004 and onwards. Before 2004 international marine bunkers are considered to be of neglible importance.

Feedstocks and non-energy use of fuels

At the moment Greenland has no production or use of feedstocks. Emissions from non-energy use of fuels (e.g. bitumen and solvents) are included in other sectors of the Greenlandic inventory (Industrial Processes (CRF sector 2) and Solvent and Other Product Use (CRF sector 3)).

16.3.3 Methodological issues

Activity data

The Greenlandic emission inventory for fuel combustion has been performed according to the IPCC tier 1 methodology. The inventory is based on activity data from the Greenlandic energy statistics and on emission factors for different fuels, plants and sectors.

Total fuel combustion is based on data from Polaroil, Statoil and Malik Supply A/S. Polaroil imports and distributes fuel in all parts of Greenland. Statoil imports and distributes fuel in Kangerlussuaq. Malik Supply A/S, a Danish company, re-distributes fuel bought from Polaroil to Greenlandic trawlers, ships etc. By using detailed data from Polaroil, Statoil and Malik Supply A/S it is possible to determine total import, total export, total international bunkers and total domestic fuel combustion.

Total domestic fuel combustion is then divided into sectors and private households by using data from a survey on energy consumption, company specific sales data from Polaroil and local fuel distributors, company tax accountings, municipal accountings and Greenland Government accountings, and by estimation.

In 2008, 2009 and 2010 Statistics Greenland conducted a survey among larger companies. By completing a questionnaire each company returned detailed information on the consumption of specific types of fuel in 2004-2009. The survey covered 51.7% of total GHG emission from energy combustion in 2009, see Table 16.3.4.

By using detailed information on sales from Polaroil and local fuel distributors it is possible to determine fuel combustion in private companies and public offices with an automatic deal on supply. The sales data covers 12% of total GHG emission from energy combustion in 2009, see Table 16.3.4.

Tax accountings in DKK are used to determine annual consumption of fuel in private companies, in municipalities, and within the Greenland Government. At the moment tax accountings are primarily used for determining fuel combustion in municipalities and public offices in settlements. Accountings cover 13.7% of total GHG emission from energy combustion in 2009, see Table 16.3.4.

The remaining amount of total inland fuel combustion is divided into sectors and private households by estimation. This work is carried out by involving statistical material on population, housing, public finances, fisheries and hunting, and national accountings. The Greenlandic Business Register (GER) is used to divide remaining companies into sectors. Information on employees, operating units, vehicles etc. is used to determine the activity in each company.

Fuel combustion in private households is estimated using detailed information from a number of local fuel distributors. Fuel deliveries are registered by buildings. In Greenland each building has a unique number registered in the Greenlandic Area Register (NIN). By combining the NIN-register and the GER-register (see above) with statistics on housing and population each building is labelled *private household* or located to a sector describing the main activity in the building. This new building-sector register, completed annually, is used extensively to determine the buyer of fuel delivered by Polaroil or local fuel distributors.

Fuel combustion in road traffic is based on a model designed by Statistics Greenland. The model contains data on the vehicle stock obtained from the Greenland Police Department's register on engine data. The vehicles are divided into broad categories of type i.e. personal car, lorry, taxi, truck, ambulance, motorbike etc. Each category is assigned with ratios on fuel type and mileage. Input data on mileage is derived from a survey among businesses and private road traffic in 2008, 2009 and 2010. Each vehicle is divided in business categories or labelled *private vehicle* according to the owner. For each group the emissions are estimated by combining vehicle and annual mileage numbers with standard emission factors according to the type of fuel. The model does not take cold start or hot engines into account.

For air traffic annual emissions are based on activity data from Air Greenland A/S and sales data from the Greenland Airport Authority. For navigation, ferries and freight, annual emissions are based on activity data from Royal Arctic Line A/S (freight), Royal Arctic Tankers A/S (freight), Royal Arctic Bygdeservice A/S (freight/passengers), and Arctic Umiaq Line A/S (passengers) and the liquidated Assartuivik A/S (passengers).

Table 16.3.4 shows the part of total CO_2 emission divided into sources - survey, specific sales data, tax accountings, and estimation.

Table 16.3.4 CO_2 emission from fuel combustion by sources to sectoral division (2004-2009).

	2004	2005	2006	2007	2008	2009
			pct.			
Total	100.0	100.0	100.0	100.0	100.0	100.0
Survey	49.1	48.9	48.7	50.2	50.1	51.7
Sales data from Polaroil	2.4	3.1	3.3	3.7	5.3	5.5
Sales data from local fuel distributors	0.0	0.0	3.3	5.2	6.7	6.6
Accountings	13.3	14.4	13.6	14.1	11.7	13.7
Estimation	35.2	33.6	31.2	26.8	26.3	22.5

The procedure described above is used to divide total fuel combustion into sectors and private households during the period 2004-2009. Formerly, the period 1990-2003, activity data on sectors and private households were estimated using aggregated statistics on population, housing, companies, data on sales from Polaroil, and data on energy consumption in larger companies.

An increasing part of municipal waste incineration is utilised for heat and power production. Thus, incineration with energy-recovery is included in the Energy sector.

Table 16.3.5 shows the activity data on fuel combustion for the period 1990-2009.

Table 16.3.5 Activity data on fuel combustion (SINK categories).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
					TJ					
Total	8 559	8 358	8 166	7 484	6 801	7 331	8 190	8 475	8 189	8 172
Energy industries	2 519	2 447	2 393	2 169	1 944	1 685	1 698	1 794	1 766	1 805
Manufacturing and construction	360	349	340	307	274	598	607	630	546	626
Domestic aviation	541	556	547	524	500	581	636	660	775	748
Road transport	501	488	476	437	397	370	369	387	361	401
National navigation	288	280	273	249	224	285	285	299	276	308
Commercial/Institutional	682	662	645	583	520	715	724	748	658	744
Residential	2 120	2 062	2 014	1 832	1 651	1 710	1 731	1 787	1 576	1 777
AFF	1 436	1 405	1 372	1 288	1 205	1 287	2 039	2 070	2 134	1 663
Other	112	109	106	96	86	99	99	99	99	99
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total	9 192	8 514	7 995	8 964	8 712	8 775	9 080	9 012	9 473	8 231
Energy industries	1 868	1 885	1 900	1 915	1 971	1 954	2 047	1 947	2 066	1 813
Manufacturing and construction	658	624	590	680	654	727	714	797	848	579
Domestic aviation	738	632	603	646	604	637	695	704	756	639
Road transport	417	399	388	433	450	463	492	492	530	481
National navigation	321	308	298	334	415	381	359	337	352	358
Commercial/Institutional	774	716	690	787	910	901	980	968	1 026	858
Residential	1 851	1 748	1 670	1 895	1 756	1 736	1 794	1 733	1 879	1 669
AFF	2 465	2 101	1 755	2 174	1 860	1 878	1 893	1 937	1 913	1 761
Other	99	99	99	99	92	99	105	96	102	72

Sources: Statistics Greenland. Notes: Data on fuel combustion in 1993 are interpolated from 1992 and 1994, since no data is available for 1993.

Emission factors

For each fuel and source category a set of general area source emission factors has been determined. The emission factors are either nationally referenced or based on the IPCC Reference Manual (IPCC, 1997).

CO_2

The CO_2 emission factors applied for 2009 are presented in Table 16.3.6. For municipal waste, time-series has been estimated according to the Danish emission factors. For all other fuels the same emission factor is applied for 1990-2009.

In reporting to the Climate Convention, the CO_2 emission is aggregated to three fuel types: Liquid fuel, Biomass and Other fuel.

The CO_2 emission from incineration of municipal waste with energy-recovery (79.6 + 32.5 kg pr GJ) is divided into two parts: the emission from combustion of the plastic content of waste (which is included in the Greenlandic total) and the emission from combustion of the rest of the waste – the biomass part (which is reported as a memo item). In the IPCC reporting, the fossil part of the waste and the associated emissions from fuel combustion of the plastic content of the waste is reported in the fuel category, *Other fuels*.

Table 16.3.6 CO_2 emission factors 2009.

Fuel	Emission factor	Unit	Reference type	IPCC fuel Category
Gas oil	73.326	kg pr GJ	IPCC reference manual	Liquid
Kerosene	71.148	kg pr GJ	IPCC reference manual	Liquid
Jet-Kerosene	70.785	kg pr GJ	IPCC reference manual	Liquid
Gasoline	68.607	kg pr GJ	IPCC reference manual	Liquid
Waste oil	76.593	kg pr GJ	IPCC reference manual	Liquid
Municipal waste – biomass	79.600	kg pr GJ	Country specific	Biomass
Municipal waste – fossil fuel	32.500	kg pr GJ	Country specific	Other fuels

The CO_2 emission has been calculated by using the same methodology as described in the IPCC Guidelines (IPCC, 1997). This methodology implies use of C content pr fuel type (default) and fraction of carbon oxidised (default); see the equation below.

$$E_{CO_2} = \sum Act_a \times EF_{C,a} \times Ox \times 44/12$$

where:

Act_{fuel} = activity; consumption of fuel a

$EF_{C,fuel}$ = C emission factor for fuel a

Ox = oxidation factor

The emissions of CH_4, N_2O, NO_X, CO and NMVOC have been calculated at sector/fuel level by using IPCC default emission factors combined with measured/Danish EF waste incineration (with energy recovery), se Table 16.3.7 – Table 16.3.9 below.

The equation applied for each pollutant is:

$$E = \sum (EF_{ab} \times Act_{ab})$$

where:

EF = emission factor

Act = activity; fuel input

a = fuel type

b = sector activity

CH₄

The CH_4 emission factors applied for 2009 are presented in Table 16.3.7. For municipal waste, time-series has been estimated according to the Danish emission factors. For all other fuels the same emission factor is applied for 1990-2009.

Emission factors for municipal waste refer to emission measurements carried out in Danish plants (Nielsen et al., 2009). Other emission factors refer to the IPCC Guidelines (IPCC, 1997).

Table 16.3.7 CH_4 emission factors 2009.

Fuel group	Fuel	CRF sector		Emission factor g pr GJ	Reference
Liquid	Gas oil	1A1	Energy Industries	3	IPCC, 1997
		1A2	Manufacturing Industries and Constructions	2	IPCC, 1997
		1A3a	Transport – Civil aviation	0.5	IPCC, 1997
		1A3b	Transport – Road transportation	5	IPCC, 1997
		1A3d	Transport – Navigation	5	IPCC, 1997
		1A4a	Other sectors – Commercial / Institutional	10	IPCC, 1997
		1A4b	Other sectors – Residential	10	IPCC, 1997
		1A4c	Other sectors – AFF stationary	10	IPCC, 1997
		1A4c	Other sectors – AFF mobile	5	IPCC, 1997
		1A5b	Other – Military mobile	5	IPCC, 1997
	Kerosene	1A1	Energy Industries	3	IPCC, 1997
		1A2	Manufacturing Industries and Constructions	2	IPCC, 1997
		1A3a	Transport – Civil aviation	0.5	IPCC, 1997
		1A3b	Transport – Road transportation	20	IPCC, 1997
		1A3d	Transport – Navigation	5	IPCC, 1997
		1A4a	Other sectors – Commercial / Institutional	10	IPCC, 1997
		1A4b	Other sectors – Residential	10	IPCC, 1997
		1A4c	Other sectors – AFF stationary	10	IPCC, 1997
		1A4c	Other sectors – AFF mobile	5	IPCC, 1997
		1A5b	Other – Military mobile	5	IPCC, 1997
	Gasoline	1A1	Energy Industries	3	IPCC, 1997
		1A2	Manufacturing Industries and Constructions	2	IPCC, 1997
		1A3a	Transport – Civil aviation	0.5	IPCC, 1997
		1A3b	Transport – Road transportation	20	IPCC, 1997
		1A3d	Transport – Navigation	5	IPCC, 1997
		1A4a	Other sectors – Commercial / Institutional	10	IPCC, 1997
		1A4b	Other sectors – Residential	10	IPCC, 1997
		1A4c	Other sectors – AFF stationary	10	IPCC, 1997
		1A4c	Other sectors – AFF mobile	5	IPCC, 1997
		1A5b	Other – Military mobile	5	IPCC, 1997
	Waste oil	1A1	Energy Industries	3	IPCC, 1997
Biomass	Municipal waste	1A1	Energy Industries	30	Nielsen et al., 2009
Other fuel	Municipal waste	1A1	Energy Industries	30	Nielsen et al., 2009

N_2O

The N_2O emission factors applied for the 2009 inventory are listed in Table 16.3.8. The same emission factors have been applied in the period 1990-2009.

Emission factors for municipal waste refer to emission measurements carried out in Danish plants (Nielsen et al. 2009). Other emission factors refer to the IPCC Guidelines (IPCC, 1997).

Table 16.3.8 N_2O emission factors 2009.

Fuel group	Fuel	CRF sector		Emission factor g pr GJ	Reference
Liquid	Gas oil	1A1	Energy Industries	0.6	IPCC, 1997
		1A2	Manufacturing Industries and Constructions	0.6	IPCC, 1997
		1A3a	Transport – Civil aviation	2	IPCC, 1997
		1A3b	Transport – Road transportation	0.6	IPCC, 1997
		1A3d	Transport – Navigation	0.6	IPCC, 1997
		1A4	Other sectors	0.6	IPCC, 1997
		1A5b	Other – Military mobile	0.6	IPCC, 1997
	Kerosene	1A1	Energy Industries	0.6	IPCC, 1997
		1A2	Manufacturing Industries and Constructions	0.6	IPCC, 1997
		1A3a	Transport – Civil aviation	2	IPCC, 1997
		1A3b	Transport – Road transportation	0.6	IPCC, 1997
		1A3d	Transport – Navigation	0.6	IPCC, 1997
		1A4	Other sectors	0.6	IPCC, 1997
		1A5b	Other – Military mobile	0.6	IPCC, 1997
	Gasoline	1A1	Energy Industries	0.6	IPCC, 1997
		1A2	Manufacturing Industries and Constructions	0.6	IPCC, 1997
		1A3a	Transport – Civil aviation	2	IPCC, 1997
		1A3b	Transport – Road transportation	0.6	IPCC, 1997
		1A3d	Transport – Navigation	0.6	IPCC, 1997
		1A4	Other sectors	0.6	IPCC, 1997
		1A5b	Other – Military mobile	0.6	IPCC, 1997
	Waste oil	1A1	Energy Industries	0.6	IPCC, 1997
Biomass	Municipal waste	1A1	Energy Industries	4	Nielsen et al., 2009
Other fuel	Municipal waste	1A1	Energy Industries	4	Nielsen et al., 2009

SO_2, NO_X, NMVOC and CO

Emission factors for SO_2, NO_X, NMVOC and CO are listed in Table 16.3.9. The same emission factors have been applied in the period 1990-2009.

Table 16.3.9 SO_2, NO_X, NMVOC and CO emission factors 2009 (g pr GJ).

Fuel group	Fuel	CRF sector		NO_X	CO	NMVOC	SO_2	Reference
Liquid	Gas oil	1A1	Energy Industries	200	15	5	141	1
		1A2	Manufacturing Industries and Constructions	200	10	5	141	1
		1A3a	Transport – Civil aviation	300	100	50	141	1
		1A3b	Transport – Road transportation	800	1 000	200	141	1
		1A3d	Transport – Navigation	1 500	1 000	200	141	1
		1A4a,b	Other sectors	100	20	5	141	1
		1A4c	Other sectors – AFF stationary	100	20	5	141	1
		1A4c	Other sectors – AFF mobile	1 200	1 000	200	141	1
		1A5b	Other – Military mobile	1 500	1 000	200	141	1
	Kerosene	1A1	Energy Industries	200	15	5	23	1
		1A2	Manufacturing Industries and Constructions	200	10	5	23	1
		1A3a	Transport – Civil aviation	300	100	50	23	1
		1A3b	Transport – Road transportation	600	8 000	1 500	23	1
		1A3d	Transport – Navigation	1 500	1 000	200	23	1
		1A4a,b	Other sectors	100	20	5	23	1
		1A4c	Other sectors – AFF stationary	100	20	5	23	1
		1A4c	Other sectors – AFF mobile	1 200	1 000	200	23	1
		1A5b	Other – Military mobile	1 500	1 000	200	23	1
	Gasoline	1A1	Energy Industries	200	15	5	46	1
		1A2	Manufacturing Industries and Constructions	200	10	5	46	1
		1A3a	Transport – Civil aviation	300	100	50	46	1
		1A3b	Transport – Road transportation	600	8 000	1 500	46	1
		1A3d	Transport – Navigation	1 500	1 000	200	46	1
		1A4a,b	Other sectors	100	20	5	46	1
		1A4c	Other sectors – AFF stationary	100	20	5	46	1
		1A4c	Other sectors – AFF mobile	1 200	1 000	200	46	1
		1A5b	Other – Military mobile	1 500	1 000	200	46	1
	Waste oil	1A1	Energy Industries	200	15	5	477	1
Biomass	Municipal waste	1A1	Energy Industries	100	1 000	50	6	2
Other fuel	Municipal waste	1A1	Energy Industries	100	1 000	50	6	2

Sources: 1) IPCC Guidelines (IPCC, 1997). 2) Nielsen et al., 2009.

Emissions

The greenhouse gas (GHG) emissions are listed in Table 16.3.10. The total emission of greenhouse gases from fuel combustion (Sectoral Approach) accounts for 93.9 % of total Greenlandic GHG emission.

The CO_2 emission from fuel combustion (Sectoral Approach) accounts for 99.5 % of the Greenlandic CO_2 emission (excluding net CO_2 emission from Land Use, Land Use Change and Forestry (LULUCF). The CH_4 emission from fuel combustion (Sectoral Approach) accounts for 9.2 % of the Greenlandic emission and the N_2O emission from fuel combustion accounts for 9.8 % of the Greenlandic N_2O emission.

Table 16.3.10 Greenhouse gas emission for the year 2009

		CO_2	CH_4	N_2O
		Gg CO_2-equivalent		
1A1	Fuel consumption, Energy Industries	125.7	0.2	0.5
1A2	Fuel consumption, Manufacturing Industries and Construction	42.4	0.0	0.1
1A3	Fuel consumption, Transport	105.4	0.2	0.6
1A4	Fuel consumption, Other sectors	317.9	0.7	0.8
Total emission from fuel consumption (Sectoral Approach)		591.4	1.1	2.0
Greenlandic emission (excluding net emission from LULUCF)		594.6	12.2	20.4
		%		
Emission share for fuel consumption (Sectoral Approach)		99.5	9.2	9.8

CO_2 is the most important GHG pollutant and accounts for 99.5 % of the GHG emission in CO_2 equivalents from fuel combustion (Sectoral Approach), see Figure 16.3.4.

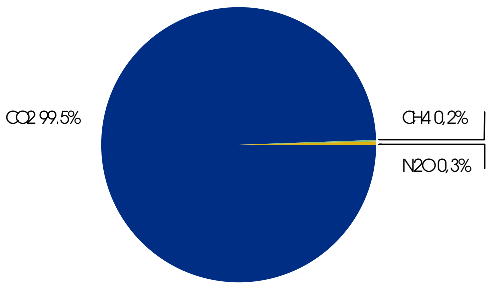


Figure 16.3.4 GHG emissions (CO_2 equivalent) from stationary combustion plants.

Figure 16.3.5 depicts the time-series of GHG emission in CO_2 equivalents from fuel combustion (Sectoral Approach). As shown by the blue curve the development in total GHG emission follows the CO_2 emission development very closely. Both CO_2 and total GHG emission are 5 % lower in 2009 compared to 1990.

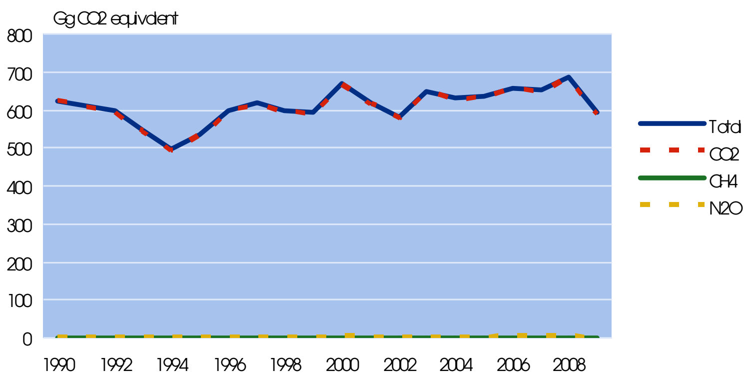


Figure 16.3.5 GHG emission time-series for fuel combustion (Sectoral Approach).

From 1990 to 1994 total GHG emission was reduced by 21 %. This was primarily due to the introduction of the first hydropower plant in 1993 but also to the introduction of burning waste to produce heat for district heating network in 1989. Dependence on gas oil conversion decreased immediately. Nevertheless, from 1995 an onwards consumption of gas oil once again increased due to the general economic development

In 2001-2002 total GHG emission decreased due to a minor recession in the economy. However since 1994 GHG emissions have increased in general with some fluctuations from year to year. The fluctuations are largely a result of outdoor temperature variations from year to year i.e. in 2008 the winter was relatively colder than in 2007. As a result fuel consumption increased in 2008 increasing GHG emission from fuel combustion. In 2009 GHG emission decreased by 13.3% due to a significantly substitution in Energy Industries from fuel consumption to hydro power production together with a relatively warmer winter.

CO_2

Stationary combustion plants are the most important GHG emission sources to CO_2 emission from fuel combustion. In 2009 CO_2 emission from stationary combustion plants accounted for 21.3% of the Greenlandic CO_2 emission from fuel combustion, see Table 16.3.11.

Table 16.3.11 lists CO_2 emission for fuel combustion in 2009 as well as the relative percentage for each category under the sectoral approach. The table reveals that *Electricity and Heat Production* – the only active category under Energy Industries – accounts for 21.3% of the CO_2 emission from fuel combustion. Other large CO_2 emission sources are transportation, residential plants and activities regarding agriculture, forestry and fisheries. These are sectors, which also account for a considerable share of fuel consumption.

Table 16.3.11 CO_2 emission from fuel combustion 2009.

		2009	
		Gg	%
1A1	Energy Industries (Electricity and Heat Production)	125.7	21.3
1A2	Industry	42.4	7.2
1A3	Transport	105.4	17.8
1A4a	Commercial / Institutional	62.7	10.6
1A4b	Residential	122.1	20.6
1A4c	Agriculture / Forestry / Fisheries	127.8	21.6
1A5	Other	5.2	0.9
Total		591.4	100.0

The CO_2 emission from combustion of biomass fuels is not included in the total CO_2 emission data, since biomass fuels are considered CO_2 neutral. The CO_2 emission from biomass combustion is reported as a memo item in the Climate Convention reporting. In 2009, the CO_2 emission from biomass combustion was 13.9 Gg.

Time-series for CO_2 emissions are provided in Figure 16.3.6. Fluctuations in CO_2 emission from agriculture, forestry and fisheries primarily regard fluctuations in fishing activities from year to year. Fluctuations in CO_2 emission from residential plants are largely a result of outdoor temperature variations from year to year. This also causes fluctuations in CO_2 emission from energy industries which cover electricity and heat production.

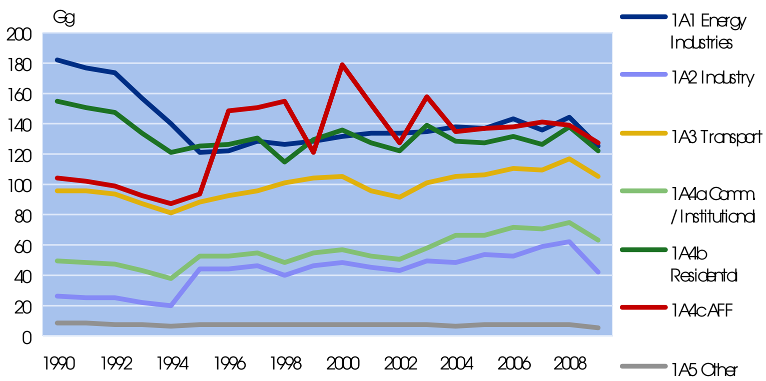


Figure 16.3.6 CO_2 emission time-series for fuel combustion (Sectoral Approach).

Detailed trend discussion on CRF category level is available in Section 16.2.

CH₄

CH_4 emission from fuel combustion accounts for 9.2 % of the Greenlandic CH_4 emission. Table 16.3.12 lists the CH_4 emission inventory for fuel combustion in 2009. The table reveals that Energy Industries – *Electricity and Heat Production* – accounts for 19 % of the CH_4 emission from fuel combustion, which is somewhat less than the fuel combustion share. Residential plants accounts for 31.2 % of the emission.

Table 16.3.12 CH_4 emission from fuel combustion 2009.

		2009	
		Mg	%
1A1	Energy Industries (Electricity and Heat Production)	10.2	19.0
1A2	Industry	1.2	2.2
1A3	Transport	7.6	14.3
1A4a	Commercial / Institutional	8.6	16.1
1A4b	Residential	16.7	31.2
1A4c	Agriculture / Forestry / Fisheries	8.8	16.6
1A5	Other	0.4	0.7
Total		53.4	100.0

The CH_4 emission from fuel combustion has increased by 6.7 % since 1990. Time-series for CH_4 emissions are provided in Figure 16.3.7. Fluctuations in CH_4 emission from agriculture, forestry and fisheries primarily regard fluctuations in fishing activities from year to year. Fluctuations in CH_4 emission from residential plants are largely a result of outdoor temperature variations from year to year. This also causes fluctuations in CH_4 emission from energy industries, which cover electricity and heat production.

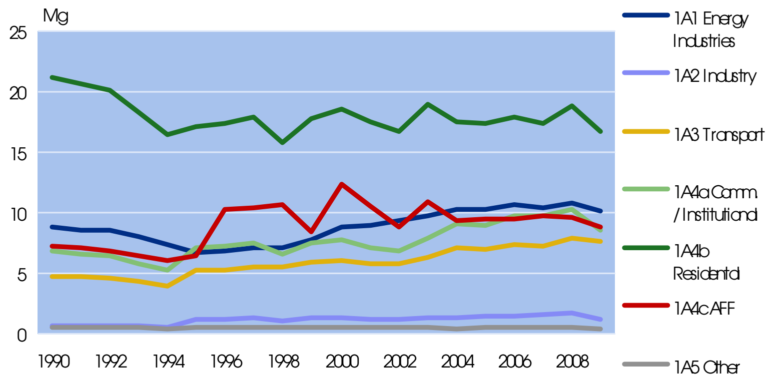


Figure 16.3.7 CH_4 emission time-series for fuel combustion (Sectoral Approach).

Detailed trend discussion on CRF category level is available in Section 16.2.

N_2O

The N_2O emission from fuel combustion accounts for 9.8 % of the Greenlandic N_2O emission. Table 16.3.13 lists the N_2O emission inventory for fuel combustion in 2009. The table reveals that Energy Industries – *Electricity and Heat Production* – accounts for 26.2 % of the N_2O emission from fuel combustion. This is higher than the fuel consumption share. Transport accounts for 27.7 % of the emission.

Table 16.3.13 N_2O emission from fuel combustion 2009.

		2009	
		Mg	%
1A1	Energy Industries (Electricity and Heat Production)	1.7	26.2
1A2	Industry	0.3	5.4
1A3	Transport	1.8	27.7
1A4a	Commercial / Institutional	0.5	8.0
1A4b	Residential	1.0	15.6
1A4c	Agriculture / Forestry / Fisheries	1.1	16.4
1A5	Other	0.0	0.7
Total		6.4	100

Figure 16.3.8 shows the time-series for the N_2O emission from fuel combustion. The N_2O emission has increased by 6.3% from 1990 to 2009. Once again fluctuations are primarily caused by variations in outdoor temperature from year to year.

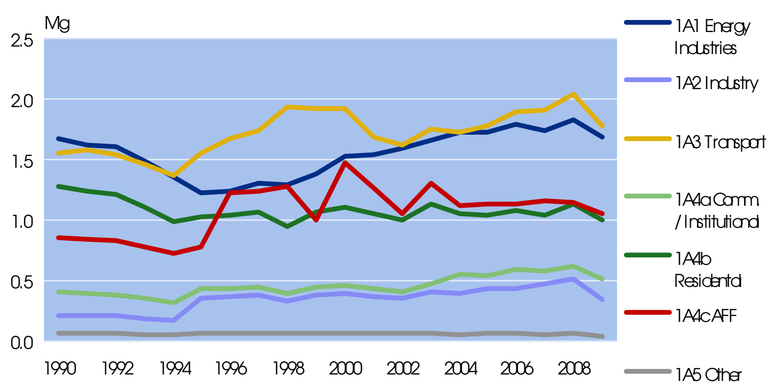


Figure 16.3.8 N_2O emission time-series for fuel combustion (Sectoral Approach).

Detailed trend discussion on CRF category level is available in Section 16.2.

SO_2, NO_X, NMVOC and CO

The emissions of SO_2, NO_X, NMVOC and CO from Greenlandic fuel combustion in 2009 are presented in Table 16.3.14. SO_2 from fuel combustion accounts for 99.4 % of the Greenlandic SO_2 emission. NO_X, CO and NMVOC account for 99.1, 89.6 % and 73.8 % respectively, of the Greenlandic emissions for these substances.

Table 16.3.14 SO_2, NO_X, NMVOC and CO emission from fuel combustion 2009.

	NO_X	CO	NMVOC	SO_2
	Gg	Gg	Gg	Gg
1A1 Fuel consumption, Energy Industries	0.3	0.2	0.0	0.2
1A2 Fuel consumption, Manuf. Industries and Constr.	0.1	0.0	0.0	0.1
1A3 Fuel consumption, Transport	1.1	2.4	0.5	0.1
1A4 Fuel consumption, Other sectors	2.5	1.9	0.4	0.6
Total emission from fuel consumption	4.0	4.4	0.9	1.0
Greenlandic emission	4.0	4.9	1.2	1.0
		%		
Emission share for fuel consumption	99.1	89.6	73.8	99.4

16.3.4 Uncertainties

A tier 1 uncertainty assessment has been carried out in accordance with the IPCC GPG (IPCC, 2000). The uncertainty has been estimated for all sources included in the reporting for the energy sector. The uncertainties for the activity data and emission factors are shown in Table 16.3.15.

Table 16.3.15 Uncertainties for activity data and emission factors for the energy sector.

Subsector	Pollutant	Activity data uncertainty	Emission factor uncertainty
1A, Liquid fuels	CO_2	2	5
1A, Municipal waste	CO_2	2	25
1A, Liquid fuels	CH_4	2	100
1A, Municipal waste	CH_4	2	100
1A, Biomass	CH_4	2	100
1A, Liquid fuels	N_2O	2	500
1A, Municipal waste	N_2O	2	500
1A, Biomass	N_2O	2	200

The activity data comes from the official Greenlandic energy statistics, which is considered to be of high quality, therefore the uncertainty of the activity data has been set to 2 %.

Regarding the emission factor uncertainty, the CO_2 emission factors are considered the most certain, and for liquid fuels an emission factor uncertainty of 5 % has been assumed. To account for the more inhomogeneous nature of municipal waste the emission factor uncertainty has been set to 25 %. For CH_4 the emission factor uncertainty has been set to 100% in accordance with the IPCC GPG (IPCC, 2000). For N_2O the emission factor uncertainties have been estimated to between 200% and 500 %. This is based on a first estimate and can be improved upon in the future.

The resulting uncertainties for the individual greenhouse gases and the total uncertainty on the greenhouse gas emission are shown in Table 16.3.16.

Table 16.3.16 Uncertainties for the emission estimates.

	Uncertainty %	Trend 1990-2009 %	Trend uncertainty %
GHG	5.5	-4.9	±2.7
CO_2	5.3	-5.0	±2.7
CH_4	90	6.7	±9.7
N_2O	446	6.3	±47

16.3.5 Source specific QA/QC

The elaboration of a formal QA/QC plan is to be completed.

However, the official Greenland energy statistics has gone through a great deal of quality work with regard to accuracy, comparability and completeness. Statistics Greenland is responsible for the official Greenlandic energy statistics, and as such responsible for the completeness of data. The uncertainties connected with estimating fuel consumption do not influence the coherence between the energy statistics and the datasets used in the emission inventory submission. For the remainder of the datasets, it is assumed that the level of uncertainty is relatively small. See chapter regarding uncertainties for further comments.

Statistics on fuel consumption is reported by Statistics Greenland in form of a spreadsheet. Annual consumption of gas oil, kerosene and gasoline are divided into business categories and private households. To ensure consistency data are compared with those from previous years and large discrepancies are checked.

All external data used for the emission inventory submission are archived in spreadsheets. Data are archived annually in order to ensure that the basic data for a given report are always available in their original form.

Safely stored and quality checked activity data are then processes by using a methodological approach consistent with international guidelines.

Calculated emission factors are compared with guideline emission factors to ensure that they are reasonable. The calculations follow the principle in international guidelines.

During data processing, it is checked that calculations are being carried out correctly. However, a documentation plan for this is to be elaborated.

Time-series for activity data, emission factors and calculated emissions are used to identify possible errors in the calculation procedure. In fact, during the calculation, numerous controls take place to ensure correctness. Sums are checked of the various stages in the calculation procedure. Implied emission factors are compared to emission factors.

Every single time-series imported to the CRF Reporter is checked for fuel rate, units for fuel rate, emission factor and plant-specific emissions. Additional checks are performed on the database. The database encloses every single activity data, emission factors, emission, notation key and comment imported to the CRF Reporter. In other words, no information is typed manually into the CRF Reporter. Instead, all information is imported to the CRF Reporter through XML-files to ensure maximum accuracy and completeness.

16.3.5.1 Reference approach

In addition to the sector-specific CO_2 emission inventories (the Greenlandic approach), the CO_2 emission is also estimated using the reference approach described in the IPCC Reference manual (IPCC, 1997). The reference approach is based on data for fuel production, import, export and stock change. The CO_2 emission inventory based on the reference approach is reported to the Climate Convention and used for verification of the official data in the Greenlandic approach.

Data for import, export and stock change used in the reference approach originate from the annual "basic data" table prepared by Statistics Greenland. The fraction of carbon oxidised has been assumed to be 1.00. The carbon emission factors are default factors originating from the IPCC Reference Manual (IPCC, 1997). The country-specific emission factors are not used in the reference approach, the approach being for the purposes of verification.

The Climate Convention reporting tables include a comparison of the Greenlandic approach and the reference approach estimates. To make results comparable, the CO_2 emission from incineration of the plastic content of municipal waste is added in the reference approach while the fuel consumption is subtracted.

In 2009 the fuel consumption rates in the two approaches differ by -1.0 % and the CO_2 emission differs by 1.0%. In the period 1990-2008 both the fuel consumption and the CO_2 emission differ by less than 1.2%. The differences in energy consumption are below 1 % for all years. The difference in CO_2 emission is above 1 % from 1990 to 1994, and below 1 % since 1995. According to IPCC Good Practice Guidance (IPCC, 2000) the difference should be within 2 %. A comparison of the Greenlandic approach and the reference approach is illustrated in Figure 16.3.9.

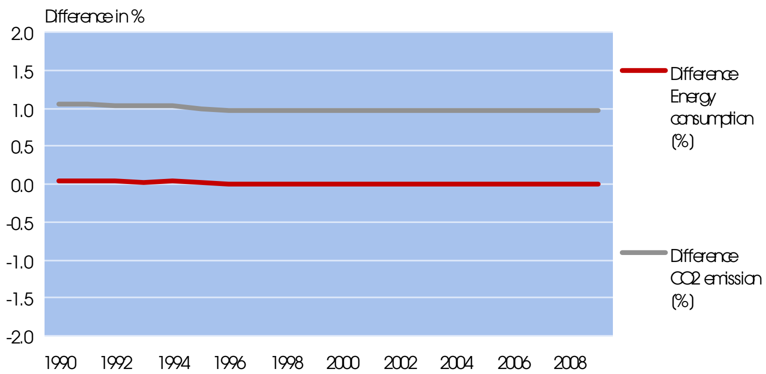


Figure 16.3.9 Comparison of the reference approach and the national approach.

16.3.6 Source specific recalculations and improvements

Improvements and recalculations since the 2010 emission inventory submission include:

- Update of fuel rates according to the latest energy statistics. The update includes the years 2004-2008.
- Adjustment of municipal waste with energy recovery according to improvements in population statistics, which is used in the estimation of municipal waste.

Table 6.3.17 shows recalculations in the energy sector compared with the 2010 submission.

Table 16.3.17 Changes in GHG emission in the energy sector compared with the 2010 submission.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Previous inventory, Gg CO_2 eqv.	625.2	610.3	596.1	545.8	495.3	533.5	596.6	617.4	595.9	593.8
Recalculated, Gg CO_2 eqv.	625.2	610.3	596.1	545.8	495.3	533.5	596.6	617.4	595.9	593.8
Change in Gg CO_2 eqv.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Change in pct.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Previous inventory, Gg CO_2 eqv.	667.6	617.9	579.2	649.8	631.1	635.5	657.4	652.2	685.9	-
Recalculated, Gg CO_2 eqv.	667.6	617.9	579.2	649.8	631.0	635.5	657.4	652.2	685.9	594.5
Change in Gg CO_2 eqv.	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	-
Change in pct.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-

16.3.7 Source specific planned improvements

Some planned improvements to the emission inventories are discussed below.

1) Improved documentation for emission factors

The reporting of, and references for, the applied emission factors have been improved in the current year and will be further developed in future inventories. This will happen on the advice from the Danish National Environmental Research Institute.

2) Improvements in plant specific fuel combustion

Plant specific fuel combustion will be further improved according to the developments made by Statistics Greenland in the energy statistics.

3) Uncertainty estimates

Uncertainty estimates are largely based on the default uncertainty levels for activity rates and emission factors. More country-specific uncertainty estimates will be incorporated in future inventories.

16.3.8 References

Consulting Company Carl Bro, 1996: Survey on waste from private households and companies in Greenland.

Consulting Company Carl Bro, 2001: Survey on waste from private households and companies in Greenland.

IPCC, 1997: Revised 1996 IPCC Guidelines for National Greenhouse Gas inventories. Available at: http://www.ipcc-nggip.iges.or.jp/public/gl/invs6.htm (15-04-2007).

IPCC, 2000: Penman, J., Kruger, D., Galbally, I., Hiraishi, T., Nyenzi, B., Emmanuel, S., Buendia, L., Hoppaus, R., Martinsen, T., Meijer, J., Miwa,

K. & Tanabe, K. (Eds). Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. Published: IPCC/OECD/IEA/IGES, Hayama, Japan. Available at:
http://www.ipcc-nggip.iges.or.jp/public/gp/english/ (15-04-2007).

European Environmental Agency (EEA), 2007: EMEP/CORINAIR Emission Inventory Guidebook 2007, Technical Report No 16/2007. Prepared by the UNECE/EMEP Task Force on Emissions Inventories and Projections, 2007 update. Available at:
http://www.eea.europa.eu/publications/EMEPCORINAIR5 (2009-02-27). Previous version of the Guidebook can be linked from this page.

KEMIN, 2008: Ministry of Climate and Energy. Law on CO_2 quotas, nr. 348 of 09/05/2008. (Danish legislation). Available (in Danish) at: https://www.retsinformation.dk/Forms/R0710.aspx?id=117147 (2009-03-01).

Greenland Government, Ministry of Housing, Infrastructure and Transport: Data on municipal waste incineration with energy-recovery.

Nielsen M., 2003. Estimates based on a large number of plant specific emission data. Not published.

Nielsen, O.-K., Lyck, E., Mikkelsen, M.H., Hoffmann, L., Gyldenkærne, S., Winther, M., Nielsen, M., Fauser, P., Thomsen, M., Plejdrup, M.S., Albrektsen, R., Hjelgaard, K., Johannsen, V.K., Vesterdal, L., Rasmussen, E., Arfaoui, K., Baunbæk, L. 2010: Denmark's National Inventory Report 2010 - Emission Inventories 1990-2008 - Submitted under the United Nations Framework Convention on Climate Change and the Kyoto Protocol. National Environmental Research Institute, University of Aarhus. 1178 pp. – NERI Technical Report no. 784. Available at:
http://www.dmu.dk/Pub/FR784.pdf

Pulles, T. & Aardenne, J.v. 2004: Good Practice for CLRTAP Emission Inventories, 24. June 2004. Available at:
http://www.eea.europa.eu/publications/EMEPCORINAIR4/BGPG.pdf (2009-02-27).

Statistics Greenland: Energy Consumption in Greenland 2004-2008 published in Danish. Available at :
http://www.stat.gl/Statistik/MiljoogEnergi/tabid/92/language/da-DK/Default.aspx as "Grønlands energiforbrug 2004-2008" (30-11-2009).

Statistics Greenland: Energy Consumption in Greenland 2009 published in Danish. Available at :
http://www.stat.gl/Statistik/MiljoogEnergi/tabid/92/language/da-DK/Default.aspx as "Grønlands energiforbrug 2009" (29-11-2010).

Statistics Greenland, 2009: The Greenlandic energy statistics aggregated to SINK categories. Not published.

16.4 Industrial processes (CRF sector 2)

16.4.1 Overview of sector

In this chapter industrial emissions of greenhouse gases, not related to generation of energy, are presented.

The emission of greenhouse gases from industrial processes includes CO_2, HFCs and SF_6. The emissions are reported in CRF Tables 2(I), 2(I).A, 2(II), 2(II).C, 2(II).E and 2(II).F. Furthermore, the emission of non-methane volatile organic compounds (NMVOC) and CO from industrial processes related to asphalt roofing, road paving with asphalt and production of food and drink are given in CRF Table 2(I).

An overview of sources identified is presented in Table 16.4.1 with an indication of the contribution to the industrial part of the emission of greenhouse gases in 2009. Emissions are extracted from the CRF tables.

Table 16.4.1 Overview of greenhouse gas sources (2009).

Process	IPCC Code	Substance	Emission tonnes CO_2 eqv.	%
Mineral Products				
Limestone and Dolomite Use	2A	CO_2	0.03	0.000
Asphalt Roofing	2A	CO_2	0.06	0.001
Road Paving with Asphalt	2A	CO_2	0.11	0.002
Consumption of Halocarbons and SF_6				
Refrigeration and Air Conditioning Equipment	2F	HFCs	6 568	99.951
Electrical Equipment	2F	SF_6	2.99	0.045
Total emission			6 571	100

The subsectors *Mineral Products* (2A) constitutes 0.003 % and *Consumption of Halocarbons and SF_6* (2F) constitutes 99.997 % of the industrial emission of greenhouse gases. The total emission of greenhouse gases (excl. LULUCF) in Greenland is estimated to 633.7 Gg CO_2-equivalent, of which industrial processes contribute with 6.571 Gg CO_2-equivalent (1.04%). The emission of greenhouse gases from industrial processes from 1990-2009 are presented in Figure 16.4.1.

Greenland has no chemical industry, metal production or production of halocarbons or SF_6. Greenland has no consumption of PFCs.

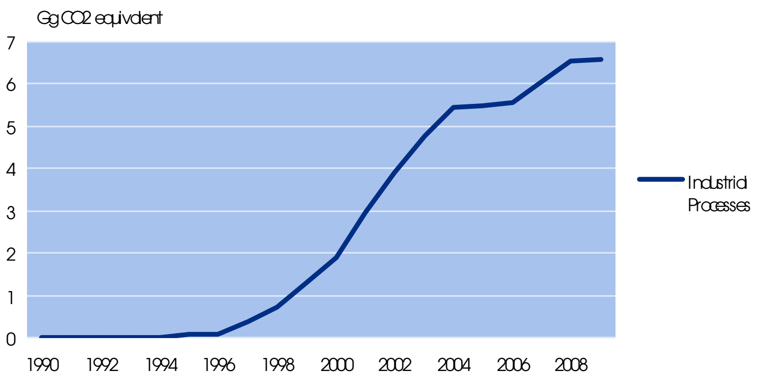


Figure 16.4.1 Emission of greenhouse gases from industrial processes 1990-2009.

The key categories in the industrial sector *Mineral Products* and *Consumption of Halocarbons and SF_6* constitute 0.00003% and 1.0 % of the total emission of greenhouse gases. The trends in greenhouse gases from the industrial sector/subsectors are presented in Table 16.4.2. The emissions are extracted from the CRF tables.

Table 16.4.2 Emission of greenhouse gases from industrial processes in different subsectors from 1990-2009.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CO_2 (tonnes CO_2)										
A. Mineral Products	0.11	0.11	0.11	0.11	0.10	0.11	0.10	0.13	0.12	0.13
CH_4	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
N_2O	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFCs (tonnes CO_2 eq.)										
F. Consumption of Halocarbons and SF_6	NE	NE	NE	NE	16	25	77	390	713	1 279
PFCs (tonnes CO_2 eq.)										
F. Consumption of Halocarbons and SF_6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
SF_6 (tonnes CO_2 eq.)										
F. Consumption of Halocarbons and SF_6	NE	NE	NE	NE	NE	35.9	3.4	3.4	3.3	3.3
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CO_2 (tonnes CO_2)										
A. Mineral Products	4.09	2.94	1.46	3.05	2.06	0.52	0.20	1.70	3.24	0.20
CH_4	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
N_2O	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HFCs (tonnes CO_2 eq.)										
F. Consumption of Halocarbons and SF_6	1 871	2 964	3 898	4 750	5 425	5 499	5 558	6 065	6 527	6 568
PFCs (tonnes CO_2 eq.)										
F. Consumption of Halocarbons and SF_6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
SF_6 (tonnes CO_2 eq.)										
F. Consumption of Halocarbons and SF_6	3.3	3.2	3.2	3.2	3.1	3.1	3.1	3.0	3.0	3.0

Greenland has no production of halocarbons or SF_6. Data on consumption of F-gases (HFCs and SF_6) are obtained from the Statistics Greenland (imports) and by an annual survey on consumption halocarbons and SF_6. Information on consumption of F-gases is available from 1995 onwards. Greenland has no consumption of PFCs.

One single plant in Greenland has reported use of SF_6 in 1995. The emission of SF_6 was 35.9 tonnes CO_2-eqv. in 1995. The annual emission from 1996 and onwards is assumed to be 0.5% of the amount filled into the plant in 1995. This causes a relative high emission of SF_6 in 1995 and a much lower emission in the period 1996-2009.

Energy consumption associated with industrial processes and emissions thereof are included in the Energy sector of the inventory.

16.4.2 Source category description

Mineral products

The subsector *Mineral products* (2A) cover the following processes:

- Limestone and dolomite use.
- Roof covering with asphalt materials.
- Road paving with asphalt.

The time-series for the emission of CO_2 from Mineral products (2A) are presented in Table 16.4.3. The emissions are extracted from the CRF tables and the values are rounded.

Table 16.4.3 Time-series for emission of CO_2 (tonnes) from Mineral products (2A).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
3. Limestone and dolomite use	-	-	-	-	-	-	-	-	-	-
5. Asphalt roofing	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.00
6. Road paving	0.10	0.10	0.10	0.10	0.10	0.10	0.09	0.11	0.11	0.13
Total	0.11	0.11	0.11	0.11	0.10	0.11	0.10	0.13	0.12	0.13
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
3. Limestone and dolomite use	3.96	2.77	1.32	2.64	1.80	0.11	0.03	1.51	2.96	0.03
5. Asphalt roofing	0.01	0.00	0.02	0.04	0.07	0.03	0.05	0.04	0.08	0.06
6. Road paving	0.12	0.17	0.12	0.37	0.19	0.38	0.12	0.15	0.20	0.11
Total	4.09	2.94	1.46	3.05	2.06	0.52	0.20	1.70	3.24	0.20

The use of limestone and dolomite started in 2000. Hence there is no emission from limestone and dolomite use before 2000. The use of limestone and dolomite has been estimated from the annual import of these products to Greenland. Imports seem to vary a great deal from year to year, which causes the estimated use to vary as well. In 2009 the estimated use of limestone and dolomite decrease significantly, which leads to an additionally decrease in emission of CO_2.

The increase in CO_2 emission is most significant for the use of asphalt roofing. From 1990 to 2009, the CO_2 emission increased from 0.01 to 0.06 tonnes CO_2; an increase of 560 %. The increase in CO_2 from asphalt roofing has primarily taken place from 2002 and onwards. Since 2002 annual building activities have increased by an average of 5.5 % for dwellings alone compared to 1990.

The most significant CO_2 emission comes from the use of road paving, which constitutes 53.2 % of the total CO_2 emission from mineral products in 2009. The maximum emission from road paving occurred in 2005 and constituted 0.38 tonnes CO_2.

The CO_2 emission from subsectors under mineral products fluctuates a great deal from year to year. This is caused by fluctuations in building activities and road paving. However fluctuations in CO_2 are also caused by the fact that activity data for mineral products are based on import data, which do not allow distinction of imported amount into consumption and stockpiling.

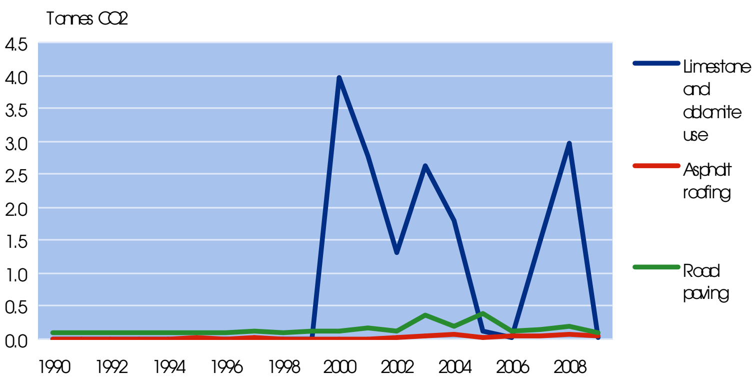


Figure 16.4.2 Emission of CO_2 from mineral products.

Consumption of Halocarbons and SF_6

The subsector *Consumption of Halocarbons and SF_6* (2F) includes the following source categories and the following F-gases of relevance for Greenlandic emissions:

- 2F1: Refrigeration: HFC32, 125, 134a, 143a, unspecified HFCs.
- 2F8: Electrical equipment: SF_6.

A quantitative overview is given below for each of these source categories and each F-gas, showing their emissions in tonnes through the time-series. The data is extracted from the CRF tables that form part of this submission and the data presented is rounded values. It must be noticed that the inventories for the years 1990-1993 (1994) might not cover emissions of these gases in full. The chosen base-year for these gases is 1995 for Greenland.

Table 16.4.4 Emission of HFCs from refrigeration (t).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
HFC32	NE	NE	NE	NE	NE	NA	0.00	0.00	0.00	0.00
HFC125	NE	NE	NE	NE	NE	NA	0.01	0.04	0.08	0.15
HFC134a	NE	NE	NE	NE	0.01	0.02	0.03	0.06	0.10	0.17
HFC143a	NE	NE	NE	NE	NE	NA	0.01	0.05	0.09	0.16
Unspecified HFCs	NE	NE	NE	NE	NE	NA	0.00	0.00	0.00	0.00
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
HFC32	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
HFC125	0.22	0.35	0.46	0.56	0.64	0.64	0.65	0.71	0.76	0.77
HFC134a	0.24	0.35	0.45	0.55	0.63	0.65	0.65	0.68	0.67	0.64
HFC143a	0.24	0.39	0.51	0.63	0.71	0.72	0.72	0.79	0.86	0.88
Unspecified HFCs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 16.4.5 Emission of SF_6 from electrical equipment (kg).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
SF_6	NE	NE	NE	NE	NE	1.50	0.14	0.14	0.14	0.14
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
SF_6	0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13

The emission of SF_6 was highest in 1995, when one single plant in Greenland reported use of SF_6. The emission of SF_6 was 1.5 kg in 1995. Since 1995 the annual emission is assumed to be 0.5% of the amount filled into the plant in 1995. This causes a relative high emission of SF_6 in 1995 and a much lower emission in the following years. In 2009 the emission of SF_6 was 0.13 kg.

HFCs are used in various types of refrigeration in industry, retail, buildings and onboard ships. In 1994 and 1995 consumption of HFC134a was the only reported HFC used for refrigeration. Since 1996 consumption of HFC32, 125, 134A, 143A has been reported continuously. The emission of HFCs has increased rapidly since 1995.

Table 16.4.6 and Figure 16.4.3 and Figure 16.4.4 quantify an overview of the emissions of the gases in CO_2-eqv. The reference is the trend table as included in the CRF table for year 2009.

Table 16.4.6 Time-series for emission of HFCs and SF_6 (tonnes CO_2-eqv.).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
HFCs	NE	NE	NE	NE	16	25	77	390	713	1 279
SF_6	NE	NE	NE	NE	NE	35.9	3.4	3.4	3.3	3.3
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
HFCs	1 871	2 964	3 898	4 750	5 425	5 499	5 558	6 065	6 527	6 568
SF_6	3.3	3.2	3.2	3.2	3.1	3.1	3.1	3.0	3.0	3.0

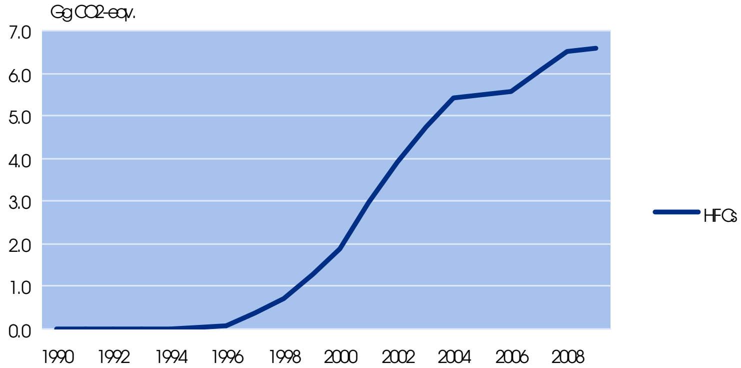


Figure 16.4.3 Emission of HFCs (from refrigeration).

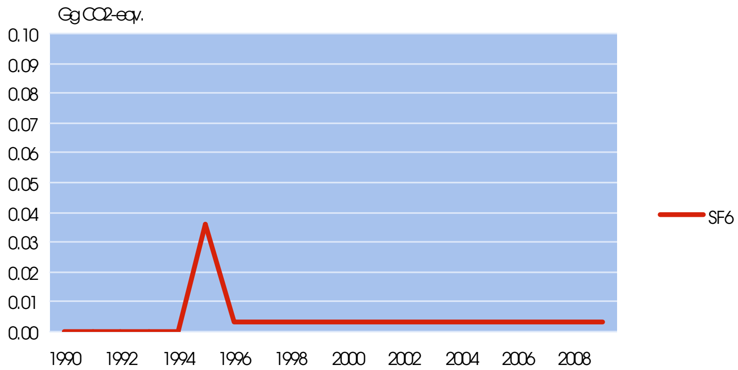


Figure 16.4.4 Emission of SF_6 (from electrical equipment).

HFCs is by far the most dominant group. HFCs constitute a key category both with regard to the key category level and the trend analysis.

16.4.3 Methodological issues

General

The CO_2 emission from the use of limestone and dolomite, asphalt materials used for roof covering and road paving has been estimated from the annual import of these products to Greenland.

The emissions of HFCs and SF_6 have been estimated from data on consumption of F-gases. Activity data includes annual imports and data on consumption of halocarbons and SF_6 obtained from an annual survey among importers and consumers of F-gases.

The following sections contain a description of activity data and emission factors used for the subsectors under industrial processes. The section is concluded by a description of the emissions of greenhouse gases from industrial processes.

Activity data

Activity data for subsectors *Mineral Products* (2A) and *Other Production* (2D) are presented in Table 16.4.7. Activity data under subsector *Other Production* (2D) are used for calculation of emission of non-methane volatile organic compounds (NMVOC).

The activity data are rounded. Notice that production of beer is given in hectolitre (hl). All other activity data are given in tonnes (t).

Statistics on imports are used to estimate annual consumption of mineral products. Statistics on imports of whole coffee beans and yeast for baking are used to estimate annual production of coffee and bread. Statistics on landings of fish and seafood to domestic plants are used to determine domestic processing of fish and seafood. Statistics on imports are produced by Statistics Greenland (2010b).

Production of beer including a fermentation process has taken place at the brewery "Godthåb Bryghus" since 2005 (Godthåb Bryghus, 2011). The brewery has reported annual production in rounded hectolitre. The much larger company "Nuuk Imeq" has no production of beer including a fermentation process. As a bottling company the activity at "Nuuk Imeq" only includes diluting of the concentrated quantities imported to Greenland and afterwards bottling of the beer.

Table 16.4.7 Time-series for activity data for Mineral Products and Other Production (Godthåb Bryghus, 2011, Statistics Greenland, 2010b).

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Mineral Products											
2A3	Limestone and dolomite use (t)	-	-	-	-	-	-	-	-	-	-
2A5	Asphalt materials used for roofing (t)	37	35	39	39	13	56	29	59	39	7
2A6	Asphalt used for road paving (t)	591	581	595	604	597	577	532	664	649	752
Other Production											
2D2	Food and Drink - Beans roasted to produce coffee (t)	0	0	0	0	-	0	-	-	0	0
2D2	Food and Drink - Production of bread (t)	356	346	339	358	501	244	415	500	847	689
2D2	Food and Drink - Landings of fish and seafood (t)	81 768	72 395	65 553	59 423	64 479	67 786	60 662	62 244	67 247	63 750
2D2	Food and Drink - Production of beer (hl)	-	-	-	-	-	-	-	-	-	-

continued		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Source
Mineral Products												
2A3	Limestone and dolomite use (t)	9	6	3	6	4	0	0	3	7	0	1
2A5	Asphalt materials used for roofing (t)	26	11	81	149	263	114	193	148	321	241	1
2A6	Asphalt used for road paving (t)	694	988	705	2 218	1 127	2 258	698	910	1 206	629	1
Other Production												
2D2	Food and Drink - Beans roasted to produce coffee (t)	0	1	-	0	0	0	0	1	0	0	2
2D2	Food and Drink - Production of bread (t)	687	566	1 020	1 048	1 338	1 014	1 134	622	931	587	2
2D2	Food and Drink - Landings of fish and seafood (t)	74 105	66 929	85 970	80 667	102 570	103 642	111 351	118 260	109 420	102 393	3
2D2	Food and Drink - Production of beer (hl)	-	-	-	-	-	1 000	2 000	2 000	1 850	1 650	4

Sources:

1) Statistics on imports are used to estimate annual consumption of mineral products.

2) Statistics on imports of whole coffee beans and yeast for baking are used to estimate annual production of coffee and bread.

3) Statistics on landings of fish and seafood to domestic plants are used to determine domestic processing of fish and seafood.

4) Data from the brewery "Godthåb Bryghus" are used to determine annual production of beer.

The data for emission of HFCs and SF_6 has been obtained in continuation on the work on inventories for previous years. The determination includes the quantification and determination of any import and export of HFCs and SF_6 contained products and substances in stock form. This is in accordance with IPCC guidelines (IPCC (1997), vol. 3, p. 2.43ff), as well as the relevant decision trees from the IPCC Good Practice Guidance (IPCC (2000) p. 3.53ff).

The following sources of information have been used (Statistics Greenland, 2010a):

- Importers, wholesaler and suppliers.
- Statistics Greenland.
- Consuming enterprises.

Importers and suppliers provide consumption data of F-gases. Emission factors are defaults from the GPG. Import/export data for sub-source categories where import/export is relevant are quantified on estimates from import/export statistics of products + default values of the amount of gas in the product.

The determination of emissions of F-gases is based on a calculation of the actual emission. The actual emission is the emission in the evaluation year, accounting for the time lapse between consumption and emission. The actual emission includes Greenlandic emissions from production and from products during their lifetimes. Consumption and emissions of F-gases are, whenever possible for individual substances, even though the consumption of certain HFCs has been limited. This has been varied out to ensure transparency of evaluation in the determination of GWP values. However, the continued use for Other HFCs has been necessary since not all importers and suppliers have specified records of sales for individual substances.

Only the actual emission has been calculated. Thus, the potential emission is assumed to be the same as the actual emission in the CRF tables.

Table 16.4.8 Content (w/w%) of "pure" HFC in HFC-mixtures, used as trade names.

HFC mixtures	HFC32	HFC125	HFC134a	HFC143a	Unspecified HFCs
	%	%	%	%	%
HFC-134, total			100		
HFC-404, total		44	4	52	
HFC-407c, total	23	25	52		
HFC-507a, total		50		50	
Unspecified HFCs					100

The substances have been accounted for in the survey according to their trade names, which are mixtures of HFCs used in the CRF. In the transfer to the "pure" substances used in the CRF reporting schemes, the ratios shown in Table 16.4.8 have been used.

Activity data for the consumption of F-gases is shown in Table 16.4.9. The activity data are rounded and given in kg.

Table 16.4.9 Time-series for activity data for the consumption of F-gases by trade-names (Statistics Greenland, 2010a).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
					Kg					
HFC-134										
Domestic	NE	NE	NE	264	139	91	187	134	453	319
Commercial and Industry	NE	NE	NE	-	-	-	123	123	247	247
Transport	NE	NE	NE	-	-	-	64	64	128	128
HFC-404a										
Commercial and Industry	NE	NE	NE	-	-	-	488	488	976	976
Transport	NE	NE	NE	-	-	-	82	82	164	164
HFC-407c										
Commercial and Industry	NE	NE	NE	-	-	-	34	34	68	68
HFC-507a										
Transport	NE	NE	NE	-	-	-	113	113	225	225
Unspecified HFCs										
Commercial and Industry	NE	NE	NE	-	-	-	45	45	90	90
SF_6										
Electrical Equipment	NE	NE	NE	-	-	30	-	-	-	-
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
HFC-134										
Domestic	289	492	774	635	635	-	-	-	-	-
Commercial and Industry	493	493	493	493	260	208	680	329	312	195
Transport	256	256	256	256	120	120	30	30	-	-
HFC-404a										
Commercial and Industry	1 952	1 952	1 952	1 952	1 324	1 041	2 033	2 069	1 950	2 089
Transport	328	328	328	328	154	222	369	413	384	241
HFC-407c										
Commercial and Industry	135	135	135	135	68	83	31	4	112	90
HFC-507a										
Transport	450	450	450	450	-	-	120	180	-	120
Unspecified HFCs										
Commercial and Industry	180	180	180	180	326	314	556	698	309	400
SF_6										
Electrical Equipment	-	-	-	-	-	-	-	-	-	-

Emission factors

The CO_2 emission factors applied for mineral products in 2009 are presented in Table 16.4.10. The same emission factor has been applied for 1990-2009.

Table 16.4.10 CO_2 emission factors 2009.

Product	Emission factor	Unit	Reference	IPCC Category
Limestone and dolomite use	440	kg pr tonne	IPCC, 1997	2A3
Asphalt materials used for roofing	0.25	kg pr tonne	Nielsen et al., 2009	2A5
Asphalt used for road paving	0.168	kg pr tonne	Nielsen et al., 2009	2A6

The CO emission factors applied for the consumption of asphalt products under mineral products in 2009 are presented in Table 16.4.11. The same emission factor has been applied for 1990-2009.

Table 16.4.11 CO emission factors 2009.

Product	Emission factor	Unit	Reference	IPCC Category
Asphalt materials used for roofing	0.01	kg pr tonnes	Nielsen et al., 2009	2A5
Asphalt used for road paving	0.075	kg pr tonnes	Nielsen et al., 2009	2A6

The NMVOC emission factors applied for the consumption of asphalt products under mineral products and products used in the production of food and drink in 2009 are presented in Table 16.4.12. The same emission factor has been applied for 1990-2009.

Table 16.4.12 NMVOC emission factors 2009.

Product	Emission factor	Unit	Reference	IPCC Category
Asphalt materials used for roofing	0.08	kg pr tonnes	Nielsen et al., 2009	2A5
Asphalt used for road paving	0.015	kg pr tonnes	Nielsen et al., 2009	2A6
Food and Drink - Beans roasted to produce coffee	0.55	kg pr tonnes	IPCC, 1997	2D2
Food and Drink - Production of bread	8	kg pr tonnes	IPCC, 1997	2D2
Food and Drink - Landings of fish and seafood	0.3	kg pr tonnes	IPCC, 1997	2D2
Food and Drink - Production of beer	0.0625	kg pr hl	Nielsen et al., 2009	2D2

Emissions

The greenhouse gas (GHG) emissions are listed in Table 16.4.13. The emission from industrial processes accounts for 1.0 % of the Greenlandic GHG emission.

The CO_2 emission from industrial processes accounts for just 0.00003% of the Greenlandic CO_2 emission (excluding net CO_2 emission from Land Use, Land Use Change and Forestry (LULUCF). The HFC emission from industrial processes accounts for 100% of the Greenlandic emission and the SF_6 emission accounts for 100% of the Greenlandic SF_6 emission.

Table 16.4.13 Greenhouse gas emission for the year 2009.

		CO_2	HFC	SF_6
		Tonne CO_2-equivalent		
2A3	Limestone and Dolomite Use	0.03	NA	NA
2A5	Asphalt Roofing	0.06	NA	NA
2A6	Road Paving with Asphalt	0.11	NA	NA
2F1	Refrigeration	NA	6 568	NA
2F8	Electrical Equipment	NA	NA	3.0
Total emission from industrial processes		0.20	6 568	3.0
		Gg CO_2-equivelent		
Greenlandic emission (excluding net emission from LULUCF)		594.6	6.568	0.003
			%	
Emission share for industrial processes		0.00003	100	100

HFC is the most important GHG pollutant and accounts for 99.95 % of the GHG emission in CO_2 equivalents from industrial processes. Illustration of the percentage of share in a figure is omitted due to the large share of HFC, which completely dominates as the most significant GHG pollutant from industrial processes.

CO_2

Figure 16.4.5 depicts the time-series of CO_2 emission from industrial processes. As shown by the blue curve total CO_2 emission follows the CO_2 emission from use of limestone and dolomite closely. Limestone and dolomite first was imported in 2000. Thus emission of CO_2 from the use of mineral products increased significantly in 2000. The emission of CO_2 has increased by a factor 30 from 1990 to 2008 primarily due to the introduction of limestone and dolomite import in 2000. In 2009 limestone and dolomite imports decreased significantly causing emissions from mineral products to drop as well.

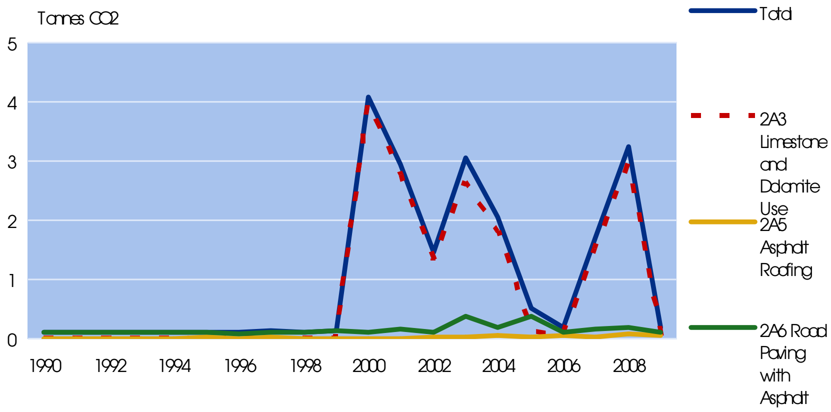


Figure 16.4.5 Emission of CO_2 from industrial processes.

Emission of HFCs and SF_6 are illustrated in Figure 16.4.3 and Figure 16.4.4.

NMVOC and CO

The emissions of NMVOC and CO from industrial processes in 2009 are presented in Table 16.4.14. NMVOC and CO account for 3.03 % and 0.001 % respectively, of the Greenlandic emissions for these substances.

Table 16.4.14 NMVOC and CO emission from industrial processes 2009.

	NMVOC	CO
	Tonnes	
2A5 Asphalt Roofing	0.02	0.00
2A6 Road Paving with Asphalt	0.01	0.05
2D2 Food and Drink	35.52	NA
Total emission from industrial processes	35.55	0.05
Greenlandic emission	1 173.7	4 946.4
	%	
Emission share for industrial processes	3.03	0.001

16.4.4 Uncertainties

A tier 1 uncertainty assessment has been carried out in accordance with the IPCC GPG (IPCC, 2000). The uncertainty has been estimated for all sources included in the reporting for industrial processes. The uncertainties for the activity data and emission factors are shown in Table 16.4.15.

Table 16.4.15 Uncertainties for activity data and emission factors for industrial processes.

Subsector	Pollutant	Activity data uncertainty	Emission factor uncertainty
2A3 Limestone and dolomite use	CO_2	5	5
2A5 Asphalt roofing	CO_2	5	25
2A6 Road paving with asphalt	CO_2	10	50
2F Consumption of HFC	HFC	10	50
2F Consumption of SF6	SF_6	10	50

The activity data comes from the import statistics, which is considered to be of high quality, therefore the uncertainty of the activity data has been set to 5 % for limestone and dolomite use and asphalt roofing, while it is assumed to be 10 % for road paving and consumption of HFCs and SF_6.

Regarding the emission factor uncertainty, the CO_2 emission factor for limestone and dolomite use is considered very certain. It is derived from stoichiometric calculations. Thus an emission factor of 5 % has been assumed. The uncertainty levels for asphalt roofing and road paving are expert judgements. The emission of F-gases is dominated by emissions from refrigeration equipment and, therefore, the uncertainties assumed for this sector will be used for all the F-gases. The IPCC propose an uncertainty at 30-40% for regional estimates. However, Greenlandic statistics have been developed over a number of years and, therefore the uncertainty on activity data is assumed to be 10%. The uncertainty on the emission factor is, on the other hand, assumed to be 50 %. The base year for F-gases for Greenland is 1995.

The resulting uncertainties for the individual greenhouse gases and the total uncertainty on the greenhouse gas emission are shown in Table 16.4.16.

Table 16.4.16 Uncertainties for the emission estimates.

	Uncertainty %	Trend 1990-2009[1] %	Trend uncertainty %
GHG	36	15 378	±4 276
CO_2	15.7	83	±21.8
HFC	51	26 692	±3 789
SF_6	51	-92	±1.2

[1] For f-gases the base year of 1995 is used

16.4.5 Source specific QA/QC

The elaboration of a formal QA/QC plan is to be completed.

However, the official Greenland import statistics has gone through a great deal of quality work with regard to accuracy, comparability and completeness. Statistics Greenland is responsible for the official Greenlandic import statistics, and as such responsible for the completeness of data.

Statistics on imports is reported by Statistics Greenland in form of a spreadsheet. Annual import of limestone and dolomite, asphalt materials used for roof covering and road paving, whole coffee beans and yeast for baking are compared with imports in previous years and large discrepancies are checked. The same procedure is used to ensure accuracy in annual use of F-gases and statistics on landings of fish and seafood to domestic plants.

All external data used for the emission inventory submission are archived in spreadsheets. Data are archived annually in order to ensure that the basic data for a given report are always available in their original form.

Safely stored and quality checked activity data are then processes by using a methodological approach consistent with international guidelines.

Calculated emission factors are compared with guideline emission factors to ensure that they are reasonable. The calculations follow the principle in international guidelines.

During data processing, it is checked that calculations are being carried out correctly. However, a documentation plan for this needs to be elaborated.

Time-series for activity data, emission factors and calculated emissions are used to identify possible errors in the calculation procedure. In fact, during the calculation, numerous controls take place to ensure correctness. Sums are checked in the various stages in the calculation procedure. Implied emission factors are compared to emission factors.

Every single time-series imported to the CRF Reporter is checked for annual activity, units for activity, emission factor and emissions. Additional checks are performed on the database. The database encloses every single activity data, emission factors, emission, notation key and comment imported to the CRF Reporter. In other words, no information is typed manually into the CRF Reporter. Instead, all information is imported to the CRF Reporter through XML-files to ensure maximum accuracy and completeness.

16.4.6 Source specific recalculations and improvements

The sectors *Mineral Products* (2A) and *Other Production* (2D) were included in the inventory for the first time in the 2010 submission. During implementation the following improvements were made:

- Introduction of new activity data on non-energy use of limestone and dolomite, products containing bitumen used for asphalt roofing, and road paving with asphalt.
- Introduction of new activity data on consumption of products used in the production of food and drink i.e. raw coffee beans, yeast used for baking, landings of fish, shellfish, seals and whales, and production of beer. Use of these products caused no CO_2 emission only non-methane volatile organic compounds (NMVOC).
- Improved data on use of F-gases. Activity data on F-gases are now divided into domestic, commercial and industry, transport, and electrical equipment. Further more the substances, which are accounted according to their trade names, are now transferred into "pure" substances.

In the 2011 emission inventory submission there have been no further improvements or recalculations compared to the 2010 submission. Therefore Table 16.4.17 shows no changes in recalculations relating to industrial processes compared with the 2010 submission.

Table 16.4.17 Changes in GHG emission in the industrial processes sector compared with the 2010 submission.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Previous inventory, Gg CO_2 eqv.	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.4	0.7	1.3
Recalculated, Gg CO_2 eqv.	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.4	0.7	1.3
Change in Gg CO_2 eqv.	-	-	-	-	-	-	-	-	-	-
Change in pct.	-	-	-	-	-	-	-	-	-	-
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Previous inventory, Gg CO_2 eqv.	1.9	3.0	3.9	4.8	5.4	5.5	5.6	6.1	6.5	-
Recalculated, Gg CO_2 eqv.	1.9	3.0	3.9	4.8	5.4	5.5	5.6	6.1	6.5	6.6
Change in Gg CO_2 eqv.	-	-	-	-	-	-	-	-	-	
Change in pct.	-	-	-	-	-	-	-	-	-	

16.4.7 Source specific planned improvements

Some planned improvements to the emission inventories are discussed below.

1) Distribution of unspecified mix of HFCs into single HFCs

An unspecified mix of HFCs are used in commercials and industries. In future inventories attempts will be made in order to distribute the unspecified mix of HFCs into single substances.

16.4.8 References

Godthåb Bryghus (Brewery in Nuuk), 2011: Data on production of beer 2006-2009. Not published.

IPCC, 1997: Revised 1996 IPCC Guidelines for National Greenhouse Gas inventories. Available at: http://www.ipcc-nggip.iges.or.jp/public/gl/invs6.htm (15-04-2007).

IPCC, 2000: Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. Available at: http://www.ipcc-nggip.iges.or.jp/public/gp/english/ (15-04-2007).

Nielsen, O.-K., Lyck, E., Mikkelsen, M.H., Hoffmann, L., Gyldenkærne, S., Winther, M., Nielsen, M., Fauser, P., Thomsen, M., Plejdrup, M.S., Albrektsen, R., Hjelgaard, K., Johannsen, V.K., Vesterdal, L., Rasmussen, E., Arfaoui, K., Baunbæk, L. 2010: Denmark's National Inventory Report 2010 - Emission Inventories 1990-2008 - Submitted under the United Nations Framework Convention on Climate Change and the Kyoto Protocol. National Environmental Research Institute, University of Aarhus. 1178 pp. – NERI Technical Report no. 784. Available at: http://www.dmu.dk/Pub/FR784.pdf

Statistics Greenland, 2010a: Annual survey among importers, suppliers and consumers of F-gases in Greenland in 2009. Not published.

Statistics Greenland, 2010b: Foreign Trade, Import and Export. Available at:

http://www.stat.gl/Statistik/Udenrigshandel/tabid/101/language/da-DK/Default.aspx as "Grønlands udenrigshandel 2009 (foreløbige tal)" (31-03-2010). Data more detailed than the published version of the foreign trade statistics are used in order to access imports at the most detailed level.

16.5 Solvent and other product use (CRF sector 3)

16.5.1 Overview of sector

This section presents the methodology used for calculating CO_2 and NMVOC emissions from use of solvents in industrial processes and households that are related to the source categories Paint application (CRF sector 3A), Degreasing and dry cleaning (CRF sector 3B), Chemical products, manufacture and processing (CRF sector 3C) and Other (CRF sector 3D).

Solvents are chemical compounds that are used on a global scale in industrial processes and as constituents in final products to dissolve e.g. paint, cosmetics, adhesives, ink, rubber, plastic, pesticides, aerosols or are used for cleaning purposes, i.e. degreasing. NMVOCs are main components in solvents - and solvent use in industries and households is typically the dominant source of anthropogenic NMVOC emissions. In industrial processes where solvents are produced or used NMVOC emissions to air and as liquid can be recaptured and either used or destroyed. Solvent containing products are used indoor and outdoor and the majority of solvent sooner or later evaporate. A small fraction of the solvent ends up in waste or as emissions to water and may finally also contribute to air pollution by evaporation from these compartments.

In this section the methodology for the Greenland NMVOC emission inventory for solvent use is presented and the results for the period 1990 – 2009 are summarised. The method is based on the detailed approach described in EMEP/CORINAIR (2004) and emissions are calculated for the CRF sectors mentioned above.

16.5.2 Source category description

Table 16.5.1 and Figure 16.5.1 show the emissions of chemicals from 1990 to 2009, where the used amounts of single chemicals have been assigned to specific products and CRF categories.

Table 16.5.2 shows the used amounts of chemicals for the same period. Table 16.5.1 is derived from Table 16.5.2 by applying emission factors relevant to individual chemicals and production or use activities. Table 16.5.3 shows the used amounts of products from 1990 to 2009.

The default NMVOC-CO_2 conversion factor of 0.85 * 3.667 = 3.11 is used.

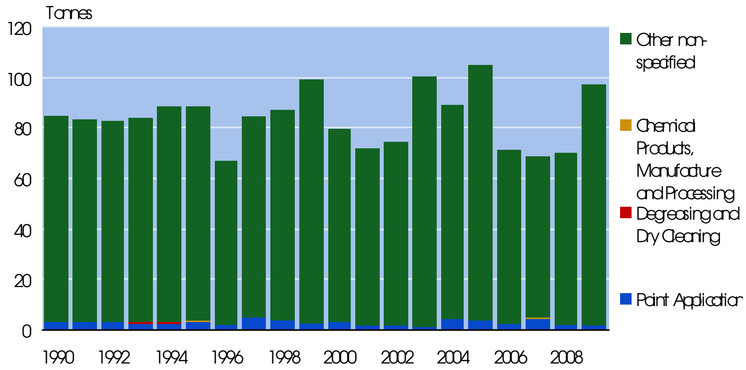


Figure 16.5.1 Emission of NMVOC from solvent and other product use. The methodological approach for finding emissions is described in the text. Figures can be seen in Table 16.5.1.

Table 16.5.1 Emission of chemicals in tonnes per year.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Paint application (3A)	3.1	3.0	2.9	2.8	2.5	3.4	2.1	5.2	3.8	2.5
Degreasing and dry cleaning (3B)	0.1	0.1	0.1	0.1	0.4	NO	NO	0.1	0.2	NO
Chemical products, manufacturing and processing (3C)	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1
Other (3D)	81.2	80.1	79.4	81.2	85.4	85.2	64.9	79.2	82.8	96.8
Total NMVOC	84.4	83.3	82.5	84.1	88.3	88.7	67.1	84.4	86.9	99.4
Total CO_2	263.4	259.7	257.4	262.5	275.6	276.7	209.3	263.4	271.0	310.1
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Paint application (3A)	3.1	1.9	2.1	1.3	4.4	3.9	2.2	4.7	1.8	2.0
Degreasing and dry cleaning (3B)	NO	NO	NO	NO	NO	NO	NO	NO	0.0	0.0
Chemical products, manufacturing and processing (3C)	0.0	0.0	0.1	0.0	0.2	0.1	0.1	0.1	0.0	0.0
Other (3D)	76.4	69.8	72.7	99.3	84.3	100.5	69.2	63.9	68.2	95.1
Total NMVOC	79.5	71.7	74.8	100.7	88.9	104.5	71.5	68.7	70.0	97.2
Total CO_2	247.9	223.6	233.5	314.0	277.5	326.1	223.0	214.3	218.3	303.2

Table 16.5.2 Used amounts of chemicals in tonnes per year.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Paint application (3A)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Degreasing and dry cleaning (3B)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Chemical products, manufacturing and processing (3C)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Other (3D)	37.0	36.6	35.1	34.8	59.6	43.5	45.4	32.8	27.1	36.5
Total NMVOC	37.0	36.6	35.1	34.8	59.6	43.5	45.4	32.8	27.1	36.5
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Paint application (3A)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Degreasing and dry cleaning (3B)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Chemical products, manufacturing and processing (3C)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Other (3D)	18.6	33.0	20.0	31.9	27.5	27.4	30.4	24.1	26.2	54.7
Total NMVOC	18.6	33.0	20.0	31.9	27.5	27.4	30.4	24.1	26.2	54.7

Table 16.5.3 Used amounts of products in tonnes per year.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Paint application (3A)	3.9	3.8	3.7	3.5	3.1	4.3	2.7	6.5	4.8	3.1
Degreasing and dry cleaning (3B)	0.2	0.2	0.1	0.1	0.8	NO	NO	0.1	0.4	NO
Chemical products, manufacturing and processing (3C)	0.3	0.2	0.2	0.2	0.5	0.1	0.1	0.1	0.1	0.8
Other (3D)	84.6	83.5	83.5	85.8	84.9	84.5	61.8	81.8	90.9	105.7
Total products	89.0	87.7	87.5	89.7	89.4	89.0	64.6	88.6	96.1	109.5
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Paint application (3A)	3.8	2.4	2.6	1.6	5.5	4.8	2.8	5.8	2.3	2.6
Degreasing and dry cleaning (3B)	NO	NO	NO	NO	NO	NO	NO	NO	0.0	0.0
Chemical products, manufacturing and processing (3C)	0.0	0.1	0.4	0.2	0.5	0.3	0.4	2.0	0.2	0.0
Other (3D)	83.8	72.2	83.3	109.5	96.2	107.2	74.3	67.6	71.5	97.2
Total products	87.6	74.6	86.2	111.4	102.2	112.3	77.5	75.4	73.9	99.7

16.5.3 Methodological issues

Emission modelling of solvents can basically be done in two ways: 1) By estimating the amount of (pure) solvents consumed, or 2) By estimating the amount of solvent containing products consumed, taking account of their solvent content (EMEP/CORINAIR, 2004).

In 1) all relevant solvents must be estimated, or at least those together representing more than 90% of the total NMVOC emission, and in 2) all relevant source categories must be inventoried or at least those together contributing more than 90% of the total NMVOC emission. A simple approach is to use a pr capita emission for each category, whereas a detailed approach is to get all relevant consumption data (EMEP/CORINAIR, 2004).

The detailed method 1) is used in the emission inventory for solvent use, thus representing a chemicals approach, where each chemical (NMVOC) and chemical containing product (group) is estimated separately. The sum of emissions of all estimated NMVOCs used as solvents equals the NMVOC emission from solvent use.

Activity data

The definitions of solvents and VOC that are used are as defined in the solvent directive (Directive 1999/13/EC) of the EU legislation: "Organic solvent shall mean any VOC which is used alone or in combination with other agents, and without undergoing a chemical change, to dissolve raw materials, products or waste materials, or is used as a cleaning agent to dissolve contaminants, or as a dissolver, or as a dispersion medium, or as a viscosity adjuster, or as a surface tension adjuster, or a plasticiser, or as a preservative". VOCs are defined as follows: "Volatile organic compound shall mean any organic compound having at 293.15 K a vapour pressure of 0.01 kPa or more, or having a corresponding volatility under the particular condition of use".

Import figures of chemicals and chemical containing products are obtained from Statistics Greenland. There is no production or export of chemicals and chemical containing products, therefore the import amount is assumed to be equivalent to the used amount.

Emission factors

For some chemicals the emission factors are precise but for others they are rough estimates. In the Danish inventory emission factors are divided into four categories: 1) chemical industry (lowest EF), 2) other industry, 3) non-industrial activities, 4) domestic and other diffuse use (highest EF). This implies that high emission factors are applicable for use of solvent containing products and lower emission factors are applicable for use in industrial processes

The emission factors used in the Greenlandic inventory are the same as developed for the Danish inventory (please refer to Chapter 5). For the chemicals assumed to be used for industrial purposes the mean value of category 1 and 2 above is used.

Emissions

Table 16.5.1 and Figure 16.5.1 show the emissions of chemicals from 1994 to 2009, where the used amounts of single chemicals have been assigned to specific products and CRF categories. Table 16.5.2 shows the used amounts of chemicals for the same period. Table 16.5.1 is derived from Table 16.5.2 by applying emission factors relevant to individual chemicals and production or use activities. Table 16.5.3 showing the used amount of products is derived from Table 16.5.2, by assessing the amount of chemicals that is comprised within products belonging to each of the four source categories. The default NMVOC-CO_2 conversion factor of 0.85 * 3.667 = 3.11 is used.

16.5.4 Uncertainties

A tier 1 uncertainty assessment has been carried out in accordance with the IPCC GPG (IPCC, 2000). The uncertainty has been estimated for all sources included in the reporting for solvent and other product use. The uncertainties for the activity data and emission factors are shown in Table 16.5.4.

Table 16.5.4 Uncertainties for activity data and emission factors for solvents.

Subsector	Pollutant	Activity data uncertainty	Emission factor uncertainty
3A Paint application	CO_2	10	15
3B Degreasing and dry cleaning	CO_2	10	15
3C Chemical products, manufacturing and processing	CO_2	10	15
3D5 Other	CO_2	10	20

The activity data comes from the import statistics, which is considered to be of high quality, therefore the uncertainty of the activity data has been set to 10 %.

Regarding the emission factor uncertainties, the uncertainty comprises of both the uncertainty of the NMVOC emission factor, and the uncertainty of the conversion factor of NMVOC to CO_2.

The resulting uncertainty for CO_2 is shown in Table 16.5.5.

Table 16.5.5 Uncertainties for the emission estimates.

	Uncertainty %	Trend 1990-2009 %	Trend uncertainty %
CO_2	21.9	15.1	±15.9

16.5.5 Source specific QA/QC

Time series of activity data and emissions are analysed large inter annual variations is investigated further to ensure the accuracy of the estimates.

16.5.6 Source specific recalculations and improvements

Emissions from solvent and other product use were included in the Greenlandic emission inventory for the first time in the 2010 submission.

There have been no further improvements in the 2011 emission inventory submission.

Table 16.5.6 Changes in GHG emission in the industrial processes sector compared with the 2010 submission.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Previous inventory, Gg CO_2 eqv.	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.3	0.3
Recalculated, Gg CO_2 eqv.	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.3	0.3
Change in Gg CO_2 eqv.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Change in pct.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Previous inventory, Gg CO_2 eqv.	0.2	0.2	0.2	0.3	0.3	0.3	0.2	0.2	0.2	-
Recalculated, Gg CO_2 eqv.	0.2	0.2	0.2	0.3	0.3	0.3	0.2	0.2	0.2	0.3
Change in Gg CO_2 eqv.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
Change in pct.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-

16.5.7 Source specific planned improvements

It will be investigated whether use of N_2O is occurring in Greenland.

16.5.8 References

Statistics Greenland. Available at http://www.stat.gl

Nielsen, O.-K., Lyck, E., Mikkelsen, M.H., Hoffmann, L., Gyldenkærne, S., Winther, M., Nielsen, M., Fauser, P., Thomsen, M., Plejdrup, M.S., Albrektsen, R., Hjelgaard, K., Johannsen, V.K., Vesterdal, L., Rasmussen, E., Arfaoui, K., Baunbæk, L. 2010: Denmark's National Inventory Report 2010 - Emission Inventories 1990-2008 - Submitted under the United Nations Framework Convention on Climate Change and the Kyoto Protocol. National Environmental Research Institute, University of Aarhus. 1178 pp. – NERI Technical Report no. 784. Available at: http://www.dmu.dk/Pub/FR784.pdf

Emission Inventory Guidebook 3rd edition, prepared by the UNECE/EMEP Task Force on Emissions Inventories and Projections, 2002update. Available at: http://reports.eea.eu.int/EMEP-CORINAIR3/en (07-11-2003).

Directive 1999/13/EC of 11 March 1999 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations, Brüssel, 1999.

16.6 Agriculture (CRF sector 4)

The emission of greenhouse gases from agricultural activities includes CH_4 emission from enteric fermentation, CH_4 and N_2O emission from manure management and N_2O emission from agricultural soils. The emissions are reported in CRF Tables 4.A, 4.B and 4.D.

Emission from rice production, burning of agricultural crop residue and burning of savannas does not occur in Greenland and the CRF Tables 4.F, 4.C and 4.E have, consequently, not been completed.

Emission of non-methane volatile organic compounds (NMVOC) from agricultural activities has not been estimated.

16.6.1 Overview of sector

In CO_2 equivalents, the agricultural sector (without LULUCF) contributes with 1.6% of the overall greenhouse gas emission (GHG) in 2009. From 1990 to 2009, the emissions increased from 9.19 Gg CO_2 equivalents to 10.22 Gg CO_2 equivalents, which correspond to an increase of 11% (Table 16.6.1). This emission increase is primarily caused by a significant rise in the use of synthetic fertiliser.

Table 16.6.1 Emission of GHG in the agricultural sector 1990-2009.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	Gg CO_2-eqv.									
CH_4	6.16	6.21	5.58	4.89	5.33	5.72	5.89	6.42	6.16	5.52
N_2O	3.03	3.08	2.86	2.63	2.83	2.99	4.02	3.56	4.48	4.55
Total	9.19	9.29	8.44	7.51	8.16	8.72	9.92	9.98	10.64	10.07
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CH_4	5.36	5.46	5.26	5.33	5.60	5.82	5.64	5.77	5.63	5.52
N_2O	4.11	4.26	4.14	4.22	4.45	4.66	4.71	4.22	6.00	4.70
Total	9.47	9.72	9.40	9.55	10.05	10.48	10.35	9.98	11.63	10.22

As showed in Figure 16.6.1, CH_4 emission contributed with 54% of the total GHG emission from the agricultural sector in 2009 and N_2O contributed with the remaining 46% given in CO_2 equivalents. The major part of the emission is related to livestock production, which in Greenland particularly means the production of sheep. A smaller part is related to the reindeer production. Concerning the emission from agricultural soils, the main sources are, use of synthetic fertiliser, nitrogen leaching from leaching and run-off and emission from grassing animals.

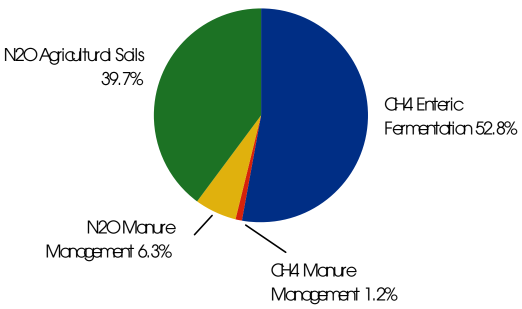


Figure 16.6.1 Emission of greenhouse gases from agriculture in 2009.

16.6.2 Source category description

The calculations of the emissions are based on methods described in the IPCC Reference Manual (IPCC, 1997) and the Good Practice Guidance (IPCC, 2000).

Statistics Greenland is responsible for collecting of data, preparation of emission inventory and reporting. Inputs of data are basically obtained from Statistics Greenland and the Greenland Agricultural Consulting Services (ACS). Data on climate are supplied by the Danish Meteorological Institute (DMI) and Greenland Survey (ASIAQ), and published by Statistics Greenland.

Table 16.6.2 List of institutes involved in the emission inventory for the agricultural sector.

References	Link	Abbreviation	Data/information
Statistics Greenland	www.stat.gl	GST	- reporting - data collecting - no. of animal - feed import - use of synthetic fertiliser - spring temperature
The Agricultural Consulting Services	http://nunalerineq.org/	ACS	- N-excretion - milk yield - feed consumption and composition - stable- and grassing situation - animal growth and weight - land use - crop production
The Danish Plant Directorate	www.pdir.dk	PD	- N content in different fertiliser types
The Danish Agricultural Advisory Centre, Aarhus University	www.lr.dk	DAAC	- N content in crop residue

16.6.3 CH_4 emission from Enteric Fermentation (CRF sector 4A)

Description

The major part of the agricultural CH_4 emission originates from digestive processes. In 2009, this source accounts for 53 % of the total GHG emission from agricultural activities. The emission is primarily related to ruminants, which in Greenland is sheep. In 2009 sheep contributed with 88% and the remaining 12 % from reindeer.

Methodological issues

The implied emission factors for all animal categories are based on the Tier 2/Country Specific (CS) approach. Feed consumption and composition for sheep and reindeer is based on data from Statistics Greenland and the Agricultural Consulting Services (ACS), which has information concerning the agricultural conditions in practice. Default values for the methane conversion rate (Y_m) for sheep given by the IPCC are used, as an average of mature sheep and lambs, which mean an Y_m value of 6 %.

Gross energy intake (GE)

The gross energy intake for sheep and reindeer is based on feeding plans for sheep from the Greenland Agricultural Consulting Services supplemented by data on imported feed. For reindeer information on gross energy intake is based on an article on reindeer management in Greenland.

Table 16.6.3 Parameters for calculation of emission from enteric fermentation.

Animal Category	Gross Energy (GE)	Methane conversion factor (Y_m)	Emission factor
	MJ pr head pr day		Kg CH_4 pr head pr yr
Sheep	28.4	0.06	11.2
Reindeer	27.5	0.06	10.7

The default CH_4 emission factor for sheep Tier 1 methodology is estimated to 8 kg CH_4 per animal per year. The default GE is given as 20 MJ/head/yr, which is lower than the calculated GE for Greenland, and can explain the lower emission factor. Another reason could be the fact that the national value for feed intake includes lambs. After lambing, ewes and lambs are put out to pasture. Thus lambs only feed through their mother and grass. Lambs are not fed separately before slaughter.

There is no default GE for reindeer. However, Norway, Sweden and Finland have estimated gross energy intake for reindeer to 29.6 – 31.6 MJ/head/day. Based on an article on reindeer management in southern Greenland by H.E. Rasmussen in 1992, the Greenlandic gross energy intake for reindeer has been estimated to 27.5 MJ pr head pr day, which is lower than Norway, Sweden and Finland. However, holding in mind that food conditions for reindeer is more scarcely in Greenland compared to conditions in Norway, Sweden and Finland, which have more forest, and that reindeer in Greenland are not fed separately, the estimated of gross energy intake for reindeer in Greenland seems acceptable.

Activity data

Table 16.6.4 shows the development in livestock. The number of sheep is varying slightly. The number of reindeer has decreased considerably since 1990. The reindeer livestock decreased significantly in 1999, when one of two reindeer stations closed. Since 1999 there has been only one reindeer station in Greenland.

Table 16.6.4 Number of animals from 1990-2009 (CRF Table 4.A. 4.B (a) and 4.B (b).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Sheep	19 929	20 134	17 900	16 256	17 818	19 464	20 163	23 134	19 929	21 007
Reindeer	6 000	6 000	5 600	4 300	4 600	4 600	4 600	3 800	6 000	2 106
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Sheep	20 444	20 394	18 967	19 259	20 383	21 317	21 289	21 704	21 080	20 139
Reindeer	2 000	2 480	3 100	3 100	3 100	3 100	2 318	2 441	2 500	3 000

Implied emission factor

The implied emission factor (IEF) could vary across years for sheep and reindeer due to changes in feed consumption. However, no existing data can document a change in feed intake. Therefore the same IEF is used for all years.

Time-series consistency

The emission from enteric fermentation is given in Table 16.6.5. From 1990 to 2009, the emission has decreased by 10% due to a fall in number of reindeer.

Table 16.6.5 Emission of CH_4 from Enteric Fermentation 1990 – 2008, tonnes CH_4.

CRF 4.A	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Sheep	222	225	200	181	199	217	225	258	222	234
Reindeer	64	64	60	46	49	49	49	41	64	23
Total, tonnes CH_4	287	289	260	227	248	266	274	299	287	257
Total, tonnes CO_2 eqv.	6 018	6 066	5 452	4 775	5 208	5 594	5 758	6 275	6 018	5 396
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Sheep	228	228	212	215	227	238	238	242	235	225
Reindeer	21	27	33	33	33	33	25	26	27	32
Total, tonnes CH_4	250	254	245	248	261	271	262	268	262	257
Total, tonnes CO_2 eqv.	5 240	5 336	5 141	5 209	5 473	5 692	5 510	5 635	5 502	5 393

16.6.4 CH_4 and N_2O emission from Manure Management (CRF sector 4B)

Description

The emissions of CH_4 and N_2O from manure management are given in CRF Table 4.B (a) and 4.B (b). This source contributes with 8% of the total emission from the agricultural sector in 2009. The major part of the emission originates from the production of sheep.

Methodological issues

CH_4 emission

The IPCC Tier 2/CS methodology has been used for the estimation of the CH_4 emission from manure management. Calculation of volatile solids, VS is based on national value of gross energy intake (GE). Default values is used for the maximum methane producing capacity (B_0), digestibility (DE), the ash content and the methane conversion factor (MCF).

For reindeer no default values exists. Thus DE, ASH and B_o estimates for sheep are used. Sheep and reindeer are similar creatures, both ruminants. Greenlandic reindeer weigh an average of 70 kg. Greenlandic sheep weight approximately 50 kg. However, while sheep are fed relative more intensively, reindeer only feed on what they find in nature all year around. On these arguments the best estimate is to use DE, ASH and B_0 estimates for sheep on reindeer as well.

Table 16.6.6 CH_4 – Manure management – use of national parameters and IPCC default values.

Parameter	Unit	Sheep	Reindeer	Default or national value
Gross energy intake (GE)	MJ pr head pr day	28.4	27.2	National
Digestibility (DE)	Percent	60	60	IPCC default
Ash content (ASH)	Percent	8	8	IPCC default
Volatile solids (VS)	Kg VS pr head pr day	0.57	0.54	National
Max. methane producing capacity (B_0)	M^3 pr kg VS	0.19	0.19	IPCC default
CH_4 conversion factor (MCF), solid storage and pasture	Percent	1	1	IPCC default
Emission factor	Kg CH_4 pr head pr yr	0.26	0.25	Tier 2

There are no changes in stable conditions or feed intake during the years 1990 to 2009. The implied emission factor is therefore the same for all years.

The default emission factor for sheep is 0.19 kg CH_4 pr head pr yr. The higher national value is due to a higher estimate for gross energy intake.

Table 16.6.7 shows a decrease in the CH_4 emission from manure management from 1990 to 2009 by 10 %, which chiefly is related to the fall in the production of reindeer.

Table 16.6.7 Emission of CH_4 from Manure Management 1990-2009, tonnes CH_4.

CRF 4.A	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Sheep	5.2	5.2	4.7	4.2	4.6	5.1	5.2	6.0	5.2	5.5
Reindeer	1.5	1.5	1.4	1.1	1.2	1.2	1.2	1.0	1.5	0.5
Total, tonnes CH_4	6.7	6.7	6.1	5.3	5.8	6.2	6.4	7.0	6.7	6.0
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Sheep	5.3	5.3	4.9	5.0	5.3	5.5	5.5	5.6	5.5	5.2
Reindeer	0.5	0.6	0.8	0.8	0.8	0.8	0.6	0.6	0.6	0.8
Total, tonnes CH_4	5.8	5.9	5.7	5.8	6.1	6.3	6.1	6.3	6.1	6.0

N_2O emission

Based on information from the Greenland Agricultural Consulting Services it is estimated that for sheep 55% of the N-excretion is taken place in stable and all manure is handling as solid manure. The IPCC default emission value is applied, which mean 2.0% of the N-excretion for solid manure.

Reindeer is grassing all year. The emission from manure deposits on grass is included in "Pasture, Range and Paddock".

The total nitrogen excretion for sheep has increased by 1% from 1990 to 2009 (Table 16.6.8) due to a small growth of sheep production.

Table 16.6.8 Total nitrogen excretion for sheep, 1990-2009, tonnes N.

CRF table 4.B(b)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Livestock category										
N-excreted, tonnes in total	120	121	107	98	107	117	121	139	120	126
N-excretion, tonnes in stable	66	66	59	54	59	64	67	76	66	69
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Livestock category										
N-excreted, tonnes in total	123	122	114	116	122	128	128	130	126	121
N-excretion, tonnes in stable	67	67	63	64	67	70	70	72	70	66

Time-series consistency

As shown in Table 16.6.9 total emission from manure management from 1990 to 2009 in CO_2 equivalents has decreased by 1 % due to a decrease in the number of reindeer.

Table 16.6.9 Emissions of N_2O and CH_4 from Manure Management 1990-2009.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
N_2O emission, tonnes CO_2 eqv.	641	647	576	523	573	626	648	744	641	675
CH_4 emission, tonnes CO_2 eqv.	140	141	127	111	121	130	134	146	140	126
Total, tonnes CO_2 eqv.	781	789	703	634	694	756	783	890	781	801
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
N_2O emission, tonnes CO_2 eqv.	657	656	610	619	655	685	684	698	678	647
CH_4 emission, tonnes CO_2 eqv.	122	124	120	121	128	133	128	131	128	126
Total, tonnes CO_2 eqv.	779	780	730	741	783	818	813	829	806	773

16.6.5 N_2O emission from Agricultural Soils (CRF sector 4D)

Description

The N_2O emissions from agricultural soils CRF Table 4.D contributed in 2009 with 40% of the national emission from the agricultural sector. Figure 16.6.2 shows the overall development from 1990 to 2009 and the distribution on different sources. The total emission has more than doubled from 1990 to 2008; a result of an increasing use of synthetic fertiliser. However, in 2009 emission of N_2O from agricultural soils dropped due to a significant decrease in the use of synthetic fertiliser.

Emission from synthetic fertiliser and nitrogen leaching is an essential part of the total emission from agricultural soils and contributes totally with 45%. Of the remaining sources the greatest part of the emission, by 26%, origins from cultivation of histosols. Emissions from all sources have increased from 1990 to 2008 except from atmospheric depositions and grassing animal where a fall in number of reindeer has taken place.

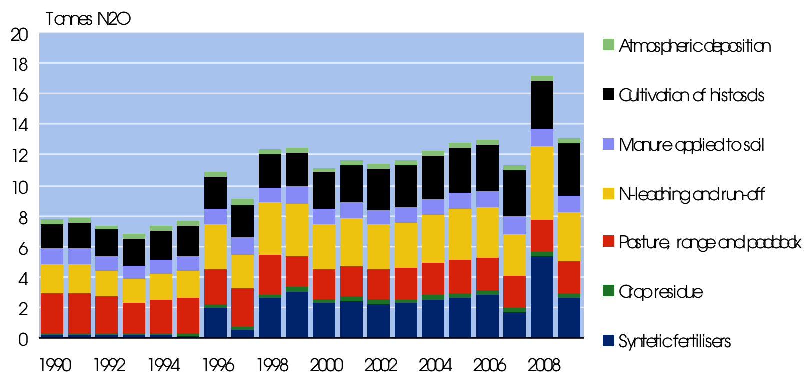


Figure 16.6.2 N_2O emissions from agricultural soils 1990-2009.

Methodological issues

To calculate the N_2O emission a combination of IPCC Tier 1a and Tier 1b is used. Tier 1b is use in calculation of emission from crops residue. Emissions of N_2O are closely related to the nitrogen balance. Data concerning the N-excretion, evaporation of ammonia from synthetic fertiliser and grassing animal are based on national values.

The NH_3 and N_2O emission factor survey is presented in Table 16.6.10 and shows that except from histosols all N_2O emission factor is based on IPCC default values. The estimated emissions from the different sub-sources are described in the text which follows.

Table 16.6.10 Emissions factor - N_2O emission from the Agricultural Soils 1990-2009.

Agricultural soils – emission sources CRF Table 4.D	Ammonia emission factor	N_2O emission factor (country specific value)	N_2O emission factor (IPCC default value)
	Kg NH_3-N pr kg N	kg N_2O-N pr ha	kg N_2O -N pr kg N
1. Direct Soil Emissions			
Synthetic Fertiliser Applied to Soils	0.01 (CS)		0.0125
Animal Wastes Applied to Soils	0.20 (IPCC default)		0.0125
N-fixing Crops			0.0125
Crop Residue			0.0125
Cultivation of Histosols		8	
2. Animal Production	0.07 (CS)		0.02
3. Indirect Soil Emissions			
Atmospheric Deposition			0.01
Nitrogen Leaching and Runoff			0.025

CS = country specific value

Direct emissions

Synthetic fertiliser

The calculation of nitrogen (N) applied to soil from use of synthetic fertiliser is based on data on imports from the Statistics Greenland. No data is available before 1994. The consumption for 1990 to 1993 is assumed to be on the same level as 1994. The nitrogen content for each fertiliser type is estimated based on expert judgement from the Danish Plant Directorate (Troels Knudsen, pers. comm.).

Table 16.6.11 shows the consumption of each type of fertiliser. Furthermore, the ammonia emission factor for each fertiliser is given, based on the values given in EMEP/EEA emission inventory guide book 2009 (Table 3-2). The emission factors are depending on the mean spring temperature estimated to 7 degrees in Greenland. The spring temperature has to reflect the time where the fertilisers are applied, which in Greenland normally is June.

Table 16.6.11 Synthetic fertiliser consumption 2009 and the NH_3 emission factors.

Synthetic fertiliser year 2008	Calculation of ammonia emission factor (ts=mean spring temperature=7 degree)[1]	NH_3 Emission factor[1] kg NH_3-N pr kg N	Consumption[2] t N
Fertiliser type			
Ammonium sulphate	=0.0107+0.0006*ts	1.49	NO
Ammonium nitrate	=0.008+0.0001*ts	0.87	11
Calcium ammonium nitrate	=0.008+0.0001*ts	0.87	0
Anhydrous ammonia	=0.0127+0.0012*ts	2.11	NO
Urea	=0.1067+0.0035*ts	13.12	0
Nitrogen solutions	=0.0481+0.0025*ts	6.56	NO
Ammonium phosphates	=0.0107+0.0006*ts	1.49	NO
Other NK and NPK	=0.008+0.0001*ts	0.87	124
Total consumption of N in synthetic fertiliser			134
National emission of NH_3-N, tonnes	1.2		
Average NH_3-N emission (FracGASF)	0.01		

[1]) EMEP/EEA (2009).
[2]) Statistics Greenland and the Danish Plant Directorate

The Greenlandic value for the FracGASF is estimated to less than 0.01 in 2009, which is considerably lower than the recommended default value in IPCC, i.e. 0.10. The major part of the fertiliser types used in Greenland is related to ammonia nitrate and NPK fertiliser where the emission factor is quite low, i.e. 0.0087 kg NH_3-N pr kg N. Before 1995 urea accounted for a higher fraction. The value of FracGASF for these years is estimated to 0.10-0.13.

Table 16.6.12 FracGASF, 1990-2009.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
FracGASM	0.13	0.13	0.13	0.13	0.13	0.10	0.02	0.03	0.01	0.01
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
FracGASM	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01

Table 16.6.13 shows an over time increase in use of fertiliser and a particularly high increase in 2008. Due to a relatively small number of farms the individual handling of one farmer has a high effect on the total consumptions. With consumption of fertilisers being based on imports of fertilisers it is not possible to account for fertilisers bought for stockpiling. Thus it is possible that the relative high increase in use of fertilisers in 2008 is due to stockpiling. Another explanation could be that both 2007 and 2008 were relative dry years leading to a considerable decrease in amount of hey harvested. Hence, it is possible that farmers have tended to increase the use of fertilisers in 2008 to produce more feed. The use of fertiliser decreased in 2009.

Table 16.6.13 Nitrogen applied as fertiliser to agricultural soils 1990-2009.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
N content in synthetic fertiliser, tonnes N	9	9	9	9	9	6	102	28	135	158
NH_3-N emission, tonnes	1	1	1	1	1	1	2	1	1	1
N in fertiliser applied on soil, tonnes N	8	8	8	8	8	6	100	27	134	157
N_2O emission, tonnes	0.16	0.16	0.16	0.16	0.16	0.11	1.97	0.53	2.63	3.08
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
N content in synthetic fertiliser, tonnes N	117	126	114	117	128	136	144	86	273	134
NH_3-N emission, tonnes	1	1	1	1	1	1	1	1	2	1
N in fertiliser applied on soil, tonnes N	116	125	113	116	127	135	142	85	271	133
N_2O emission, tonnes	2.28	2.45	2.22	2.27	2.49	2.65	2.80	1.67	5.32	2.62

Manure applied to soil

The amount of nitrogen applied to soil from sheep on stables is estimated as the N-excretion in stables minus the ammonia emission, which occur in stables, under storage and in relation to the application of manure. There are no measurements of ammonia emission from stables in Greenland. Thus IPCC default is used. However, the FracGASM default at 0.20 (IPCC 1997. Table 4-19) match the Danish emission ammonia from sheep, which are estimated to 24% in 1990 reduced to 19% in 2008. A lower ammonia emission in Greenland is expected due to the cold climate, but on the other hand no ammonia reducing measures are implemented as in Denmark. The FracGASM at 0.20 are therefore considered as reliable.

Table 16.6.14 shows the development in nitrogen excretion in stables, the estimated amount of N applied on soil and the N_2O emission.

Table 16.6.14 Nitrogen applied as manure to agricultural soils 1990-2009.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
N-excretion in stable, tonnes N	66	66	59	54	59	64	67	76	66	69
NH_3-N emission, tonnes N	13	13	12	11	12	13	13	15	13	14
N in manure applied on soil, tonnes N	53	53	47	43	47	51	53	61	53	55
N_2O emission, tonnes N_2O	1.03	1.04	0.93	0.84	0.92	1.01	1.05	1.20	1.03	1.09
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
N-excretion in stable, tonnes N	67	67	63	64	67	70	70	72	70	66
NH_3-N emission, tonnes N	13	13	13	13	13	14	14	14	14	13
N in manure applied on soil, tonnes N	54	54	50	51	54	56	56	57	56	53
N_2O emission, tonnes N_2O	1.06	1.06	0.98	1.00	1.06	1.11	1.10	1.13	1.09	1.04

Crop residue

The cultivated area is approximately 1,096 ha with the main part as grass fields, only 6,5 ha from 2001 are used for potato production. To estimate the emission from crop residue, IPCC Tier 1b has been applied. N_2O emissions from crop residues are calculated based on the total aboveground N-content in crop residue returned to soil, which in Greenland includes residue of leafs from grass fields and the top from potatoes.

National values for nitrogen content used are provided by the Faculty of Agricultural Sciences, Aarhus University (Djurhuus and Hansen 2003). Values are calculated based on relatively few observations related to Danish conditions, but are at present the best available data.

Table 16.6.15 N-content in crops residue 2009.

	Stubble	Husks	Top	Leafs	Frequency of ploughing	Nitrogen content in crop residue	
Crop type	kg N pr ha	kg N pr ha	kg N pr ha	kg N pr ha	No. of year before ploughing	kg N pr ha pr yr	kg N pr yr
Potatoes (top), non-harvest	-	-	48.7	-	1	48.7	17 925
Grass- and clover field in rotation	32.3		-	10.0	5	16.5	317
Total N from crop residue – 2009, kg							18 241

Reference: Djurhuus and Hansen 2003

To calculate the N_2O emission the IPCC standard emission factor 1.25 % is used. The national emission from crop residues has more than doubled from 1990 to 2009 (Table 16.6.16) as a result of increasing agricultural area.

Table 16.6.16 Emissions from crop residue 1990-2009.

Crop residue	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Grass stub/leaves, kg N	8 071	8 498	8 925	9 352	9 778	10 205	10 632	11 059	11 486	11 912
Potato tops, kg N	0	0	0	0	0	0	0	0	0	0
Crop residue total, kg N	8 071	8 498	8 925	9 352	9 778	10 205	10 632	11 059	11 486	11 912
N_2O emission, kg	159	167	175	184	192	200	209	217	226	234
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Grass stub/leaves, kg N	12 339	12 766	14 005	14 384	14 614	15 176	15 823	16 018	16 378	17 925
Potato tops, kg N	0	244	244	244	244	244	244	244	244	317
Crop residue total, kg N	12 339	13 010	14 249	14 628	14 857	15 420	16 066	16 262	16 621	18 241
N_2O emission, kg	242	256	280	287	292	303	316	319	326	358

Frac vaules

There is no cultivation of nitrogen fixing crops, why the Fraction value $Frac_{NCRBF}$ is not relevant. Until national data is available, the default value of $Frac_{NCRO}$ by 0.015 is used. The default value of $Frac_R$ is not current for the Greenlandic conditions, where the main part of the aboveground biomass is harvest and used for ensilage. Until national data is available, the $Frac_R$ is registered as "Not Estimated".

Cultivation of histosols

N_2O emissions from histosols are based on the area with organic soils multiplied by the emission factor of 8 kg N_2O-N pr. kg N. See Section 16.7 on LULUCF for further description on cultivation of histosols.

Table 16.6.17 shows an increase in the N_2O emission from 1990 to 2009 due to extend of the agricultural area.

Table 16.6.17 Activity data and emission from cultivation of histosols 1990-2009.

CRF – Table 4.D	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Cultivated histosols, ha	123	129	136	142	149	155	161	168	174	181
N_2O emission, kg	1 541	1 622	1 704	1 785	1 867	1 948	2 030	2 111	2 192	2 274
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Cultivated histosols, ha	187	195	214	220	223	232	242	245	250	274
N_2O emission, kg	2 355	2 453	2 689	2 762	2 805	2 913	3 036	3 073	3 142	3 442

Pasture, Range and Paddock

The amount of nitrogen deposited on grass includes grassing from reindeer 365 days a year and from sheep 164 days a year. An ammonia emission factor of 7% is used for all animal categories based on investigations from the Netherlands and the United Kingdom (Jarvis et al., 1989a. Jarvis et al., 1989b and Bussink, 1994). EMEP/EEA emission inventory guidebook 2009 use a similar emission factor at 6% for grassing dairy cattle (calculated from 4B, Appendix B).

Table 16.6.18 shows the estimated values of N-excretion from grassing animals, ammonia emission, the N_2O emission and the FracGRAZ value. As a consequence of all in number of reindeer, both the N_2O emission and the FracGRAZ value have decreased from 1990 to 2009.

Table 16.6.18 Emission from grassing animals 1990-2009.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
N-excretion on grass, tonnes N	88	89	81	69	75	79	81	84	88	69
NH_3-N emission, tonnes	6	6	6	5	5	6	6	6	6	5
N deposited on grass, tonnes N	82	83	75	64	69	73	75	78	82	64
N_2O emission, tonnes	2.58	2.60	2.35	2.01	2.18	2.31	2.36	2.46	2.58	2.01
FracGRAZ	0.57	0.57	0.58	0.56	0.56	0.55	0.55	0.52	0.57	0.50
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
N-excretion on grass, tonnes N	67	69	69	70	73	75	71	73	71	72
NH_3-N emission, tonnes	5	5	5	5	5	5	5	5	5	5
N deposited on grass, tonnes N	62	64	64	65	68	70	66	68	66	67
N_2O emission, tonnes	1.95	2.03	2.02	2.04	2.13	2.20	2.07	2.12	2.08	2.09
FracGRAZ	0.50	0.51	0.52	0.52	0.52	0.52	0.50	0.50	0.51	0.52

Indirect emissions

Atmospheric deposition

Atmospheric deposition includes ammonia emission from manure management, use of synthetic fertiliser and from grassing animals

The N_2O emission from atmospheric deposition is nearly unaltered from 1990 to 2009. The fall in the reindeer production compensate for increase in number of sheep and a rise in use of synthetic fertiliser.

Table 16.6.19 Emission from atmospheric deposition 1990-2009.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
NH_3-N manure management, tonnes	13	13	12	11	12	13	13	15	13	14
NH_3-N synthetic fertliser, tonnes	1	1	1	1	1	1	2	1	1	1
NH_3-N pasture, tonnes	6	6	6	5	5	6	6	6	6	5
NH_3-N total, tonnes	21	21	19	17	18	19	21	22	21	20
N_2O emission, tonnes	0.32	0.33	0.29	0.26	0.29	0.30	0.33	0.34	0.32	0.32
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
NH_3-N manure management, tonnes	13	13	13	13	13	14	14	14	14	13
NH_3-N synthetic fertliser, tonnes	1	1	1	1	1	1	1	1	2	1
NH_3-N pasture, tonnes	5	5	5	5	5	5	5	5	5	5
NH_3-N total, tonnes	19	19	18	19	20	21	20	21	21	19
N_2O emission, tonnes	0.30	0.30	0.29	0.29	0.31	0.32	0.32	0.33	0.33	0.31

Nitrogen leaching and Run-off

The amount of nitrogen lost by leaching and run-off is calculated by using the IPCC default FracLEACH at 0.3 (IPCC 1997, Table 4-24).

The emission from 1990 to 2008 has more than doubled. The total nitrogen content in manure has decreased due to a fall in the reindeer production. The increasing is due to a significant rise in use of synthetic fertiliser. In 2009 the amount of nitrogen lost by leaching and run-off primarily due to a decrease in the use of synthetic fertiliser.

Table 16.6.20 Emission from N-leaching and runoff 1990-2009.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
N-excretion total, tonnes N	154	155	140	122	133	143	147	161	154	138
N in synthetic fertiliser, tonnes	9	9	9	9	9	6	102	28	135	158
N_2O emission, tonnes	1.92	1.94	1.75	1.55	1.68	1.76	2.94	2.22	3.41	3.50
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
N-excretion total, tonnes N	134	137	132	133	140	146	141	144	141	138
N in synthetic fertiliser, tonnes	117	126	114	117	128	136	144	86	273	134
N_2O emission, tonnes	2.96	3.09	2.89	2.95	3.16	3.32	3.36	2.72	4.88	3.21

Activity data

Table 16.6.21 provides an overview on activity data from 1990 to 2009 used to the estimation of N_2O emission from agricultural soils. For all emission sources the unit tonnes of nitrogen are used except from cultivation of histosols, where the unit is given as hectare.

Table 16.6.21 Activity data - agricultural soils 1990-2009, tonnes N (cultivation of histosols = ha).

CRF – Table 4.D	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1. Direct Emissions										
Synthetic Fertiliser	8	8	8	8	8	6	100	27	134	157
Animal Manure Applied to Soils	53	53	47	43	47	51	53	61	53	55
Crop Residue	8	8	9	9	10	10	11	11	11	12
Cultivation of histosols	123	129	136	142	149	155	161	168	174	181
2. Pasture, Range and Paddock Manure	82	83	75	64	69	73	75	78	82	64
3. Indirect Emissions										
Atmospheric Deposition	21	21	19	17	18	19	21	22	21	20
Nitrogen Leaching and Run-off	49	49	45	39	43	45	75	56	87	89
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1. Direct Emissions										
Synthetic Fertiliser	116	125	113	116	127	135	142	85	271	133
Animal Manure Applied to Soils	54	54	50	51	54	56	56	57	56	53
Crop Residue	12	13	14	15	15	15	16	16	17	18
Cultivation of histosols	187	195	214	220	223	232	242	245	250	274
2. Pasture, Range and Paddock Manure	62	64	64	65	68	70	66	68	66	67
3. Indirect Emissions										
Atmospheric Deposition	19	19	18	19	20	21	20	21	21	19
Nitrogen Leaching and Run-off	75	79	74	75	80	85	85	69	124	82

Time-series consistency

The N_2O emissions from agricultural soils have increased from 7.7 tonnes N_2O in 1990 to 17.2 tonnes N_2O in 2008. The more than doubled emission is a consequence of a significant increase in use of nitrogen in synthetic fertiliser. In 2009 N_2O emissions from agricultural soils decreased primarily due to a fall in the use of synthetic fertiliser.

Table 16.6.22 Emissions of N_2O from Agricultural Soils 1990 – 2008, tonnes N_2O.

CRF – Table 4.D	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total N_2O emission	7.72	7.85	7.37	6.79	7.29	7.63	10.89	9.08	12.40	12.50
1. Direct Emissions										
Synthetic Fertiliser	0.16	0.16	0.16	0.16	0.16	0.11	1.97	0.53	2.63	3.08
Animal Manure Applied on Soil	1.03	1.04	0.93	0.84	0.92	1.01	1.05	1.20	1.03	1.09
Crop Residue	0.16	0.17	0.18	0.18	0.19	0.20	0.21	0.22	0.23	0.23
Cultivation of Histosols	1.54	1.62	1.70	1.79	1.87	1.95	2.03	2.11	2.19	2.27
2. Pasture, Range and Paddock Manure	2.58	2.60	2.35	2.01	2.18	2.31	2.36	2.46	2.58	2.01
3. Indirect Emissions										
Atmospheric Deposition	0.32	0.33	0.29	0.26	0.29	0.30	0.33	0.34	0.32	0.32
Nitrogen Leaching and Run-off	1.92	1.94	1.75	1.55	1.68	1.76	2.94	2.22	3.41	3.50
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total N_2O emission	11.15	11.63	11.37	11.60	12.25	12.81	13.00	11.35	17.18	13.07
1. Direct Emissions										
Synthetic Fertiliser	2.28	2.45	2.22	2.27	2.49	2.65	2.80	1.67	5.32	2.62
Animal Manure Applied on Soil	1.06	1.06	0.98	1.00	1.06	1.11	1.10	1.13	1.09	1.04
Crop Residue	0.24	0.26	0.28	0.29	0.29	0.30	0.32	0.32	0.33	0.36
Cultivation of Histosols	2.36	2.45	2.69	2.76	2.81	2.91	3.04	3.07	3.14	3.44
2. Pasture, Range and Paddock Manure	1.95	2.03	2.02	2.04	2.13	2.20	2.07	2.12	2.08	2.09
3. Indirect Emissions										
Atmospheric Deposition	0.30	0.30	0.29	0.29	0.31	0.32	0.32	0.33	0.33	0.31
Nitrogen Leaching and Run-off	2.96	3.09	2.89	2.95	3.16	3.32	3.36	2.72	4.88	3.21

16.6.6 Uncertainties

A tier 1 uncertainty assessment has been carried out in accordance with the IPCC GPG (IPCC, 2000). The uncertainty has been estimated for all sources included in the reporting for agricultural sector. The uncertainties for the activity data and emission factors are shown in Table 16.6.23.

Table 16.6.23 Uncertainties for activity data and emission factors for agriculture.

Subsector	Pollutant	Activity data uncertainty	Emission factor uncertainty
4A Enteric Fermentation	CH_4	10	100
4B Manure Management	CH_4	10	100
4B Manure Management	N_2O	10	100
4D1 Direct N_2O emissions from agricultural soils	N_2O	20	50
4D2 Pasture range and paddock	N_2O	20	25
4D3 Indirect N_2O emissions from agricultural soils	N_2O	20	50

The resulting uncertainties for the individual greenhouse gases and the total uncertainty on the greenhouse gas emission are shown in Table 16.6.24.

Table 16.6.24 Uncertainties for the emission estimates.

	Uncertainty %	Trend 1990-2008 %	Trend uncertainty %
GHG	55	11.2	±20
CH_4	98	-10.4	±12
N_2O	33	54.9	±32

16.6.7 Source specific QA/QC

The elaboration of a formal QA/QC plan is to be completed.

However, data on livestock, land-use categories, synthetic fertilisers and cultivation of histosols has gone through a great deal of quality work with regard to accuracy, comparability and completeness.

All external data used for the emission inventory submission are archived in spreadsheets. Data are archived annually in order to ensure that the basic data for a given report are always available in their original form.

Annual data on livestock, land-use categories, synthetic fertilisers and cultivation of histosols are compared with previous years and large discrepancies are checked.

Safely stored and quality checked activity data are then processes by using a methodological approach consistent with international guidelines.

Calculated emission factors are compared with guideline emission factors to ensure that they are reasonable. The calculations follow the principle in international guidelines.

During data processing, it is checked that calculations are being carried out correctly. However, a documentation plan for this needs to be elaborated.

Time-series for activity data, emission factors and calculated emissions are used to identify possible errors in the calculation procedure. In fact, during the calculation, numerous controls take place to ensure correctness. Sums are checked of the various stages in the calculation procedure. Implied emission factors are compared to emission factors.

Every single time-series imported to the CRF Reporter is checked for annual activity, units for activity, emission factor and emissions. Additional checks are performed on the database. The database encloses every single activity data, emission factors, emission, notation key and comment imported to the CRF Reporter. In other words, no information is typed manually into the CRF Reporter. Instead, all information is imported to the CRF Reporter through XML-files to ensure maximum accuracy and completeness.

16.6.8 Source specific recalculations and improvements

Table 16.6.25 shows recalculations in the agricultural sector compared with the 2010 submission. There have been no improvements in the 2011 emission inventory submission.

Table 16.6.25 Changes in GHG emission in the agricultural sector compared with the 2009 submission.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Previous inventory, Gg CO_2 eqv.	9.2	9.3	8.4	7.5	8.2	8.7	9.9	10.0	10.6	10.1
Recalculated, Gg CO_2 eqv.	9.2	9.3	8.4	7.5	8.2	8.7	9.9	10.0	10.6	10.1
Change in Gg CO_2 eqv.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Change in pct.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Previous inventory, Gg CO_2 eqv.	9.5	9.7	9.4	9.5	10.1	10.5	10.4	10.0	11.6	-
Recalculated, Gg CO_2 eqv.	9.5	9.7	9.4	9.5	10.1	10.5	10.4	10.0	11.6	10.2
Change in Gg CO_2 eqv.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
Change in pct.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-

16.6.9 Source specific planned improvements

The Greenlandic emission inventory for the agricultural sector largely meets the request as set down in the IPCC Good Practice Guidance. Thus for the moment improvements especially concern the QA/QC practice.

16.6.10 References

Greenland Agricultural Consulting Service: Statistics on livestock (sheep and reindeer) and background data on land use (cropland and grassland).

Bussink, D.W. 1994: Relationship between ammonia volatilisation and nitrogen fertilizer application rate, intake and excretion of herbage nitrogen by cattle on grazed swards. Fertil. Res. 38, 111-121.

CRF, Common Reporting Format. Available at
http://cdr.eionet.europa.eu/dk/Air_Emission_Inventories

Djurhuus, J. & Hansen, E.M. 2003: Notat vedr. tørstof og kvælstof i efterladte planterester for landbrugsjord – af 21. maj 2003. Forskningscenter Foulum, Tjele. (In Danish).

EMEP/EEA Guidebook, 2009: Draft version of the new EMEP/EEA

IPCC, 1997: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. Available at
http://www.ipcc-ggip.iges.or.jp/public/gl/invs1.html (08-02-2010).

IPCC, 2000: Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. Available at
http://www.ipcc-nggip.iges.or.jp/public/gp/english/ (08-02-2010).

Jarvis, S.C., Hatch, D.J. & Roberts, D.H., 1989a: The effects of grassland management on nitrogen losses from grazed swards through ammonia volatilization; the relationship to extral N returns from cattle. J. Agric. Sci. Camb. 112,205-216.

Jarvis, S.C., Hatch, D.J. & Lockyer, D.R., 1989b: Ammonia fluxes from grazed grassland annual losses form cattle production systems and their relation to nitrogen inputs. J. Agric. Camp. 113, 99-108.

Nielsen, O.-K., Lyck, E., Mikkelsen, M.H., Hoffmann, L., Gyldenkærne, S., Winther, M., Nielsen, M., Fauser, P., Thomsen, M., Plejdrup, M.S., Albrektsen, R., Hjelgaard, K., Johannsen, V.K., Vesterdal, L., Rasmussen, E., Arfaoui, K., Baunbæk, L. 2010: Denmark's National Inventory Report 2010 - Emission Inventories 1990-2008 - Submitted under the United Nations Framework Convention on Climate Change and the Kyoto Protocol. National Environmental Research Institute, University of Aarhus. 1178 pp. – NERI Technical Report no. 784. Available at:
http://www.dmu.dk/Pub/FR784.pdf

Rasmussen, H.E., 1992: Reindeer Management in Southern Greenland (1992). Published in Danish as "Den sydgrønlandske rendrift" (1992)

Statistics Greenland, Stat Bank: Data on average temperature in June in Southern Greenland. Available at:
http://bank2.stat.gl/Dialog/varval.asp?ma=MIE1MID&path=../Database/Greenland/Environment%20and%20energy/Environment/&lang=1

Statistics Greenland, Statistical Yearbook 1990-2010: Data on livestock (sheep and reindeer).

16.7 LULUCF (CRF sector 5)

16.7.1 Overview of LULUCF

This LULUCF chapter covers only the territory of Greenland. Greenland is part of the Danish Kingdom.

Figure 16.7.1 Municipalities and major cities in Greenland.

Greenland is the world's largest non-continental island on the northern American continent between the Arctic Ocean and the North Atlantic Ocean, northeast of Canada. The northernmost point of Greenland, Cape Morris Jesup, is only 740 km from then North Pole. The southernmost point is Cape Farewell, which lies at about the same latitude as Oslo in Norway. Geographical coordinates are 72 00 N, 40 00 W.

Greenland is covering approx. 2,166,086 km². It has been estimated that 81 % is covered permanently with ice leaving only 410,449 km² ice free. The distance from the South to the North is 2,670 km, and from East to West 1,050 km.

The Terrain is flat to gradually sloping ice cap, which covers all but a narrow, mountainous, barren, rocky coast. The ice cap is up to 3 km thick, and contains 10 percent of the world's resources of freshwater.

The climate is Arctic to sub arctic with cool winters and cold summers in which the mean temperature does not exceed 10° C.

The mean temperature in January is for Nuuk, -8.6°, Kangerlussuaq, -17.0° and Ilulissat -9.6° (2007) and for July: Nuuk 7.7°, Kangerlussuaq 11.5° and Ilulissat 9.6° (2007).

Greenland is normally defined as having three different climatic zones. For the purpose of reporting is used the definition "Polar and Moist" according to IPCC GPG 2006 although some areas may qualify as Arctic deserts.

The sparse population is confined to small settlements along the coast, but close to one-quarter of the population lives in the capital, Nuuk. The total population in January 2009 was 56,194 inhabitants.

Due to the cold climate and the small constant population there is almost no land use change occurring. The total area with Forests has been estimated to 232.5 hectares and 6.5 hectares with Cropland. Grassland is divided into improved Grassland covering 1089 hectares and unimproved Grassland covering 241,000 hectares. Wetlands consist of man made water reservoirs – in total 1,076 hectares. Settlements cover 5,105 hectares. Land classified as "Other Land" is then 99.9 % of the total area.

In the following text the abbreviations are used in accordance with definitions in the IPCC guidelines:

A:	Afforestation, areas with forest established after 1990 under Article 3.3.
R:	Reforestation, areas which have temporarily been unstocked for less than 10 years - included under Article 3.4.
D:	Deforestation, areas where forests are permanently removed to allow for other land use, included under Article 3.3.
FF:	Forest remaining Forest, areas remaining forest after 1990.
FL:	Forest Land meeting the definition of forests.
CL:	Cropland.
GL:	Grassland.
SE:	Settlements.
OL:	Other land, unclassified land.
FM:	Forest Management, areas managed under Article 3.4.
CM:	Cropland Management, areas managed under Article 3.4.
GM:	Grazing land Management, areas managed under Article 3.4.

The LULUCF sector differs from the other sectors in that it contains both sources and sinks of carbon dioxide. LULUCF are reported in the new CRF format. Removals are given as negative figures and emissions are reported as positive figures according to the guidelines.

In total the LULUCF sector has been estimated as a net sink of -0.89 Gg CO_2-eqv. in 2009 equivalent to 0.14 % of the total Greenlandic emission.

The overall land use change from 1990 to 2009 is very small. Afforestation has been made on 14 hectares. No deforestation has occurred and the Cropland area has increased from none to 6.5 hectares.

The emission data are reported in the new CRF format under IPCC categories 5A (Forestry), 5B (Cropland), 5C (Grassland), 5D (Wetlands) and 5E (Settlements) and 5F (Other Land).

Fertilisation of forests and other land is not occurring and all fertiliser consumption is therefore reported in the agricultural sector. No drainage of forest soils is made. All liming is reported under Grassland because liming is not occurring in the forests and the very small area with Cropland. Field burning of wooden biomass is not occurring. Wildfires may occur sporadic in the mountains and these are reported as “Other land”. Hence wildfires are reported as NO.

Table 16.7.1 gives an overview of the emission from the LULUCF sector in Greenland. The Forests are a net sink. Cropland is ranging from being zero in 1990 (no Cropland were occurring in 1990) to being a net source in 2009. GL has been estimated to be a net sink due to the increased area with living biomass.

Table 16.7.1 Overall emission (Gg CO_2) from the LULUCF sector in Greenland, 1990-2008.

Greenhouse gas source and sink categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
5. Land Use, Land-Use Change and Forestry, CO_2	-0,25	-0,20	-0,20	-0,19	-0,19	-0,18	-0,18	-0,18	-0,17	-0,17
A. Forest Land	NA	-0,01	-0,02	-0,02	-0,02	-0,02	-0,02	-0,02	-0,03	-0,03
B. Cropland	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO
C. Grassland	-0,25	-0,19	-0,18	-0,18	-0,17	-0,16	-0,16	-0,15	-0,15	-0,14
D. Wetlands	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
E. Settlements	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
F. Other Land	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Land Use, Land-Use Change and Forestry, N_2O	0.05	0.04	0.04	0.03	0.04	0.03	0.04	0.03		0.03
A. Forest Land	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO		NA,NE,NO
B. Cropland	NA	NA	NA	NA	NA	NA	NA	NA		NA
C. Grassland	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO		NA,NO
D. Wetlands	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO		NA,NO
E. Settlements	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE		NA,NE
F. Other Land	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO		NA,NO
G. Other	NA	NA	NA	NA	NA	NA	NA	NA		NA
5. Land Use, Land-Use Change and Forestry, CO_2-eqv. CO_2 and N_2O	-0,25	-0,20	-0,20	-0,19	-0,19	-0,18	-0,18	-0,18	-0,17	-0,17
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
5. Land Use, Land-Use Change and Forestry, CO_2	-0,16	-0,15	-0,72	-0,08	0,03	-0,21	-0,27	0,06	-0,06	-0,89
A. Forest Land	-0,03	-0,03	-0,04	-0,04	-0,04	-0,04	-0,05	-0,05	-0,05	-0,03
B. Cropland	IE,NA,NO	-0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02
C. Grassland	-0,13	-0,10	-0,71	-0,07	0,04	-0,19	-0,25	0,09	-0,03	-0,87
D. Wetlands	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
E. Settlements	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
F. Other Land	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Land Use, Land-Use Change and Forestry, N_2O	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO		NA,NE,NO
A. Forest Land	NA	NA	NA	NA	NA	NA	NA	NA		NA
B. Cropland	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO		NA,NO
C. Grassland	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO		NA,NO
D. Wetlands	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE		NA,NE
E. Settlements	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO		NA,NO
F. Other Land	NA	NA	NA	NA	NA	NA	NA	NA		NA
G. Other	NE	NE	NE	NE	NE	NE	NE	NE		NE
5. Land Use, Land-Use Change and Forestry, CO_2-eqv. CO_2 and N_2O	-0,16	-0,15	-0,72	-0,08	0,03	-0,21	-0,27	0,06	-0,06	-0,89

16.7.2 Forest remaining forest (5.A.1)

Forests and forest management

Greenland has virtually no forests and therefore there exist no official forest statistics. All forests are situated in the most southern part of Greenland. In an attempt to introduce trees to Greenland research were carried out to find species adaptable for the Greenlandic climate. This resulted in establishment of the Greenlandic Arboretum, which covers 150 hectares out of the total area of 218.5 hectares, Figure 16.7.2 and Table 16.7.2. Information about the Greenlandic Arboret can be found at http://www.sl.life.ku.dk/Faciliteter/GroenlandsArboretet.aspx?forside=false&expath=&type=

Figure 16.7.2 The position of the Greenlandic forests (Courtesy to Rasmus Enoksen Christensen).

Table 16.7.2 Forests in Greenland 1990 and 2009.

Location	Established	Dominant tree	Area	1990 average tree height (m)	2009 average tree height	Density 1990 (trees/ha)	Density 2009
Qinngua Valley	Natural	Birch and mountain ash	45 hectares	n.a	6	100	100
Qanassiassat Forest	1953-63	Conifer	1	5	10.3	1500	1000
Kuussuaq Forest	1962-64 -1982	Conifer	5	3	9.3	1300	900
Kuussuaq Forest	2008	Conifer	3	***	< 1	***	3500
Greenland Arboretum	(1976-1980)	Conifer	3	4	7	300	300
Greenland Arboretum	1980 -	Conifer	150	2	3	1500	1700
Itilleq	2004-2005	Conifer	6	***	< 1	***	3500
Upernaviarsuk	1954	Conifer	0,5	1,5	3	200	200
Lejrskolen	1999-2005	Conifer	4	***	1	***	2500
Klosterdalen	2000	Conifer	1	***	1	***	2000
Total			218,5				

Forest definition

The forest definition adopted in Greenland is almost identical to the FAO definition (TBFRA, 2000). It includes "wooded areas larger than 0.5 ha, that are able to form a forest with a height of at least 5 m and crown cover of at least 10%. The minimum width is 20 m." Temporarily non wooded areas, fire breaks, and other small open areas, that are an integrated part of the forest, are also included. However, due to extreme slow growing rates many of the forests are currently below 5 meters height.

Figure 16.7.3 shows a picture of the best developed forest in Greenland.

Figure 16.7.3 The forest in Kuusuaq. Photo: Rasmus E. Christensen, 2005.

Of special interest is the forest in Qinngua Valley. The Qinngua Valley is situated in a remote area. It consists of natural birch (*Betula pubescens spp. czerepanovii* and *B. glandulosa.)* which develops to forest like trees (Figure 7.3) probably due to an introgressiv hybridisation (Rasmus Enoksen Christensen). This forest will probably not follow the FAO forest definition but are included in the inventory as a sub-division under forests. The Qinngua-valley is not included in the FAO forest statistics.

Figure 16.7.4 Kuussuaq, Tasermiut fjor. Photo: Rasmus Christensen, Juni 2004.

Methodological issues for forests

Estimation of volume, biomass and carbon pools

Due to lack of precise data and slow growth rates, simple functions are used that only include the height of the trees and the number per hectare.

The height of the trees has been estimated by Rasmus Enoksen Christensen based on data from the Aboretum. It is assumed that the trees are conical and the stem diameter at ground level is based on the general formula for even-aged forests (Vanclay, 2009).

$D = \beta(H - 1.3)/ \ln(N)$ (eq.1)

Where:

D = diameter at breast height, cm

ß = slope, species dependent

H = Height of the trees (meters)

N = Number of trees per hectare

Eq. 1 has been simplified by omitting the breast height (1.3 meters) to

$D = \beta(H)/ \ln(N)$ (eq.2)

so that D is representing the diameter at ground level. The ß-value used is given in table 7.2

Table 16.7.2 ß-values for estimating the diameter of trees (from Vanclay, 2009).

	Betula, spp	Conifers
ß-values	6.54	7.51

In order to estimate the C stock and C stock change is used the average default values from the IPCC 2006 guidelines for BCEF, density, C-content and Root-Shoot ratio for Boreal stands with a growing stock level of 21-50 m^3, IPCC table 4.5, pp 4.50. The values are given in Table 16.7.3.

Table 16.7.3 Biomass expansion factors used for Greenland.

		Qinngua Walley (Betula, spp.) Birch	Conifers	Orpiuteqarfia (Larix sibirica) Sibirian Larch)
BCEF	Dimensionless	0.7	0.66	0.78
Density	kg dry matter per litre	0.51	0.4	0.46
C-content	kg C per kg dry matter	0.48	0.51	0.51
Root-shoot-ratio	Dimensionless	0.39	0.39	0.39
Dead Organic Matter	kg per kg aboveground biomass	0.1	0.2	0.1

Source: IPCC 2006 guidelines.

Dead wood volume, biomass and carbon

The volume of dead organic matter (DOM) is estimated as a fraction of the aboveground biomass (Table 16.7.3). It is assumed that litter is included in DOM.

Forest soils: forest floors and mineral soil

Following the cold climate and the slow growing rate it is assumed that no changes takes place in C-stock in the soil and hereby following the IPCC 2006 guidelines at Tier 1 level.

Uncertainties and time-series consistency

The uncertainty in estimation of the C stock changes in the Greenlandic forests is very high. As there are very limited resources to visit and monitor in the remote areas there are very few data available. The current inventory is therefore based on the best knowledge available. It should also be taken into consideration that the importance of the forest sector in Greenland is marginal as only very little thinning is taking place as well as no deforestation and that the effect on the inventory is almost not measurable.

In the overall uncertainty section for the LULUCF is made a Tier 1 uncertainty analysis.

QA/QC and verification

Focus on the measurements of carbon pools in forest in Greenland will contribute to QA/QC and verification, but at the moment there are no plans to a further monitoring of the Greenlandic forests.

Recalculations and changes made in response to the review process

No recalculations have been made.

Planned improvements

No improvements are planned.

Land converted to forests

Forest area

See Section 16.2.1 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation.

Forest definition

See Section 16.2.1 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories (e.g. land use and land-use change matrix).

Methodological issues for land converted to forest

See also Section 16.2.1.

Since 1990 there has been a slight increase in the forest area of 14 hectares. This has taken place on land converted from "OL".

Uncertainties and time-series consistency

See Section 16.2.1. For uncertainties, please se Chapter 16.7.13.

QA/QC and verification

No QA/QC plan has been made yet. The afforestated area is known.

Recalculations, including changes made in response to the review process

None

Recalculation for 1990 - 2009

No recalculations have been made.

Planned improvements

No improvements are planned.

16.7.3 Cropland – 5B

Cropland and cropland management – 5B1

In 1990 there were no cropland occurring in Greenland. Due to the global warming it is now possible to have a few crops which may mature. In 2001 the first five hectares with annual crops were established. These are reported under 5.B.2. A more intensive description of the agriculture in Greenland can be found at
http://nunalerineq.gl/english/landbrug/jord/index-jord.htm

Land converted to cropland – 5B2

In 2001 the first annual crops were grown in Greenland. Approximately five hectares with garden crops were grown. Of this is it assumed that 25 % of the area is on organic soils (pers. comm. with Kenneth Høeg, former chief agricultural advisor in Greenland). The area converted to cropland was improved grassland.

Figure 16.7.5 Cropland and Grassland in Greenland.
(Photos from: http://nunalerineq.gl/english/landbrug/landbrug/index-landbrug.htm)

The region is generally characterized by a slightly podsol type of soil with a low pH value and small amounts of accessible plant nutrients. Larger concentrations of clay rarely occur, but considerable quantities of silt are often observable on the surface. Also, a certain amount of brown earth occurs in inland areas.

Methodological issues

Change in carbon stock in living biomass
For land converted to cropland is used a standard default value of 5,000 kg DM (dry matter) per hectare in above- and below-ground (IPCC 2006).

Change in carbon stock in dead organic matter
No organic matter is reported under CL.

Change in carbon stock in soils
No C stock changes in mineral soils are assumed. The emission in the 25 % organic soils is estimated by using the IPCC 2006 default value for cropland, Table 5.6 pp 5.19 of 5,000 kg C per ha per year.

Uncertainties and time-series consistency
The time-series are complete. For uncertainties, please se Chapter 16.7.13.

Category-specific QA/QC and verification
The number of hectares is provided by the Greenlandic Agricultural Consulting Services. As agricultural activities are economically subsidised in Greenland the figures are very accurate.

Category-specific recalculation
No recalculation has been made.

Category-specific planned improvements
No improvements are planned.

16.7.4 Grassland – 5C

Grassland remaining grassland – 5C1
Grassland in Greenland is dominated by unimproved grassland where the sheep is grazing. The total area with GL has been estimated to 242,000 hectares. Of these only approximately 1,000 hectare is improved where stones have been removed combined with sowing of more high yielding species, see Figure 16.7.5.

Since 1990 the area with improved grassland has been extended from 460 hectares to 1089 hectares.

Methodological issues for grassland

Grassland is divided into improved and unmanaged Grassland.

Change in carbon stock in living biomass

As more GL becomes improved the amount of living biomass at peak is increased. To estimate the amount of living biomass in improved GL is using the same default value as for Cropland, e.g. 5000 kg DM per hectare, IPCC 2006 default value for cropland, Table 5.9 pp 5.28. For unmanaged Grassland is used a default value of 1700 kg DM per hectare according to IPCC 2006 default, Table 6.4 pp 6.27. No estimates for below-ground biomass are given. For conversion from DM to C is used a default value of 0.5 kg C per kg DM.

Change in carbon stock in dead organic matter

No changes in dead organic matter are estimated as this is not occurring for this category.

Change in carbon stock in soils

No changes in the carbon stock in mineral soils are assumed. For organic soils on improved grassland is used a default EF of 250 kg C per ha per year (IPCC, 2006) default value for grassland, Table 6.3 pp 6.17. For unmanaged grassland no carbon stock change is expected.

Uncertainties and time-series consistency

The time-series is complete. For uncertainties, please se Chapter 16.7.13.

Category-specific QA/QC and verification

The number of hectares is provided by the Greenlandic Agricultural Consulting Services. As the agriculture is subsidised in Greenland the figures are very accurate.

Recalculations

No recalculation has been made.

Planned improvements

No improvements are planned.

16.7.5 Wetlands – 5D

Wetland in Greenland includes only human made water reservoirs and not naturally occurring wetlands. In total 1,076 hectares with ponds and water reservoirs distributed on 48 locations are reported.

No emission estimates from these reservoirs has been made yet.

Uncertainties and time-series consistency

Not estimated.

QA/QC and verification

QA and QC has been made by NERI and Statistics Greenland.

Recalculation

No recalculations have been made.

Category-specific planned improvements

No improvements are planned.

16.7.6 Settlements – 5E

In total there are approximately 56,000 inhabitants in Greenland with about one quarter of the population in the capital, Nuuk.

Table 7.4 Inhabitants and the area occupied with houses, hectares.

	1990	2000	2008
Cities, inhabitants	44,427	45,734	47.074
Small villages, inhabitants	11,131	10,373	9.120
City area, ha	2,964	3,051	3,245
Villages, ha	1,825	1,825	1,825
Settlements, total, ha	4,789	4,876	5,070

The cities are build on the rocky coastline where almost none vegetation occurs. As a consequence estimates for C stock in living biomass and in soil have been made.

The small increase in the area with Settlements since 1990 has taken place on "Other land".

Currently, no official data or measurements of the area of villages and settlements is available. Alternatively, land utilized for villages and settlements have been measured by the use of NunaGIS, which is a digital internet atlas displaying maps over villages and settlements in Greenland. NunaGIS is available at www.nunagis.gl.

16.7.7 Other land

The far major part of Greenland is covered with snow or rocks. Thus Other Land consists of 99.9 % of the total area.

No emission estimates have been made for this area.

The global warming can be seen in Greenland with longer and warmer summers, which again increase the amount of living biomass. Especially since the early 1990's there has been changes observed in the environment, e.g. as given in the area with Cropland and Grassland has increased. However, no methodology exists currently to estimate a proper estimate of the amount of living biomass in the large area classified as "Other land".

16.7.8 Direct N2O emissions from N fertilization of Forest Land and Other land use – 5(I)

Not occurring.

16.7.9 Non-CO2 emissions from drainage of forest soils and wetlands – 5(II)

Not occurring.

16.7.10 N2O emissions from disturbance associated with land-use conversion to cropland – 5(III)

Not occurring.

16.7.11 CO_2 emissions from agricultural lime application – 5(IV)

As part of the agricultural practice liming is taking place on acidic agricultural soils (Kenneth Høeg, personal communation). The total amount of lime consumed in 2009, based on import statistics, is 5 tonnes lime and 5 tonnes dolomite.

The amount of C is calculated according to the guidelines with a 90 % purity of lime and 95 % purity for dolomite. It is assumed that all C disappear as CO_2 the same year as the lime is applied.

Planned Improvements

None.

16.7.12 Biomass burning – 5(V)

No biomass burning takes place in Greenland, and wildfires rarely occur due to the moist climate.

16.7.13 Uncertainties

A tier 1 uncertainty assessment has been carried out in accordance with the IPCC GPG (IPCC, 2000). The uncertainty has been estimated for all sources included in the reporting for LULUCF. The uncertainties for the activity data and emission factors are shown in Table 16.7.4.

Table 16.7.4 Uncertainties for activity data and emission factors for LULUCF.

Subsector	Pollutant	Activity data uncertainty	Emission factor uncertainty
5A Forest	CO_2	5	50
5B Cropland	CO_2	5	50
5C Grassland	CO_2	5	50

The assumed uncertainties represent expert judgement.

The resulting uncertainties for the individual greenhouse gases and the total uncertainty on the greenhouse gas emission are shown in Table 16.7.5.

Table 16.7.5 Uncertainties for the emission estimates.

		1990 Emission/sink, Gg CO_2-eqv.	2009 Emission/sink, Gg CO_2-eqv.	Activity data, %	Emission factor, %	Combined uncertainty	Total uncertainty, %	Uncertainty 95%, Gg CO_2-eqv.
5. LULUCF		-0,246	-0,018				36,4	0,006
5.A Forests		0,000	-0,030				50,2	0,015
Forests	CO_2	NA	-0,030	5	50	50,2	50,2	0,015
5.B Cropland		0,000	0,004				50,2	0,002
Cropland	CO_2	NA,NO	0,004	5	50	50,2	50,2	0,002
5.C.Grassland		-0,255	0,004				50,2	0,002
Grassland	CO_2	-0,255	0,004	5	50	50,2	50,2	0,002
5(IV) Liming	CO_2	0,008	0,004				50,2	0,002
	CO_2	0,008	0,004	5	50	50,2	50,2	0,002

16.7.14 References

Christensen, R.E. 2010: Information on Greenlandic forests. Not published.

IPCC, 2006: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston, H.S., Buendia, L., Miwa, K., Ngara, T. & Tanabe, K. (eds). Published: IGES, Japan. Available at:
http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

Vanclay, J.K. 2009: Tree diameter, height and stocking in even-aged forests, Ann. For. Sci. 66. 702 Available online at: EDP Sciences, 2009 www.afs-journal.org DOI: 10.1051/forest/2009063.

16.8 Waste (CRF sector 6)

16.8.1 Overview of sector

The waste sector consists of the CRF source category 6.A. Solid Waste Disposal on Land, 6.B. Wastewater Handling, 6.C. Waste Incineration and 6.D. Other.

In 2009 the waste sector accounted for 3.5% of the total greenhouse gas emissions in Greenland. This corresponded to an emission of 22.1 Gg CO_2 equivalents.

The Greenlandic inventory includes CH_4 emissions from solid waste disposal on land, CH_4 and N_2O from wastewater handling and CO_2, CH_4, N_2O, NO_x, CO, NMVOC and SO_2 from waste incineration. Only emissions from waste incineration without energy recovery are included in the waste sector. Emissions from waste incineration with energy recovery are included in the energy sector.

Table 16.8.1 shows the greenhouse gas emissions from the waste sector. The emissions are taken from the CRF tables and are presented as rounded figures.

Table 16.8.1 Emissions for the waste sector, Gg CO_2 equivalents.

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
6 A. Solid Waste Disposal on Land	C	3.6	3.7	3.8	3.8	3.9	3.9	4.0	4.1	4.1	4.1
6 B. Wastewater Handling	N	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2
6 C. Waste incineration	C	2.6	2.6	2.6	2.6	2.7	2.7	2.9	3.0	3.4	3.3
6 C. Waste incineration	C	2.3	2.3	2.3	2.3	2.3	2.4	2.3	2.3	2.2	2.1
6 C. Waste incineration	N	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.0
6. Waste	T	24.7	24.8	24.9	25.0	25.2	25.4	25.6	25.8	26.0	25.7
continued		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
6 A. Solid Waste Disposal on Land	C	4.2	4.2	4.1	4.1	4.1	4.1	4.0	4.0	4.0	3.9
6 B. Wastewater Handling	N	15.2	15.2	15.2	15.2	15.3	15.2	15.3	15.7	16.2	12.9
6 C. Waste incineration	C	3.1	3.1	3.1	3.0	2.9	2.9	2.9	2.9	2.9	2.9
6 C. Waste incineration	C	1.8	1.8	1.7	1.6	1.6	1.6	1.6	1.6	1.6	1.6
6 C. Waste incineration	N	0.9	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8
6. Waste	T	25.1	25.2	25.1	24.8	24.6	24.6	24.7	25.0	25.5	22.1

The largest source of greenhouse gas emission in 2009 from the waste sector is N_2O emission from wastewater handling (58 %), more specifically from industrial effluents. Other large sources are CH_4 from solid waste disposal on land (18 %) and CO_2 from waste incineration (13 %).

The total greenhouse gas emission from the waste sector has decreased by 10.6 % from 1990 to 2009. Emissions of N_2O from wastewater handling, CH_4 from waste incineration and N_2O from waste incineration gave been slightly decreasing in 2009, while emissions of CH_4 from solid waste disposal on land and CO_2 from waste incineration have been increasing in 2009.

16.8.2 Solid waste management

Activity data for waste amounts for solid waste management are shown in Table 16.8.2.

Table 16.8.2 Waste amounts for solid waste management, tonnes.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
6 A1. Managed Waste Disposal	6 068	6 135	6 178	6 240	6 342	6 436	6 416	6 422	6 150	5 704
6 A2. Unmanaged Waste Disposal	1 353	1 352	1 351	1 354	1 336	1 284	1 212	1 156	1 056	982
6 C. Waste incin., energy recovery	5 518	5 577	5 617	5 732	5 917	6 073	6 180	6 277	6 401	8 202
6 C. Waste incin., without energy rec.	16 575	16 721	16 814	16 961	17 201	17 464	17 832	18 165	18 759	17 831
6. Waste total	29 515	29 785	29 960	30 287	30 795	31 257	31 640	32 020	32 366	32 719
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
6 A1. Managed Waste Disposal	4 883	4 950	4 755	4 460	4 221	4 252	4 272	4 300	4 324	4 358
6 A2. Unmanaged Waste Disposal	904	864	837	828	823	822	812	786	754	737
6 C. Waste incin., energy recovery	11 281	11 525	12 657	14 085	15 312	15 572	15 789	16 058	16 366	16 682
6 C. Waste incin., without energy rec.	16 073	16 291	15 881	15 227	14 706	14 795	14 841	14 828	14 788	14 848
6. Waste total	33 140	33 629	34 129	34 599	35 062	35 441	35 714	35 972	36 233	36 626

The waste amounts are based on municipal data on waste and waste incineration with energy recovery on local incinerator plants in 2004, and a survey by Consulting Company Carl Bro in 1996 and 2001, where waste amounts pr person pr year was identified as 650 kg and 455 kg for Greenlandic towns and villages, respectively. For the time-series these amounts were regulated by 1 % per year upwards for years after 2004 and by 1 % per year downwards for years before 2004. Further, to construct the time-series statistical data from Statistics Greenland on population in towns and villages were used. Other results of the survey used for the time-series are that it was estimated that (1) 70 % of waste amounts is incinerated and 30 % deposited and (2) 80 % of combustible waste amounts deposited is burned in open burning.

Solid waste disposal

Source Category Description

The category consists of managed and unmanaged disposal of waste on land.

Methodological issues, activity data, emission factors and emissions

In Table 16.8.3 the composition of the waste according to the survey mentioned is shown.

Table 16.8.3 Composition of household and commercial waste before and after open burning.

Fraction	Household waste[2]	Commercial waste[2]	Household / Commercial Weighted	After open burning	Weighted (after open burning)
			%		
Paper/cardboard, dry	8.00[1]	20.00	11.84	2.37	7.66
Paper/cardboard, wet	10.00[1]	7.00	9.04	1.81	5.85
Plastics	7.00[1]	9.00	7.64	1.53	4.94
Organic waste	44.00[1]	34.00	40.80	8.16	26.40
Other combustible	17.50[1]	16.00	17.02	3.40	11.00
Glass	7.50[1]	3.00[1]	6.06	6.06	19.60
Metal	3.50[1]	3.00[1]	3.34	3.34	10.80
Other, non combustible	1.00[1]	5.00	2.28	2.28	7.37
Hazardous waste	1.50[1]	3.00[1]	1.98	1.98	6.40
Total	100.00	100.00	100.00	30.93	100.00
Pct (%)	68[3]	32[3]		80[4]	

Notes:

[1] Measured values.

[2] Source: Environmental and Nature Agency, Ministry of Infrastructure and Environment.

[3] Distribution of household and commercial waste.

[4] Share of combustible waste burned at waste disposal sites.

A Tier 2 approach with a first order decay model is introduced for estimation of emissions of CH_4 from the solid waste disposals. For this purpose the activity data in Table 16.8.2 are estimated back to 1960 (not shown) based on the methodology described in connection to Table 16.8.2. Combining these activity data and the composition data in Table 16.8.3 time-series for 1960-2009 with amounts of waste in waste fractions are calculated.

For these time-series the waste fractions are associated to (1) DOC values according to Section 16.8.2 of this NIR and (2) emission factors based on DOC values and values of methane correction factors, fraction of DOC dissimilated and fraction of CH_4 in gas emitted according to the IPCC GL and GPG for managed disposals, Table 16.8.4 and unmanaged disposal, Table 16.8.5.

Table 16.8.4 DOC values and emission factors for CH_4 for managed disposals.

	Paper / cardboard, dry	Paper / cardboard, wet	Plastics	Organic waste	Other combustible	Glass	Metal	Other, non combustible	Hazardous waste
DOC weighted (after open burning) fraction	0.40	0.20	0.00	0.20	0.20	0.00	0.00	0.00	0.00
Emission factor kg CH_4/tonnes[1]	133.3	66.7	0.0	66.7	66.7	0.0	0.0	0.0	0.0

[1]) based on:

Methane correction factor	1
Fraction of DOC dissimilated and emitted	0.5
Fraction of CH_4 in gas emitted	0.5

Table 16.8.5 DOC values and emission factors for CH_4 for unmanaged disposals.

	Paper/ cardboard dry	Paper/ cardboard wet	Plastics	Organic waste	Other combustible	Glass	Metal	Other, non combustible	Hazardous waste
DOC weighted (after open burning) fraction	0.40	0.20	0.00	0.20	0.20	0.00	0.00	0.00	0.00
Emission factor kg CH_4/tonnes[1]	53.3	26.7	0.0	26.7	26.7	0.0	0.0	0.0	0.0

[1]) based on:

Methane correction factor	0.4
Fraction of DOC dissimilated and emitted	0.5
Fraction of CH_4 in gas emitted	0.5

For managed and unmanaged disposals the default half life time of 14 years and a time lag of 0.5 years are used. For the oxidation factor and according to the GPG for managed disposal 0.1 and for unmanaged 0.0 are used.

In Tables 16.8.6 and 16.8.7 are shown selected data and results for 1990-2009 for managed and unmanaged disposal, respectively. The data in the tables are as follows. The AD for the FOD model as amounts of waste in fractions, the potential emission of CH_4 calculated with emission factors on waste amounts in fractions, the annual generated emission of CH_4 calculated with the FOD model using the potential emissions, the oxidized CH_4 and the actual annual CH_4 emission calculated as the annual generated emission minus the CH_4 oxidized. Calculations are performed since 1960 and are not shown.

Table 16.8.6 Managed disposal. AD for the FOD model (amounts of waste in fractions), the potential emission of CH_4, the oxidized CH_4 and the annual CH_4 emission for 1990-2009.

	Paper /cardboard dry	Paper /cardboard wet	Plastics	Organic waste	Other combustible	Glass	Metal	Other, non combustible	Hazardous waste	Waste total	Potential emission	Annual generated emission	Annual oxidized emission	Annual emission
Unit	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes CH_4	Tonnes CH_4	Tonnes CH_4	Tonnes CH_4
1990	465	355	300	1 601	668	1 189	655	447	388	6 068	233.2	175.1	17.5	157.6
1991	470	359	303	1 619	675	1 202	663	452	393	6 135	236.9	178.1	17.8	160.3
1992	473	361	305	1 630	680	1 210	667	455	395	6 178	239.5	181.1	18.1	163.0
1993	478	365	308	1 646	687	1 223	674	460	399	6 240	241.1	184.0	18.4	165.6
1994	486	371	313	1 673	698	1 243	685	467	406	6 342	243.6	186.9	18.7	168.2
1995	493	376	318	1 698	708	1 261	695	474	412	6 436	247.5	189.8	19.0	170.8
1996	491	375	317	1 693	706	1 257	693	473	411	6 416	251.2	192.7	19.3	173.5
1997	492	375	317	1 694	707	1 258	693	473	411	6 422	250.4	195.5	19.6	176.0
1998	471	360	304	1 623	677	1 205	664	453	394	6 150	250.7	198.2	19.8	178.4
1999	437	333	282	1 505	628	1 118	616	420	365	5 704	240.1	200.2	20.0	180.2
2000	374	285	241	1 288	537	957	527	360	313	4 883	222.6	201.3	20.1	181.2
2001	379	289	245	1 306	545	970	535	365	317	4 950	190.6	200.8	20.1	180.7
2002	364	278	235	1 254	523	932	513	351	304	4 755	193.2	200.4	20.0	180.4
2003	341	261	220	1 177	491	874	482	329	286	4 460	185.6	199.7	20.0	179.7
2004	323	247	209	1 114	465	827	456	311	270	4 221	174.1	198.5	19.8	178.6
2005	326	249	210	1 122	468	833	459	313	272	4 252	164.8	196.8	19.7	177.2
2006	327	250	211	1 127	470	837	461	315	273	4 272	166.0	195.3	19.5	175.8
2007	329	251	212	1 135	473	843	464	317	275	4 300	166.7	194.0	19.4	174.6
2008	331	253	214	1 141	476	847	467	319	277	4 324	167.8	192.7	19.3	173.4
2009	334	255	215	1 150	480	854	471	321	279	4 358	168.8	191.5	19.2	172.4

Table 16.8.7 Unmanaged disposal. AD for the FOD model (amounts of waste in fractions), the potential emission of CH_4, the oxidized CH_4 and the annual CH_4 emission for 1990-2009.

	Paper /cardboard dry	Paper /cardboard wet	Plastics	Organic waste	Other com-bustible	Glass	Metal	Other, non combustible	Hazardous waste	Waste total	Potential emission	Annual generated emission	Annual oxidized emission	Annual emission
Unit	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes	Tonnes CH_4	Tonnes CH_4	Tonnes CH_4	Tonnes CH_4
1990	104	79	67	357	149	265	146	100	87	1 353	21	15.7	0.0	15.7
1991	104	79	67	357	149	265	146	100	87	1 352	21	16.0	0.0	16.0
1992	103	79	67	357	149	265	146	100	87	1 351	21	16.2	0.0	16.2
1993	104	79	67	357	149	265	146	100	87	1 354	21	16.5	0.0	16.5
1994	102	78	66	352	147	262	144	98	86	1 336	21	16.7	0.0	16.7
1995	98	75	63	339	141	252	139	95	82	1 284	21	16.9	0.0	16.9
1996	93	71	60	320	133	238	131	89	78	1 212	20	17.1	0.0	17.1
1997	89	68	57	305	127	227	125	85	74	1 156	19	17.1	0.0	17.1
1998	81	62	52	279	116	207	114	78	68	1 056	18	17.2	0.0	17.2
1999	75	57	49	259	108	192	106	72	63	982	16	17.2	0.0	17.2
2000	69	53	45	238	99	177	98	67	58	904	15	17.1	0.0	17.1
2001	66	50	43	228	95	169	93	64	55	864	14	16.9	0.0	16.9
2002	64	49	41	221	92	164	90	62	54	837	13	16.8	0.0	16.8
2003	63	48	41	218	91	162	89	61	53	828	13	16.6	0.0	16.6
2004	63	48	41	217	91	161	89	61	53	823	13	16.4	0.0	16.4
2005	63	48	41	217	90	161	89	61	53	822	13	16.2	0.0	16.2
2006	62	47	40	214	89	159	88	60	52	812	13	16.1	0.0	16.1
2007	60	46	39	207	86	154	85	58	50	786	13	15.9	0.0	15.9
2008	58	44	37	199	83	148	81	56	48	754	12	15.7	0.0	15.7
2009	56	43	36	194	81	144	80	54	47	737	12	15.5	0.0	15.5

16.8.3 Wastewater handling

Source category description

In Greenland no wastewater treatment occurs; although it should be mentioned some filtering of solid residues from industry may occur and likewise there are ongoing projects focussing on septic tanks at household levels. N_2O emission from human sewage is estimated. It is assumed that no methane emission occurs.

Methodological issues

According to the IPCC Guidelines (IPCC, 1997) the important factors for CH_4 production from handling of wastewater are: wastewater characteristics, handling systems, temperature and BOD vs. COD.

The Guidelines state that production of CH_4 generally requires temperatures above 15˚C, and at temperatures below this the lagoon is principally a sedimentation tank. (IPCC, 1997) Temperatures in Greenland rarely exceed 15˚C, and the monthly average temperature has not exceeded 12˚C during the period 1993-2009. Therefore CH_4 is reported as Not Applicable in the CRF.

N_2O emission from wastewater handling

The IPCC default methodology only includes N_2O emissions from human sewage based on annual per capita protein intake. The methodology account for nitrogen intake ("outcome"), i.e. faeces and urine, only and neither the industrial nitrogen input nor non-consumption protein from kitchen, bath and laundry discharges are included.

The formula used for calculation of the emission from effluent WWTP discharges is:

$$E_{effluents} = P \cdot F_N \cdot N_{pop} \cdot F_{nc} \cdot F \cdot EF \cdot effluent \cdot \frac{M_{N_2O}}{M_{N_2}}$$

where P is the annual protein per capita consumption per person per year set constant to 171.5 g/day (see below text)

FN is the fraction of nitrogen in protein, i.e. 0.16 (IPCC, 1997)

Npop is the Greenlandic population (Source: Statistics Greenland)

Fnc is the fraction of the population not connected to the municipal sewer system, i.e. set to 1 as no wastewater treatment plants exists in Greenland at this point

F is the fraction of non-consumption protein in domestic wastewater. i.e. 1.1 (IPCC, 2006)

$EFN_2O.WWTP.effluent$ is the IPCC GL default emission factor of 0.01 kg N_2O-N/kg sewage-N produced (IPCC, 1996)[35]

[35] The IPCC (2006) gives a default value for the N_2O emissions from domestic wastewater nitrogen effluent of 0.005 (0.0005 - 0.25) kg N_2O-N/kg N. However, the IPCC EF from the 1996 guidelines has been used.

MN_2O and MN_2 are the mass ratio. i.e. 44/28 to convert the discharged units in mass of total N to emissions in mass N_2O.

For households

A large part of the diet originates from seafood, fish or sea mammals, but imported fabricated foods are expected to continue to take over an increasing part of human energy consumption. Due to weather conditions most of fresh food comes from wild animals or fish. Greenland has a production of lamb and a limited supply of vegetables; still most of the produced foods are imported from outside (Mulvad et al., 2007).

In Greenland, the traditional diet based on meat and fish has undergone diversification towards more carbohydrates with the development of a monetary economy; in 1855 the protein content of a mean diet was 377 g protein, whereas 80 years later, in 1935 – 43, the protein content of a mean diet was 257 g protein (Périssé and François, 1981). Today, the majority of young urbanised Greenlandic Inuit have Western dietary habits and consume less meat from marine mammals, terrestrial mammals and birds than Inuit from the hunting districts; Dietary profiles of Canadian Baffin Island Inuit with a high consumption of traditional foods have shown a mean daily protein intake of 199-144 g/day in 41- to 61-year-old (Laursen et al, 2001).

As no data on the protein intake are available a protein intake of 172 g/day, i.e. the average of the Canadian Inuit were adopted, as it is assumed that the protein intake has declined even more since 1935 due to increased number of urbanised Greenlandic Inuit. For comparison the Danish yearly protein consumption according to FAOSTAT has increased from 98 g/day in 1990 to 112 g/day in 2005. Using this number, the yearly protein intakes may be derived by multiplying with the population number and days in a year. Based on the above it was decided to set the protein intake to the average value of the Canadian Inuit data, 171.5 g/day. The N-content in effluent wastewater in Greenland was calculated the equation shown above.

From industries

The production of residue products from the fish industry in Greenland amounts to around 14,000 tons per year (Nielsen et al, 2005). Overall the waste amount from the Greenland halibut production is around 40%, while the waste amount from codfish production is 50%; this governs only the fish production including pre-processing.

According to IPCC, the fraction of nitrogen in protein is 0.16 (IPCC, 1996). The IPCC reports a range of 0.3 to 3.1 kg total N/ton fish referring to effluent loads form cod filleting; i.e. 0.0031. The report also presents values of the total N content of untreated wastewater from the fish industry in the range of 400-1000 mg/l corresponding to a fraction of corresponding. However, as it was not possible to find data for all fish groups, and as it was not possible to determine that fraction of fish, which was pre-processed and how big a fraction that was sold without pre-processing, the below approach was adopted.

From the EC BAT note (EC, 2003) the total N-content of untreated wastewater from the fishing industry was reported to be between 400 and 1000 mg/L with an average value of 700 mg/L. The number was multiplied by the water used within the fishing industry reported for 2004 to 2009 by Statistics Greenland. The effluent N-content for 1990 to 2003 was set equal to the estimated value for 2003.

Emissions

Emission of N_2O from wastewater handling is shown in Table 16.8.8.

Table 16.8.8 N_2O emissions from households and industries 1990-2009.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
N_2O emission, effluents households, Gg	0.0096	0.0096	0.0096	0.0096	0.0096	0.0097	0.0097	0.0097	0.0097	0.0097
N_2O emission, effluents industries, Gg	0.0394	0.0394	0.0394	0.0394	0.0394	0.0394	0.0394	0.0394	0.0394	0.0394
N_2O emission, effluents sum, Gg	0.0490	0.0490	0.0489	0.0489	0.0490	0.0490	0.0490	0.0491	0.0491	0.0491
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
N_2O emission, effluents households, Gg	0.0097	0.0098	0.0098	0.0098	0.0099	0.0099	0.0098	0.0098	0.0098	0.0098
N_2O emission, effluents industries, Gg	0.0394	0.0394	0.0394	0.0394	0.0394	0.0393	0.0396	0.0410	0.0425	0.0318
N_2O emission, effluents sum, Gg	0.0491	0.0491	0.0492	0.0492	0.0492	0.0492	0.0494	0.0508	0.0522	0.0415

Total emission of N_2O has increased in later years due to an increase in the emission from industrial effluents.

16.8.4 Waste incineration

Source category description

In Greenland waste incineration is carried out both with and without energy recovery. According to IPCC Guidelines the emissions associated with waste incineration for energy production is included in the energy sector more specifically in the source category 1.A1a Public Electricity and Heat Production. The emissions from waste incineration without energy recovery is reported in source category 6.C. Waste Incineration. Additionally in Greenland open burning of waste occurs at landfill sites. Emissions associated with this are also reported under sector 6.C. Waste Incineration.

Methodological issues

The methodology used follows the IPCC Guidelines. For waste incineration the Danish emission factors are used, as it is trusted that they are also a good representation of Greenlandic conditions.

Neither the revised 1996 IPCC Guidelines (IPCC, 1997) nor the Good Practice Guidance (IPCC, 2000) contains a methodology for estimating emissions from open burning, therefore the methodology provided in the 2006 IPCC Guidelines (IPCC, 2006) is used.

The emission factors used for both waste incineration and open burning are included in Section 16.8.4.4.

Activity data

The amount of waste incinerated without energy recovery is presented in Table 16.8.9. The activity data is provided by the method described in Section 16.8.2.

Table 16.8.9 Activity data for waste incineration without energy recovery, Mg.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Waste incinerated without energy recovery, Mg	NO	NO	NO	NO	56	225	795	1 242	2 665	2 898
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Waste incinerated without energy recovery, Mg	3 150	3 308	3 392	3 418	3 440	3 463	3 487	3 470	3 446	3 468

The open burning of waste is assumed to be 80 % of the waste deposited to landfills (Survey on waste by Carl Bro, 1996 and 2001). The activity data for open burning is presented in Table 8.10. The activity data for open burning is provided by the method described in Section 16.8.2.

Table 16.8.10 Activity data for open burning of waste, Mg.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Open burning of waste, Mg	16 575	16 721	16 814	16 961	17 146	17 240	17 036	16 924	16 094	14 932
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Open burning of waste, Mg	12 923	12 983	12 488	11 809	11 265	11 332	11 353	11 358	11 342	11 380

16.8.4.1 Emission factors

Waste incineration

For waste incineration without energy recovery the same emission factors have been assumed as for waste incineration with energy recovery. The emission factors refer to the Danish emission factors (Nielsen et al., 2009). The greenhouse gas emission factors are shown in Table 16.8.11.

Table 16.8.11 Emission factors for greenhouse gases from waste incineration.

	Emission factor	Unit
CO_2	32.5	Kg pr GJ
CH_4	30	G pr GJ
N_2O	4	G pr GJ

The emission factors used for the indirect greenhouse gases are shown in table 16.8.12.

Table 16.8.12 Emission factors for indirect greenhouse gases from waste incineration.

	NO_x	SO_2	NMVOC	CO
Waste incineration, g/GJ	100	6	50	1000

Open burning

For open burning emissions are calculated using the methodology, standard parameters and emission factors provided by the 2006 IPCC Guidelines.

The CH_4 emission factor used recommended and default is 6500 g per t MSW wet weight. This factor refers to US EPA (2001).

For N_2O a default emission factor of 150 g/t MSW dry weight is recommended (IPCC, 2006) this is corrected for the dry matter content to acquire an N_2O emission factor of 214 g per tonne MSW wet weight.

For calculating the CO_2 emission the dry matter content, carbon content and the fossil carbon content of the waste fractions are used. The parameters are included in Table 16.8.13.

Table 16.8.13 Parameter used in calculating CO_2 emissions from open burning.

	Dry matter content	Total carbon content,%	Fossil carbon content as percent of total carbon
Paper	0,9	46	1
Cardboard	0,9	46	1
Plastics	1,0	75	100
Organic waste	0,4	38	0
Other	0,9	3	100

Source: 2006 IPCC Guidelines, Volume 5, Chapter 2, Table 2.4.

An oxidation factor of 58% is assumed for open burning (IPCC, 2006).

The emission factors for NO_x, SO_2, NMVOC and CO are presented in Table 16.8.14. The emission factors are from the US EPA (1992).

Table 16.8.14 Emission factors for indirect greenhouse gases from open burning of waste.

	NO_x	SO_2	NMVOC	CO
Open burning of municipal refuse, kg/Mg	3	0.5	15	42

Emissions

Total emission of greenhouse gases from sector 6.C. Waste Incineration is shown in Table 16.8.15. Figure 16.8.2 shows total emission of greenhouse gases from sector 6.C. Waste incineration is shown in Figure 16.8.1.

Table 16.8.15 Greenhouse gas emissions from waste incineration.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CO_2, Gg	2.6	2.6	2.6	2.6	2.7	2.7	2.9	3.0	3.4	3.3
CH_4, Mg	107.7	108.7	109.3	110.2	111.5	112.1	111.0	110.4	105.4	98.0
N_2O, Mg	3.5	3.6	3.6	3.6	3.7	3.7	3.7	3.7	3.6	3.3
CO_2 eqv., Gg	5.9	6.0	6.0	6.1	6.1	6.2	6.4	6.5	6.7	6.4
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CO_2, Gg	3.1	3.1	3.1	3.0	2.9	2.9	2.9	2.9	2.9	2.9
CH_4, Mg	85.0	85.4	82.2	77.8	74.3	74.7	74.9	74.9	74.8	75.1
N_2O, Mg	2.9	2.9	2.8	2.7	2.6	2.6	2.6	2.6	2.6	2.6
CO_2 eqv., Gg	5.7	5.8	5.7	5.4	5.3	5.3	5.3	5.3	5.3	5.3

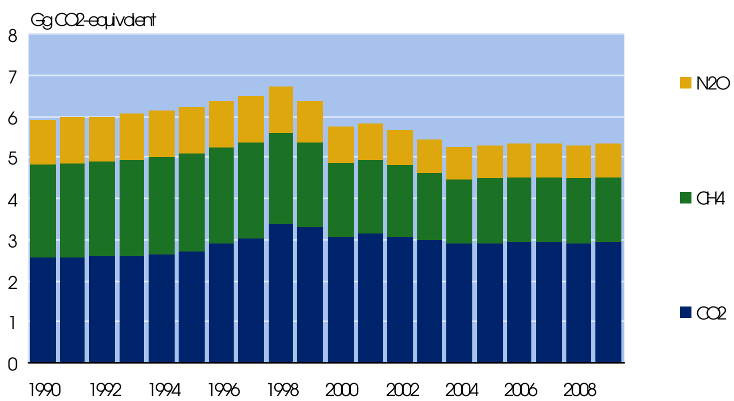


Figure 16.8.1 Emission of greenhouse gases from waste incineration.

The emissions of indirect greenhouse gases from waste incineration are shown in Table 16.8.16.

Table 16.8.16 Emissions of indirect greenhouse gases from waste incineration, Mg.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
NO_x	49.7	50.2	50.4	50.9	51.5	51.9	51.9	52.1	51.1	47.8
SO_2	8.3	8.4	8.4	8.5	8.6	8.6	8.6	8.5	8.2	7.6
NMVOC	248.6	250.8	252.2	254.4	257.2	258.7	256.0	254.5	242.8	225.5
CO	696.2	702.3	706.2	712.4	720.6	726.3	723.9	723.8	703.9	657.6
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
NO_x	42.1	42.4	41.0	39.0	37.4	37.6	37.7	37.7	37.6	37.8
SO_2	6.7	6.7	6.4	6.1	5.8	5.9	5.9	5.9	5.9	5.9
NMVOC	195.5	196.5	189.1	178.9	170.8	171.8	172.1	172.2	171.9	172.5
CO	575.8	580.0	560.1	531.9	509.3	512.3	513.5	513.5	512.6	514.4

16.8.5 Uncertainties

A tier 1 uncertainty assessment has been carried out in accordance with the IPCC GPG (IPCC, 2000). The uncertainty has been estimated for all sources included in the reporting for the waste sector. The uncertainties for the activity data and emission factors are shown in Table 16.8.17.

Table 16.8.17 Uncertainties for activity data and emission factors for the waste sector.

Subsector	Pollutant	Activity data uncertainty	Emission factor uncertainty
6C Waste incineration	CO_2	10	25
6A Solid Waste Disposal on Land	CH_4	10	100
6C Waste incineration	CH_4	10	50
6B Wastewater Handling	N_2O	30	100
6C Waste incineration	N_2O	10	100

The amount of waste incinerated and burned is relatively well known and the uncertainty is set to 10%. The same is the case for the waste deposited to landfills. For waste water handling an uncertainty of 30% on the activity data has been assumed.

Regarding the emission factor uncertainty, a value of 100% has been used for CH_4 from solid waste disposal, N_2O from wastewater treatment and N_2O from waste incineration. This is in the same range as recommended by the IPCC GPG. For CO_2 and CH_4 from waste incineration emission factor uncertainties of 25% and 50% respectively have been chosen.

The resulting uncertainties for the individual greenhouse gases and the total uncertainty on the greenhouse gas emission are shown in Table 16.8.18.

Table 16.8.18 Uncertainties for the emission estimates.

	Uncertainty %	Trend 1990-2009 %	Trend uncertainty %
GHG	64	-10.6	±22.7
CO_2	27	15.0	±16.3
CH_4	73	-6.4	±14.4
N_2O	98	-16.1	±33.6

16.8.6 Source specific QA/QC

The elaboration of a formal QA/QC plan is to be completed.

However, data on solid waste disposal, waste water handling and waste incineration has gone through a great deal of quality work with regard to accuracy, comparability and completeness.

All external data used for the emission inventory submission are archived in spreadsheets. Data are archived annually in order to ensure that the basic data for a given report are always available in their original form.

Annual data on solid waste disposal, waste water handling and waste incineration are compared with previous years and large discrepancies are checked.

Safely stored and quality checked activity data are then processed by using a methodological approach consistent with international guidelines.

Calculated emission factors are compared with guideline emission factors to ensure that they are reasonable. The calculations follow the principle in international guidelines.

During data processing, it is checked that calculations are being carried out correctly.

Time-series for activity data, emission factors and calculated emissions are used to identify possible errors in the calculation procedure. In fact, during the calculation, numerous controls take place to ensure correctness. Sums are checked in the various stages in the calculation procedure. Implied emission factors are compared to emission factors.

Every single time-series imported to the CRF Reporter is checked for annual activity, units for activity, emission factor and emissions. Additional checks are performed on the database. The database encloses every single activity data, emission factors, emission, notation key and comment imported to the CRF Reporter. In other words, no information is typed manually into the CRF Reporter. Instead, all information is imported to the CRF Reporter through XML-files to ensure maximum accuracy and completeness.

16.8.7 Source specific recalculations and improvements

The sector *Waste Water Handling* (6B) was included in the inventory for the first time in the 2010 emission inventory submission. No improvements have been carried out regarding waste water handling in the 2011 submission.

However, due to revisions in population statistics minor revisions have been conducted in the first order decay model for estimation of emission of CH_4 from solid waste disposals. The update includes the years 1990-2008.

Table 16.8.19 shows recalculations in the energy sector compared with the 2010 submission. The changes are of neglible importance.

Table 16.8.19 Changes in GHG emission in the waste sector compared with the 2010 submission.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Previous inventory, Gg CO2 eqv.	24.7	24.8	24.9	25.0	25.2	25.4	25.6	25.7	26.0	25.7
Recalculated, Gg CO2 eqv.	24.7	24.8	24.9	25.0	25.2	25.4	25.6	25.8	26.0	25.7
Change in Gg CO2 eqv.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Change in pct.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Previous inventory, Gg CO2 eqv.	25.1	25.2	25.1	24.8	24.6	24.6	24.7	25.0	25.4	-
Recalculated, Gg CO2 eqv.	25.1	25.2	25.1	24.8	24.6	24.6	24.7	25.0	25.5	22.1
Change in Gg CO2 eqv.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
Change in pct.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-

16.8.8 Source specific planned improvements

Some planned improvements to the emission inventories are discussed below.

1) Improved data on solid waste disposals

In future inventories attempts will be made in order to improve data on solid waste disposals in general.

2) Improved data on waste water handling

In future inventories attempts will be made in order to improve data on waste water handling in general.

16.8.9 References

EC, 2003: Reference Document on BAT in the food, drink and milk industry. Available at:
http://gasunie.eldoc.ub.rug.nl/FILES/root/2003/2665985/2665985.pdf

IPCC, 1997: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. Available at:
http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.html

IPCC, 2000: Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. Penman, J., Kruger, D., Galbally, I., Hiraishi, T., Nyenzi, B., Emmanuel, S., Buendia, L., Hoppaus, R., Martinsen, T., Meijer, J., Miwa, K. & Tanabe, K. (Eds). Published: IPCC/OECD/IEA/IGES, Hayama, Japan. Available at:
http://www.ipcc-nggip.iges.or.jp/public/gp/english/index.html

IPCC, 2006: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan. Available at:
http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

Laursen, J., Milman, N., Pedersen, H.S., Mulvad, G., Saaby, H. and Byg, K.-E., 2001: Elements in autopsy liver tissue samples from Greenlandic Inuit and Danes. III. zinc measured by X-ray fluorescence spectrometry. Journal of Trace Elements in Medicine and Biology, 15:209-214.

Mulvad, G., Petersen, H.S.and Olsen, J., 2007: Arctic health problems and environmental challenges in Greenland. In: Ørbæk, J.B., Kallenborn, R., Tombre, I., Hegseth, E.N., Falk-Petersen, S. and Hoel, A.H. Arctic Alpine

Ecosystems and People in a Changing Environment.
http://www.springerlink.com/content/tu377x6715200027/fulltext.pdf

Nielsen, U., Nielsen, K., Mai, P., Frederiksen, O., 2006: Organisk industriaffald i Grønland – Værktøjer til fremme af bedste tilgængelige teknik og nyttiggørelse af restprodukter nr. M. 127/001-0164. Realistiske muligheder for nyttiggørelse/udnyttelse af organisk industriaffald i Grønland. (In Danish)

Périssé, J. and François, P., 1981: Variability of the protein-calorie ratio in diets. FAO/WHO/UNUEPR/81/40. Available at:
http://www.fao.org/docrep/MEETING/004/AA054E/AA054E00.HTM

Statistics Greenland, 2010: Statistics on Population 1960-2010. Available at:
http://bank.stat.gl/database/Grønland/Befolkning/Folketal/Folketal.asp

US EPA, 1992: AP 42, Fifth Edition, Volume I Chapter 2.5 : Open burning. Available at:
http://www.epa.gov/ttn/chief/ap42/ch02/final/c02s05.pdf

US EPA, 2001: US-EPA Emission Inventory Improvement Program. Volume III Chapter 16 Open Burning. United States Environmental Protection Agency (USEPA). Available at:
http://www.epa.gov/ttn/chief/eiip/techreport/volume03/iii16_apr2001.pdf

16.9 Other

In CRF Sector 7, there are no activities and emissions or removals for the inventory of Greenland.

16.10 Recalculations and improvements

The 2011 submission is the second year where Greenland on the request of the ERT has submitted a full CRF.

For recalculations and improvements please refer to Sections 16.3 - 16.8 and Section 16.11.

16.11 KP-LULUCF

16.11.1 General information

In the following text, the abbreviations used are in accordance with definitions in the IPCC guidelines:

A: Afforestation

R: Reforestation

D: Deforestation

FF:	Forest remaining Forest, areas remaining forest after 1990
FL:	Forest Land meeting the Danish definition of forests
CL:	Cropland
GL:	Grassland
SE:	Settlements
OL:	Other land, unclassified land
FM:	Forest Management, areas managed under article 3.4
CM:	Cropland Management, areas managed under article 3.4
GM:	Grazing land Management, areas managed under article 3.4

Definition of forest and any other criteria

For the estimation of anthropogenic emissions by sources and removals by sinks associated with afforestation (A), reforestation (R) and deforestation (D) since 1990 under Article 3.3 and forest management (FM) under Article 3.4 of the Kyoto Protocol, the following forest definition will be applied:

- Minimum values for tree crown cover: 10 % tree crown cover for forests.
- Minimum values for land area: 0.5 ha.
- Minimum value for tree height: trees must be able to reach a minimum height of 5 m in the site.

In addition, the forest area includes temporarily unstocked areas, smaller open areas in the forest needed for management purposes and fire breaks. Forests in national parks, reserves or areas under special protection are included. Windbreaks and groves covering more than 0.5 ha and with a minimum width of 20 m are also considered as forests.

Woody biomass does not exist out side the forest and hence not reported under Cropland and Grassland.

Elected activities under Article 3, paragraph 4, of the Kyoto Protocol

As regards the possibility of including in the first commitment period emissions and removals associated with land use, land-use change and forestry activities under Article 3.4 of the Kyoto Protocol, it has been decided to include emissions and removals from forest management (FM), cropland management (CM) and grazing land management (GM).

The national system has identified land areas associated with the activities under Article 3.4 of the Kyoto Protocol in accordance with definitions, modalities, rules and guidelines relating to land use, land-use change and forestry activities under the protocol by satellite monitoring, use of EU Land Parcel Information System (LPIS), detailed crop information data on field level, soil mapping and sample plots from the national forest inventory (NFI).

Inventories of emissions and removals under Article 3.3 and Article 3.4 are prepared for 2009, and reported annually in 2010 together with the other greenhouse gas inventory information.

Description of how the definitions of each activity under Article 3.3 and each elected activity under Article 3.4 have been implemented and applied consistently over time

The definition of afforestation, reforestation and deforestation is in accordance with the GPG (IPCC 2003).

Afforestation or reforestation is identified when areas have wooded tree-cover and fulfils the forest definition given above. The time of the AF is given by the time of action, i.e. planting of trees. No deforestation and reforestation is reported for Greenland as this is not occurring. All types of establishment of forest (AF or RF) are considered human induced.

As no reforestation has taken place Table 5(KP-I)A.1.2 "Units of land harvested since the beginning of the commitment period" is filled in as included elsewhere although it is not occurring.

As for the forest management (Article 3.4), the forest areas fulfilling the definition given above are included under this activity. All forest areas are considered managed except for the remote Qinngua-valley.

For Cropland and Grassland the area accounted for under Art. 3.4 has been estimated with the best knowledge from the Greenlandic Agricultural Consulting Services. As the agriculture in Greenland is economically subsidized the area is estimated with a high accuracy. Only areas that are reported as CL and GL are included in the accounted area.

Description of precedence conditions and/or hierarchy among article 3.4 activities and how they have been consistently applied in determining how land was classified

All Forest activities have precedence, after this Cropland activities and then Grassland activities.

Afforestation has precedence. All land converted to forest are included as afforested area. Deforestated areas are not reported as this is not occurring. The following categories in the Convention reporting are included under afforestation:

- 5A25 OL to A

FM activities are only related to:

- 5A1 Forest remaining Forest

CM activities are related to:

- 5B22 GL to CL

GM activities area related to:

- 5C1 GL remaining GL

No elected land has left land that is not accounted for. Land conversion between elected activities (FM, CM and GM) has been allowed but is currently not occurring. No land elected under 3.4 activities has been converted to Other Land. Other land converted to elected activities is included in the respective category. As a consequence there has been a steady increase in the land which is accounted for under Art. 3.3 and Art. 3.4 with 14 hectares from 1990 to 2009.

The Land Use matrix developed for the purpose of reporting Art. 3.3 and 3.4 activities for 2008 are shown in Table 16.11.1.

Table 16.11.1 Land Use matrix for art. 3.3 and 3.4 activities in 2009.

From previous inventory year \ To current inventory year		Article 3.3 activities		Article 3.4 activities				Other (5)
		Afforestation and Reforestation	Deforestation	Forest Management (if elected)	Cropland Management (if elected)	Grazing Land Management (if elected)	Revegetation (if elected)	
		(kha)						
Article 3.3 activities	Afforestation and Reforestation	0,03	NO					
	Deforestation		NO					
Article 3.4 activities	Forest Management (if elected)		NO	0,21				
	Cropland Management(4) (if elected)	NO	NO		0,01	NO	NA	
	Grazing Land Management(4) (if elected)	NO	NO		NO	241,99	NA	
	Revegetation(4) (if elected)	NA			NA	NA	NA	
Other (5)		0,00	NO	NO	0,00	NO	NO	216.366,37
Total area at the end of the current inventory year		0,03	NO	0,21	0,01	241,99	NA,NO	216.366,37

16.11.2 Spatial assessment unit used for determining the areas of the units of land under Article 3.3

Afforestation and reforestation are identified as areas which not were covered by forest in 1990. The increase in the forest area is planted.

Methodology used to develop the land transition matrix

The land use matrix is based on the best available data. No vector maps exist of the individual forests, cropland and grassland.

Maps and/or database to identify the geographical locations, and the system of identification codes for the geographical locations

The forests have been given individual names. For the Cropland and Grassland area no identification has been made.

16.11.3 Afforestation, Reforestation & Deforestation (ARD)

Methods for carbon stock change and GHG emission and removal estimates

For afforestation the carbon stock change in the period 1990 - 2009 is based both on the area of afforestation and the information on species composition.

In the afforestation a steady increase in carbon stock is found.

Description of the methodologies and the underlying assumptions used

See Chapter 7.

Justification when omitting any carbon pool or GHG emissions/removals from ARD

C stock changes in the soil is not expected due to the cold climate to occur and hence following the guidelines for a Tier 1 approach. As the afforestation is made by hand planting no damages of the existing soil C is expected to take place.

Information on whether or not indirect and natural GHG emissions and removals have been factored out

No factoring out has been performed in the emission and removal estimates.

Changes in data and methods since the previous submission (recalculations)

No recalculation has been performed.

Uncertainty estimates

Uncertainty estimates are given in Table 16.11.2.

Table 16.11.2 Uncertain estimates for 1990 and 2009 for the KP sector.

						1990		2009	
KP total					**36,4**	**-0,443**	**0,161**	**-1,484**	**0,539**
A. Article 3.3 activities					52,2	IE,NA,NR	NA	IE,NA,NR	NA
B. Article 3.4 activities					37,6	-0,443	0,1662326	-1,484	0,557
KP A.1.1 Afforestation and Reforestation		Activity data, %	Emission factor, %	Combined uncertainty	Total uncertainty, %	Emission, Gg CO_2-eqv.	Uncertainty 95 %, Gg CO_2-eqv.	Emission, Gg CO_2-eqv.	Uncertainty 95 %, Gg CO_2-eqv.
Area subject to the activity, kha						NO		0,028	
Area of organic soils, kha						NA		0,003	
Net CO_2 emissions/removals					52,2	NA,NR	NA	IE,NA,NR	NA
Net CO_2 emissions/removals	Net change	15	50	52,2	52,2	NA,NR	NA	IE,NA,NR	NA
KP A.2 Deforestation									
Area subject to the activity, kha						NO		NO	
Area of organic soils, kha						NO		NO	
Net CO_2 emissions/removals					NA	NA	NA	NA	NA
Net CO_2 emissions/removals	Net change	15	50	52,2	NA	NA	NA	NA	NA
KP B.1 Forest Management									
Area subject to the activity, kha						0,205		0,205	
Area of organic soils, kha						0,025		0,025	
Net CO_2 emissions/removals					52,2	NA,NR	NA	-0,030	0,0159
Net CO_2 emissions/removals	Net change	15	50	52,2	52,2	NA,NR	NA	-0,030	0,0159
KP B.2 Cropland Management									
Area subject to the activity, kha						NA		0,007	
Area of organic soils, kha						NA		0,002	
Net CO_2 emissions/removals					51,0	NA	NA	0,016	0,0082
Net CO_2 emissions/removals	Net change	10	50	51,0	51,0	NA	NA	0,016	0,0082
KP B.3 Grassland Management									
Area subject to the activity, kha						242,000		241,994	
Area of organic soils, kha						7,368		7,499	
Net CO_2 emissions/removals					51,0	-0,451	0,2300	-1,474	0,7515
Net CO_2 emissions/removals	Net change	10	50	51,0	51,0	-0,451	0,2300	-1,474	0,7515
KP-II 4 Lime consumption									
Total amount of lime applied						18,5		9,3	
Emission					50,2	0,008	0,0043	0,004	0,0021
Carbon		5	50	50,2	50,2	0,008	0,0043	0,004	0,0021

Information on other methodological issues

See Chapter 16.7.

The year of the onset of an activity, if after 2008
Not applicable.

16.11.4 Forest Management (FM)

Methods for carbon stock change and GHG emission and removal estimates
See Chapter 16.7 in LULUCF on "Forest remaining forest (5.A.1)".

Methodologies and the underlying assumptions
See Chapter 16.7 in LULUCF on "Forest remaining forest (5.A.1)".

Omission of pools from FM
C changes in forest soils are omitted and hereby following GPG 2003 guidelines at a Tier 1 level.

Factoring out
No factoring out has been performed.

Recalculations
No recalculation has been performed.

Uncertainty estimates
See table 16.11.2

Information on other methodological issues
See Chapter 16.7 in LULUCF on "Forest remaining forest (5.A.1)".

The year of the onset of an activity, if after 2008
Not applicable.

16.11.5 Cropland Management (CM)

Methods for carbon stock change and GHG emission and removal estimates
Methodologies and the underlying assumptions used
The area with agricultural Cropland is reported as the area given in Statistics Greenland.

The same methodology as used in the Convention reporting is used in the KP reporting.

Omission of pool from CM
Aboveground and belowground living biomass, litter and dead organic are only reported for perennial woody crops in accordance with IPCC GPG 2003. No litter and dead organic matter are reported under Cropland as these are not occurring. Therefore only aboveground living biomasses are reported under Cropland. Below-ground biomass is included in above-ground biomass.

Factoring out
No factoring out has been made.

Recalculations
No recalculation has been performed.

Uncertainty estimates
See Table 16.11.2.

Information on other methodological issues
None.

The year of the onset of an activity, if after 2008
Not applicable.

16.11.6 Grazing land management (GM)

Methods for carbon stock change and GHG emission and removal estimates
Grazing land is defined as land improved grassland and unmanaged grassland.

Description of the methodologies and the underlying assumptions used
The major part of the grassland is unmanaged (241,000 hectare). Only 1089 hectares is improved grassland with occasional reseeding and fertiliser application. The methodology used is the default Tier 1. This is in accordance with IPCC GPG 2003 (3.4.1.2.1.2) as the total emission from LULUCF consists of less than 0.14 % of the total emission from Greenland.

Omission of pools from GM
Aboveground and belowground living biomass, litter and dead organic are only reported for perennial woody crops in accordance with IPCC GPG 2003. No litter and dead organic matter are reported under Cropland as these are not occurring. Therefore only aboveground living biomasses are reported under Cropland. Below-ground biomass is included in above-ground biomass.

Factoring out
No factoring out has been made.

Recalculations
No recalculation has been performed.

Uncertainty estimates
See table 16.11.2.

Information on other methodological issues
None.

The year of the onset of an activity, if after 2008
Not applicable.

16.11.7 Article 3.3

Information that demonstrates that activities under Article 3.3 began on or after 1 January 1990 and before 31 December 2012 and are direct human-induced
All forests in Greenland are planted except for the Qinngua valley, which is in a remote area.

Information on how harvesting or forest disturbance that is followed by the re-establishment of forest is distinguished from deforestation
No deforestation is occurring and therefore not applicable.

Information on the size and geographical location of forest areas that have lost forest cover but which are not yet classified as deforested
Not applicable.

16.11.8 Article 3.4

Information that demonstrates that activities under Article 3.4 have occurred since 1 January 1990 and are human-induced

Forest Management

In Forest Management all forest areas are under management and changes in carbon stock are hence seen as human induced.

Cropland Management

Due to the cold climate and the recent increase in temperature it has only very recently been possible to grow agricultural crops in Greenland with the first fields established around 2001. Today it is estimated that 6.5 hectares are regularly ploughed.

Grassland Management

Due to the cold climate in Greenland and the recent increase in temperature it has only recently been valuable to introduce management activities in the grassland to increase the crop yield. This is well documented in the Greenlandic subsidiary system to the farmers.

Information relating to Cropland Management, Grazing Land Management and Revegetation, if elected, for the base year
No further information is available.

Information relating to Forest Management
No further information is available.

16.11.9 Other information

Key category analysis for Article 3.3 activities and any elected activities under Article 3.4
According to the IPCC Good Practice Guidance for LULUCF a category that is identified as key in the UNFCCC inventory should also be considered key under the Kyoto Protocol (IPCC, 2003).

No LULUCF categories are reported as a key source. The total emission from the LULUCF sector is only 0.14 % of the total emission from Greenland.

16.11.10 Information relating to Article 6

There are no Article 6 projects (Joint Implementation) on the Greenlandic territory.

16.12 Annex 1 Key categories

A Key Category Analysis (KCA) for year 1990 and 2009 for Greenland has been carried out in accordance with the IPCC Good Practice Guidance. For 1990 a level KCA has been carried out.

The base year in the analysis is the year 1990 for the greenhouse gases CO_2, CH_4, N_2O and 1995 for the greenhouse F-gases HFC, PFC and SF_6. The KCA approach is a Tier 1 quantitative analysis.

The level assessment of the Tier 1 KCA is a ranking of the source categories in accordance to their relative contribution to the national total of greenhouse gases calculated in CO_2 equivalents. The level key categories are found from the list of source categories ranked according to their contribution in descending order. Level key categories are those from the top of the list and of which the sum constitutes 95 % of the national total.

The trend assessment of the Tier 1 KCA is a ranking of the source categories according to their contribution to the trend of the national total of greenhouse gases, calculated in CO_2 equivalents, from the base year to the year under consideration. The trend of the source category is calculated relative to that of the national totals and the trend is then weighted with the contribution, according to the level assessment. The ranking is in descending order. As for the level assessment, the cut-off point for the sum of contribution to the trend is 95 % and the source categories from the top of the list to the cut-off line are trend key categories.

16.12.1 The result of the Key Category Analysis for Greenland for the year 1990 and 2009

The entries in the results of KCA in Tables 16.12.1 to 16.12.3 for the years 1990 and 2009 are composed from CRFs for those years in this report. Note that base-year estimates are not used in the level assessment analysis for year 2009, but are only included in Table 16.12.2 to make it more uniform with Tables 16.12.1 and 16.12.3.

The result of the Tier 1 KCA level assessment for Greenland for 1990 is shown in Table 16.12.1. For the assessment, 5 categories were identified as key categories and marked as shaded, refer Table 16.12.1.

The result of the Tier 1 KCA level assessment for Greenland for 2009 is shown in Table 16.12.2. For the assessment, 6 categories were identified as key categories, refer Table 16.12.2.

The result of the Tier 1 KCA trend assessment for Greenland for 1990/1995-2009 is shown in Table 16.12.3. For the trend assessment, 10 categories were identified as key categories, refer Table 16.12.3. Note that according to the GPG, the analysis implies that contributions to the trend are all calculated as mathematically positive to be able to perform the ranking. The LULUCF activities are in the table included with there sign, i.e. emissions: +, removals: -.

In Table 16.12.4 a summary of Key Category Analysis for Greenland is given for level assessment for year 1990/95 and 2009 and for trend for years 1990-2009. All the categories are listed by sector and key sources are shown with their ranking.

Table 16.12.1 Key Category Analysis base year 1990/1995, level assessment, Tier 1.

Table 7.A1 (of Good Practice Guidance) Tier 1 Analysis - Level Assessment GRL – inventory						
A IPCC Source Categories (LULUCF included)			B Direct GHG	C Base Year Estimate Ex,o Gg CO_2-eq	D Base Year Level Assessment Lx,o	E Base Year Cumulative total of Col. D
Energy	Combustion excluding transport	Liquid fuels	CO_2	525.131	0.7961	0.7961
Energy	Civil aviation		CO_2	38.321	0.0581	0.8542
Energy	Road transportation		CO_2	36.564	0.0554	0.9096
Energy	Domestic navigation		CO_2	21.064	0.0319	0.9415
Waste	Wastewater handling		N_2O	15.187	0.0230	0.9645
Agriculture	Enteric fermentation		CH_4	6.018	0.0091	0.9737
Waste	Solid waste disposal on land		CH_4	3.640	0.0055	0.9792
Waste	Waste incineration		CO_2	2.552	0.0039	0.9831
Waste	Waste incineration		CH_4	2.263	0.0034	0.9865
Agriculture	Direct emissions from agricultural soils		N_2O	1.696	0.0026	0.9891
Energy	Combustion excluding transport		N_2O	1.392	0.0021	0.9912
Energy	Combustion excluding transport	Other fuels	CO_2	1.149	0.0017	0.9929
Waste	Waste incineration		N_2O	1.100	0.0017	0.9946
Energy	Combustion excluding transport		CH_4	0.951	0.0014	0.9960
Agriculture	Indirect emissions from agricultural soils		N_2O	0.697	0.0011	0.9971
Agriculture	Manure management		N_2O	0.641	0.0010	0.9980
Energy	Civil aviation		N_2O	0.336	0.0005	0.9986
Solvents and other product use	Solvents		CO_2	0.263	0.0004	0.9990
LULUCF	Grassland remaining grassland		CO_2	-0.246	0.0004	0.9993
Agriculture	Manure management		CH_4	0.140	0.0002	0.9995
Energy	Road transportation		N_2O	0.093	0.0001	0.9997
Energy	Road transportation		CH_4	0.064	0.0001	0.9998
Energy	Domestic navigation		N_2O	0.054	0.0001	0.9999
Industry	Consumption of SF6		SF_6	0.033	0.0000	0.9999
Energy	Domestic navigation		CH_4	0.030	0.0000	1.0000
Industry	Consumption of HFC's		HFCs	0.025	0.0000	1.0000
Energy	Civil aviation		CH_4	0.006	0.0000	1.0000
Industry	Road Paving with asphalt		CO_2	0.000	0.0000	1.0000
Industry	Asphalt roofing		CO_2	0.000	0.0000	1.0000
Industry	Limestone and dolomite use		CO_2	0.000	0.0000	1.0000
LULUCF	Forest land remaining forest		CO_2	0.000	0.0000	1.0000
LULUCF	Conversion to cropland		CO_2	0.000	0.0000	1.0000
Total				**659.16**	**1.0000**	

Table 16.12.2 Key Category Analysis year 2009, level assessment, Tier 1.

Table 7.A1 (of Good Practice Guidance) Tier 1 Analysis - Level Assessment GRL – inventory							
A			**B**	**C**	**D**	**E**	**F**
IPCC Source Categories (LULUCF included)			**Direct GHG**	**Base Year Estimate Ex,o Gg CO_2-eq**	**Year 2009 Estimate Ex,t Gg CO_2-eq**	**Year 2009 Level Assessment Lx,t**	**Year 2009 Cumulative total of Col. E**
Energy	Combustion excluding transport	Liquid fuels	CO_2	525.1306	480.3061	0.7568	0.7568
Energy	Civil aviation		CO_2	38.3214	45.2397	0.0713	0.8281
Energy	Road transportation		CO_2	36.5641	34.3728	0.0542	0.8823
Energy	Domestic navigation		CO_2	21.0639	25.7729	0.0406	0.9229
Waste	Wastewater handling		N_2O	15.1868	12.8704	0.0203	0.9431
Industry	Consumption of HFC’s		HFCs	0.0245	6.5679	0.0103	0.9535
Energy	Combustion excluding transport	Other fuels	CO_2	1.1492	5.6929	0.0090	0.9625
Agriculture	Enteric fermentation		CH_4	6.0175	5.3932	0.0085	0.9710
Waste	Solid waste disposal on land		CH_4	3.6402	3.9465	0.0062	0.9772
Agriculture	Direct emissions from agricultural soils		N_2O	1.6963	2.9623	0.0047	0.9819
Waste	Waste incineration		CO_2	2.5519	2.9353	0.0046	0.9865
Waste	Waste incineration		CH_4	2.2625	1.5763	0.0025	0.9890
Energy	Combustion excluding transport		N_2O	1.3922	1.4406	0.0023	0.9912
Agriculture	Indirect emissions from agricultural soils		N_2O	0.6968	1.0905	0.0017	0.9929
Energy	Combustion excluding transport		CH_4	0.9511	0.9620	0.0015	0.9945
LULUCF	Grassland remaining grassland		CO_2	-0.2464	-0.8742	0.0014	0.9958
Waste	Waste incineration		N_2O	1.0996	0.8001	0.0013	0.9971
Agriculture	Manure management		N_2O	0.6407	0.6475	0.0010	0.9981
Energy	Civil aviation		N_2O	0.3357	0.3964	0.0006	0.9987
Solvents and other product use	Solvents		CO_2	0.2634	0.3032	0.0005	0.9992
Agriculture	Manure management		CH_4	0.1403	0.1257	0.0002	0.9994
Energy	Road transportation		CH_4	0.0641	0.1157	0.0002	0.9996
Energy	Road transportation		N_2O	0.0932	0.0895	0.0001	0.9997
Energy	Domestic navigation		N_2O	0.0536	0.0666	0.0001	0.9999
Energy	Domestic navigation		CH_4	0.0302	0.0376	0.0001	0.9999
LULUCF	Forest land remaining forest		CO_2	0.0000	-0.0304	0.0000	1.0000
LULUCF	Conversion to cropland		CO_2	0.0000	0.0160	0.0000	1.0000
Energy	Civil aviation		CH_4	0.0057	0.0067	0.0000	1.0000
Industry	Consumption of SF6		SF_6	0.0329	0.0027	0.0000	1.0000
Industry	Road Paving with asphalt		CO_2	0.0001	0.0001	0.0000	1.0000
Industry	Asphalt roofing		CO_2	0.0000	0.0001	0.0000	1.0000
Industry	Limestone and dolomite use		CO_2	0.0000	0.0000	0.0000	1.0000
Total				**659.16**	**632.83**	**1.000**	

Table 16.12.3 Key Category Analysis years 1990/1995-2009, trend assessment, Tier 1.

Table 7.A1 (of Good Practice Guidance) Tier 1 Analysis - Trend Assessment GRL – inventory								
A			B	C	D	E	F	G
IPCC Source Categories (LULUCF included)			Direct GHG	Base Year Estimate Ex,o Gg CO_2-eq	Year 2009 Estimate Ex,t Gg CO_2-eq	Trend Assess-ment Tx,t	Contribution to Trend	Cumul. total of col. F
Energy	Combustion excluding transport	Liquid fuels	CO_2	525.1306	480.3061	0.0362	0.4225	0.4225
Energy	Civil aviation		CO_2	38.3214	45.2397	0.0128	0.1497	0.5722
Industry	Consumption of HFC's		HFCs	0.0245	6.5679	0.0099	0.1159	0.6882
Energy	Domestic navigation		CO_2	21.0639	25.7729	0.0084	0.0983	0.7865
Energy	Combustion excluding transport	Other fuels	CO_2	1.1492	5.6929	0.0070	0.0813	0.8678
Waste	Wastewater handling		N_2O	15.1868	12.8704	0.0026	0.0303	0.8981
Agriculture	Direct emissions from agricultural soils		N_2O	1.6963	2.9623	0.0020	0.0236	0.9218
Energy	Road transportation		CO_2	36.5641	34.3728	0.0011	0.0129	0.9347
LULUCF	Grassland remaining grassland		CO_2	-0.2464	-0.8742	0.0009	0.0109	0.9457
Waste	Waste incineration		CH_4	2.2625	1.5763	0.0009	0.0106	0.9562
Waste	Waste incineration		CO_2	2.5519	2.9353	0.0007	0.0086	0.9648
Waste	Solid waste disposal on land		CH_4	3.6402	3.9465	0.0007	0.0080	0.9728
Agriculture	Indirect emissions from agricultural soils		N_2O	0.6968	1.0905	0.0006	0.0075	0.9803
Agriculture	Enteric fermentation		CH_4	6.0175	5.3932	0.0006	0.0068	0.9871
Waste	Waste incineration		N_2O	1.0996	0.8001	0.0004	0.0045	0.9916
Energy	Combustion excluding transport		N_2O	1.3922	1.4406	0.0002	0.0018	0.9935
Energy	Civil aviation		N_2O	0.3357	0.3964	0.0001	0.0013	0.9948
Energy	Road transportation		CH_4	0.0641	0.1157	0.0001	0.0010	0.9957
Solvents and other product use	Solvents		CO_2	0.2634	0.3032	0.0001	0.0009	0.9966
Energy	Combustion excluding transport		CH_4	0.9511	0.9620	0.0001	0.0009	0.9975
Agriculture	Manure management		N_2O	0.6407	0.6475	0.0000	0.0006	0.9981
LULUCF	Forest land remaining forest		CO_2	0.0000	-0.0304	0.0000	0.0005	0.9986
Industry	Consumption of SF6		SF_6	0.0329	0.0027	0.0000	0.0005	0.9991
LULUCF	Conversion to cropland		CO_2	0.0000	0.0160	0.0000	0.0003	0.9994
Energy	Domestic navigation		N_2O	0.0536	0.0666	0.0000	0.0003	0.9997
Agriculture	Manure management		CH_4	0.1403	0.1257	0.0000	0.0002	0.9998
Energy	Domestic navigation		CH_4	0.0302	0.0376	0.0000	0.0002	1.0000
Energy	Civil aviation		CH_4	0.0057	0.0067	0.0000	0.0000	1.0000
Industry	Asphalt roofing		CO_2	0.0000	0.0001	0.0000	0.0000	1.0000
Energy	Road transportation		N_2O	0.0932	0.0895	0.0000	0.0000	1.0000
Industry	Limestone and dolomite use		CO_2	0.0000	0.0000	0.0000	0.0000	1.0000
Industry	Road Paving with asphalt		CO_2	0.0001	0.0001	0.0000	0.0000	1.0000
Total				**659.16**	**632.83**		**1.0000**	

Table 16.12.4 Summary of Key Category Analysis for Greenland for level assessment for year 1990/95 and 2009 and for trend for years 1990-2009.

Summary of Key Category analysis for Greenland						
IPCC Source Categories (LULUCF included)			**GHG**	**Key categories with number according to ranking in analysis** **Identification criteria**		
				Level Tier1 1990	**Level Tier1 2009**	**Trend Tier1 1990-2009**
Energy	Combustion excluding transport	Liquid fuels	CO_2	1	1	1
Energy	Combustion excluding transport	Other fuels	CO_2			5
Energy	Combustion excluding transport		CH_4			
Energy	Combustion excluding transport		N_2O			
Energy	Road transportation		CO_2	3	3	8
Energy	Road transportation		CH_4			
Energy	Road transportation		N_2O			
Energy	Civil aviation		CO_2	2	2	2
Energy	Civil aviation		CH_4			
Energy	Civil aviation		N_2O			
Energy	Domestic navigation		CO_2	4	4	4
Energy	Domestic navigation		CH_4			
Energy	Domestic navigation		N_2O			
Industry	Limestone and dolomite use		CO_2			
Industry	Asphalt roofing		CO_2			
Industry	Road Paving with asphalt		CO_2			
Industry	Consumption of HFC's		HFCs		6	3
Industry	Consumption of SF6		SF_6			
Solvents and other product use	Solvents		CO_2			
Agriculture	Enteric fermentation		CH_4			
Agriculture	Manure management		CH_4			
Agriculture	Manure management		N_2O			
Agriculture	Direct emissions from agricultural soils		N_2O			7
Agriculture	Indirect emissions from agricultural soils		N_2O			
Waste	Solid waste disposal on land		CH_4			
Waste	Wastewater handling		N_2O	5	5	6
Waste	Waste incineration		CO_2			
Waste	Waste incineration		CH_4			10
Waste	Waste incineration		N_2O			
LULUCF	Forest land remaining forest		CO_2			
LULUCF	Conversion to cropland		CO_2			
LULUCF	Grassland remaining grassland		CO_2			9

16.13 Annex 2 Detailed discussion of methodology and data for estimating CO_2 emission from fossil fuel combustion

Detailed information regarding the methodology and input data used to calculate CO_2 emissions from fossil fuel combustion is included in Section 16.3.

16.14 Annex 3 Other detailed methodological descriptions for individual source or sink categories

All methodological descriptions are included in Sections 16.3 – 16.8 and Section 16.11.

16.15 Annex 4 CO_2 reference approach and comparison with sectoral approach, and relevant information on the national energy balance

See Section 16.3.5.1 of this annex for the results of the comparison between the sectoral and reference approach.

16.16 Annex 5 Assessment of completeness and (potential) sources and sinks of greenhouse gas emissions and removals excluded

GHG inventory

The Greenlandic greenhouse gas emission inventories for 1990-2009 include all sources identified by the Revised 1996 IPCC Guidelines and the 2000 IPCC Good Practice Guidance except the following:

In the Solvent and other product use sector currently no N_2O emissions are included in CRF category 3D, Greenland will try to obtain activity data if they exist for uses of N_2O.

Direct and indirect CH_4 emissions from agricultural soils are not estimated. Direct and indirect soil emissions are considered of minor importance for CH_4. No methodology is recommended in IPCC-GPG.

In the LULUCF sector emissions/removals from wetlands, settlements and other land are currently not estimated due to the lack of available data. The lack of data availability is also an issue for other aspects of LULUCF, e.g. harvested wood products. For more detail please see Section 16. 7.

In the Waste sector CO_2 emissions from managed waste disposal on land are not estimated. According to the 1996 IPCC Guidelines: "Decomposition of organic material derived from biomass sources (e.g., crops, forests), which are re-grown on an annual basis is the primary source of CO_2 released from waste. Hence, these CO_2 emissions are not treated as net emissions from waste in the IPCC Methodology."

KP-LULUCF inventory

The KP-LULUCF inventory is considered complete. The carbon pools not estimated has been documented as not being sources, please see Section 16.11 for further documentation.

16.17 Annex 6 Additional information to be considered as part of the annual inventory submission and the supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol or other useful reference information

No additional information for Greenland is deemed relevant.

IPCC Source category	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncer-tainty	Combined uncertainty	Combined uncer-tainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emis-sion factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncer-tainty introduced into the trend in total national emissions
		Input data Gg CO_2 eq	Input data Gg CO_2 eq	Input data %	Input data %	%	%	%	%	%	%	%
1A, Liquid fuels	CO_2	621	586	2	5	5.385	4.984	-0.016	0.889	-0.079	2.513	2.514
1A, Municipal waste	CO_2	1	6	2	25	25.080	0.226	0.007	0.009	0.174	0.024	0.176
1A, Liquid fuels	CH_4	1	1	2	100	100.020	0.160	0.000	0.002	0.005	0.004	0.006
1A, Municipal waste	CH_4	0	0	2	100	100.020	0.007	0.000	0.000	0.006	0.000	0.006
1A, Biomass	CH_4	0	0	2	100	100.020	0.010	0.000	0.000	0.007	0.000	0.007
1A, Liquid fuels	N_2O	2	2	2	500	500.004	1.403	0.000	0.003	0.023	0.008	0.024
1A, Municipal waste	N_2O	0	0	2	500	500.004	0.071	0.000	0.000	0.055	0.000	0.055
1A, Biomass	N_2O	0	0	2	200	200.010	0.040	0.000	0.000	0.028	0.001	0.028
2A3 Limestone and dolomite use	CO_2	0	0	5	5	7.071	0.000	0.000	0.000	0.000	0.000	0.000
2A5 Asphalt roofing	CO_2	0	0	5	25	25.495	0.000	0.000	0.000	0.000	0.000	0.000
2A6 Road paving with asphalt	CO_2	0	0	5	25	25.495	0.000	0.000	0.000	0.000	0.000	0.000
2F Consumption of HFC	HFC	0	7	10	50	50.990	0.529	0.010	0.010	0.496	0.141	0.516
2F Consumption of SF_6	SF_6	0	0	10	50	50.990	0.000	0.000	0.000	-0.002	0.000	0.002
3A Paint application	CO_2	0	0	10	15	18.028	0.000	0.000	0.000	0.000	0.000	0.000
3B Degreasing and dry cleaning	CO_2	0	0	10	15	18.028	0.000	0.000	0.000	0.000	0.000	0.000
3C Chemical products, manufacturing and processing	CO_2	0	0	10	15	18.028	0.000	0.000	0.000	0.000	0.000	0.000
3D5 Other	CO_2	0	0	10	20	22.361	0.010	0.000	0.000	0.002	0.006	0.007
4A Enteric Fermentation	CH_4	6	5	10	100	100.499	0.856	-0.001	0.008	-0.058	0.116	0.130
4B Manure Management	CH_4	0	0	10	100	100.499	0.020	0.000	0.000	-0.001	0.003	0.003
4.B Manure Management	N_2O	1	1	10	100	100.499	0.103	0.000	0.001	0.005	0.014	0.015
4D1 Direct N_2O emissions from agricultural soils	N_2O	1	2	20	50	53.852	0.197	0.002	0.004	0.110	0.099	0.148

Continued												
IPCC Source category	Gas	Base year emission	Year t emission	Activity data uncer-tainty	Emission factor uncer-tainty	Combined uncertainty	Combined uncer-tainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emis-sion factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncer-tainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		Gg CO_2 eq	Gg CO_2 eq	%	%	%	%	%	%	%	%	%
4D2 Pasture range and paddock	N_2O	1	1	20	25	32.016	0.033	0.000	0.001	-0.005	0.028	0.028
4D3 Indirect N_2O emissions from agricultural soils (Atmospheric deposition)	N_2O	1	1	20	50	53.852	0.093	0.001	0.002	0.032	0.047	0.057
5A Forest	CO_2	0	0	5	50	50.249	-0.002	0.000	0.000	-0.002	0.000	0.002
5B Cropland	CO_2	0	0	5	50	50.249	0.001	0.000	0.000	0.001	0.000	0.001
5.C Grassland	CO_2	0	-1	5	50	50.249	-0.069	-0.001	-0.001	-0.048	-0.009	0.049
6A Solid Waste Disposal on Land	CH_4	4	4	10	100	100.499	0.627	0.001	0.006	0.069	0.085	0.109
6B Wastewater Handling	N_2O	15	13	30	100	104.403	2.123	-0.003	0.020	-0.259	0.828	0.868
6C Waste incineration	CO_2	3	3	10	25	26.926	0.125	0.001	0.004	0.018	0.063	0.066
6C Waste incineration	CH_4	2	2	10	50	50.990	0.127	-0.001	0.002	-0.045	0.034	0.056
6C Waste incineration	N_2O	1	1	10	100	100.499	0.127	0.000	0.001	-0.039	0.017	0.042
Total		659	633				32,919					7,444
Total uncertainties				Overall uncertainty in the year (%):			5.738		Trend uncertainty (%):			2.728

17 Information regarding the aggregated submission for Denmark and Greenland

This chapter contains information on the aggregated submission for Denmark and Greenland submitted under the Kyoto Protocol. This chapter contains a trend discussion, a tier 1 uncertainty analysis, information on the aggregated reference approach, information relating to key categories and information on recalculations. Sector specific information is included for Denmark in Chapter 3-11 and for Greenland in Chapter 16.

The institutional arrangements and the overall QA/QC plan are described in Chapter 1. This description covers all the Danish submissions to the European Union, the UNFCCC and the Kyoto Protocol, and therefore information regarding the national system is not presented in this chapter. Information on the specific QA/QC activities concerning the aggregated submission is presented in Chapter 17.7.

In Chapter 17.6 a description of the aggregation process is provided. The chapter explains the technical issues in aggregating two CRF submissions, including the software used in process and the handling of background data.

17.1 Trends in emissions

Due to the small emission originating from Greenland the trends for Denmark and Greenland are practically identical to the trends for Denmark presented in Chapter 2.

17.1.1 Greenhouse Gas Emissions

The greenhouse gas emissions are estimated according to the IPCC guidelines and are aggregated into seven main sectors. The greenhouse gases include CO_2, CH_4, N_2O, HFCs, PFCs and SF_6. Figure 1 shows the estimated total greenhouse gas emissions in CO_2 equivalents from 1990 to 2009. The emissions are not corrected for electricity trade or temperature variations. CO_2 is the most important greenhouse gas contributing in 2009 to the national total in CO_2 equivalents excluding LULUCF (Land Use and Land Use Change and Forestry) with 79.3 % followed by N_2O with 9.8 %, CH_4 9.4 % and F-gases (HFCs, PFCs and SF_6) with 1.4 %. Seen over the time-series from 1990 to 2009 these percentages have been increasing for F-gases, almost constant for CO_2 and CH_4 and falling for N_2O. Stationary combustion plants, transport and agriculture represent the largest categories, followed by industrial processes, waste and solvents, see Figure 1. The net CO_2 emission by LULUCF in 2009 is 1.8 % of the total emission in CO_2 equivalents excl. LULUCF. The national total greenhouse gas emission in CO_2 equivalents excluding LULUCF has decreased by 10.3 % from 1990 to 2009 and decreased 15.8 % including LULUCF. Comments on the overall trends etc seen in Figure 17.1 are given in he sections below on the individual greenhouse gases.

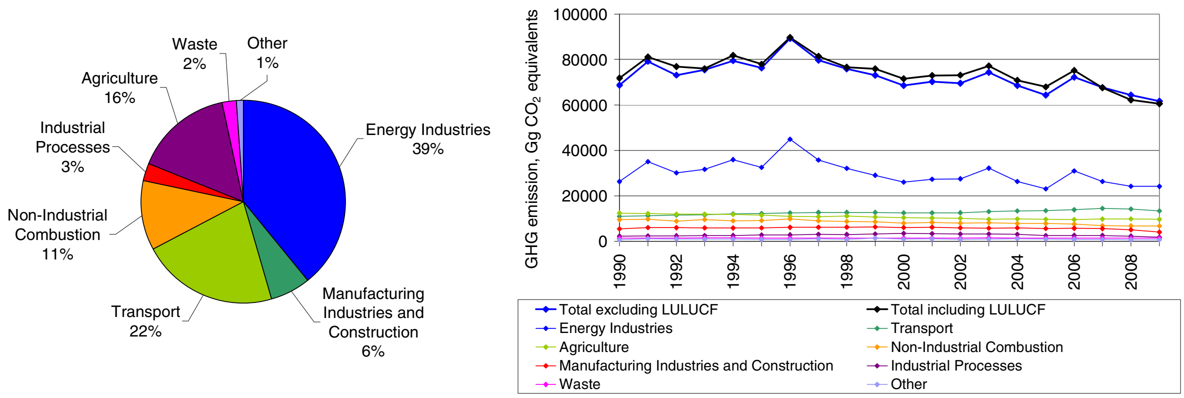


Figure 17.1 Greenhouse gas emissions in CO_2 equivalents distributed on main sectors for 2009 (excluding LULUCF) and time-series for 1990 to 2009 (including LULUCF).

17.1.2 Carbon dioxide

The largest source to the emission of CO_2 is the energy sector, which includes combustion of fossil fuels like oil, coal and natural gas (Figure 17.2). Energy Industries contribute with 49 % of the emissions (excl. LULUCF). About 27 % come from the transport sector. The main reason for the fluctuations during the time series is the variations in electricity import/export. The CO_2 emission (excl. LULUCF) decreased by 5 % from 2008 to 2009. The main reason for this decrease was the economic recession. In 2009, the CO_2 emission (excl. LULUCF) was 8 % lower than the emission in 1990.

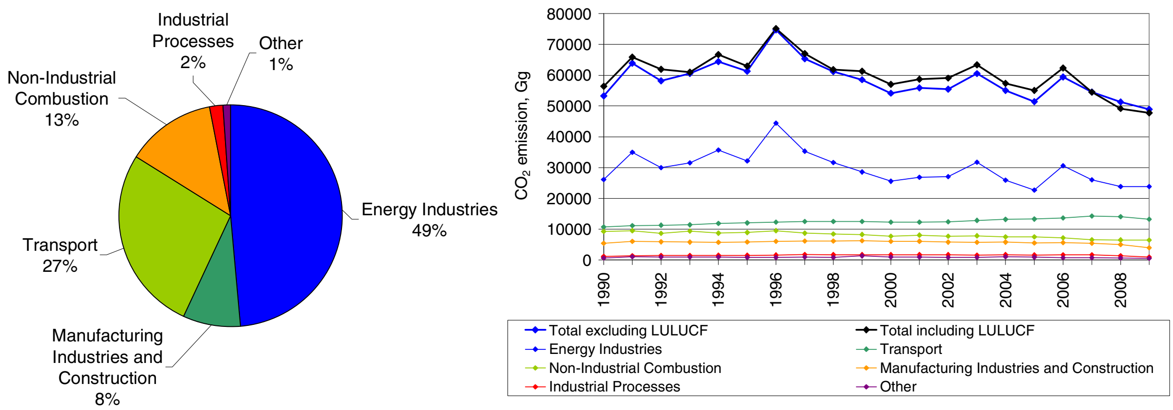


Figure 17.2 CO_2 emissions. Distribution according to the main sectors (2009) and time-series for 1990 to 2009.

17.1.3 Nitrous oxide

Agriculture is the most important N_2O emission source in 2009 contributing 91 % (Figure 17.3) of which N_2O from agricultural soils accounts for 84 %. N_2O is emitted as a result of microbial processes in the soil. Substantial emissions also come from drainage water and coastal waters where nitrogen is converted to N_2O through bacterial processes. However, the nitrogen converted in these processes originates mainly from the agricultural use of manure and nitrogen fertilisers. The main reason for the drop in the emissions of N_2O in the agricultural sector of 32 % from 1990 to 2009 is legislation to improve the utilisation of nitrogen in manure. The legislation has resulted in less nitrogen excreted pr unit of livestock produced and a considerable reduction in the use of nitrogen fertilisers. The basis for the N_2O emission is then reduced. Combustion of fossil fuels in the energy sector, both stationary and mobile sources, contributes 6.2 %. The N_2O emission from transport contributes by 2.2 % in 2009. This emission has increased during the nineties because of the increase in the use of catalyst cars. Production of nitric acid stopped in 2004 and the emissions from industrial processes is therefore not occurring from 2005 onwards. The sector Solvent and Other Product Use covers N_2O from e.g. anaesthesia.

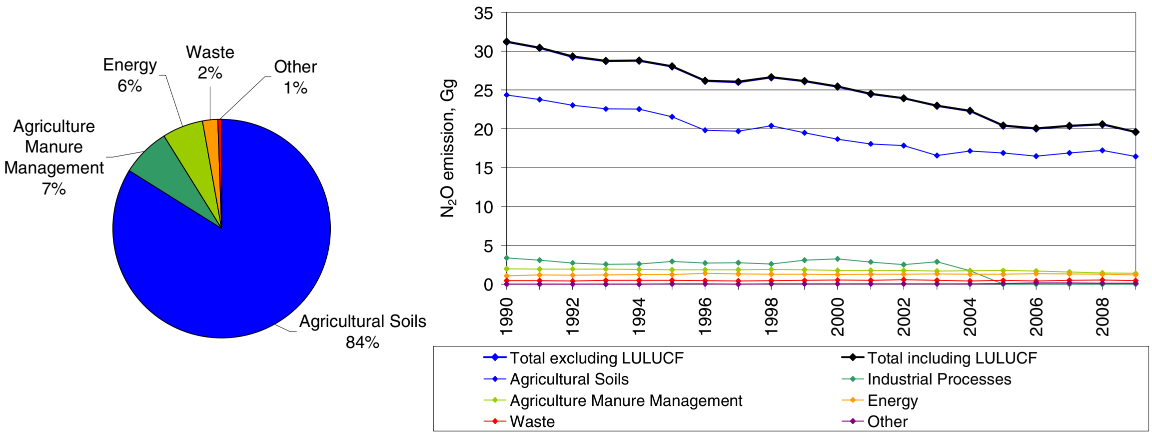


Figure 17.3 N_2O emissions. Distribution according to the main sectors (2009) and time-series for 1990 to 2009.

17.1.4 Methane

The largest sources of anthropogenic CH_4 emissions are agricultural activities contributing in 2009 with 70.3 %, waste (20.6 %), public power and district heating plants (3.2 %), see Figure 17.4. The emission from agriculture derives from enteric fermentation and management of animal manure contributing with 49.2 % and 21.1 % of the national CH_4 emission in 2009. The CH_4 emission from public power and district heating plants increased in the nineties, mainly 1992-1996, due to the increasing use of gas engines in the decentralised cogeneration plant sector. Up to 3 % of the natural gas in the gas engines is not combusted. The deregulation of the electricity market has made production of electricity in gas engines less favourable, therefore the fuel consumption has decreased and hence the CH_4 emission has decreased. Over the time-series from 1990 to 2009, the emission of CH_4 from enteric fermentation has decreased 12.0 % due to the decrease in the number of cattle. However, the emission from manure management has in the same period increased 25.8 % due to a change in traditional stable systems towards an increase in slurry-based stable systems. Altogether, the emission of CH_4 from the agriculture sector has decreased by 3.3 % from 1990 to 2009. The emission of CH_4 from waste has decreased 1.0 % since 1990 due to an increase in the incineration of waste.

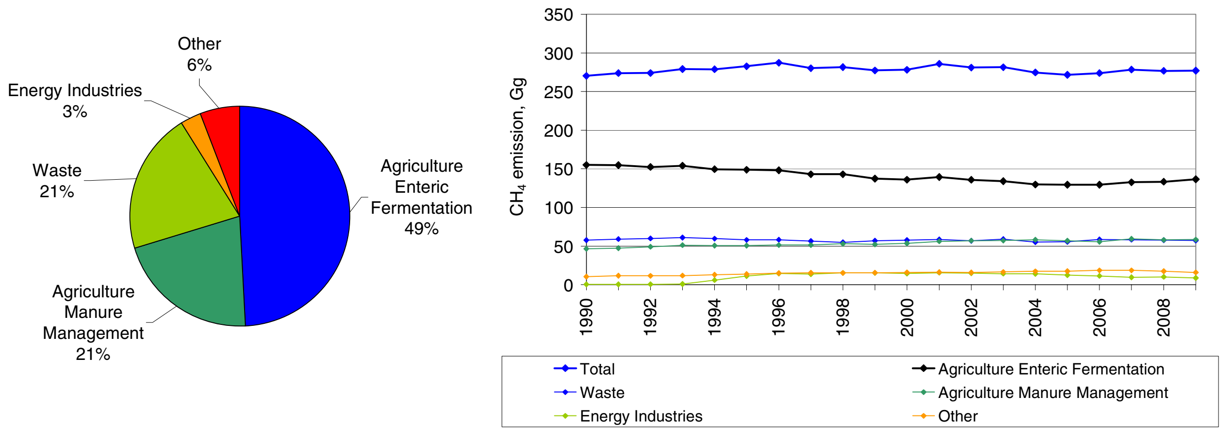


Figure 17.4 CH_4 emissions. Distribution according to the main sectors (2009) and time-series for 1990 to 2009.

17.1.5 HFCs, PFCs and SF_6

This part of the Danish KP inventory only comprises a full data set for all substances from 1995. From 1995 to 2000, there has been a continuous and substantial increase in the contribution from the range of F-gases as a whole, calculated as the sum of emissions in CO_2 equivalents, see Figure 17.5. This increase is simultaneous with the increase in the emission of HFCs. For the time-series 2000-2009, the increase is lower than for the years 1995 to 2000. The increase from 1995 to 2009 for the total F-gas emission is 163 %. SF_6 contributed considerably to the F-gas sum in earlier years, with 33 % in 1995. Environmental awareness and regulation of this gas under Danish law has reduced its use in industry, see Figure 5. A further result is that the contribution of SF_6 to F-gases in 2009 was only 4.3 %. The use of HFCs has increased several folds. HFCs have, therefore, become the even more dominant F-gases, comprising 66.9 % in 1995, but 94.1 % in 2009. HFCs are mainly used as a refrigerant. Danish legislation regulates the use of F-gases, e.g. since January 1, 2007 new HFC-based refrigerant stationary systems are forbidden. Refill of old systems are still allowed. The use of air conditioning in mobile systems and the amount of HFC for this purpose increases.

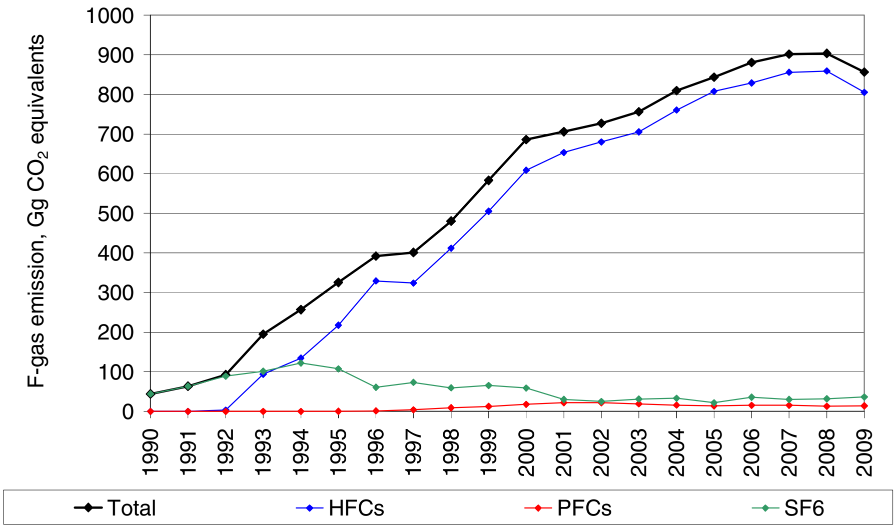


Figure 17.5 F-gas emissions. Time-series for 1990 to 2009.

17.2 The reference approach

In addition to the sector-specific CO_2 emission inventories (the national approach), the CO_2 emission is also estimated using the reference approach described in the IPCC Reference Manual (IPCC, 1997). The reference approach is based on data for fuel production, import, export and stock change. The CO_2 emission inventory based on the reference approach is reported to the Climate Convention and used for verification of the official data in the national approach.

The reference approach for Denmark and Greenland is an aggregation of the individual reference approaches for the two. The reference approach for Denmark is described in Chapter 3.4 and the reference approach for Greenland is included in Annex 9.

In 2009 the fuel consumption rates in the two approaches differ by -1.9 % and the CO_2 emission differs by -1.25 %. In the period 1990-2009 both the fuel consumption and the CO_2 emission differ by less than 2.0%. The differences are below 1 % for all years except 1998 and 2009. This is almost identical to the reference approach for Denmark, due to the very small emission from Greenland compared to Denmark. According to IPCC Good Practice Guidance (IPCC 2000) the difference should be within 2 %. A comparison of the national approach and the reference approach is illustrated in Figure 17.6. The relatively high difference in 2009 is a result of an increased statistical difference in the Danish energy statistics in 2009, see Chapter 3.4.

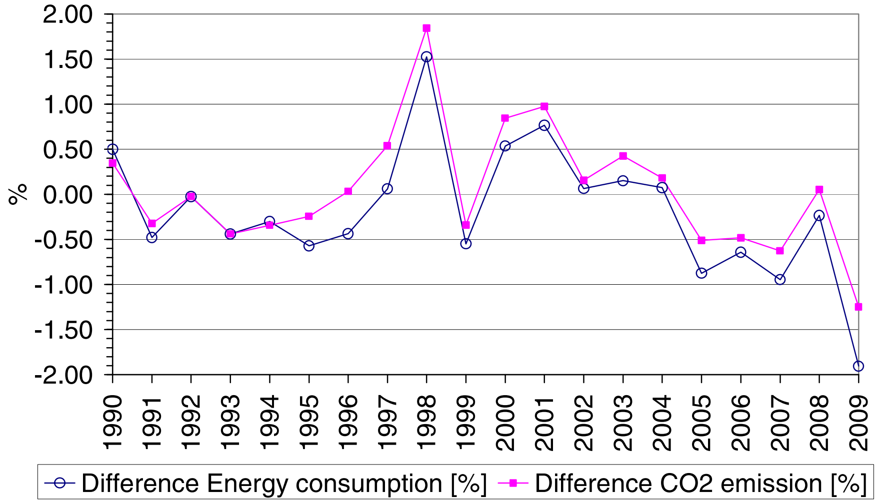


Figure 17.6 Comparison of the reference approach and the national approach.

17.3 Uncertainties

An uncertainty estimate has been calculated for Denmark and Greenland. The uncertainty estimate for Denmark is included in Chapter 1.7 and for Greenland in Chapter 16.

The uncertainty estimates are based on the Tier 1 methodology in the IPCC Good Practice Guidance (GPG) (IPCC, 2000). Uncertainty estimates cover 100 % of the total net greenhouse gas emissions and removals. The emissions from Greenland have been treated separately due to the uncertainties being different than the uncertainties in the Danish inventory. The uncertainty of the Greenlandic emissions has almost no effect on the overall uncertainty estimate, due to the low emissions originating from Greenland.

The estimated uncertainties for total GHG and for CO_2, CH_4, N_2O and F-gases are shown in Table 17.1. The base year for F-gases is 1995 and for all other sources the base year is 1990. The total net GHG emission from Denmark and Greenland is estimated with an uncertainty of ±5.6 % and the trend in net GHG emission since 1990/1995 has been estimated to be -16.1 % ± 3.0 %-age points. The GHG uncertainty estimates do not take into account the uncertainty of the GWP factors.

The uncertainty on N_2O from leaching, CH_4 emission from solid waste disposal on land, N_2O from synthetic fertilizer, N_2O from animal waste applied to soils and CO_2 from cropland, organic soil are the largest sources of uncertainty for the aggregated greenhouse gas inventory for Greenland and Denmark.

Table 17.1 Uncertainties 1990-2009.

	Uncertainty [%]	Trend [%]	Uncertainty in trend [%-age points]
GHG	5.6	-16.1	3.0
CO_2	3.7	-15.4	2.7
CH_4	24.0	2.5	4.8
N_2O	41	-37	12
F-gases	48	163	62

The uncertainties for the activity rates and emission factors are shown in Table 17.2.

Table 17.2 Uncertainties 2009 for activity rates and emission factors.

	IPCC Source category	GHG	Base year emission Input data Gg CO_2 eq	Year t emission Input data Gg CO_2 eq	Activity data uncertainty Input data %	Emission factor uncertainty Input data %
Denmark	Stationary Combustion, Coal	CO_2	23833.91	15726.15	0.9	1.1
Denmark	Stationary Combustion, BKB	CO_2	10.97	1.11	3.0	5.0
Denmark	Stationary Combustion, Coke	CO_2	137.80	81.21	2.0	5.0
Denmark	Stationary Combustion, Fosssil waste	CO_2	393.68	1265.86	4.8	25.0
Denmark	Stationary Combustion, Petroleum coke	CO_2	410.28	549.83	2.0	5.0
Denmark	Stationary Combustion, Residual oil	CO_2	2439.57	1077.40	0.9	2.0
Denmark	Stationary Combustion, Gas oil	CO_2	4546.79	1792.28	2.5	4.0
Denmark	Stationary Combustion, Kerosene	CO_2	365.68	7.86	2.6	5.0
Denmark	Stationary Combustion, LPG	CO_2	163.82	87.58	2.2	5.0
Denmark	Stationary Combustion, Refinery gas	CO_2	816.13	876.03	1.0	2.0
Denmark	Stationary Combustion, Natural gas	CO_2	4335.23	9379.80	1.0	0.4
Denmark	Stationary Combustion, SOLID	CH_4	12.88	4.26	1.0	100.0
Denmark	Stationary Combustion, LIQUID	CH_4	2.81	1.30	1.1	100.0
Denmark	Stationary Combustion, GAS	CH_4	3.13	5.95	1.0	100.0
Denmark	Natural gas fuelled engines, GAS	CH_4	0.53	191.56	1.0	2.0
Denmark	Stationary Combustion, WASTE	CH_4	1.39	1.39	5.0	100.0
Denmark	Stationary Combustion, BIOMASS	CH_4	105.43	147.71	19.8	100.0
Denmark	Biogas fuelled engines, BIOMASS	CH_4	0.00	27.99	3.7	10.0
Denmark	Stationary Combustion, SOLID	N_2O	68.11	42.76	1.0	400.0
Denmark	Stationary Combustion, LIQUID	N_2O	40.26	15.77	1.1	1000.0
Denmark	Stationary Combustion, GAS	N_2O	16.18	40.74	1.0	750.0
Denmark	Stationary Combustion, WASTE	N_2O	7.44	15.93	5.0	400.0
Denmark	Stationary Combustion, BIOMASS	N_2O	37.79	80.71	2.2	1000.0
Denmark	Transport, Road transport	CO_2	9282.09	12125.23	2.0	5.0
Denmark	Transport, Military	CO_2	119.01	159.99	2.0	5.0
Denmark	Transport, Railways	CO_2	296.75	230.20	2.0	5.0
Denmark	Transport, Navigation (small boats)	CO_2	47.92	99.92	41.0	5.0
Denmark	Transport, Navigation (large vessels)	CO_2	747.83	497.86	11.0	5.0
Denmark	Transport, Fisheries	CO_2	590.68	557.02	2.0	5.0
Denmark	Transport, Agriculture	CO_2	1272.47	1268.36	24.0	5.0
Denmark	Transport, Forestry	CO_2	35.68	17.08	30.0	5.0
Denmark	Transport, Industry (mobile)	CO_2	841.53	822.74	41.0	5.0
Denmark	Transport, Residential	CO_2	39.06	62.96	35.0	5.0
Denmark	Transport, Commercial/institutional	CO_2	73.72	174.36	35.0	5.0
Denmark	Transport, Civil aviation	CO_2	242.69	155.53	10.0	5.0
Denmark	Transport, Road transport	CH_4	52.56	14.94	2.0	40.0
Denmark	Transport, Military	CH_4	0.11	0.11	2.0	100.0
Denmark	Transport, Railways	CH_4	0.26	0.14	2.0	100.0
Denmark	Transport, Navigation (small boats)	CH_4	0.35	0.51	41.0	100.0
Denmark	Transport, Navigation (large vessels)	CH_4	0.33	0.23	11.0	100.0
Denmark	Transport, Fisheries	CH_4	0.27	0.28	2.0	100.0
Denmark	Transport, Agriculture	CH_4	2.20	2.04	24.0	100.0
Denmark	Transport, Forestry	CH_4	0.44	0.08	30.0	100.0
Denmark	Transport, Industry (mobile)	CH_4	1.25	0.63	41.0	100.0
Denmark	Transport, Residential	CH_4	1.07	1.38	35.0	100.0
Denmark	Transport, Commercial/institutional	CH_4	2.08	3.51	35.0	100.0
Denmark	Transport, Civil aviation	CH_4	0.15	0.20	10.0	100.0
Denmark	Transport, Road transport	N_2O	93.48	119.12	2.0	50.0
Denmark	Transport, Military	N_2O	1.15	1.71	2.0	1000.0
Denmark	Transport, Railways	N_2O	2.54	1.97	2.0	1000.0
Denmark	Transport, Navigation (small boats)	N_2O	0.39	1.08	41.0	1000.0
Denmark	Transport, Navigation (large vessels)	N_2O	14.60	9.74	11.0	1000.0
Denmark	Transport, Fisheries	N_2O	11.50	10.91	2.0	1000.0

Continued						
Denmark	Transport, Agriculture	N_2O	15.27	16.62	24.0	1000.0
Denmark	Transport, Forestry	N_2O	0.17	0.17	30.0	1000.0
Denmark	Transport, Industry (mobile)	N_2O	10.62	10.80	41.0	1000.0
Denmark	Transport, Residential	N_2O	0.19	0.33	35.0	1000.0
Denmark	Transport, Commercial/institutional	N_2O	0.34	0.82	35.0	1000.0
Denmark	Transport, Civil aviation	N_2O	3.19	2.51	10.0	1000.0
Denmark	1.B.2. Flaring in refinery	CO_2	23.72	16.87	11.0	5.0
Denmark	1.B.2. Flaring off-shore	CO_2	276.17	240.82	7.5	5.0
Denmark	1.B.2. Flaring in refinery	CH_4	1.32	0.11	11.0	15.0
Denmark	1.B.2. Flaring off-shore	CH_4	0.48	1.13	7.5	5.0
Denmark	1.B.2. Refinery processes	CH_4	0.78	44.88	1.0	125.0
Denmark	1.B.2. Land based activities	CH_4	17.16	29.11	2.0	40.0
Denmark	1.B.2. Off-shore activities	CH_4	14.87	37.28	2.0	30.0
Denmark	1.B.2. Transmission of natural gas	CH_4	3.57	0.19	15.0	5.0
Denmark	1.B.2. Distribution of natural gas	CH_4	5.33	2.83	25.0	10.0
Denmark	1.B.2 Venting in gas storage	CH_4	0.00	1.11	15.0	5.0
Denmark	1.B.2. Flaring in refinery	N_2O	0.13	0.04	11.0	500.0
Denmark	1.B.2. Flaring off-shore	N_2O	0.70	0.56	7.5	500.0
Denmark	2.A.1 Cement production	CO_2	882.40	764.41	1.0	2.0
Denmark	2.A.2 Lime production	CO_2	115.53	43.25	5.0	5.0
Denmark	2.A.3 Limestone and dolomite use	CO_2	13.69	37.92	5.0	5.0
Denmark	2.A.5 Asphalt roofing	CO_2	0.02	0.02	5.0	25.0
Denmark	2.A.6 Road paving with asphalt	CO_2	1.76	1.64	5.0	25.0
Denmark	2.A.7 Glass and Glass wool	CO_2	55.35	33.71	5.0	2.0
Denmark	2.B.5 Catalysts/Fertilizers, Pesticides and Sulphuric acid	CO_2	0.80	2.13	5.0	5.0
Denmark	2.C.1 Iron and steel production	CO_2	28.45	0.00	5.0	5.0
Denmark	2.D.2 Food and Drink	CO_2	4.45	1.92	5.0	5.0
Denmark	2.G Lubricants	CO_2	49.71	31.19	2.0	5.0
Denmark	2.B.2 Nitric acid production	N_2O	1042.90	0.00	2.0	25.0
Denmark	2.F Consumption of HFC	HFC	217.73	798.84	10.0	50.0
Denmark	2.F Consumption of PFC	PFC	0.50	14.18	10.0	50.0
Denmark	2.F Consumption of SF6	SF6	107.34	36.69	10.0	50.0
Denmark	3.A Paint application	CO_2	26.32	8.64	10.0	15.0
Denmark	3.B Degreasing and dry cleaning	CO_2	0.00	0.00	10.0	15.0
Denmark	3.C Chemical products, manufacturing and processing	CO_2	23.07	12.22	10.0	15.0
Denmark	3.D.5 Other	CO_2	85.71	43.54	10.0	20.0
Denmark	3.D.5 Consumption of fireworks	CO_2	0.06	0.23	8.0	300.0
Denmark	3.D.5 Consumption of fireworks	CH_4	0.00	0.00	8.0	300.0
Denmark	3.D.1 Other - Use of N2O for Anaesthesia	N_2O	0.00	33.78	5.0	5.0
Denmark	3.D.5 Consumption of fireworks	N_2O	0.77	3.23	8.0	300.0
Denmark	4.A Enteric Fermentation	CH_4	3248.56	2858.91	2.0	20.0
Denmark	4.B Manure Management	CH_4	975.97	1227.92	5.0	20.0
Denmark	4.F Field burning af agricultural residues	CH_4	1.82	2.87	25.0	50.0
Denmark	4.B Manure Management	N_2O	604.10	426.39	22.4	50.0
Denmark	4.D1.1 Syntehetic Fertilizer	N_2O	2394.60	1195.87	25.2	100.0
Denmark	4.D1.2 Animal waste applied to soils	N_2O	1096.62	1163.42	30.0	100.0
Denmark	4.D1.3 N-fixing crops	N_2O	269.47	247.65	20.0	100.0
Denmark	4.D1.4 Crop Residue	N_2O	361.22	311.86	20.0	100.0
Denmark	4.D1.5 Cultivation of histosols	N_2O	171.36	163.50	20.0	100.0
Denmark	4.D.2 Grassing animals	N_2O	310.98	212.87	25.5	100.0
Denmark	4.D3 Atmospheric deposition	N_2O	465.29	296.20	18.7	100.0
Denmark	4.D3 Leaching	N_2O	2455.16	1415.80	20.0	100.0
Denmark	4.D1.6 Sewage sludge and Industrial waste used as fertiliser	N_2O	27.92	81.17	20.0	100.0
Denmark	4.F Field Burning of Agricultural Residues	N_2O	0.70	1.10	25.0	50.0
Denmark	5.A.1 Broadleaves	CO_2	-659.04	-1011.76	15.0	50.0
Denmark	5.A.1 Conifers	CO_2	-65.88	-1579.38	15.0	50.0
Denmark	5.A.2 Broadleaves	CO_2	3.40	-78.38	15.0	50.0
Denmark	5.A.2 Conifers	CO_2	7.11	-66.93	15.0	50.0
Denmark	5IID Forest Land.	N_2O	15.66	12.04	30.0	75.0
Denmark	5.B Cropland, Living biomass	CO_2	174.01	75.73	10.0	50.0
Denmark	5.B Cropland, Dead organic matter	CO_2	6.03	1.31	10.0	50.0
Denmark	5.B Cropland, Mineral soils	CO_2	1053.63	-198.01	10.0	75.0
Denmark	5.B Cropland, Organic soils	CO_2	1343.27	1281.69	10.0	90.0
Denmark	5.B Disturbance, Land converted to cropland	N_2O	3.19	0.41	50.0	75.0
Denmark	5.C Grassland, Living biomass	CO_2	304.44	34.89	10.0	50.0
Denmark	5.C Grassland, Dead organic matter	CO_2	31.71	2.61	10.0	50.0
Denmark	5.C Grassland, Mineral soils	CO_2	1.04	24.40	10.0	75.0
Denmark	5.C Grassland, Organic soils	CO_2	137.11	137.25	10.0	90.0
Denmark	5.D Wetlands, Living biomass	CO_2	0.37	-11.33	10.0	50.0
Denmark	5.D Wetlands, Dead organic matter	CO_2	0.09	0.11	10.0	100.0
Denmark	5.D Wetlands, Soils	CO_2	86.08	16.20	10.0	100.0
Denmark	5IID Wetlands. Peatland	N_2O	0.13	0.13	10.0	100.0
Denmark	5.E Settlements, Living biomass	CO_2	89.50	54.75	10.0	50.0
Denmark	5IV Cropland Limestone	CO_2	622.92	186.24	0.0	0.0

Continued						
Denmark	6 A. Solid Waste Disposal on Land	CH_4	1110.84	1039.30	10.0	117.9
Denmark	6 B. Wastewater Handling	CH_4	66.24	74.68	44.0	78.0
Denmark	5 B. Wastewater Handling - Direct	N_2O	27.24	47.36	37.0	98.0
Denmark	6 B. Wastewater Handling - Indirect	N_2O	82.25	33.51	59.0	39.0
Denmark	6.D Accidental fires, buildings	CO_2	15.37	17.62	10.0	500.0
Denmark	6.D Accidental fires, vehicles	CO_2	6.65	10.04	10.0	500.0
Denmark	6.C Incineration of corpses	CH_4	0.01	0.01	1.0	150.0
Denmark	6.C Incineration of carcasses	CH_4	0.00	0.01	40.0	150.0
Denmark	6.D Compost production	CH_4	26.65	77.69	40.0	100.0
Denmark	6.D Accidental fires, buildings	CH_4	2.47	2.84	10.0	700.0
Denmark	6.D Accidental fires, vehicles	CH_4	0.29	0.44	10.0	700.0
Denmark	6.C Incineration of corpses	N_2O	0.19	0.19	1.0	150.0
Denmark	6.C Incineration of carcasses	N_2O	0.01	0.09	40.0	150.0
Denmark	6.D Compost production	N_2O	11.21	40.49	40.0	100.0
Denmark	6.D Accidental fires, buildings	N_2O	0.00	0.00	0.0	0.0
Denmark	6.D Accidental fires, vehicles	N_2O	0.00	0.00	0.0	0.0
Greenland	1A, Liquid fuels, Greenland	CO_2	621.08	585.69	2.0	5.0
Greenland	1A, Municipal waste, Greenland	CO_2	1.15	5.69	2.0	25.0
Greenland	1A, Liquid fuels, Greenland	CH_4	1.02	1.01	2.0	100.0
Greenland	1A, Municipal waste, Greenland	CH_4	0.01	0.05	2.0	100.0
Greenland	1A, Biomass, Greenland	CH_4	0.02	0.06	2.0	100.0
Greenland	1A, Liquid fuels, Greenland	N_2O	1.82	1.78	2.0	500.0
Greenland	1A, Municipal waste, Greenland	N_2O	0.02	0.09	2.0	500.0
Greenland	1A, Biomass, Greenland	N_2O	0.04	0.13	2.0	200.0
Greenland	2A3 Limestone and dolomite use, Greenland	CO_2	0.00	0.00	5.0	5.0
Greenland	2A5 Asphalt roofing, Greenland	CO_2	0.00	0.00	5.0	25.0
Greenland	2A6 Road paving with asphalt, Greenland	CO_2	0.00	0.00	5.0	25.0
Greenland	2F Consumption of HFC, Greenland	HFC	0.02	6.57	10.0	50.0
Greenland	2F Consumption of SF6, Greenland	SF6	0.04	0.00	10.0	50.0
Greenland	3A Paint application, Greenland	CO_2	0.01	0.01	10.0	15.0
Greenland	3B Degreasing and dry cleaning, Greenland	CO_2	0.00	0.00	10.0	15.0
Greenland	3C Chemical products, manufacturing and processing, Greenland	CO_2	0.00	0.00	10.0	15.0
Greenland	3D5 Other, Greenland	CO_2	0.25	0.30	10.0	20.0
Greenland	4A Enteric Fermentation, Greenland	CH_4	6.02	5.39	10.0	100.0
Greenland	4B Manure Management, Greenland	CH_4	0.14	0.13	10.0	100.0
Greenland	4.B Manure Management, Greenland	N_2O	0.64	0.65	10.0	100.0
Greenland	4D1 Direct N2O emissions from agriculturalsoils, Greenland	N_2O	0.90	2.31	20.0	50.0
Greenland	4D2 Pasture range and paddock, Greenland	N_2O	0.80	0.65	20.0	25.0
Greenland	4D3 Indirect N2O emissions from agricultural soils (Atmos-pheric deposition), Greenland	N_2O	0.70	1.09	20.0	50.0
Greenland	5A Forest, Greenland	CO_2	0.00	-0.03	5.0	50.0
Greenland	5B Cropland, Greenland	CO_2	0.00	0.02	5.0	50.0
Greenland	5.C Grassland, Greenland	CO_2	-0.25	-0.87	5.0	50.0
Greenland	6A Solid Waste Disposal on Land, Greenland	CH_4	3.64	3.95	10.0	100.0
Greenland	6B Wastewater Handling, Greenland	N_2O	15.19	12.87	30.0	100.0
Greenland	6C Waste incineration, Greenland	CO_2	2.55	2.94	10.0	25.0
Greenland	6C Waste incineration, Greenland	CH_4	2.26	1.58	10.0	50.0
Greenland	6C Waste incineration, Greenland	N_2O	1.10	0.80	10.0	100.0

17.4 Key category analysis

A tier 1 key category analysis (KCA) has been carried out on emissions from Denmark and Greenland. The key category analysis for Denmark is included in Chapter 1.5 and Annex 1, and the key category analysis for Greenland is included in Chapter 16.

The KCA for 1990 and 2009 has been carried out in accordance with the IPCC Guidelines 2006 and IPCC Good Practice Guidance. The KCA has been carried out at CRF level, which is slightly more aggregated than the KCA carried out for Denmark. The categorisation used results in a total of 112 source categories of which 27 are LULUCF categories.

The KCA for Denmark and Greenland includes a total of six different analyses:

- base year, reporting year and trend,
- including and excluding LULUCF.

The six different KCA for Denmark and Greenland point out 16-27 key source categories each and a total of 34 different key source categories. The number of key categories in each of the main sectors are: Energy 11, Industrial Proc. 3, Solvents and other prod. use 0, Agriculture 10, LULUCF 9 and Waste 1.

The KCA for Denmark and Greenland are shown in Tables 17.3-17.8. An overview for all KCA is given in Table 17.9.

The KCA for **1990** excluding LULUCF points out 17 key categories (23 key categories for the KCA including LULUCF). Stationary combustion of solid fuel is the main source category accounting for 35 % of the emission[36]. Stationary combustion of liquid fuel, road transport, stationary combustion of gaseous fuels account for 18 %, 14 % and 6 % respectively.

The KCA for **2009** excluding LULUCF points out 17 key categories (23 key categories for the KCA including LULUCF). Stationary combustion of solid fuel is the main source category accounting for 26 % of the emission[1]. Road transport, stationary combustion of gaseous fuels and stationary combustion of liquid fuel account for 20 %, 15 % and 13 % respectively.

The KCA for **trend (1990-2009)** excluding LULUCF points out 16 key categories (27 key categories for the KCA including LULUCF). Stationary combustion of solid fuel and gaseous fuel are the two main source categories accounting for 23 % and 22 % of the emission[1] respectively. Road transport and stationary combustion of liquid fuel account for 16 % and 12 % respectively.

[36] Data for the KCA excluding LULUCF

Table 17.3 Key Category Analysis for Denmark and Greenland, level assessment for the base year, excl. LULUCF.

IPCC Source Categories (LULUCF excluded)		GHG	Base Year Estimate Ex,o Gg CO_2-eq	Base Year Level Assessment Lx,o	Base Year Cumulative total
Energy	Combustion excluding transport, Solid Fuels	CO_2	23982.67	0.3478	0.3478
Energy	Combustion excluding transport, Liquid Fuels	CO_2	12239.56	0.1775	0.5254
Energy	Road transportation	CO_2	9318.65	0.1352	0.6605
Energy	Combustion excluding transport, Gaseous Fuels	CO_2	4335.23	0.0629	0.7234
Agriculture	Enteric Fermentation	CH_4	3254.58	0.0472	0.7706
Agriculture	Agriculture soils, indirect, Nitrogen Leaching and Run-off	N_2O	2455.76	0.0356	0.8062
Agriculture	Agriculture soils, direct emissions , Synthetic Fertilizers	N_2O	2394.65	0.0347	0.8410
Waste	Solid Waste Disposal Sites	CH_4	1114.48	0.0162	0.8571
Agriculture	Agriculture soils, direct emissions , Animal Manure Appl. to Soils	N_2O	1096.94	0.0159	0.8730
Industrial processes	Nitric acid production	N_2O	1042.90	0.0151	0.8882
Agriculture	Manure Management	CH_4	976.11	0.0142	0.9023
Industrial processes	Cement production	CO_2	882.40	0.0128	0.9151
Energy	Domestic navigation	CO_2	816.81	0.0118	0.9270
Agriculture	Manure Management	N_2O	604.74	0.0088	0.9357
Agriculture	Agriculture soils, indirect, Atmospheric Deposition	N_2O	465.39	0.0067	0.9425
Energy	Combustion excluding transport, Other Fuels	CO_2	394.82	0.0057	0.9482
Agriculture	Agriculture soils, direct emissions , Crop Residue	N_2O	361.27	0.0052	0.9534
Agriculture	Agriculture soils, pasture, range and paddock	N_2O	311.78	0.0045	0.9580
Energy	Railways	CO_2	296.75	0.0043	0.9623
Energy	Civil aviation	CO_2	281.01	0.0041	0.9663
Energy	Fugitive emissions , 1B2c2ii, Flaring gas	CO_2	276.17	0.0040	0.9703
Agriculture	Agriculture soils, direct emissions , N-fixing Crops	N_2O	269.47	0.0039	0.9743
Industrial processes	Foam Blowing	HFC	182.58	0.0026	0.9769
Agriculture	Agriculture soils, direct emissions , Cultivation of Histosols	N_2O	171.84	0.0025	0.9794
Industrial processes	Lime production	CO_2	115.53	0.0017	0.9811
Energy	Combustion excluding transport, Biomass	CH_4	106.39	0.0015	0.9826
Energy	Road transportation	N_2O	93.57	0.0014	0.9840
Solvents and other product use	Other solvent	CO_2	86.02	0.0012	0.9852
Waste	N2O indirect from human sewage	N_2O	85.23	0.0012	0.9865
Energy	Combustion excluding transport, Liquid Fuels	N_2O	80.83	0.0012	0.9876
Energy	Combustion excluding transport, Solid Fuels	N_2O	68.11	0.0010	0.9886
Industrial processes	Other emissions of SF6 i.e. from double glaze windows and laboratories	SF6	67.62	0.0010	0.9896
Waste	Waste Water Handling	CH_4	66.24	0.0010	0.9906
Energy	Road transportation	CH_4	52.62	0.0008	0.9913
Industrial processes	Other, lubricants	CO_2	49.71	0.0007	0.9920
Energy	Combustion excluding transport, Biomass	N_2O	42.87	0.0006	0.9927
Waste	N_2O direct, Domestic and Commercial Wastewater	N_2O	39.45	0.0006	0.9932
Industrial processes	Magnesium Production	SF6	35.85	0.0005	0.9938
Industrial processes	Refrigeration and AC Equipment	HFC and PFC	35.68	0.0005	0.9943
Energy	Fugitive emissions , 1B2aiv, Oil refining and storage	CH_4	32.81	0.0005	0.9947
Waste	Waste, other	CH_4	29.39	0.0004	0.9952
Industrial processes	Iron and steel production	CO_2	28.45	0.0004	0.9956
Agriculture	Agriculture soils, direct emissions , Sludge	N_2O	27.92	0.0004	0.9960
Solvents and other product use	Paint application	CO_2	26.33	0.0004	0.9964
Energy	Fugitive emissions , 1B2c2i, Flaring oil	CO_2	23.72	0.0003	0.9967
Solvents and other product use	Chemical Products, Manufacture and Processing	CO_2	23.07	0.0003	0.9971
Industrial processes	Bricks	CO_2	23.02	0.0003	0.9974
Waste	Waste, other	CO_2	22.02	0.0003	0.9977
Industrial processes	Glass production	CO_2	17.41	0.0003	0.9980
Energy	Combustion excluding transport, Gaseous Fuels	N_2O	16.18	0.0002	0.9982
Energy	Domestic navigation	N_2O	15.05	0.0002	0.9984
Industrial processes	Expanded clay	CO_2	14.93	0.0002	0.9986
Industrial processes	Limestone and dolomite use	CO_2	13.69	0.0002	0.9988
Energy	Combustion excluding transport, Solid Fuels	CH_4	12.88	0.0002	0.9990
Waste	Waste, other	N_2O	11.20	0.0002	0.9992
Energy	Combustion excluding transport, Liquid Fuels	CH_4	11.16	0.0002	0.9993
Energy	Fugitive emissions , 1B2biv, Gas distribution	CH_4	5.33	0.0001	0.9994
Industrial processes	Food and drink	CO_2	4.45	0.0001	0.9995
Industrial processes	Electrical equipment	SF6	3.91	0.0001	0.9995
Energy	Combustion excluding transport, Gaseous Fuels	CH_4	3.66	0.0001	0.9996
Energy	Fugitive emissions , 1B2biii, Gas transmission	CH_4	3.57	0.0001	0.9996
Energy	Civil aviation	N_2O	3.53	0.0001	0.9997
Waste	Waste incineration	CO_2	2.55	0.0000	0.9997

Continued					
Energy	Railways	N_2O	2.54	0.0000	0.9998
Energy	Combustion excluding transport, Other Fuels	N_2O	2.41	0.0000	0.9998
Waste	Waste incineration	CH_4	2.27	0.0000	0.9998
Agriculture	Field Burning of Agricultural Residues	CH_4	1.82	0.0000	0.9999
Industrial processes	Road Paving with asphalt	CO_2	1.76	0.0000	0.9999
Energy	Fugitive emissions , 1B2c2i, Flaring oil	CH_4	1.32	0.0000	0.9999
Waste	Waste incineration	N_2O	1.30	0.0000	0.9999
Industrial processes	Catalysts/Fertilizers, Pesticides and Sulphuric acid	CO_2	0.80	0.0000	0.9999
Solvents and other product use	Other solvent	N_2O	0.77	0.0000	0.9999
Energy	Domestic navigation	CH_4	0.71	0.0000	1.0000
Energy	Fugitive emissions , 1B2c2ii, Flaring gas	N_2O	0.70	0.0000	1.0000
Agriculture	Field Burning of Agricultural Residues	N_2O	0.70	0.0000	1.0000
Energy	Fugitive emissions , 1B2c2ii, Flaring gas	CH_4	0.48	0.0000	1.0000
Energy	Combustion excluding transport, Other Fuels	CH_4	0.46	0.0000	1.0000
Energy	Railways	CH_4	0.26	0.0000	1.0000
Energy	Civil aviation	CH_4	0.16	0.0000	1.0000
Energy	Fugitive emissions , 1B2c2i, Flaring oil	N_2O	0.13	0.0000	1.0000
Industrial processes	Asphalt roofing	CO_2	0.02	0.0000	1.0000
Solvents and other product use	Degreasing and Dry Cleaning	CO_2	0.00	0.0000	1.0000
Energy	Fugitive emissions , 1B2c Venting	CH_4	0.00	0.0000	1.0000
Industrial processes	Aerosols	HFC	0.00	0.0000	1.0000
Industrial processes	Other i.e. Fibre Optics	HFC and PFC	0.00	0.0000	1.0000
Total			68947.09	1.0000	

Table 17.4 Key Category Analysis for Denmark and Greenland, level assessment for the base year, incl. LULUCF.

IPCC Source Categories (LULUCF included)		GHG	Base Year Estimate Ex,o Gg CO_2-eq	Base Year Level Assessment Lx,o	Base Year Cumulative total
Energy	Combustion excluding transport, Solid Fuels	CO_2	23982.67	0.3261	0.3261
Energy	Combustion excluding transport, Liquid Fuels	CO_2	12239.56	0.1664	0.4925
Energy	Road transportation	CO_2	9318.65	0.1267	0.6192
Energy	Combustion excluding transport, Gaseous Fuels	CO_2	4335.23	0.0589	0.6781
Agriculture	Enteric Fermentation	CH_4	3254.58	0.0442	0.7224
Agriculture	Agriculture soils, indirect, Nitrogen Leaching and Run-off	N_2O	2455.76	0.0334	0.7557
Agriculture	Agriculture soils, direct emissions , Synthetic Fertilizers	N_2O	2394.65	0.0326	0.7883
LULUCF	Cropland, 5B Cropland rem. Cr. Organic soils	CO_2	1343.27	0.0183	0.8066
Waste	Solid Waste Disposal Sites	CH_4	1114.48	0.0152	0.8217
Agriculture	Agriculture soils, direct emissions , Animal Manure Appl. to Soils	N_2O	1096.94	0.0149	0.8366
LULUCF	Cropland, 5B Cropland rem. Cr. Mineral soils	CO_2	1054.02	0.0143	0.8510
Industrial processes	Nitric acid production	N_2O	1042.90	0.0142	0.8651
Agriculture	Manure Management	CH_4	976.11	0.0133	0.8784
Industrial processes	Cement production	CO_2	882.40	0.0120	0.8904
Energy	Domestic navigation	CO_2	816.81	0.0111	0.9015
LULUCF	Forest Land remaining Forest L., 5A1 Broadleaves	CO_2	659.04	0.0090	0.9105
LULUCF	Agricultural lime application, 5IV Cropland Limestone	CO_2	622.93	0.0085	0.9189
Agriculture	Manure Management	N_2O	604.74	0.0082	0.9272
Agriculture	Agriculture soils, indirect, Atmospheric Deposition	N_2O	465.39	0.0063	0.9335
Energy	Combustion excluding transport, Other Fuels	CO_2	394.82	0.0054	0.9389
Agriculture	Agriculture soils, direct emissions , Crop Residue	N_2O	361.27	0.0049	0.9438
Agriculture	Agriculture soils, pasture, range and paddock	N_2O	311.78	0.0042	0.9480
Energy	Railways	CO_2	296.75	0.0040	0.9520
Energy	Civil aviation	CO_2	281.01	0.0038	0.9559
Energy	Fugitive emissions , 1B2c2ii, Flaring gas	CO_2	276.17	0.0038	0.9596
Agriculture	Agriculture soils, direct emissions , N-fixing Crops	N_2O	269.47	0.0037	0.9633
Industrial processes	Foam Blowing	HFC	182.58	0.0025	0.9658
Agriculture	Agriculture soils, direct emissions , Cultivation of Histosols	N_2O	171.84	0.0023	0.9681
LULUCF	Grassland, 5C Grassland rem. Grassland. Living biomass	CO_2	159.44	0.0022	0.9703
LULUCF	Cropland, 5B Cropland remaining Cr. Living biomass	CO_2	153.38	0.0021	0.9724
LULUCF	Grassland, 5C Land converted to Grassland, Living biomass	CO_2	144.63	0.0020	0.9743
LULUCF	Grassland, 5C Grassland rem. Grassland. Organic soils	CO_2	136.49	0.0019	0.9762
Industrial processes	Lime production	CO_2	115.53	0.0016	0.9777
Energy	Combustion excluding transport, Biomass	CH_4	106.39	0.0014	0.9792
Energy	Road transportation	N_2O	93.57	0.0013	0.9805
LULUCF	Settlements, 5E Total settlements	CO_2	89.50	0.0012	0.9817
LULUCF	Wetlands, 5D Wetlands, soils	CO_2	86.08	0.0012	0.9829

Continued					
Solvents and other product use	Other solvent	CO_2	86.02	0.0012	0.9840
Waste	N_2O indirect from human sewage	N_2O	85.23	0.0012	0.9852
Energy	Combustion excluding transport, Liquid Fuels	N_2O	80.83	0.0011	0.9863
Energy	Combustion excluding transport, Solid Fuels	N_2O	68.11	0.0009	0.9872
Industrial processes	Other emissions of SF6 i.e. from double glaze windows and laboratories	SF6	67.62	0.0009	0.9881
Waste	Waste Water Handling	CH_4	66.24	0.0009	0.9890
LULUCF	Forest Land remaining Forest L., 5A1 Conifers	CO_2	65.88	0.0009	0.9899
Energy	Road transportation	CH_4	52.62	0.0007	0.9906
Industrial processes	Other, lubricants	CO_2	49.71	0.0007	0.9913
Energy	Combustion excluding transport, Biomass	N_2O	42.87	0.0006	0.9919
Waste	N2O direct, Domestic and Commercial Wastewater	N_2O	39.45	0.0005	0.9924
Industrial processes	Magnesium Production	SF6	35.85	0.0005	0.9929
Industrial processes	Refrigeration and AC Equipment	HFC and PFC	35.68	0.0005	0.9934
Energy	Fugitive emissions , 1B2aiv, Oil refining and storage	CH_4	32.81	0.0004	0.9938
LULUCF	Grassland, 5C Land converted to Cropland. Dead Org. Matter	CO_2	31.71	0.0004	0.9943
Waste	Waste, other	CH_4	29.39	0.0004	0.9947
Industrial processes	Iron and steel production	CO_2	28.45	0.0004	0.9951
Agriculture	Agriculture soils, direct emissions , Sludge	N_2O	27.92	0.0004	0.9954
Solvents and other product use	Paint application	CO_2	26.33	0.0004	0.9958
Energy	Fugitive emissions , 1B2c2i, Flaring oil	CO_2	23.72	0.0003	0.9961
Solvents and other product use	Chemical Products, Manufacture and Processing	CO_2	23.07	0.0003	0.9964
Industrial processes	Bricks	CO_2	23.02	0.0003	0.9968
Waste	Waste, other	CO_2	22.02	0.0003	0.9971
LULUCF	Cropland, 5B Land converted to Cropland. Living biomass	CO_2	20.63	0.0003	0.9973
Industrial processes	Glass production	CO_2	17.41	0.0002	0.9976
Energy	Combustion excluding transport, Gaseous Fuels	N_2O	16.18	0.0002	0.9978
LULUCF	Non-CO2 drainage of soils and wetlands, 5IID Forest Land.	N_2O	15.66	0.0002	0.9980
Energy	Domestic navigation	N_2O	15.05	0.0002	0.9982
Industrial processes	Expanded clay	CO_2	14.93	0.0002	0.9984
Industrial processes	Limestone and dolomite use	CO_2	13.69	0.0002	0.9986
Energy	Combustion excluding transport, Solid Fuels	CH_4	12.88	0.0002	0.9988
Waste	Waste, other	N_2O	11.20	0.0002	0.9989
Energy	Combustion excluding transport, Liquid Fuels	CH_4	11.16	0.0002	0.9991
LULUCF	Land converted to Forest L., 5A2 Conifers	CO_2	7.11	0.0001	0.9992
LULUCF	Cropland, 5B Land converted to Cropland. Dead Org. Matter	CO_2	6.03	0.0001	0.9993
Energy	Fugitive emissions , 1B2biv, Gas distribution	CH_4	5.33	0.0001	0.9993
Industrial processes	Food and drink	CO_2	4.45	0.0001	0.9994
Industrial processes	Electrical equipment	SF6	3.91	0.0001	0.9994
Energy	Combustion excluding transport, Gaseous Fuels	CH_4	3.66	0.0000	0.9995
Energy	Fugitive emissions , 1B2biii, Gas transmission	CH_4	3.57	0.0000	0.9995
Energy	Civil aviation	N_2O	3.53	0.0000	0.9996
LULUCF	Land converted to Forest L., 5A2 Broadleaves	CO_2	3.40	0.0000	0.9996
LULUCF	N2O Disturbance, Land converted to cropland, 5III Cropland	N_2O	3.19	0.0000	0.9997
Waste	Waste incineration	CO_2	2.55	0.0000	0.9997
Energy	Railways	N_2O	2.54	0.0000	0.9997
Energy	Combustion excluding transport, Other Fuels	N_2O	2.41	0.0000	0.9998
Waste	Waste incineration	CH_4	2.27	0.0000	0.9998
Agriculture	Field Burning of Agricultural Residues	CH_4	1.82	0.0000	0.9998
Industrial processes	Road Paving with asphalt	CO_2	1.76	0.0000	0.9999
Energy	Fugitive emissions , 1B2c2i, Flaring oil	CH_4	1.32	0.0000	0.9999
Waste	Waste incineration	N_2O	1.30	0.0000	0.9999
LULUCF	Grassland, 5C Land converted to Grassland, Mineral soils	CO_2	1.04	0.0000	0.9999
Industrial processes	Catalysts/Fertilizers, Pesticides and Sulphuric acid	CO_2	0.80	0.0000	0.9999
Solvents and other product use	Other solvent	N_2O	0.77	0.0000	0.9999
LULUCF	Grassland, 5C Land converted to Grassland, Organic soils	CO_2	0.73	0.0000	0.9999
Energy	Domestic navigation	CH_4	0.71	0.0000	0.9999
Energy	Fugitive emissions , 1B2c2ii, Flaring gas	N_2O	0.70	0.0000	1.0000
Agriculture	Field Burning of Agricultural Residues	N_2O	0.70	0.0000	1.0000
Energy	Fugitive emissions , 1B2c2ii, Flaring gas	CH_4	0.48	0.0000	1.0000
Energy	Combustion excluding transport, Other Fuels	CH_4	0.46	0.0000	1.0000
LULUCF	Cropland, 5B Land converted to Cropland. Mineral soils	CO_2	0.38	0.0000	1.0000
LULUCF	Wetlands, 5D Wetlands Living biomass	CO_2	0.37	0.0000	1.0000
Energy	Railways	CH_4	0.26	0.0000	1.0000
Energy	Civil aviation	CH_4	0.16	0.0000	1.0000
LULUCF	Non-CO_2 drainage of soils &wetlands, 5IID Wetlands. Peatland	N_2O	0.13	0.0000	1.0000
Energy	Fugitive emissions , 1B2c2i, Flaring oil	N_2O	0.13	0.0000	1.0000
LULUCF	Wetlands, 5D Wetlands, dead org. matter	CO_2	0.09	0.0000	1.0000

Continued					
Industrial processes	Asphalt roofing	CO_2	0.02	0.0000	1.0000
Solvents and other product use	Degreasing and Dry Cleaning	CO_2	0.00	0.0000	1.0000
Energy	Fugitive emissions , 1B2c Venting	CH_4	0.00	0.0000	1.0000
LULUCF	Forest Land remaining Forest L., 5A1 Larch (Greenland)	CO_2	0.00	0.0000	1.0000
LULUCF	, 5A1 Other Conifers (Greenland)	CO_2	0.00	0.0000	1.0000
LULUCF	Cropland, 5B Land converted to Cropland. Organic soils	CO_2	0.00	0.0000	1.0000
Industrial processes	Aerosols	HFC	0.00	0.0000	1.0000
Industrial processes	Other i.e. Fibre Optics	HFC and PFC	0.00	0.0000	1.0000
Total			73552.23	1.000	

Table 17.5 Key Category Analysis for Denmark and Greenland, level assessment for the reporting year, excl. LULUCF.

IPCC Source Categories (LULUCF excluded)		GHG	Reporting Year Estimate Ex,t Gg CO_2-eq	Reporting Year Level Assessment Lx,t	Reporting Year Cumulative total
Energy	Combustion excluding transport, Solid Fuels	CO_2	15808.465	0.2566	0.2566
Energy	Road transportation	CO_2	12159.878	0.1973	0.4539
Energy	Combustion excluding transport, Gaseous Fuels	CO_2	9379.802	0.1522	0.6061
Energy	Combustion excluding transport, Liquid Fuels	CO_2	7933.809	0.1288	0.7349
Agriculture	Enteric Fermentation	CH_4	2864.303	0.0465	0.7814
Agriculture	Agriculture soils, indirect, Nitrogen Leaching and Run-off	N_2O	1416.791	0.0230	0.8044
Energy	Combustion excluding transport, Other Fuels	CO_2	1271.553	0.0206	0.8250
Agriculture	Manure Management	CH_4	1228.047	0.0199	0.8449
Agriculture	Agriculture soils, direct emissions , Synthetic Fertilizers	N_2O	1196.677	0.0194	0.8643
Agriculture	Agriculture soils, direct emissions , Animal Manure Appl. to Soils	N_2O	1163.740	0.0189	0.8832
Waste	Solid Waste Disposal Sites	CH_4	1043.245	0.0169	0.9002
Industrial processes	Cement production	CO_2	764.407	0.0124	0.9126
Industrial processes	Refrigeration and AC Equipment	HFC and PFC	697.102	0.0113	0.9239
Energy	Domestic navigation	CO_2	623.557	0.0101	0.9340
Agriculture	Manure Management	N_2O	427.038	0.0069	0.9409
Agriculture	Agriculture soils, direct emissions , Crop Residue	N_2O	311.968	0.0051	0.9460
Agriculture	Agriculture soils, indirect, Atmospheric Deposition	N_2O	296.294	0.0048	0.9508
Agriculture	Agriculture soils, direct emissions , N-fixing Crops	N_2O	247.652	0.0040	0.9548
Energy	Fugitive emissions , 1B2c2ii, Flaring gas	CO_2	240.816	0.0039	0.9587
Energy	Railways	CO_2	230.202	0.0037	0.9625
Agriculture	Agriculture soils, pasture, range and paddock	N_2O	213.520	0.0035	0.9659
Energy	Civil aviation	CO_2	200.769	0.0033	0.9692
Energy	Combustion excluding transport, Gaseous Fuels	CH_4	197.509	0.0032	0.9724
Energy	Combustion excluding transport, Biomass	CH_4	176.587	0.0029	0.9753
Agriculture	Agriculture soils, direct emissions , Cultivation of Histosols	N_2O	164.572	0.0027	0.9779
Energy	Road transportation	N_2O	119.212	0.0019	0.9799
Energy	Fugitive emissions , 1B2aiv, Oil refining and storage	CH_4	111.262	0.0018	0.9817
Industrial processes	Foam Blowing	HFC	95.714	0.0016	0.9832
Energy	Combustion excluding transport, Biomass	N_2O	90.197	0.0015	0.9847
Agriculture	Agriculture soils, direct emissions , Sludge	N_2O	81.173	0.0013	0.9860
Waste	Waste, other	CH_4	80.975	0.0013	0.9873
Waste	Waste Water Handling	CH_4	74.679	0.0012	0.9885
Energy	Combustion excluding transport, Liquid Fuels	N_2O	58.355	0.0009	0.9895
Waste	N_2O direct, Domestic and Commercial Wastewater	N_2O	57.211	0.0009	0.9904
Solvents and other product use	Other solvent	CO_2	44.070	0.0007	0.9911
Industrial processes	Lime production	CO_2	43.249	0.0007	0.9918
Energy	Combustion excluding transport, Solid Fuels	N_2O	42.764	0.0007	0.9925
Energy	Combustion excluding transport, Gaseous Fuels	N_2O	40.741	0.0007	0.9932
Waste	Waste, other	N_2O	40.499	0.0007	0.9938
Industrial processes	Limestone and dolomite use	CO_2	37.921	0.0006	0.9944
Solvents and other product use	Other solvent	N_2O	37.005	0.0006	0.9950
Waste	N_2O indirect from human sewage	N_2O	36.529	0.0006	0.9956
Industrial processes	Other, lubricants	CO_2	31.190	0.0005	0.9961
Waste	Waste, other	CO_2	27.665	0.0004	0.9966
Industrial processes	Other emissions of SF6 i.e. from double glaze windows and laboratories	SF6	22.128	0.0004	0.9970
Industrial processes	Aerosols	HFC	17.706	0.0003	0.9972
Energy	Fugitive emissions , 1B2c2i, Flaring oil	CO_2	16.870	0.0003	0.9975
Industrial processes	Bricks	CO_2	16.479	0.0003	0.9978

Continued					
Energy	Road transportation	CH_4	15.059	0.0002	0.9980
Industrial processes	Electrical equipment	SF6	14.560	0.0002	0.9983
Solvents and other product use	Chemical Products, Manufacture and Processing	CO_2	12.218	0.0002	0.9985
Energy	Domestic navigation	N_2O	10.878	0.0002	0.9986
Industrial processes	Glass production	CO_2	10.753	0.0002	0.9988
Energy	Combustion excluding transport, Liquid Fuels	CH_4	10.181	0.0002	0.9990
Industrial processes	Other i.e. Fibre Optics	HFC and PFC	9.063	0.0001	0.9991
Solvents and other product use	Paint application	CO_2	8.649	0.0001	0.9993
Energy	Combustion excluding transport, Other Fuels	N_2O	6.651	0.0001	0.9994
Industrial processes	Expanded clay	CO_2	6.482	0.0001	0.9995
Energy	Combustion excluding transport, Solid Fuels	CH_4	4.256	0.0001	0.9995
Waste	Waste incineration	CO_2	2.935	0.0000	0.9996
Energy	Civil aviation	N_2O	2.905	0.0000	0.9996
Agriculture	Field Burning of Agricultural Residues	CH_4	2.868	0.0000	0.9997
Energy	Fugitive emissions , 1B2biv, Gas distribution	CH_4	2.827	0.0000	0.9997
Industrial processes	Catalysts/Fertilizers, Pesticides and Sulphuric acid	CO_2	2.129	0.0000	0.9998
Energy	Railways	N_2O	1.967	0.0000	0.9998
Industrial processes	Food and drink	CO_2	1.921	0.0000	0.9998
Industrial processes	Road Paving with asphalt	CO_2	1.645	0.0000	0.9999
Waste	Waste incineration	CH_4	1.592	0.0000	0.9999
Energy	Fugitive emissions , 1B2c2ii, Flaring gas	CH_4	1.134	0.0000	0.9999
Energy	Fugitive emissions , 1B2c Venting	CH_4	1.113	0.0000	0.9999
Agriculture	Field Burning of Agricultural Residues	N_2O	1.098	0.0000	0.9999
Waste	Waste incineration	N_2O	1.087	0.0000	1.0000
Energy	Domestic navigation	CH_4	0.779	0.0000	1.0000
Energy	Combustion excluding transport, Other Fuels	CH_4	0.620	0.0000	1.0000
Energy	Fugitive emissions , 1B2c2ii, Flaring gas	N_2O	0.563	0.0000	1.0000
Energy	Civil aviation	CH_4	0.211	0.0000	1.0000
Energy	Fugitive emissions , 1B2biii, Gas transmission	CH_4	0.193	0.0000	1.0000
Energy	Railways	CH_4	0.140	0.0000	1.0000
Energy	Fugitive emissions , 1B2c2i, Flaring oil	CH_4	0.113	0.0000	1.0000
Energy	Fugitive emissions , 1B2c2i, Flaring oil	N_2O	0.043	0.0000	1.0000
Industrial processes	Asphalt roofing	CO_2	0.016	0.0000	1.0000
Solvents and other product use	Degreasing and Dry Cleaning	CO_2	0.000	0.0000	1.0000
Industrial processes	Nitric acid production	N_2O	0.000	0.0000	1.0000
Industrial processes	Iron and steel production	CO_2	0.000	0.0000	1.0000
Industrial processes	Magnesium Production	SF_6	0.000	0.0000	1.0000
Total			61618.541	1.000	

Table 17.6 Key Category Analysis for Denmark and Greenland, level assessment for the reporting year, incl. LULUCF.

IPCC Source Categories (LULUCF included)		GHG	Reporting Year Estimate Ex,t Gg CO_2-eq	Reporting Year Level Assessment Lx,t	Reporting Year Cumulative total
Energy	Combustion excluding transport, Solid Fuels	CO_2	15808.465	0.2381	0.2381
Energy	Road transportation	CO_2	12159.878	0.1832	0.4213
Energy	Combustion excluding transport, Gaseous Fuels	CO_2	9379.802	0.1413	0.5625
Energy	Combustion excluding transport, Liquid Fuels	CO_2	7933.809	0.1195	0.6820
Agriculture	Enteric Fermentation	CH_4	2864.303	0.0431	0.7252
LULUCF	Forest Land remaining Forest L., 5A1 Conifers	CO_2	1579.375	0.0238	0.7490
Agriculture	Agriculture soils, indirect, Nitrogen Leaching and Run-off	N_2O	1416.791	0.0213	0.7703
LULUCF	Cropland, 5B Cropland rem. Cr. Organic soils	CO_2	1281.690	0.0193	0.7896
Energy	Combustion excluding transport, Other Fuels	CO_2	1271.553	0.0192	0.8088
Agriculture	Manure Management	CH_4	1228.047	0.0185	0.8273
Agriculture	Agriculture soils, direct emissions , Synthetic Fertilizers	N_2O	1196.677	0.0180	0.8453
Agriculture	Agriculture soils, direct emissions , Animal Manure Appl. to Soils	N_2O	1163.740	0.0175	0.8628
Waste	Solid Waste Disposal Sites	CH_4	1043.245	0.0157	0.8785
LULUCF	Forest Land remaining Forest L., 5A1 Broadleaves	CO_2	1011.757	0.0152	0.8938
Industrial processes	Cement production	CO_2	764.407	0.0115	0.9053
Industrial processes	Refrigeration and AC Equipment	HFC and PFC	697.102	0.0105	0.9158
Energy	Domestic navigation	CO_2	623.557	0.0094	0.9252
Agriculture	Manure Management	N_2O	427.038	0.0064	0.9316
Agriculture	Agriculture soils, direct emissions , Crop Residue	N_2O	311.968	0.0047	0.9363

Continued					
Agriculture	Agriculture soils, indirect, Atmospheric Deposition	N_2O	296.294	0.0045	0.9408
Agriculture	Agriculture soils, direct emissions , N-fixing Crops	N_2O	247.652	0.0037	0.9445
Energy	Fugitive emissions , 1B2c2ii, Flaring gas	CO_2	240.816	0.0036	0.9481
Energy	Railways	CO_2	230.202	0.0035	0.9516
Agriculture	Agriculture soils, pasture, range and paddock	N_2O	213.520	0.0032	0.9548
Energy	Civil aviation	CO_2	200.769	0.0030	0.9578
Energy	Combustion excluding transport, Gaseous Fuels	CH_4	197.509	0.0030	0.9608
LULUCF	Cropland, 5B Cropland rem. Cr. Mineral soils	CO_2	191.765	0.0029	0.9637
LULUCF	Agricultural lime application, 5IV Cropland Limestone	CO_2	186.241	0.0028	0.9665
Energy	Combustion excluding transport, Biomass	CH_4	176.587	0.0027	0.9692
Agriculture	Agriculture soils, direct emissions , Cultivation of Histosols	N_2O	164.572	0.0025	0.9717
LULUCF	Grassland, 5C Grassland rem. Grassland. Organic soils	CO_2	124.594	0.0019	0.9735
Energy	Road transportation	N_2O	119.212	0.0018	0.9753
Energy	Fugitive emissions , 1B2aiv, Oil refining and storage	CH_4	111.262	0.0017	0.9770
Industrial processes	Foam Blowing	HFC	95.714	0.0014	0.9784
Energy	Combustion excluding transport, Biomass	N_2O	90.197	0.0014	0.9798
Agriculture	Agriculture soils, direct emissions , Sludge	N_2O	81.173	0.0012	0.9810
Waste	Waste, other	CH_4	80.975	0.0012	0.9822
LULUCF	Land converted to Forest L., 5A2 Broadleaves	CO_2	78.383	0.0012	0.9834
Waste	Waste Water Handling	CH_4	74.679	0.0011	0.9845
LULUCF	Cropland, 5B Cropland remaining Cr. Living biomass	CO_2	73.111	0.0011	0.9856
LULUCF	Land converted to Forest L., 5A2 Conifers	CO_2	66.926	0.0010	0.9867
Energy	Combustion excluding transport, Liquid Fuels	N_2O	58.355	0.0009	0.9875
Waste	N_2O direct, Domestic and Commercial Wastewater	N_2O	57.211	0.0009	0.9884
LULUCF	Settlements, 5E Total settlements	CO_2	54.746	0.0008	0.9892
Solvents and other product use	Other solvent	CO_2	44.070	0.0007	0.9899
Industrial processes	Lime production	CO_2	43.249	0.0007	0.9905
Energy	Combustion excluding transport, Solid Fuels	N_2O	42.764	0.0006	0.9912
Energy	Combustion excluding transport, Gaseous Fuels	N_2O	40.741	0.0006	0.9918
Waste	Waste, other	N_2O	40.499	0.0006	0.9924
Industrial processes	Limestone and dolomite use	CO_2	37.921	0.0006	0.9930
Solvents and other product use	Other solvent	N_2O	37.005	0.0006	0.9935
Waste	N2O indirect from human sewage	N_2O	36.529	0.0006	0.9941
Industrial processes	Other, lubricants	CO_2	31.190	0.0005	0.9946
Waste	Waste, other	CO_2	27.665	0.0004	0.9950
LULUCF	Grassland, 5C Land converted to Grassland, Living biomass	CO_2	26.950	0.0004	0.9954
LULUCF	Grassland, 5C Land converted to Grassland, Mineral soils	CO_2	24.397	0.0004	0.9957
Industrial processes	Other emissions of SF6 i.e. from double glaze windows and laboratories	SF6	22.128	0.0003	0.9961
Industrial processes	Aerosols	HFC	17.706	0.0003	0.9963
Energy	Fugitive emissions , 1B2c2i, Flaring oil	CO_2	16.870	0.0003	0.9966
Industrial processes	Bricks	CO_2	16.479	0.0002	0.9968
LULUCF	Wetlands, 5D Wetlands, soils	CO_2	16.205	0.0002	0.9971
Energy	Road transportation	CH_4	15.059	0.0002	0.9973
Industrial processes	Electrical equipment	SF6	14.560	0.0002	0.9975
LULUCF	Grassland, 5C Land converted to Grassland, Organic soils	CO_2	12.908	0.0002	0.9977
Solvents and other product use	Chemical Products, Manufacture and Processing	CO_2	12.218	0.0002	0.9979
LULUCF	Non-CO_2 drainage of soils and wetlands, 5IID Forest Land.	N_2O	12.037	0.0002	0.9981
LULUCF	Wetlands, 5D Wetlands Living biomass	CO_2	11.328	0.0002	0.9983
Energy	Domestic navigation	N_2O	10.878	0.0002	0.9984
Industrial processes	Glass production	CO_2	10.753	0.0002	0.9986
Energy	Combustion excluding transport, Liquid Fuels	CH_4	10.181	0.0002	0.9987
Industrial processes	Other i.e. Fibre Optics	HFC and PFC	9.063	0.0001	0.9989
Solvents and other product use	Paint application	CO_2	8.649	0.0001	0.9990
LULUCF	Grassland, 5C Grassland rem. Grassland. Living biomass	CO_2	6.811	0.0001	0.9991
Energy	Combustion excluding transport, Other Fuels	N_2O	6.651	0.0001	0.9992
Industrial processes	Expanded clay	CO_2	6.482	0.0001	0.9993
LULUCF	Cropland, 5B Land converted to Cropland. Mineral soils	CO_2	6.245	0.0001	0.9994
Energy	Combustion excluding transport, Solid Fuels	CH_4	4.256	0.0001	0.9995
Waste	Waste incineration	CO_2	2.935	0.0000	0.9995
Energy	Civil aviation	N_2O	2.905	0.0000	0.9996
Agriculture	Field Burning of Agricultural Residues	CH_4	2.868	0.0000	0.9996
Energy	Fugitive emissions , 1B2biv, Gas distribution	CH_4	2.827	0.0000	0.9996
LULUCF	Grassland, 5C Land converted to Cropland. Dead Org. Matter	CO_2	2.611	0.0000	0.9997
LULUCF	Cropland, 5B Land converted to Cropland. Living biomass	CO_2	2.606	0.0000	0.9997
Industrial processes	Catalysts/Fertilizers, Pesticides and Sulphuric acid	CO_2	2.129	0.0000	0.9998
Energy	Railways	N_2O	1.967	0.0000	0.9998
Industrial processes	Food and drink	CO_2	1.921	0.0000	0.9998

Continued					
Industrial processes	Road Paving with asphalt	CO_2	1.645	0.0000	0.9998
Waste	Waste incineration	CH_4	1.592	0.0000	0.9999
LULUCF	Cropland, 5B Land converted to Cropland. Dead Org. Matter	CO_2	1.306	0.0000	0.9999
Energy	Fugitive emissions , 1B2c2ii, Flaring gas	CH_4	1.134	0.0000	0.9999
Energy	Fugitive emissions , 1B2c Venting	CH_4	1.113	0.0000	0.9999
Agriculture	Field Burning of Agricultural Residues	N_2O	1.098	0.0000	0.9999
Waste	Waste incineration	N_2O	1.087	0.0000	0.9999
Energy	Domestic navigation	CH_4	0.779	0.0000	1.0000
Energy	Combustion excluding transport, Other Fuels	CH_4	0.620	0.0000	1.0000
Energy	Fugitive emissions , 1B2c2ii, Flaring gas	N_2O	0.563	0.0000	1.0000
LULUCF	N_2O Disturbance, Land converted to cropland, 5III Cropland	N_2O	0.411	0.0000	1.0000
Energy	Civil aviation	CH_4	0.211	0.0000	1.0000
Energy	Fugitive emissions , 1B2biii, Gas transmission	CH_4	0.193	0.0000	1.0000
Energy	Railways	CH_4	0.140	0.0000	1.0000
LULUCF	Non-CO_2 drainage of soils and wetlands, 5IID Wetlands. Peatland	N_2O	0.135	0.0000	1.0000
Energy	Fugitive emissions , 1B2c2i, Flaring oil	CH_4	0.113	0.0000	1.0000
LULUCF	Wetlands, 5D Wetlands, dead org. matter	CO_2	0.109	0.0000	1.0000
Energy	Fugitive emissions , 1B2c2i, Flaring oil	N_2O	0.043	0.0000	1.0000
LULUCF	Cropland, 5B Land converted to Cropland. Organic soils	CO_2	0.030	0.0000	1.0000
LULUCF	Forest Land remaining Forest L., 5A1 Other Conifers (Greenland)	CO_2	0.028	0.0000	1.0000
Industrial processes	Asphalt roofing	CO_2	0.016	0.0000	1.0000
LULUCF	Forest Land remaining Forest L., 5A1 Larch (Greenland)	CO_2	0.002	0.0000	1.0000
Solvents and other product use	Degreasing and Dry Cleaning	CO_2	0.000	0.0000	1.0000
Industrial processes	Nitric acid production	N_2O	0.000	0.0000	1.0000
Industrial processes	Iron and steel production	CO_2	0.000	0.0000	1.0000
Industrial processes	Magnesium Production	SF_6	0.000	0.0000	1.0000
Total			66391.249	1.000	

Table 17.7 Key Category Analysis for Denmark and Greenland, trend assessment, excl. LULUCF.

IPCC Source Categories (LULUCF excluded)		GHG	Base Year Estimate Ex,o Gg CO_2-eq	Year 2009 Estimate Ex,t Gg CO_2-eq	Trend Assess-ment Tx,t	Contri-bution to Trend	Cumulative total
Energy	Combustion excluding transport, Solid Fuels	CO_2	23982.671	15808.465	0.0816	0.2288	0.2288
Energy	Combustion excluding transport, Gaseous Fuels	CO_2	4335.230	9379.802	0.0798	0.2239	0.4527
Energy	Road transportation	CO_2	9318.650	12159.878	0.0556	0.1558	0.6085
Energy	Combustion excluding transport, Liquid Fuels	CO_2	12239.564	7933.809	0.0436	0.1222	0.7307
Agriculture	Agriculture soils, direct emissions , Synthetic Fertilizers	N_2O	2394.649	1196.677	0.0137	0.0384	0.7691
Industrial processes	Nitric acid production	N_2O	1042.902	0.000	0.0135	0.0379	0.8070
Energy	Combustion excluding transport, Other Fuels	CO_2	394.825	1271.553	0.0133	0.0374	0.8444
Agriculture	Agriculture soils, indirect, Nitrogen Leaching and Run-off	N_2O	2455.755	1416.791	0.0113	0.0316	0.8760
Industrial processes	Refrigeration and AC Equipment	HFC and PFC	35.677	697.102	0.0096	0.0271	0.9030
Agriculture	Manure Management	CH_4	976.108	1228.047	0.0052	0.0145	0.9175
Energy	Combustion excluding transport, Gaseous Fuels	CH_4	3.659	197.509	0.0028	0.0079	0.9254
Agriculture	Agriculture soils, direct emissions , Animal Manure Appl. to Soils	N_2O	1096.941	1163.740	0.0027	0.0075	0.9329
Agriculture	Agriculture soils, indirect, Atmospheric Deposition	N_2O	465.392	296.294	0.0017	0.0049	0.9377
Agriculture	Manure Management	N_2O	604.740	427.038	0.0016	0.0046	0.9424
Energy	Domestic navigation	CO_2	816.814	623.557	0.0015	0.0043	0.9467
Energy	Fugitive emissions , 1B2aiv, Oil refining and storage	CH_4	32.808	111.262	0.0012	0.0033	0.9500
Energy	Combustion excluding transport, Biomass	CH_4	106.390	176.587	0.0012	0.0033	0.9533
Industrial processes	Foam Blowing	HFC	182.578	95.714	0.0010	0.0027	0.9561
Agriculture	Agriculture soils, pasture, range and paddock	N_2O	311.784	213.520	0.0009	0.0026	0.9587
Industrial processes	Lime production	CO_2	115.532	43.249	0.0009	0.0024	0.9612
Agriculture	Agriculture soils, direct emissions , Sludge	N_2O	27.923	81.173	0.0008	0.0023	0.9634
Waste	Waste, other	CH_4	29.385	80.975	0.0008	0.0022	0.9657
Energy	Combustion excluding transport, Biomass	N_2O	42.872	90.197	0.0008	0.0021	0.9678
Energy	Civil aviation	CO_2	281.013	200.769	0.0007	0.0020	0.9698
Waste	Solid Waste Disposal Sites	CH_4	1114.483	1043.245	0.0007	0.0019	0.9717
Agriculture	Enteric Fermentation	CH_4	3254.582	2864.303	0.0006	0.0018	0.9736
Waste	N_2O indirect from human sewage	N_2O	85.233	36.529	0.0006	0.0016	0.9752
Industrial processes	Other emissions of SF6 i.e. from double glaze windows and laboratories	SF_6	67.616	22.128	0.0006	0.0016	0.9767
Solvents and other product use	Other solvent	N_2O	0.767	37.005	0.0005	0.0015	0.9782
Energy	Road transportation	N_2O	93.573	119.212	0.0005	0.0014	0.9796
Energy	Railways	CO_2	296.745	230.202	0.0005	0.0014	0.9811
Solvents and other product use	Other solvent	CO_2	86.022	44.070	0.0005	0.0013	0.9824
Industrial processes	Magnesium Production	SF_6	35.850	0.000	0.0005	0.0013	0.9837
Energy	Road transportation	CH_4	52.624	15.059	0.0005	0.0013	0.9850
Waste	Waste, other	N_2O	11.198	40.499	0.0004	0.0012	0.9862
Energy	Combustion excluding transport, Gaseous Fuels	N_2O	16.177	40.741	0.0004	0.0011	0.9873
Industrial processes	Limestone and dolomite use	CO_2	13.692	37.921	0.0004	0.0010	0.9884
Industrial processes	Iron and steel production	CO_2	28.447	0.000	0.0004	0.0010	0.9894
Industrial processes	Cement production	CO_2	882.402	764.407	0.0004	0.0010	0.9904
Waste	N_2O direct, Domestic and Commercial Wastewater	N_2O	39.447	57.211	0.0003	0.0009	0.9913
Energy	Combustion excluding transport, Solid Fuels	N_2O	68.113	42.764	0.0003	0.0007	0.9920
Industrial processes	Aerosols	HFC	0.000	17.706	0.0003	0.0007	0.9927
Waste	Waste Water Handling	CH_4	66.244	74.679	0.0002	0.0006	0.9934
Solvents and other product use	Paint application	CO_2	26.326	8.649	0.0002	0.0006	0.9940
Energy	Combustion excluding transport, Liquid Fuels	N_2O	80.833	58.355	0.0002	0.0006	0.9945

Continued							
Industrial processes	Other, lubricants	CO_2	49.706	31.190	0.0002	0.0005	0.9951
Industrial processes	Electrical equipment	SF_6	3.908	14.560	0.0002	0.0005	0.9955
Agriculture	Agriculture soils, direct emissions , Cultivation of Histosols	N_2O	171.839	164.572	0.0002	0.0004	0.9960
Agriculture	Agriculture soils, direct emissions , Crop Residue	N_2O	361.266	311.968	0.0002	0.0004	0.9964
Industrial processes	Other i.e. Fibre Optics	HFC and PFC	0.000	9.063	0.0001	0.0004	0.9968
Solvents and other product use	Chemical Products, Manufacture and Processing	CO_2	23.074	12.218	0.0001	0.0003	0.9971
Waste	Waste, other	CO_2	22.024	27.665	0.0001	0.0003	0.9974
Energy	Combustion excluding transport, Solid Fuels	CH_4	12.876	4.256	0.0001	0.0003	0.9977
Industrial processes	Expanded clay	CO_2	14.929	6.482	0.0001	0.0003	0.9980
Agriculture	Agriculture soils, direct emissions , N-fixing Crops	N_2O	269.467	247.652	0.0001	0.0003	0.9983
Energy	Fugitive emissions , 1B2c2ii, Flaring gas	CO_2	276.165	240.816	0.0001	0.0002	0.9985
Industrial processes	Glass production	CO_2	17.407	10.753	0.0001	0.0002	0.9987
Energy	Combustion excluding transport, Other Fuels	N_2O	2.415	6.651	0.0001	0.0002	0.9989
Energy	Fugitive emissions , 1B2c2i, Flaring oil	CO_2	23.719	16.870	0.0001	0.0002	0.9991
Industrial processes	Bricks	CO_2	23.016	16.479	0.0001	0.0002	0.9993
Energy	Fugitive emissions , 1B2biii, Gas transmission	CH_4	3.568	0.193	0.0000	0.0001	0.9994
Energy	Domestic navigation	N_2O	15.047	10.878	0.0000	0.0001	0.9995
Industrial processes	Food and drink	CO_2	4.450	1.921	0.0000	0.0001	0.9996
Energy	Fugitive emissions , 1B2biv, Gas distribution	CH_4	5.327	2.827	0.0000	0.0001	0.9996
Industrial processes	Catalysts/Fertilizers, Pesticides and Sulphuric acid	CO_2	0.800	2.129	0.0000	0.0001	0.9997
Agriculture	Field Burning of Agricultural Residues	CH_4	1.824	2.868	0.0000	0.0001	0.9998
Energy	Fugitive emissions , 1B2c Venting	CH_4	0.000	1.113	0.0000	0.0000	0.9998
Energy	Fugitive emissions , 1B2c2i, Flaring oil	CH_4	1.323	0.113	0.0000	0.0000	0.9998
Energy	Fugitive emissions , 1B2c2ii, Flaring gas	CH_4	0.477	1.134	0.0000	0.0000	0.9999
Waste	Waste incineration	CO_2	2.552	2.935	0.0000	0.0000	0.9999
Agriculture	Field Burning of Agricultural Residues	N_2O	0.698	1.098	0.0000	0.0000	0.9999
Waste	Waste incineration	CH_4	2.273	1.592	0.0000	0.0000	0.9999
Energy	Railways	N_2O	2.535	1.967	0.0000	0.0000	0.9999
Energy	Civil aviation	N_2O	3.525	2.905	0.0000	0.0000	1.0000
Energy	Combustion excluding transport, Other Fuels	CH_4	0.455	0.620	0.0000	0.0000	1.0000
Energy	Combustion excluding transport, Liquid Fuels	CH_4	11.155	10.181	0.0000	0.0000	1.0000
Energy	Domestic navigation	CH_4	0.710	0.779	0.0000	0.0000	1.0000
Energy	Railways	CH_4	0.259	0.140	0.0000	0.0000	1.0000
Waste	Waste incineration	N_2O	1.297	1.087	0.0000	0.0000	1.0000
Energy	Fugitive emissions , 1B2c2i, Flaring oil	N_2O	0.128	0.043	0.0000	0.0000	1.0000
Energy	Civil aviation	CH_4	0.158	0.211	0.0000	0.0000	1.0000
Industrial processes	Road Paving with asphalt	CO_2	1.762	1.645	0.0000	0.0000	1.0000
Energy	Fugitive emissions , 1B2c2ii, Flaring gas	N_2O	0.701	0.563	0.0000	0.0000	1.0000
Industrial processes	Asphalt roofing	CO_2	0.019	0.016	0.0000	0.0000	1.0000
Solvents and other product use	Degreasing and Dry Cleaning	CO_2	0.000	0.000	0.0000	0.0000	1.0000
Total			68947.092	61618.541		1.0000	

Table 17.8 Key Category Analysis for Denmark and Greenland, trend assessment, incl. LULUCF.

IPCC Source Categories (LULUCF included)		GHG	Base Year Estimate Ex,o Gg CO_2-eq	Year 2009 Estimate Ex,t Gg CO_2-eq	Trend Assess-ment Tx,t	Contri-bution to Trend	Cumulative total
Energy	Combustion excluding transport, Gaseous Fuels	CO_2	4335.230	9379.802	0.0781	0.2119	0.2119
Energy	Road transportation	CO_2	9318.650	12159.878	0.0590	0.1602	0.3721
Energy	Combustion excluding transport, Solid Fuels	CO_2	23982.671	15808.465	0.0587	0.1592	0.5313
Energy	Combustion excluding transport, Liquid Fuels	CO_2	12239.564	7933.809	0.0318	0.0862	0.6175
LULUCF	Forest Land remaining Forest L., 5A1 Conifers	CO_2	-65.884	-1579.375	0.0204	0.0555	0.6730
LULUCF	Cropland, 5B Cropland rem. Cr. Mineral soils	CO_2	1054.016	-191.765	0.0146	0.0397	0.7127
Energy	Combustion excluding transport, Other Fuels	CO_2	394.825	1271.553	0.0128	0.0347	0.7474
Industrial processes	Nitric acid production	N_2O	1042.902	0.000	0.0119	0.0323	0.7797
Agriculture	Agriculture soils, direct emissions , Synthetic Fertilizers	N_2O	2394.649	1196.677	0.0110	0.0300	0.8097
Industrial processes	Refrigeration and AC Equipment	HFC and PFC	35.677	697.102	0.0091	0.0246	0.8343
Agriculture	Agriculture soils, indirect, Nitrogen Leaching and Run-off	N_2O	2455.755	1416.791	0.0088	0.0238	0.8580
Agriculture	Manure Management	CH_4	976.108	1228.047	0.0056	0.0151	0.8731
LULUCF	Agricultural lime application, 5IV Cropland Limestone	CO_2	622.931	186.241	0.0046	0.0124	0.8855
LULUCF	Forest Land remaining Forest L., 5A1 Broadleaves	CO_2	-659.039	-1011.757	0.0034	0.0091	0.8946
Agriculture	Agriculture soils, direct emissions , Animal Manure Appl. to Soils	N_2O	1096.941	1163.740	0.0033	0.0090	0.9036
Energy	Combustion excluding transport, Gaseous Fuels	CH_4	3.659	197.509	0.0026	0.0072	0.9108
LULUCF	Cropland, 5B Cropland rem. Cr. Organic soils	CO_2	1343.270	1281.690	0.0021	0.0057	0.9165
Agriculture	Enteric Fermentation	CH_4	3254.582	2864.303	0.0018	0.0049	0.9214
LULUCF	Grassland, 5C Grassland rem. Grassland. Living biomass	CO_2	159.442	6.811	0.0017	0.0047	0.9261
Waste	Solid Waste Disposal Sites	CH_4	1114.483	1043.245	0.0015	0.0040	0.9301
LULUCF	Grassland, 5C Land converted to Grassland, Living biomass	CO_2	144.634	26.950	0.0013	0.0035	0.9336
Agriculture	Agriculture soils, indirect, Atmospheric Deposition	N_2O	465.392	296.294	0.0013	0.0035	0.9371
Energy	Combustion excluding transport, Biomass	CH_4	106.390	176.587	0.0012	0.0032	0.9403
Energy	Fugitive emissions , 1B2aiv, Oil refining and storage	CH_4	32.808	111.262	0.0011	0.0031	0.9434
LULUCF	Land converted to Forest L., 5A2 Broadleaves	CO_2	3.395	-78.383	0.0011	0.0030	0.9464
Agriculture	Manure Management	N_2O	604.740	427.038	0.0011	0.0030	0.9493
LULUCF	Land converted to Forest L., 5A2 Conifers	CO_2	7.110	-66.926	0.0010	0.0027	0.9520
Energy	Domestic navigation	CO_2	816.814	623.557	0.0008	0.0023	0.9543
Agriculture	Agriculture soils, direct emissions , Sludge	N_2O	27.923	81.173	0.0008	0.0021	0.9564
Industrial processes	Foam Blowing	HFC	182.578	95.714	0.0008	0.0021	0.9586
Waste	Waste, other	CH_4	29.385	80.975	0.0008	0.0021	0.9606
LULUCF	Wetlands, 5D Wetlands, soils	CO_2	86.080	16.205	0.0008	0.0021	0.9627
LULUCF	Cropland, 5B Cropland remaining Cr. Living biomass	CO_2	153.378	73.111	0.0008	0.0021	0.9647
Energy	Combustion excluding transport, Biomass	N_2O	42.872	90.197	0.0007	0.0020	0.9668
Industrial processes	Lime production	CO_2	115.532	43.249	0.0007	0.0020	0.9687
Agriculture	Agriculture soils, pasture, range and paddock	N_2O	311.784	213.520	0.0007	0.0018	0.9705
Energy	Road transportation	N_2O	93.573	119.212	0.0006	0.0015	0.9720
Solvents and other product use	Other solvent	N_2O	0.767	37.005	0.0005	0.0013	0.9733
Energy	Civil aviation	CO_2	281.013	200.769	0.0005	0.0013	0.9746
Waste	N2O indirect from human sewage	N_2O	85.233	36.529	0.0005	0.0013	0.9759
Industrial processes	Other emissions of SF6 i.e. from double glaze windows and laboratories	SF6	67.616	22.128	0.0005	0.0013	0.9772
Waste	Waste, other	N_2O	11.198	40.499	0.0004	0.0011	0.9784
Industrial processes	Magnesium Production	SF6	35.850	0.000	0.0004	0.0011	0.9795
Energy	Road transportation	CH_4	52.624	15.059	0.0004	0.0011	0.9805
Solvents and other product use	Other solvent	CO_2	86.022	44.070	0.0004	0.0010	0.9816

Continued							
Energy	Combustion excluding transport, Gaseous Fuels	N_2O	16.177	40.741	0.0004	0.0010	0.9826
Industrial processes	Limestone and dolomite use	CO_2	13.692	37.921	0.0004	0.0010	0.9836
Waste	N2O direct, Domestic and Commercial Wastewater	N_2O	39.447	57.211	0.0003	0.0009	0.9844
LULUCF	Grassland, 5C Land converted to Cropland. Dead Org. Matter	CO_2	31.708	2.611	0.0003	0.0009	0.9853
Industrial processes	Cement production	CO_2	882.402	764.407	0.0003	0.0009	0.9862
Industrial processes	Iron and steel production	CO_2	28.447	0.000	0.0003	0.0009	0.9871
LULUCF	Grassland, 5C Land converted to Grassland, Mineral soils	CO_2	1.036	24.397	0.0003	0.0009	0.9880
Agriculture	Agriculture soils, direct emissions , N-fixing Crops	N_2O	269.467	247.652	0.0003	0.0008	0.9888
Agriculture	Agriculture soils, direct emissions , Cultivation of Histosols	N_2O	171.839	164.572	0.0003	0.0008	0.9895
LULUCF	Settlements, 5E Total settlements	CO_2	89.505	54.746	0.0003	0.0008	0.9903
Waste	Waste Water Handling	CH_4	66.244	74.679	0.0003	0.0007	0.9910
Energy	Railways	CO_2	296.745	230.202	0.0003	0.0007	0.9917
Industrial processes	Aerosols	HFC	0.000	17.706	0.0002	0.0007	0.9923
LULUCF	Cropland, 5B Land converted to Cropland. Living biomass	CO_2	20.629	2.606	0.0002	0.0005	0.9929
Energy	Combustion excluding transport, Solid Fuels	N_2O	68.113	42.764	0.0002	0.0005	0.9934
Solvents and other product use	Paint application	CO_2	26.326	8.649	0.0002	0.0005	0.9939
LULUCF	Grassland, 5C Land converted to Grassland, Organic soils	CO_2	0.732	12.908	0.0002	0.0005	0.9943
LULUCF	Wetlands, 5D Wetlands Living biomass	CO_2	0.370	-11.328	0.0002	0.0004	0.9948
Industrial processes	Electrical equipment	SF6	3.908	14.560	0.0002	0.0004	0.9952
Industrial processes	Other, lubricants	CO_2	49.706	31.190	0.0001	0.0004	0.9956
LULUCF	Grassland, 5C Grassland rem. Grassland. Organic soils	CO_2	136.487	124.594	0.0001	0.0004	0.9959
Energy	Combustion excluding transport, Liquid Fuels	N_2O	80.833	58.355	0.0001	0.0003	0.9963
Waste	Waste, other	CO_2	22.024	27.665	0.0001	0.0003	0.9966
Energy	Fugitive emissions , 1B2c2ii, Flaring gas	CO_2	276.165	240.816	0.0001	0.0003	0.9970
Industrial processes	Other i.e. Fibre Optics	HFC and PFC	0.000	9.063	0.0001	0.0003	0.9973
Agriculture	Agriculture soils, direct emissions , Crop Residue	N_2O	361.266	311.968	0.0001	0.0003	0.9976
Solvents and other product use	Chemical Products, Manufacture and Processing	CO_2	23.074	12.218	0.0001	0.0003	0.9979
Energy	Combustion excluding transport, Solid Fuels	CH_4	12.876	4.256	0.0001	0.0002	0.9981
Industrial processes	Expanded clay	CO_2	14.929	6.482	0.0001	0.0002	0.9984
LULUCF	Cropland, 5B Land converted to Cropland. Mineral soils	CO_2	-0.385	-6.245	0.0001	0.0002	0.9986
Energy	Combustion excluding transport, Other Fuels	N_2O	2.415	6.651	0.0001	0.0002	0.9987
Industrial processes	Glass production	CO_2	17.407	10.753	0.0001	0.0001	0.9989
LULUCF	Cropland, 5B Land converted to Cropland. Dead Org. Matter	CO_2	6.026	1.306	0.0001	0.0001	0.9990
Energy	Fugitive emissions , 1B2c2i, Flaring oil	CO_2	23.719	16.870	0.0000	0.0001	0.9991
Industrial processes	Bricks	CO_2	23.016	16.479	0.0000	0.0001	0.9992
Energy	Fugitive emissions , 1B2biii, Gas transmission	CH_4	3.568	0.193	0.0000	0.0001	0.9993
LULUCF	N2O Disturbance, Land converted to cropland, 5III Cropland	N_2O	3.191	0.411	0.0000	0.0001	0.9994
Industrial processes	Food and drink	CO_2	4.450	1.921	0.0000	0.0001	0.9995
Energy	Domestic navigation	N_2O	15.047	10.878	0.0000	0.0001	0.9996
Energy	Fugitive emissions , 1B2biv, Gas distribution	CH_4	5.327	2.827	0.0000	0.0001	0.9996
Industrial processes	Catalysts/Fertilizers, Pesticides and Sulphuric acid	CO_2	0.800	2.129	0.0000	0.0001	0.9997
Agriculture	Field Burning of Agricultural Residues	CH_4	1.824	2.868	0.0000	0.0000	0.9997
Energy	Fugitive emissions , 1B2c Venting	CH_4	0.000	1.113	0.0000	0.0000	0.9998
LULUCF	Non-CO2 drainage of soils and wetlands, 5IID Forest Land.	N_2O	15.659	12.037	0.0000	0.0000	0.9998
Energy	Fugitive emissions , 1B2c2i, Flaring oil	CH_4	1.323	0.113	0.0000	0.0000	0.9998
Energy	Combustion excluding transport, Liquid Fuels	CH_4	11.155	10.181	0.0000	0.0000	0.9999
Waste	Waste incineration	CO_2	2.552	2.935	0.0000	0.0000	0.9999
Energy	Fugitive emissions , 1B2c2ii, Flaring gas	CH_4	0.477	1.134	0.0000	0.0000	0.9999
Agriculture	Field Burning of Agricultural Residues	N_2O	0.698	1.098	0.0000	0.0000	0.9999
Waste	Waste incineration	CH_4	2.273	1.592	0.0000	0.0000	1.0000
Energy	Combustion excluding transport, Other Fuels	CH_4	0.455	0.620	0.0000	0.0000	1.0000

Continued							
Energy	Domestic navigation	CH_4	0.710	0.779	0.0000	0.0000	1.0000
Industrial processes	Road Paving with asphalt	CO_2	1.762	1.645	0.0000	0.0000	1.0000
Energy	Railways	N_2O	2.535	1.967	0.0000	0.0000	1.0000
Energy	Civil aviation	CH_4	0.158	0.211	0.0000	0.0000	1.0000
Energy	Railways	CH_4	0.259	0.140	0.0000	0.0000	1.0000
Energy	Fugitive emissions , 1B2c2i, Flaring oil	N_2O	0.128	0.043	0.0000	0.0000	1.0000
Energy	Civil aviation	N_2O	3.525	2.905	0.0000	0.0000	1.0000
LULUCF	Cropland, 5B Land converted to Cropland. Organic soils	CO_2	0.000	0.030	0.0000	0.0000	1.0000
LULUCF	Wetlands, 5D Wetlands, dead org. matter	CO_2	0.094	0.109	0.0000	0.0000	1.0000
LULUCF	Forest Land remaining Forest L., 5A1 Other Conifers (Greenland)	CO_2	0.000	-0.028	0.0000	0.0000	1.0000
Energy	Fugitive emissions , 1B2c2ii, Flaring gas	N_2O	0.701	0.563	0.0000	0.0000	1.0000
LULUCF	Non-CO2 drainage of soils and wetlands, 5IID Wetlands. Peatland	N_2O	0.135	0.135	0.0000	0.0000	1.0000
LULUCF	Forest Land remaining Forest L., 5A1 Larch (Greenland)	CO_2	0.000	-0.002	0.0000	0.0000	1.0000
Waste	Waste incineration	N_2O	1.297	1.087	0.0000	0.0000	1.0000
Solvents and other product use	Degreasing and Dry Cleaning	CO_2	0.000	0.000	0.0000	0.0000	1.0000
Industrial processes	Asphalt roofing	CO_2	0.019	0.016	0.0000	0.0000	1.0000
Total			72101.612	60499.630		1.000	

Table 17.9 Key Category Analysis for Denmark and Greenland, overview.

IPCC Source Categories		GHG	Key categories with number					
			Excluding LULUCF			Including LULUCF		
			Level Tier1 1990	Level Tier1 2009	Trend Tier1 1990-2009	Level Tier1 1990	Level Tier1 2009	Trend Tier1 1990-2009
Energy	Combustion excluding transport, Liquid Fuels	CO_2	2	4	4	2	4	4
Energy	Combustion excluding transport, Solid Fuels	CO_2	1	1	1	1	1	3
Energy	Combustion excluding transport, Gaseous Fuels	CO_2	4	3	2	4	3	1
Energy	Combustion excluding transport, Other Fuels	CO_2	16	7	7	20	9	7
Energy	Combustion excluding transport, Liquid Fuels	CH_4						
Energy	Combustion excluding transport, Solid Fuels	CH_4						
Energy	Combustion excluding transport, Gaseous Fuels	CH_4			11			16
Energy	Combustion excluding transport, Biomass	CH_4						23
Energy	Combustion excluding transport, Other Fuels	CH_4						
Energy	Combustion excluding transport, Liquid Fuels	N_2O						
Energy	Combustion excluding transport, Solid Fuels	N_2O						
Energy	Combustion excluding transport, Gaseous Fuels	N_2O						
Energy	Combustion excluding transport, Biomass	N_2O						
Energy	Combustion excluding transport, Other Fuels	N_2O						
Energy	Road transportation	CO_2	3	2	3	3	2	2
Energy	Road transportation	CH_4						
Energy	Road transportation	N_2O						
Energy	Civil aviation	CO_2						
Energy	Civil aviation	CH_4						
Energy	Civil aviation	N_2O						
Energy	Domestic navigation	CO_2	13	14	15	15	17	
Energy	Domestic navigation	CH_4						
Energy	Domestic navigation	N_2O						
Energy	Railways	CO_2				23	23	
Energy	Railways	CH_4						
Energy	Railways	N_2O						
Energy	Fugitive emissions , 1B2aiv, Oil refining and storage	CH_4			16			24
Energy	Fugitive emissions , 1B2biii, Gas transmission	CH_4						
Energy	Fugitive emissions , 1B2biv, Gas distribution	CH_4						
Energy	Fugitive emissions , 1B2c Venting	CH_4						
Energy	Fugitive emissions , 1B2c2ii, Flaring gas	CO_2					22	
Energy	Fugitive emissions , 1B2c2ii, Flaring gas	CH_4						
Energy	Fugitive emissions , 1B2c2ii, Flaring gas	N_2O						
Energy	Fugitive emissions , 1B2c2i, Flaring oil	CO_2						
Energy	Fugitive emissions , 1B2c2i, Flaring oil	CH_4						
Energy	Fugitive emissions , 1B2c2i, Flaring oil	N_2O						
Industrial processes	Cement production	CO_2	12	12		14	15	
Industrial processes	Lime production	CO_2						
Industrial processes	Limestone and dolomite use	CO_2						
Industrial processes	Asphalt roofing	CO_2						
Industrial processes	Road Paving with asphalt	CO_2						
Industrial processes	Glass production	CO_2						
Industrial processes	Bricks	CO_2						
Industrial processes	Expanded clay	CO_2						
Industrial processes	Nitric acid production	N_2O	10		6	12		8

Continued

Industrial processes	Catalysts/Fertilizers, Pesticides and Sulphuric acid	CO_2						
Industrial processes	Iron and steel production	CO_2						
Industrial processes	Food and drink	CO_2						
Industrial processes	Refrigeration and AC Equipment	HFC and PFC		13	9		16	10
Industrial processes	Foam Blowing	HFC						
Industrial processes	Aerosols	HFC						
Industrial processes	Electrical equipment	SF6						
Industrial processes	Other emissions of SF6 i.e. from double glaze windows and laboratories	SF6						
Industrial processes	Other i.e. Fibre Optics	HFC and PFC						
Industrial processes	Magnesium Production	SF6						
Industrial processes	Other, lubricants	CO_2						
Solvents and other product use	Paint application	CO_2						
Solvents and other product use	Degreasing and Dry Cleaning	CO_2						
Solvents and other product use	Chemical Products, Manufacture and Processing	CO_2						
Solvents and other product use	Other solvent	CO_2						
Solvents and other product use	Other solvent	N_2O						
Agriculture	Enteric Fermentation	CH_4	5	5		5	5	18
Agriculture	Manure Management	CH_4	11	8	10	13	10	12
Agriculture	Manure management	N_2O	14	15	14	18	18	26
Agriculture	Agriculture soils, direct emissions , Synthetic Fertilizers	N_2O	7	9	5	7	11	9
Agriculture	Agriculture soils, direct emissions , Animal Manure Appl. to Soils	N_2O	9	10	12	10	12	15
Agriculture	Agriculture soils, direct emissions , N-fixing Crops	N_2O					21	
Agriculture	Agriculture soils, direct emissions , Crop Residue	N_2O	17	16		21	19	
Agriculture	Agriculture soils, direct emissions , Cultivation of Histosols	N_2O						
Agriculture	Agriculture soils, direct emissions , Sludge	N_2O						
Agriculture	Agriculture soils, pasture, range and paddock	N_2O				22		
Agriculture	Agriculture soils, indirect, Atmospheric Deposition	N_2O	15	17	13	19	20	22
Agriculture	Agriculture soils, indirect, Nitrogen Leaching and Run-off	N_2O	6	6	8	6	7	11
Agriculture	Field Burning of Agricultural Residues	CH_4						
Agriculture	Field Burning of Agricultural Residues	N_2O						
Waste	Solid Waste Disposal Sites	CH_4	8	11		9	13	20
Waste	N2O direct, Domestic and Commercial Wastewater	N_2O						
Waste	N2O indirect from human sewage	N_2O						
Waste	Waste Water Handling	CH_4						
Waste	Waste incineration	CO_2						
Waste	Waste incineration	CH_4						
Waste	Waste incineration	N_2O						
Waste	Waste, other	CO_2						
Waste	Waste, other	CH_4						
Waste	Waste, other	N_2O						
LULUCF	Forest Land remaining Forest L., 5A1 Broadleaves	CO_2				16	14	14
LULUCF	Forest Land remaining Forest L., 5A1 Conifers	CO_2					6	5
LULUCF	Forest Land remaining Forest L., 5A1 Larch (Greenland)	CO_2						
LULUCF	Forest Land remaining Forest L., 5A1 Other Conifers (Greenland)	CO_2						
LULUCF	Land converted to Forest L., 5A2 Broadleaves	CO_2						25
LULUCF	Land converted to Forest L., 5A2 Conifers	CO_2						27
LULUCF	Cropland, 5B Cropland rem. Cr. Organic soils	CO_2				8	8	17
LULUCF	Cropland, 5B Cropland rem. Cr. Mineral soils	CO_2				11		6
LULUCF	Cropland, 5B Cropland remaining Cr. Living biomass	CO_2						
LULUCF	Cropland, 5B Land converted to Cropland. Organic soils	CO_2						

Continued								
LULUCF	Cropland, 5B Land converted to Cropland. Mineral soils	CO_2						
LULUCF	Cropland, 5B Land converted to Cropland. Living biomass	CO_2						
LULUCF	Cropland, 5B Land converted to Cropland. Dead Org. Matter	CO_2						
LULUCF	Grassland, 5C Grassland rem. Grassland. Organic soils	CO_2						
LULUCF	Grassland, 5C Grassland rem. Grassland. Living biomass	CO_2						19
LULUCF	Grassland, 5C Land converted to Grassland, Living biomass	CO_2						21
LULUCF	Grassland, 5C Land converted to Cropland. Dead Org. Matter	CO_2						
LULUCF	Grassland, 5C Land converted to Grassland, Organic soils	CO_2						
LULUCF	Grassland, 5C Land converted to Grassland, Mineral soils	CO_2						
LULUCF	Wetlands, 5D Wetlands Living biomass	CO_2						
LULUCF	Wetlands, 5D Wetlands, dead org. matter	CO_2						
LULUCF	Wetlands, 5D Wetlands, soils	CO_2						
LULUCF	Settlements, 5E Total settlements	CO_2						
LULUCF	Non-CO2 drainage of soils and wetlands, 5IID Forest Land.	N_2O						
LULUCF	Non-CO2 drainage of soils and wetlands, 5IID Wetlands. Peatland	N_2O						
LULUCF	N2O Disturbance, Land converted to cropland, 5III Cropland	N_2O						
LULUCF	Agricultural lime application, 5IV Cropland Limestone	CO_2				17		13

17.5 Recalculations

17.5.1 Implications for emission levels

For the national total CO_2 equivalent emissions without Land-Use, Land-Use Change and Forestry, the general impact of the improvements and recalculations performed is small and the changes for the whole time-series are between -0.37 % (2007) and -1.61 % (1996). Therefore, the implications of the recalculations on the level and on the trend, 1990-2008, of this national total are small, refer Table 17.10.

For the national total CO_2 equivalent emissions with Land-Use, Land-Use Change and Forestry, the general impact of the recalculations is larger due to recalculations in the LULUCF sector. The changes vary between –7.84 % (2008) and +1.45 % (2001), refer Table 17.10.

The impact of recalculation in the Greenlandic inventory is insignificant compared to the recalculations in the Danish inventory. Therefore the explanations and justifications are not repeated in this Chapter. Detailed information on the recalculations in the Danish inventory is provided in Chapter 10 and in the sectoral Chapters 3-8. The recalculations carried out for the Greenlandic inventory are described in Chapter 16.

Table 17.10 Recalculation performed on national total for 1990-2008. Differences in pct of CO_2-eqv between this submission and the October 2010 submission for Denmark under the Kyoto Protocol, i.e. Denmark & Greenland.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total CO_2 Equiv. Emissions with Land-Use Change and Forestry	-1.03	-1.40	-1.31	-1.43	-0.62	-1.04	-1.49	-1.27	-1.03	-0.61
Total CO_2 Equiv. Emissions without Land-Use Change and Forestry	-1.54	-1.50	-1.50	-1.47	-0.73	-1.19	-1.61	-1.48	-1.13	-1.03
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Total CO_2 Equiv. Emissions with Land-Use Change and Forestry	1.08	1.45	1.43	0.95	1.24	0.98	-0.17	-5.32	-7.84	
Total CO_2 Equiv. Emissions without Land-Use Change and Forestry	-1.04	-0.62	-0.48	-0.97	-0.58	-0.77	-0.56	-0.37	-0.79	

Table 17.11 Recalculation for CO_2 performed in the 2011 submission for 1990-2008. Differences in Gg CO_2-eqv. between this and the October 2010 submission for Denmark under the Kyoto Protocol, i.e. Denmark & Greenland.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total National Emissions and Removals	130	-232	-174	-250	124	-58	-265	-131	-165	113
1. Energy	-200	-282	-271	-274	46	-165	-370	-274	-239	-183
1.A. Fuel Combustion Activities	-200	-282	-271	-274	51	-165	-370	-274	-239	-183
1.A.1. Energy Industries	-263	-384	-371	-414	-12	-158	-358	-271	-225	-199
1.A.2. Manufacturing Industries and Construction	-12	21	105	158	-46	-63	-74	-65	-76	-55
1.A.3. Transport	89	97	98	94	90	87	79	78	78	102
1.A.4. Other Sectors	-14	-16	-102	-112	19	-31	-16	-17	-16	-31
1.A.5. Other	-	-	-	-	-	-	-	-	-	-
1.B. Fugitive Emissions from Fuels	0	0	0	0	-6	0	0	0	0	0
2. Industrial Processes	0	0	0	0	0	0	2	0	0	0
2.A. Mineral Products	0	0	0	0	0	0	2	0	0	0
2.B. Chemical Industry	-	-	-	-	-	-	-	-	-	-
2.C. Metal Production	-	-	-	-	-	-	-	-	-	-
2.D. Other Production	-	-	-	-	-	-	-	-	-	-
2.G. Other	-	-	-	-	-	-	-	-	-	-
3. Solvent and Other Product Use	0	0	0	0	0	0	0	0	0	0
4. Agriculture	-	-	-	-	-	-	-	-	-	-
5. Land Use, Land-Use Change and Forestry (net)	328	49	95	23	77	105	103	142	74	295
5.A. Forest Land	188	155	170	117	142	117	104	107	43	157
5.B. Cropland	-157	-250	-249	-257	-273	-206	-220	-193	-215	-174
5.C. Grassland	271	108	120	99	121	102	109	104	106	145
5.D. Wetlands	0	0	0	0	4	0	0	0	1	1
5.E. Settlements	25	36	54	63	83	93	110	124	139	167
5.F. Other Land	-	-	-	-	-	-	-	-	-	-
5.G. Other	-	-	-	-	-	-	-	-	-	-
6. Waste	1	1	1	1	1	1	1	1	1	1
6.C. Waste Incineration	-21	-21	-23	-21	-22	-24	-25	-24	-22	-24
6.D. Other	22	23	24	22	23	25	26	25	23	25
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Total National Emissions and Removals	1 354	1 539	1 387	1 267	1 204	1 114	354	-3 526	-4 837	
1. Energy	-130	58	16	-185	-67	-44	71	16	-57	
1.A. Fuel Combustion Activities	-130	58	16	-185	-67	-44	71	16	-57	
1.A.1. Energy Industries	-158	-166	-162	-321	-163	-97	40	132	129	
1.A.2. Manufacturing Industries and Construction	-59	-52	-66	-99	-89	-166	-187	-297	-291	
1.A.3. Transport	112	126	121	115	113	115	127	133	132	
1.A.4. Other Sectors	-25	150	123	119	73	105	91	49	-28	
1.A.5. Other	-	-	-	-	0	0	0	-1	1	
1.B. Fugitive Emissions from Fuels	0	0	0	0	0	0	0	0	-	
2. Industrial Processes	0	0	0	0	0	0	0	0	0	
2.A. Mineral Products	0	0	0	0	0	0	0	0	0	
2.B. Chemical Industry	-	-	-	-	-	-	-	-	-	
2.C. Metal Production	-	-	-	-	-	-	-	-	-	
2.D. Other Production	-	-	-	-	-	-	-	-	-	
2.G. Other	-	-	-	-	-	-	-	-	-	
3. Solvent and Other Product Use	0	0	0	0	0	0	0	0	0	
4. Agriculture	-	-	-	-	-	-	-	-	-	
5. Land Use, Land-Use Change and Forestry (net)	1 483	1 480	1 370	1 451	1 269	1 157	283	-3 541	-4 780	
5.A. Forest Land	1 360	1 355	1 221	1 277	1 063	1 028	159	-3 746	-5 008	
5.B. Cropland	-186	-197	-166	-170	-149	-237	-257	-193	-187	
5.C. Grassland	131	129	113	124	121	117	118	119	120	
5.D. Wetlands	1	1	1	1	1	1	1	1	1	
5.E. Settlements	177	191	201	219	233	247	263	278	294	

Continued									
5.F. Other Land	-	-	-	-	-	-	-	-	-
5.G. Other	-	-	-	-	-	-	-	-	-
6. Waste	1	1	1	1	1	1	0	0	0
6.C. Waste Incineration	-23	-23	-23	-24	-22	-23	-25	-26	-29
6.D. Other	24	24	24	25	23	24	25	26	28

Table 17.12 Recalculation for CH_4 performed in the 2011 submission for 1990-2008. Differences in Gg CO_2-eqv. between this and the October 2010 submission for Denmark under the Kyoto Protocol, i.e. Denmark & Greenland.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total National Emissions and Removals	112.96	102.34	89.07	51.80	110.26	103.90	87.04	76.19	76.04	93.42
1. Energy	2.34	2.01	-9.15	-48.76	13.20	13.04	2.39	0.98	-2.37	-1.81
1.A. Fuel Combustion Activities	2.29	1.92	-9.25	-48.84	10.87	10.52	-1.00	-2.07	-4.39	-3.20
1.A.1. Energy Industries	-12.88	-18.96	-23.90	-54.37	-8.89	-9.62	-19.92	-22.23	-19.20	-15.50
1.A.2. Manufacturing Industries and Construction	-6.52	-6.10	-5.15	-4.75	-7.75	-7.71	-8.09	-8.32	-8.03	-8.46
1.A.3. Transport	-2.48	-1.47	-1.15	-1.39	-0.68	-0.59	-0.75	-0.95	-1.24	-1.58
1.A.4. Other Sectors	24.17	28.46	20.96	11.67	28.19	28.43	27.76	29.43	24.09	22.35
1.A.5. Other	0.00	-0.01	-0.01	-0.01	0.00	0.00	0.00	0.00	-0.01	-0.01
1.B. Fugitive Emissions from Fuels	0.05	0.10	0.10	0.09	2.33	2.52	3.39	3.05	2.01	1.39
2. Industrial Processes	-	-	-	-	-	-	-	-	-	-
3. Solvent and Other Product Use	-	-	-	-	-	-	-	-	-	-
4. Agriculture	48.06	34.89	29.89	30.03	25.58	24.42	13.07	-0.87	3.08	10.85
4.A. Enteric Fermentation	-12.59	-16.33	-18.77	-19.05	-16.97	-16.19	-18.65	-24.08	-19.74	-15.13
4.B. Manure Management	60.65	51.22	48.66	49.09	42.55	40.61	31.71	23.21	22.82	25.98
4.F. Field Burning of Agricultural Residues	-	-	-	-	-	-	-	-	-	-
5. Land Use, Land-Use Change and Forestry (net)	-	-	-	-	-	-	-	-	-	-
6. Waste	62.56	65.44	68.32	70.53	71.48	66.44	71.58	76.09	75.33	84.38
6.A. Solid Waste Disposal on Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6.B. Waste-water Handling	35.81	36.01	36.13	35.69	33.85	32.01	30.72	29.46	26.84	27.23
6.C. Waste Incineration	-2.64	-2.72	-2.93	-2.63	-2.65	-3.04	-3.08	-2.88	-2.62	-2.80
6.D. Other	29.39	32.14	35.12	37.46	40.27	37.47	43.93	49.51	51.11	59.96
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Total National Emissions and Removals	75.97	102.92	87.25	93.05	92.78	95.86	54.19	74.29	69.83	
1. Energy	-2.31	-9.21	-11.26	-14.06	-5.66	-12.01	-22.03	-21.05	-1.44	
1.A. Fuel Combustion Activities	-2.25	-9.34	-11.36	-14.16	-5.77	-12.09	-22.11	-19.46	-0.09	
1.A.1. Energy Industries	-13.62	-12.91	-13.00	-14.97	-6.68	-8.44	-5.92	-1.42	30.94	
1.A.2. Manufacturing Industries and Construction	-7.99	-7.92	-6.34	-6.55	-6.20	-4.18	-5.60	-5.98	-5.83	
1.A.3. Transport	-1.95	-2.02	-2.23	-2.76	-2.87	-3.49	-3.57	-3.70	-3.85	
1.A.4. Other Sectors	21.31	13.53	10.23	10.13	10.01	4.05	-7.00	-8.35	-21.33	
1.A.5. Other	0.00	-0.01	-0.01	-0.01	-0.03	-0.03	-0.01	-0.02	-0.02	
1.B. Fugitive Emissions from Fuels	-0.06	0.13	0.10	0.10	0.11	0.08	0.08	-1.59	-1.35	
2. Industrial Processes	-	-	-	-	-	-	-	-	-	
3. Solvent and Other Product Use	-	-	-	-	-	-	-	-	-	
4. Agriculture	-11.48	21.68	14.50	20.26	13.03	16.26	-20.18	-8.24	-25.60	
4.A. Enteric Fermentation	-24.46	-11.37	-19.27	-14.77	-15.07	-13.71	-22.78	-20.07	-23.26	
4.B. Manure Management	12.99	33.05	33.77	35.03	28.10	29.98	2.60	11.83	-2.34	
4.F. Field Burning of Agricultural Residues	-	-	-	-	-	-	-	-	-	
5. Land Use, Land-Use Change and Forestry (net)	-	-	-	-	-	-	-	-	-	
6. Waste	89.75	90.45	84.01	86.85	85.41	91.61	96.40	103.58	96.86	
6.A. Solid Waste Disposal on Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
6.B. Waste-water Handling	29.10	28.36	23.04	23.30	25.02	26.67	27.75	27.01	27.14	
6.C. Waste Incineration	-2.76	-2.72	-2.64	-2.93	-2.58	-2.68	-2.92	-3.21	-3.30	
6.D. Other	63.41	64.80	63.61	66.47	62.97	67.61	71.56	79.78	73.02	

Table 17.13 Recalculation for N_2O performed in the 2011 submission for 1990-2008. Differences in Gg CO_2-eqv. between this and the October 2010 submission for Denmark under the Kyoto Protocol, i.e. Denmark & Greenland.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total National Emissions and Removals	-990.17	-1025.99	-935.89	-902.07	-744.12	-861.40	-1182.77	-996.71	-705.05	-671.82
1. Energy	-72.44	-73.54	-65.72	-71.74	-78.31	-83.29	-92.12	-83.87	-81.59	-77.31
1.A. Fuel Combustion Activities	-72.50	-73.68	-65.86	-71.86	-78.41	-83.35	-92.19	-84.01	-81.70	-77.54
1.A.1. Energy Industries	-33.55	-35.34	-34.31	-33.78	-35.07	-37.86	-46.53	-41.72	-41.12	-37.22
1.A.2. Manufacturing Industries and Construction	-2.27	-0.20	1.67	-1.71	-10.34	-14.27	-14.72	-16.46	-16.19	-16.62
1.A.3. Transport	-1.94	-3.05	-2.23	-2.19	-2.77	-0.96	0.47	2.43	2.54	3.14
1.A.4. Other Sectors	-34.74	-35.03	-30.95	-34.15	-30.19	-30.18	-31.38	-28.22	-26.89	-26.83
1.A.5. Other	0.00	-0.05	-0.03	-0.03	-0.04	-0.08	-0.03	-0.05	-0.04	-0.02
1.B. Fugitive Emissions from Fuels	0.07	0.14	0.14	0.12	0.10	0.06	0.08	0.15	0.11	0.23
2. Industrial Processes	-	-	-	-	-	-	-	-	-	-
3. Solvent and Other Product Use	0.77	1.02	1.10	0.97	1.18	1.80	1.65	1.30	2.11	4.00
4. Agriculture	-932.99	-969.29	-888.14	-849.47	-683.46	-800.07	-1115.32	-939.99	-655.92	-637.62
4.A. Enteric Fermentation	-	-	-	-	-	-	-	-	-	-
4.B. Manure Management	11.18	10.49	11.15	10.62	8.19	13.06	12.34	12.82	15.35	17.48
4.D. Agricultural Soils	-944.17	-979.78	-899.29	-860.09	-691.64	-813.14	-1127.65	-952.81	-671.27	-655.09
4.F. Field Burning of Agricultural Residues	-	-	-	-	-	-	-	-	-	-
5. Land Use, Land-Use Change and Forestry (net)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.A. Forest Land	-	-	-	-	-	-	-	-	-	-
5.B. Cropland	-	-	-	-	-	-	-	-	-	-
5.C. Grassland	-	-	-	-	-	-	-	-	-	-
5.D. Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.E. Settlements	-	-	-	-	-	-	-	-	-	-
5.F. Other Land	-	-	-	-	-	-	-	-	-	-
5.G. Other	-	-	-	-	-	-	-	-	-	-
6. Waste	14.49	15.83	16.87	18.17	16.48	20.17	23.02	25.85	30.35	39.10
6.B. Waste-water Handling	3.29	3.45	3.25	3.36	0.46	4.81	5.06	5.21	5.67	5.54
6.C. Waste Incineration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6.D. Other	11.20	12.38	13.62	14.81	16.02	15.36	17.96	20.64	24.68	33.56
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Total National Emissions and Removals	-664.96	-601.10	-443.12	-633.30	-426.13	-550.29	-535.80	-342.80	-526.71	
1. Energy	-70.49	-65.55	-59.03	-54.38	-51.12	-50.07	-47.54	-47.42	-46.80	
1.A. Fuel Combustion Activities	-70.65	-65.71	-59.16	-54.52	-51.28	-50.18	-47.64	-47.50	-46.88	
1.A.1. Energy Industries	-35.09	-33.87	-32.64	-26.35	-22.87	-21.78	-23.49	-21.98	-20.69	
1.A.2. Manufacturing Industries and Construction	-15.96	-17.02	-13.97	-16.84	-17.61	-18.66	-15.92	-19.13	-18.90	
1.A.3. Transport	3.53	5.72	6.31	6.70	7.10	6.02	6.22	6.40	6.27	
1.A.4. Other Sectors	-23.13	-20.54	-18.86	-18.04	-17.92	-15.78	-14.46	-12.78	-13.56	
1.A.5. Other	0.00	0.00	0.00	0.01	0.02	0.01	0.00	0.00	0.00	
1.B. Fugitive Emissions from Fuels	0.15	0.16	0.13	0.14	0.15	0.11	0.11	0.08	0.08	
2. Industrial Processes	-	-	-	-	-	-	-	-	-	
3. Solvent and Other Product Use	2.91	2.30	2.84	3.63	5.18	2.21	2.53	2.68	2.62	
4. Agriculture	-644.00	-584.82	-444.48	-638.83	-415.40	-540.86	-530.60	-348.75	-525.59	
4.A. Enteric Fermentation	-	-	-	-	-	-	-	-	-	
4.B. Manure Management	14.76	20.71	20.73	24.36	24.21	16.83	12.32	13.92	-14.78	
4.D. Agricultural Soils	-658.76	-605.53	-465.20	-663.19	-439.61	-557.69	-542.92	-362.67	-510.82	
4.F. Field Burning of Agricultural Residues	-	-	-	-	-	-	-	-	-	
5. Land Use, Land-Use Change and Forestry (net)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
5.A. Forest Land	-	-	-	-	-	-	0.00	0.00	0.00	

Continued									
5.B. Cropland	-	-	-	-	-	-	-	-	-
5.C. Grassland	-	-	-	-	-	-	-	-	-
5.D. Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.E. Settlements	-	-	-	-	-	-	-	-	-
5.F. Other Land	-	-	-	-	-	-	-	-	-
5.G. Other	-	-	-	-	-	-	-	-	-
6. Waste	46.62	46.98	57.54	56.28	35.21	38.43	39.81	50.68	43.06
6.B. Waste-water Handling	6.04	6.16	7.88	6.28	5.60	7.26	5.84	11.85	6.89
6.C. Waste Incineration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6.D. Other	40.58	40.82	49.65	50.00	29.61	31.17	33.97	38.83	36.18

Table 17.14 Recalculation for HFCs, PFCs and SF_6 performed in the 2011 submission for 1990-2008. Differences in Gg CO_2-eqv. between this and the October 2010 submission for Denmark under the Kyoto Protocol, i.e. Denmark & Greenland.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
HFC	-	-	-	-	-	-	-	-	-	-
PFC	-	-	-	-	-	-	-	-	-	-
SF6	-	-	-	-	-	-	-	-	-	-
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	
HFC	-	-	-	-	-	-	-	-	-	
PFC	-	-	-	-	-	-	-	-	-	
SF6	-	-	-	-	-	-	-	-	-	

17.6 Technical description of the aggregation of the emission inventories of Denmark and Greenland

In order to accommodate the request of the ERT of full inclusion of the Greenlandic emission data in the full CRF format, Denmark operates separate installations for Denmark and Greenland (and the Faroe Islands). The country identification codes provided by the UNFCCC secretariat are DNM for Denmark and GRL for Greenland (FRO for the Faroe Islands). Two additional installations are necessary to enable the submission of aggregated submissions under the Kyoto Protocol (Denmark and Greenland) and under UNFCCC (Denmark, Greenland and the Faroe Islands). The country identification codes provided by the UNFCCC secretariat are DKE for the submission under the Kyoto Protocol (Denmark and Greenland) and DNK for the UNFCCC submission (Denmark, Greenland and the Faroe Islands).

These five versions of CRF Reporter are installed on separate virtual MS Windows XP machines. The installations are at the NERI VMWare environment, which is operated and maintained by the IT department at NERI. As such backups of these systems are performed routinely on a daily basis.

For the aggregation of the submissions three IT tools are used.

- EU CRF Aggregator developed by the European Environment Agency – Aggregation of global CRF variables
- NERI CRF Aggregator developed by NERI – Aggregation of local CRF variables
- MS Excel

The three main work processes in connection with the aggregation of the submissions are:

- In the EU CRF Aggregator the following work processes take place:
    - o Aggregation of global variables; sum of emissions and activity data, notation keys and comments.
    - o As input data the xml submission files from the CRF Reporter installations for DNM (Denmark), GRL (Greenland) and FRO (Faroe Islands) are used.
    - o As output file a CRF Reporter xml import file is generated. This file is then imported in the installation for the aggregated submission, DKE (KP) or DNK (UNFCCC).

- In NERI CRF Aggregator the following work processes take place:
    - o Aggregation of local variables; sum of emissions and activity data, notation keys and comments. Aggregation of additional information variables either as sums or uniform values.
    - o As input data the simple CRF Reporter xml files from the CRF Reporter installations for DNM (Denmark), GRL (Greenland) and FRO (Faroe Islands) are used.
    - o As output file a CRF Reporter simple xml import file is generated. This file is then imported in the installation for the aggregated submission, DKE (KP) or DNK (UNFCCC).

- In MS Excel the following work processes take place:
    - o Aggregation of additional information variables where average values or weighted average values are used.
    - o Aggregation of KP-LULUCF/NIR-1 and KP-LULUCF/NIR-2.
    - o The aggregated data is at the moment copy/pasted from the CRF Reporter installations of Denmark and Greenland to Excel aggregated and copy/pasted back to the CRF Reporter installations of the KP submission (DKE).

Efforts are ongoing to ensure the highest possible degree of automation to avoid the risk of errors during the manual work processes.

17.7 QA/QC of the aggregated submission for Denmark and Greenland

The QA/QC procedures for the Danish inventory are described in Chapter 1.6 and the sectoral chapters. Please refer to Chapter 1.6 for a general description of the QA/QC system, and the structural setup of the Danish QA/QC system for the greenhouse gas inventory. The QA/QC procedures carried out by Greenlandic authorities for the Greenlandic inventory are described in Chapter 16. The following focuses on the specific QA/QC measures carried out at NERI both on the data (CRF tables and documentation) received from Greenland and the QC checks carried out for the aggregated versions of the inventory for reporting to the Kyoto Protocol and the UNFCCC. The PM’s relevant for this are listed in Table 17.15.

Table 17.15 PM's specific to the handling of Greenlandic emission data and the aggregated submissions.

Data Storage level 4	3.Completeness	DS.4.3.3	Check that the no sources where methodology exists in the IPCC guidelines are reported as NE by Greenland.
	4.Consistency	DS.4.4.2	Check time-series consistency of the reporting by Greenland prior to aggregating the final submissions.
	5.Correctness	DS.4.5.1	Check that the aggregated submissions for Denmark under the Kyoto Protocol and the UNFCCC match the sum of the individual submissions.
	7.Transparency	DS.4.7.2	Perform QA on the documentation report provided by the Government of Greenland.

Data Storage level 4	3.Completeness	DS.4.3.3	Check that no sources where a methodology exists in the IPCC guidelines or good practice guidance are reported as NE by Greenland

A check is made to filter any NE's from the CRF tables. If any greenhouse gas emissions are reported as NE, it is checked whether methodologies exist in the IPCC guidelines or the IPCC good practice guidance. If methodologies do exist efforts are made to quickly estimate and report emissions.

Data Storage level 4	4.Consistency	DS.4.4.2	Check time-series consistency of the reporting of Greenland and the Faroe Islands prior to aggregating the final submissions

The time-series for all pollutants in the submissions from Greenland and the Faroe Islands are checked at the CRF 3 level for large variations in the time-series. Any large variations are explained or corrected in cooperation with the authorities in Greenland and the Faroe Islands.

Data Storage level 4	5.Correctness	DS.4.5.1	Check that the aggregated submissions for Denmark under the Kyoto Protocol and the UNFCCC matches the sum of the individual submissions

To ensure that the submission for Denmark under the Kyoto Protocol matches the sum of the submissions of Denmark and Greenland a spreadsheet check has been implemented to ensure complete correctness of the submitted inventory. The same procedure is followed for the submission under the UNFCCC, where it is ensured that the submitted emissions equate to the sum of Denmark, Greenland and the Faroe Islands. Special attention is paid to the additional information provided in the CRF, e.g. for the agricultural sector. Certain parameters can not simply be added, e.g. animal weights. In these cases a weighted average is reported in the CRF tables.

Data Storage level 4	7.Transparency	DS.4.7.2	Perform QA on the documentation report provided by the Government of Greenland

The documentation report is received by NERI from the Government of Greenland in the early spring every year. The documentation report is included in the NIR as Chapter 16. NERI experts read and provide comments on the report to the Government of Greenland, so that any questions are resolved prior to the UNFCCC reporting deadline of April 15.

Annex 1 Key Category Analyses

Description of the methodology used for identifying key Categories

Key Category Analysis (KCA) tier 1 and 2 for year 1990 and 2009 for Denmark (excluding Greenland and Faroe Islands) has been carried out in accordance with the IPCC Good Practice Guidance / IPCC Guidelines (2006). The KCA has been carried out excl. and incl. the LULUCF sector. KCA (tier 1) have also been worked out for Greenland and for Denmark and Greenland; refer to Chapter 16 and Chapter 17, respectively.

The base year in the analysis is the year 1990 for the greenhouse gases CO_2, CH_4, N_2O and 1995 for the greenhouse F-gases HFC, PFC and SF_6. The KCA approach is a tier 1 quantitative analysis and a tier 2 approach using tier 1 uncertainties.

The level assessment of the tier 1 KCA is a ranking of the source categories in accordance to their relative contribution to the national total of greenhouse gases calculated in CO_2 equivalent units. The level key categories are found from the list of source categories ranked according to their contribution in descending order. Level key categories are those from the top of the list and of which the sum constitutes 95 % of the national total.

The trend assessment of the tier 1 KCA is a ranking of the source categories according to their contribution to the trend of the national total of greenhouse gases, calculated in CO_2 equivalents, from the base year to the year under consideration. The trend of the source category is calculated relative to that of the national totals and the trend is then weighted with the contribution, according to the level assessment. The ranking is in descending order. As for the level assessment, the cut-off point for the sum of contribution to the trend is 95 % and the source categories from the top of the list to the cut-off line are trend key categories.

In addition, a tier 2 KCA has been carried out to provide additional insight into categories being key sources. The categorisation used is as for the tier 1 analysis and the uncertainties used are tier 1 uncertainties as listed in Annex 7.

The level tier 2 KCA is a ranking of the categories according to their relative contribution to the national total multiplied by the uncertainty of the emission of the category as the combined uncertainty on activity data and on emission factor. Chosen for cut of for key categories in the analysis is 90 %.

The trend tier 2 KCA is a ranking of the categories according to their relative contribution to the trend 1990-2009 of the national total multiplied by the uncertainty of the emission of the category. Chosen for cut of for key categories in the analysis is 90 %.

Since the level KCA is carried out for 1990 and 2009 (exclusive and inclusive LULUCF) and for tier 1 and 2 a total 12 KCA tables for Denmark (excluding Greenland and Faroe Islands) has been worked out along the suggestions in the GPG Tables 7.A1-2. Further, two overview tables based on the GPG Table 7.A3 (exclusive and inclusive LULUCF) are shown. The overview table shows summary results of the KCA for 1990 for 2009 and for the trend 1990-2009.

The inclusion of the LULUCF sector in the level analysis implies that the emissions in this sector are all calculated positive, i.e. the absolute value of removals are included. Note also that according to the GPG, the analysis implies that contributions to the trend are all calculated as mathematically positive to be able to perform the ranking. The LULUCF activities are in the table included with their sign, i.e. emissions: +, removals: -.

The level of disaggregation

The starting-point for source categories is GPG Table 7.1. This table constitutes a suggested list of source categories for the KCA. It is mentioned in the GPG that categories for the KCA should be chosen in a way so that emissions from a single category are estimated with the same method and the same emission factor. Therefore, for categories in Table 7.1, which in our Corinair database are composed of activities with different emission factors or estimated with different methods, splits were made accordingly.

The categorisation has been somewhat revised compared to the 2010 submission. The categories follow the categorisation used for the uncertainty analyses, cf Annex 7.

The source categories in the KCA for stationary combustion are defined according to the greenhouse gas and fuel. For CH_4 and N_2O fuels are aggregated to the fuel categories solid, liquid, gas, waste and biomass.

Table A1.1 KCA source categories for stationary combustion.

CRF, part of category	KCA category	GHG
1A1, 1A2 and 1A4	Stationary Combustion, Coal	CO_2
1A1, 1A2 and 1A4	Stationary Combustion, BKB	CO_2
1A1, 1A2 and 1A4	Stationary Combustion, Coke	CO_2
1A1, 1A2 and 1A4	Stationary Combustion, Fossil waste	CO_2
1A1, 1A2 and 1A4	Stationary Combustion, Petroleum coke	CO_2
1A1, 1A2 and 1A4	Stationary Combustion, Residual oil	CO_2
1A1, 1A2 and 1A4	Stationary Combustion, Gas oil	CO_2
1A1, 1A2 and 1A4	Stationary Combustion, Kerosene	CO_2
1A1, 1A2 and 1A4	Stationary Combustion, LPG	CO_2
1A1, 1A2 and 1A4	Stationary Combustion, Refinery gas	CO_2
1A1, 1A2 and 1A4	Stationary Combustion, Natural gas	CO_2
1A1, 1A2 and 1A4	Stationary Combustion, SOLID	CH_4
1A1, 1A2 and 1A4	Stationary Combustion, LIQUID	CH_4
1A1, 1A2 and 1A4	Stationary Combustion, GAS	CH_4
1A1, 1A2 and 1A4	Natural gas fuelled engines, GAS	CH_4
1A1, 1A2 and 1A4	Stationary Combustion, WASTE	CH_4
1A1, 1A2 and 1A4	Stationary Combustion, BIOMASS	CH_4
1A1, 1A2 and 1A4	Biogas fuelled engines, BIOMASS	CH_4
1A1, 1A2 and 1A4	Stationary Combustion, SOLID	N_2O
1A1, 1A2 and 1A4	Stationary Combustion, LIQUID	N_2O
1A1, 1A2 and 1A4	Stationary Combustion, GAS	N_2O
1A1, 1A2 and 1A4	Stationary Combustion, WASTE	N_2O
1A1, 1A2 and 1A4	Stationary Combustion, BIOMASS	N_2O

KCA source categories for mobile combustion are shown in Table A1-2. The categorisation is used for both CO_2, CH_4 and N_2O.

Table A1.2 KCA source categories for mobile combustion.

CRF, part of category	KCA category	GHG
1.A.3.b	Transport, Road transport	CO_2
1.A.5.b	Transport, Military	CO_2
1.A.3.c	Transport, Railways	CO_2
1.A.3.d (part)	Transport, Navigation (small boats)	CO_2
1.A.3.d (part)	Transport, Navigation (large vessels)	CO_2
1.A.4.c (part)	Transport, Fisheries	CO_2
1.A.4.c (part)	Transport, Agriculture	CO_2
1.A.4.c (part)	Transport, Forestry	CO_2
1.A.2.f (part)	Transport, Industry (mobile)	CO_2
1.A.4.b (part)	Transport, Residential	CO_2
1.A.4.a (part)	Transport, Commercial/institutional	CO_2
1.A.3.a	Transport, Civil aviation	CO_2
1.A.3.b	Transport, Road transport	CH_4
1.A.5.b	Transport, Military	CH_4
1.A.3.c	Transport, Railways	CH_4
1.A.3.d (part)	Transport, Navigation (small boats)	CH_4
1.A.3.d (part)	Transport, Navigation (large vessels)	CH_4
1.A.4.c (part)	Transport, Fisheries	CH_4
1.A.4.c (part)	Transport, Agriculture	CH_4
1.A.4.c (part)	Transport, Forestry	CH_4
1.A.2.f (part)	Transport, Industry (mobile)	CH_4
1.A.4.b (part)	Transport, Residential	CH_4
1.A.4.a (part)	Transport, Commercial/institutional	CH_4
1.A.3.a	Transport, Civil aviation	CH_4
1.A.3.b	Transport, Road transport	N_2O
1.A.5.b	Transport, Military	N_2O
1.A.3.c	Transport, Railways	N_2O
1.A.3.d (part)	Transport, Navigation (small boats)	N_2O
1.A.3.d (part)	Transport, Navigation (large vessels)	N_2O
1.A.4.c (part)	Transport, Fisheries	N_2O
1.A.4.c (part)	Transport, Agriculture	N_2O
1.A.4.c (part)	Transport, Forestry	N_2O
1.A.2.f (part)	Transport, Industry (mobile)	N_2O
1.A.4.b (part)	Transport, Residential	N_2O
1.A.4.a (part)	Transport, Commercial/institutional	N_2O
1.A.3.a	Transport, Civil aviation	N_2O

For fugitive emissions, the categorisation used in the KCA is shown in Table A1-3. Data can be found directly in the CRF.

Table A1-3 KCA source categories for fugitive emissions.

CRF and KCA category	GHG
1.B.2. Flaring in refinery	CO_2
1.B.2. Flaring off-shore	CO_2
1.B.2. Flaring in refinery	CH_4
1.B.2. Flaring off-shore	CH_4
1.B.2. Refinery processes	CH_4
1.B.2. Land based activities	CH_4
1.B.2. Off-shore activities	CH_4
1.B.2. Transmission of natural gas	CH_4
1.B.2. Distribution of natural gas	CH_4
1.B.2 Venting in gas storage	CH_4
1.B.2. Flaring in refinery	N_2O
1.B.2. Flaring off-shore	N_2O

KCA categories for industry are shown in Table A1-4. All data can be found in CRF. Base year for the consumption of HFC, PFC and SF_6 is 1995.

Table A1-4 KCA source categories for industry.

CRF and KCA category	GHG
2A1 Cement production	CO_2
2A2 Lime production	CO_2
2A3 Limestone and dolomite use	CO_2
2A5 Asphalt roofing	CO_2
2A6 Road paving with asphalt	CO_2
2A7 Glass and Glass wool	CO_2
2B5 Catalysts/Fertilizers, Pesticides and Sulphuric acid	CO_2
2C1 Iron and steel production	CO_2
2D2 Food and Drink	CO_2
2G Lubricants	CO_2
2B2 Nitric acid production	N_2O
2F Consumption of HFC	HFC
2F Consumption of PFC	PFC
2F Consumption of SF6	SF_6

KCA categories for solvents are shown in Table A1-5. All data can be found in CRF.

Table A1-5 KCA source categories for solvents.

CRF and KCA category	GHG
3A Paint application	CO_2
3B Degreasing and dry cleaning	CO_2
3C Chemical products, manufacturing and processing	CO_2
3D5 Other	CO_2
3D5 Consumption of fireworks	CO_2
3D5 Consumption of fireworks	CH_4
3D1 Other - Use of N2O for Anaesthesia	N_2O
3D5 Consumption of fireworks	N_2O

KCA categories for agriculture are shown in Table A1-6. All data can be found in CRF.

Table A1-6 KCA source categories for agriculture.

CRF and KCA category	GHG
4A Enteric Fermentation	CH_4
4B Manure Management	CH_4
4F Field burning of agricultural residues	CH_4
4.B Manure Management	N_2O
4.D1.1 Synthetic Fertilizer	N_2O
4.D1.2 Animal waste applied to soils	N_2O
4.D1.3 N-fixing crops	N_2O
4.D1.4 Crop Residue	N_2O
4.D1.5 Cultivation of histosols	N_2O
4.D.2 Grassing animals	N_2O
4.D3 Atmospheric deposition	N_2O
4.D3 Leaching	N_2O
4.D1.6 Sewage sludge and Industrial waste used as fertiliser	N_2O
4.F Field Burning of Agricultural Residues	N_2O

For LULUCF the categorisation used for this KCA is according to Table A1-7. KCA have been estimated both including and excluding LULUCF.

Table A1-7 KCA source categories for LULUCF.

CRF and KCA category	GHG
5.A.1 Broadleaves	CO_2
5.A.1 Conifers	CO_2
5.A.2 Broadleaves	CO_2
5.A.2 Conifers	CO_2
5IID Forest Land.	N_2O
5.B Cropland, Living biomass	CO_2
5.B Cropland, Dead organic matter	CO_2
5.B Cropland, Mineral soils	CO_2
5.B Cropland, Organic soils	CO_2
5.B Disturbance, Land converted to cropland	N_2O
5.C Grassland, Living biomass	CO_2
5.C Grassland, Dead organic matter	CO_2
5.C Grassland, Mineral soils	CO_2
5.C Grassland, Organic soils	CO_2
5.D Wetlands, Living biomass	CO_2
5.D Wetlands, Dead organic matter	CO_2
5.D Wetlands, Soils	CO_2
5IID Wetlands. Peatland	N_2O
5.E Settlements, Living biomass	CO_2
5IV Cropland Limestone	CO_2

KCA categories for the waste sector are shown in Table A1-8.

Table A1-8 KCA source categories for the waste sector.

CRF and KCA category	GHG
6 A. Solid Waste Disposal on Land	CH_4
6 B. Wastewater Handling	CH_4
6 B. Wastewater Handling - Direct	N_2O
6 B. Wastewater Handling - Indirect	N_2O
6.D Accidental fires, buildings	CO_2
6.D Accidental fires, vehicles	CO_2
6.C Incineration of corpses	CH_4
6.C Incineration of carcasses	CH_4
6.D Compost production	CH_4
6.D Accidental fires, buildings	CH_4
6.D Accidental fires, vehicles	CH_4
6.C Incineration of corpses	N_2O
6.C Incineration of carcasses	N_2O
6.D Compost production	N_2O
6.D Accidental fires, buildings	N_2O
6.D Accidental fires, vehicles	N_2O

The choice of categories identifies 123 categories for the analysis excluding LULUCF and 143 categories for the analysis including LULUCF. The categorisation in full is listed in Tables 1.13 and 1.14 of the main report.

The result of the Key Category Analysis for Denmark for the year 1990 and 2009

The entries for the KCA are composed from the databases producing the CRF inventory and from CRFs.

An overview of results of the KCA excluding LULUCF are shown in Table A1-9 and results of the KCA including LULUCF in Table A1-10. The number of key source categories for each of the KCA are shown in Table A1-11. The 12 different KCA for Denmark point out 26-36 key source categories. Nine source categories are key in all 12 KCA:

- Stationary Combustion, Coal, CO_2
- Transport, Road transport, CO_2
- Transport, Agriculture, CO_2
- 4B Manure Management, CH_4

- 4B Manure Management, N_2O
- 4D1.1 Syntehetic Fertilizer, N_2O
- 4D1.2 Animal waste applied to soils, N_2O
- 4D3 Atmospheric deposition, N_2O
- 4D3 Leaching, N_2O

In addition *5A1 Broadleaves, CO_2, 5B Cropland, Mineral soils, CO_2* and *5B Cropland, Organic soils, CO_2* are key source categories for all KCA including LULUCF.

The 12 different KCA point out a total of 63 different key source categories (out of the total 143 source categories), see Table A1-9 and Table A1-10.

The tier 1 approach point out mainly the large emission sources as key categories and thus CO_2 emission from stationary and mobile combustion are important key categories. The tier 2 approach point out some of the sources with larger uncertainty rates.

The list below gives an overview of the different KCA for Denmark (not including Greenland) that are presented in Table A1-12 – Table A1-23.

Level 1990

The two approaches point out different main key categories. The key categories accounting for more than 5 % of the emission (tier 2: uncertainty of emission) each are shown below for the two approaches[1].

[1] LULUCF categories are not among the top key categories.

Tier 1:	
Stationary Combustion, Coal	CO_2
Transport, Road transport	CO_2
Stationary Combustion, Gas oil	CO_2
Stationary Combustion, Natural gas	CO_2

Tier 2:	
4.D3 Leaching	N_2O
4.D1.1 Syntehetic Fertilizer	N_2O
6 A. Solid Waste Disposal on Land	CH_4
4.D1.2 Animal waste applied to soils	N_2O
5.B Cropland, Organic soils	CO_2

Level 2009

The two approaches point out different main key categories. The key categories accounting for more than 5 % of the emission (tier 2: uncertainty of emission) each are shown below for the two approaches[2].

Tier 1:	
Stationary Combustion, Coal	CO_2
Transport, Road transport	CO_2
Stationary Combustion, Natural gas	CO_2

Tier 2:	
4.D3 Leaching	N_2O
4.D1.1 Syntehetic Fertilizer	N_2O
6 A. Solid Waste Disposal on Land	CH_4
4.D1.2 Animal waste applied to soils	N_2O
Stationary Combustion, BIOMASS	N_2O
5.B Cropland, Organic soils	CO_2
5.A.1 Conifers	CO_2

Trend 1990-2009

The two approaches point out different main key categories. The key categories accounting for more than 5 % of the emission trend (tier 2: emission trend uncertainty) each are shown below for the two approaches.

[2] LULUCF categories are not among the top key categories.

Tier 1:	
Stationary Combustion, Coal	CO_2
Stationary Combustion, Natural gas	CO_2
Transport, Road transport	CO_2
Stationary Combustion, Gas oil	CO_2
5.A.1 Conifers	CO_2

Tier 2:	
4.D1.1 Syntehetic Fertilizer	N_2O
4.D3 Leaching	N_2O
Stationary Combustion, BIOMASS	N_2O
2F Consumption of HFC	HFC
5.B Cropland, Mineral soils	CO_2
5.A.1 Conifers	CO_2

Table A1-9 Summary of KCA for Denmark, level and trend for 1990-2009, excl. LULUCF, tier 1 and tier 2.

IPCC Source Categories (LULUCF excluded)		GHG	Key categories with number according to ranking in analysis Identification criteria Level Tier 1 1990	Level Tier 1 2009	Trend Tier 1 1990-2009	Level Tier 2 1990	Level Tier 2 2009	Trend Tier 2 1990-2009
Energy	Stationary Combustion, Coal	CO_2	1	1	1	12	18	13
Energy	Stationary Combustion, BKB	CO_2						
Energy	Stationary Combustion, Coke	CO_2						
Energy	Stationary Combustion, Fosssil waste	CO_2	22	8	8		10	6
Energy	Stationary Combustion, Petroleum coke	CO_2	21	19	15			
Energy	Stationary Combustion, Residual oil	CO_2	7	12	5			
Energy	Stationary Combustion, Gas oil	CO_2	3	5	4	19		12
Energy	Stationary Combustion, Kerosene	CO_2	23		12			
Energy	Stationary Combustion, LPG	CO_2						
Energy	Stationary Combustion, Refinery gas	CO_2	16	14	17			
Energy	Stationary Combustion, Natural gas	CO_2	4	3	2		27	18
Energy	Stationary Combustion, SOLID	CH_4						
Energy	Stationary Combustion, LIQUID	CH_4						
Energy	Stationary Combustion, GAS	CH_4						
Energy	Natural gas fuelled engines, GAS	CH_4			13			
Energy	Stationary Combustion, WASTE	CH_4						
Energy	Stationary Combustion, BIOMASS	CH_4					24	23
Energy	Biogas fuelled engines, BIOMASS	CH_4						
Energy	Stationary Combustion, SOLID	N_2O				17	20	15
Energy	Stationary Combustion, LIQUID	N_2O				8	23	8
Energy	Stationary Combustion, GAS	N_2O				24	13	9
Energy	Stationary Combustion, WASTE	N_2O						25
Energy	Stationary Combustion, BIOMASS	N_2O				9	5	3
Energy	Transport, Road transport	CO_2	2	2	3	6	6	7
Energy	Transport, Military	CO_2						
Energy	Transport, Railways	CO_2	26	26				
Energy	Transport, Navigation (small boats)	CO_2						
Energy	Transport, Navigation (large vessels)	CO_2	17	20	16			
Energy	Transport, Fisheries	CO_2	19	18				
Energy	Transport, Agriculture	CO_2	9	7	18	15	12	28
Energy	Transport, Forestry	CO_2						
Energy	Transport, Industry (mobile)	CO_2	15	15	22	11	9	
Energy	Transport, Residential	CO_2						
Energy	Transport, Commercial/institutional	CO_2			21			24
Energy	Transport, Civil aviation	CO_2			24			
Energy	Transport, Road transport	CH_4						
Energy	Transport, Military	CH_4						
Energy	Transport, Railways	CH_4						
Energy	Transport, Navigation (small boats)	CH_4						
Energy	Transport, Navigation (large vessels)	CH_4						
Energy	Transport, Fisheries	CH_4						
Energy	Transport, Agriculture	CH_4						
Energy	Transport, Forestry	CH_4						

Continued								
Energy	Transport, Industry (mobile)	CH_4						
Energy	Transport, Residential	CH_4						
Energy	Transport, Commercial/institutional	CH_4						
Energy	Transport, Civil aviation	CH_4						
Energy	Transport, Road transport	N_2O						
Energy	Transport, Military	N_2O						
Energy	Transport, Railways	N_2O						
Energy	Transport, Navigation (small boats)	N_2O						
Energy	Transport, Navigation (large vessels)	N_2O				23	28	26
Energy	Transport, Fisheries	N_2O				25	25	
Energy	Transport, Agriculture	N_2O				22	22	
Energy	Transport, Forestry	N_2O						
Energy	Transport, Industry (mobile)	N_2O					26	
Energy	Transport, Residential	N_2O						
Energy	Transport, Commercial/institutional	N_2O						
Energy	Transport, Civil aviation	N_2O						
Energy	1.B.2. Flaring in refinery	CO_2						
Energy	1.B.2. Flaring off-shore	CO_2		25				
Energy	1.B.2. Flaring in refinery	CH_4						
Energy	1.B.2. Flaring off-shore	CH_4						
Energy	1.B.2. Refinery processes	CH_4						22
Energy	1.B.2. Land based activities	CH_4						
Energy	1.B.2. Off-shore activities	CH_4						
Energy	1.B.2. Transmission of natural gas	CH_4						
Energy	1.B.2. Distribution of natural gas	CH_4						
Energy	1.B.2 Venting in gas storage	CH_4						
Energy	1.B.2. Flaring in refinery	N_2O						
Energy	1.B.2. Flaring off-shore	N_2O						
Industrial Proc.	2A1 Cement production	CO_2	14	17				
Industrial Proc.	2A2 Lime production	CO_2			25			
Industrial Proc.	2A3 Limestone and dolomite use	CO_2						
Industrial Proc.	2A5 Asphalt roofing	CO_2						
Industrial Proc.	2A6 Road paving with asphalt	CO_2						
Industrial Proc.	2A7 Glass and Glass wool	CO_2						
Industrial Proc.	2B5 Catalysts/Fertilizers, Pesticides and Sulphuric acid	CO_2						
Industrial Proc.	2C1 Iron and steel production	CO_2						
Industrial Proc.	2D2 Food and Drink	CO_2						
Industrial Proc.	2G Lubricants	CO_2						
Industrial Proc.	2B2 Nitric acid production	N_2O	12		7	18		5
Industrial Proc.	2F Consumption of HFC	HFC		16	10	26	8	4
Industrial Proc.	2F Consumption of PFC	PFC						
Industrial Proc.	2F Consumption of SF6	SF6			26			
Solvent and Other Prod. Use	3A Paint application	CO_2						
Solvent and Other Prod. Use	3B Degreasing and dry cleaning	CO_2						
Solvent and Other Prod. Use	3C Chemical products, manufacturing and processing	CO_2						
Solvent and Other Prod. Use	3D5 Other	CO_2						
Solvent and Other Prod. Use	3D5 Consumption of fireworks	CO_2						
Solvent and Other Prod. Use	3D5 Consumption of fireworks	CH_4						

Continued								
Solvent and Other Prod. Use	3D1 Other - Use of N_2O for Anaesthesia	N_2O						
Solvent and Other Prod. Use	3D5 Consumption of fireworks	N_2O						
Agriculture	4A Enteric Fermentation	CH_4	5	4		5	7	
Agriculture	4B Manure Management	CH_4	13	9	11	20	15	14
Agriculture	4F Field burning af agricultural residues	CH_4						
Agriculture	4.B Manure Management	N_2O	18	21	20	13	17	17
Agriculture	4.D1.1 Syntehetic Fertilizer	N_2O	8	10	6	2	2	1
Agriculture	4.D1.2 Animal waste applied to soils	N_2O	11	11	14	4	4	10
Agriculture	4.D1.3 N-fixing crops	N_2O		24		16	16	
Agriculture	4.D1.4 Crop Residue	N_2O	24	22		10	11	
Agriculture	4.D1.5 Cultivation of histosols	N_2O				21	21	
Agriculture	4.D.2 Grassing animals	N_2O	25		23	14	19	16
Agriculture	4.D3 Atmospheric deposition	N_2O	20	23	19	7	14	11
Agriculture	4.D3 Leaching	N_2O	6	6	9	1	1	2
Agriculture	4.D1.6 Sewage sludge and Industrial waste used as fertiliser	N_2O						20
Agriculture	4.F Field Burning of Agricultural Residues	N_2O						
Waste	6 A. Solid Waste Disposal on Land	CH_4	10	13		3	3	21
Waste	6 B. Wastewater Handling	CH_4						
Waste	5 B. Wastewater Handling - Direct	N_2O						
Waste	6 B. Wastewater Handling - Indirect	N_2O						
Waste	6.D Accidental fires, buildings	CO_2					29	
Waste	6.D Accidental fires, vehicles	CO_2						
Waste	6.C Incineration of corpses	CH_4						
Waste	6.C Incineration of carcasses	CH_4						
Waste	6.D Compost production	CH_4						19
Waste	6.D Accidental fires, buildings	CH_4						
Waste	6.D Accidental fires, vehicles	CH_4						
Waste	6.C Incineration of corpses	N_2O						
Waste	6.C Incineration of carcasses	N_2O						
Waste	6.D Compost production	N_2O						27
Waste	6.D Accidental fires, buildings	N_2O						
Waste	6.D Accidental fires, vehicles	N_2O						

Table A1-10 Summary of KCA for Denmark, level and trend for 1990-2009, incl. LULUCF, tier 1 and tier 2.

IPCC Source Categories (LULUCF included)		GHG	Key categories with number according to ranking in analysis					
			Identification criteria					
			Level Tier 1	Level Tier 1	Trend Tier 1	Level Tier 2	Level Tier 2	Trend Tier 2
			1990	2009	1990-2009	1990	2009	1990-2009
Energy	Stationary Combustion, Coal	CO_2	1	1	3	15	21	22
Energy	Stationary Combustion, BKB	CO_2						
Energy	Stationary Combustion, Coke	CO_2						
Energy	Stationary Combustion, Fosssil waste	CO_2	26	10	8		13	8
Energy	Stationary Combustion, Petroleum coke	CO_2	25	22	19			
Energy	Stationary Combustion, Residual oil	CO_2	7	14	7			
Energy	Stationary Combustion, Gas oil	CO_2	3	5	4	22		17
Energy	Stationary Combustion, Kerosene	CO_2	27		15			
Energy	Stationary Combustion, LPG	CO_2						
Energy	Stationary Combustion, Refinery gas	CO_2	18	17	21			
Energy	Stationary Combustion, Natural gas	CO_2	4	3	1		32	20
Energy	Stationary Combustion, SOLID	CH_4						
Energy	Stationary Combustion, LIQUID	CH_4						
Energy	Stationary Combustion, GAS	CH_4						
Energy	Natural gas fuelled engines, GAS	CH_4		32	22			
Energy	Stationary Combustion, WASTE	CH_4						
Energy	Stationary Combustion, BIOMASS	CH_4					27	21
Energy	Biogas fuelled engines, BIOMASS	CH_4						
Energy	Stationary Combustion, SOLID	N_2O				20	23	25
Energy	Stationary Combustion, LIQUID	N_2O				10	26	12
Energy	Stationary Combustion, GAS	N_2O				29	16	11
Energy	Stationary Combustion, WASTE	N_2O						34
Energy	Stationary Combustion, BIOMASS	N_2O				11	7	5
Energy	Transport, Road transport	CO_2	2	2	2	8	8	9
Energy	Transport, Military	CO_2			35			
Energy	Transport, Railways	CO_2	31	29				
Energy	Transport, Navigation (small boats)	CO_2			36			
Energy	Transport, Navigation (large vessels)	CO_2	19	23	25			
Energy	Transport, Fisheries	CO_2	23	21	34			
Energy	Transport, Agriculture	CO_2	10	9	20	18	15	28
Energy	Transport, Forestry	CO_2						
Energy	Transport, Industry (mobile)	CO_2	17	18	26	13	12	30
Energy	Transport, Residential	CO_2						
Energy	Transport, Commercial/institutional	CO_2			27			33
Energy	Transport, Civil aviation	CO_2						
Energy	Transport, Road transport	CH_4						
Energy	Transport, Military	CH_4						
Energy	Transport, Railways	CH_4						
Energy	Transport, Navigation (small boats)	CH_4						
Energy	Transport, Navigation (large vessels)	CH_4						
Energy	Transport, Fisheries	CH_4						
Energy	Transport, Agriculture	CH_4						

Continued								
Energy	Transport, Forestry	CH_4						
Energy	Transport, Industry (mobile)	CH_4						
Energy	Transport, Residential	CH_4						
Energy	Transport, Commercial/institutional	CH_4						
Energy	Transport, Civil aviation	CH_4						
Energy	Transport, Road transport	N_2O						
Energy	Transport, Military	N_2O						
Energy	Transport, Railways	N_2O						
Energy	Transport, Navigation (small boats)	N_2O						
Energy	Transport, Navigation (large vessels)	N_2O				27	33	
Energy	Transport, Fisheries	N_2O				30	30	
Energy	Transport, Agriculture	N_2O				26	25	35
Energy	Transport, Forestry	N_2O						
Energy	Transport, Industry (mobile)	N_2O					31	
Energy	Transport, Residential	N_2O						
Energy	Transport, Commercial/institutional	N_2O						
Energy	Transport, Civil aviation	N_2O						
Energy	1.B.2. Flaring in refinery	CO_2						
Energy	1.B.2. Flaring off-shore	CO_2	32	28				
Energy	1.B.2. Flaring in refinery	CH_4						
Energy	1.B.2. Flaring off-shore	CH_4						
Energy	1.B.2. Refinery processes	CH_4						27
Energy	1.B.2. Land based activities	CH_4						
Energy	1.B.2. Off-shore activities	CH_4						
Energy	1.B.2. Transmission of natural gas	CH_4						
Energy	1.B.2. Distribution of natural gas	CH_4						
Energy	1.B.2 Venting in gas storage	CH_4						
Energy	1.B.2. Flaring in refinery	N_2O						
Energy	1.B.2. Flaring off-shore	N_2O						
Industrial Proc.	2A1 Cement production	CO_2	16	20				
Industrial Proc.	2A2 Lime production	CO_2						
Industrial Proc.	2A3 Limestone and dolomite use	CO_2						
Industrial Proc.	2A5 Asphalt roofing	CO_2						
Industrial Proc.	2A6 Road paving with asphalt	CO_2						
Industrial Proc.	2A7 Glass and Glass wool	CO_2						
Industrial Proc.	2B5 Catalysts/Fertilizers, Pesticides and Sulphuric acid	CO_2						
Industrial Proc.	2C1 Iron and steel production	CO_2						
Industrial Proc.	2D2 Food and Drink	CO_2						
Industrial Proc.	2G Lubricants	CO_2						
Industrial Proc.	2B2 Nitric acid production	N_2O	14		9	21		10
Industrial Proc.	2F Consumption of HFC	HFC		19	12	31	11	6
Industrial Proc.	2F Consumption of PFC	PFC						
Industrial Proc.	2F Consumption of SF6	SF6						
Solvent and Other Prod. Use	3A Paint application	CO_2						
Solvent and Other Prod. Use	3B Degreasing and dry cleaning	CO_2						
Solvent and Other Prod. Use	3C Chemical products, manufacturing and processing	CO_2						
Solvent and Other Prod. Use	3D5 Other	CO_2						
Solvent and Other Prod. Use	3D5 Consumption of fireworks	CO_2						

Continued								
Solvent and Other Prod. Use	3D5 Consumption of fireworks	CH_4						
Solvent and Other Prod. Use	3D1 Other - Use of N_2O for Anaesthesia	N_2O						
Solvent and Other Prod. Use	3D5 Consumption of fireworks	N_2O						
Agriculture	4A Enteric Fermentation	CH_4	5	4	24	7	9	
Agriculture	4B Manure Management	CH_4	15	11	13	23	18	19
Agriculture	4F Field burning af agricultural residues	CH_4						
Agriculture	4.B Manure Management	N_2O	22	24	31	16	20	31
Agriculture	4.D1.1 Syntehetic Fertilizer	N_2O	8	12	10	2	2	1
Agriculture	4.D1.2 Animal waste applied to soils	N_2O	12	13	17	5	4	7
Agriculture	4.D1.3 N-fixing crops	N_2O		27		19	19	
Agriculture	4.D1.4 Crop Residue	N_2O	28	25		12	14	
Agriculture	4.D1.5 Cultivation of histosols	N_2O				24	24	
Agriculture	4.D.2 Grassing animals	N_2O	29	30		17	22	29
Agriculture	4.D3 Atmospheric deposition	N_2O	24	26	29	9	17	18
Agriculture	4.D3 Leaching	N_2O	6	7	11	1	1	4
Agriculture	4.D1.6 Sewage sludge and Industrial waste used as fertiliser	N_2O						24
Agriculture	4.F Field Burning of Agricultural Residues	N_2O						
LULUCF	5.A.1 Broadleaves	CO_2	20	16	16	14	10	15
LULUCF	5.A.1 Conifers	CO_2		6	5		6	3
LULUCF	5.A.2 Broadleaves	CO_2			30			32
LULUCF	5.A.2 Conifers	CO_2			32			
LULUCF	5IID Forest Land.	N_2O						
LULUCF	5.B Cropland, Living biomass	CO_2			33			
LULUCF	5.B Cropland, Dead organic matter	CO_2						
LULUCF	5.B Cropland, Mineral soils	CO_2	13	31	6	6	28	2
LULUCF	5.B Cropland, Organic soils	CO_2	9	8	23	4	5	13
LULUCF	5.B Disturbance, Land converted to cropland	N_2O						
LULUCF	5.C Grassland, Living biomass	CO_2	30		18	25		16
LULUCF	5.C Grassland, Dead organic matter	CO_2						
LULUCF	5.C Grassland, Mineral soils	CO_2						
LULUCF	5.C Grassland, Organic soils	CO_2				28	29	
LULUCF	5.D Wetlands, Living biomass	CO_2						
LULUCF	5.D Wetlands, Dead organic matter	CO_2						
LULUCF	5.D Wetlands, Soils	CO_2						26
LULUCF	5IID Wetlands. Peatland	N_2O						
LULUCF	5.E Settlements, Living biomass	CO_2						
LULUCF	5IV Cropland Limestone	CO_2	21		14			
Waste	6 A. Solid Waste Disposal on Land	CH_4	11	15	28	3	3	14
Waste	6 B. Wastewater Handling	CH_4						
Waste	5 B. Wastewater Handling - Direct	N_2O						
Waste	6 B. Wastewater Handling - Indirect	N_2O						
Waste	6.D Accidental fires, buildings	CO_2						
Waste	6.D Accidental fires, vehicles	CO_2						
Waste	6.C Incineration of corpses	CH_4						
Waste	6.C Incineration of carcasses	CH_4						
Waste	6.D Compost production	CH_4						23
Waste	6.D Accidental fires, buildings	CH_4						
Waste	6.D Accidental fires, vehicles	CH_4						

Continued									
Waste	6.C Incineration of corpses	N_2O							
Waste	6.C Incineration of carcasses	N_2O							
Waste	6.D Compost production	N_2O							
Waste	6.D Accidental fires, buildings	N_2O							
Waste	6.D Accidental fires, vehicles	N_2O							

Table A1-11 Summary of KCA for Denmark, number of key source categories in each of the KCA.

	Level Tier 1 1990	Level Tier 1 2009	Trend Tier 1 1990-2009	Level Tier 2 1990	Level Tier 2 2009	Trend Tier 2 1990-2009
Excluding LULUCF	26	26	26	26	29	28
Including LULUCF	32	32	36	31	33	35

Table A1-12 KCA for Denmark, level assessment base year excl. LULUCF, tier 1.

Tier 1 Analysis IPCC Source Categories (LULUCF excluded)		GHG	DK - inventory Base Year Estimate Ex,o Mt CO2-eq	Base Year Level Assessment Lx,o	Base Year Cumulative Total of Lx,o
Energy	Stationary Combustion, Coal	CO_2	23.834	0.349	0.349
Energy	Transport, Road transport	CO_2	9.282	0.136	0.485
Energy	Stationary Combustion, Gas oil	CO_2	4.547	0.067	0.552
Energy	Stationary Combustion, Natural gas	CO_2	4.335	0.063	0.615
Agriculture	4A Enteric Fermentation	CH_4	3.249	0.048	0.663
Agriculture	4.D3 Leaching	N_2O	2.455	0.036	0.699
Energy	Stationary Combustion, Residual oil	CO_2	2.440	0.036	0.734
Agriculture	4.D1.1 Syntehetic Fertilizer	N_2O	2.395	0.035	0.769
Energy	Transport, Agriculture	CO_2	1.272	0.019	0.788
Waste	6 A. Solid Waste Disposal on Land	CH_4	1.111	0.016	0.804
Agriculture	4.D1.2 Animal waste applied to soils	N_2O	1.097	0.016	0.820
Industrial Proc.	2B2 Nitric acid production	N_2O	1.043	0.015	0.836
Agriculture	4B Manure Management	CH_4	0.976	0.014	0.850
Industrial Proc.	2A1 Cement production	CO_2	0.882	0.013	0.863
Energy	Transport, Industry (mobile)	CO_2	0.842	0.012	0.875
Energy	Stationary Combustion, Refinery gas	CO_2	0.816	0.012	0.887
Energy	Transport, Navigation (large vessels)	CO_2	0.748	0.011	0.898
Agriculture	4.B Manure Management	N_2O	0.604	0.009	0.907
Energy	Transport, Fisheries	CO_2	0.591	0.009	0.915
Agriculture	4.D3 Atmospheric deposition	N_2O	0.465	0.007	0.922
Energy	Stationary Combustion, Petroleum coke	CO_2	0.410	0.006	0.928
Energy	Stationary Combustion, Fosssil waste	CO_2	0.394	0.006	0.934
Energy	Stationary Combustion, Kerosene	CO_2	0.366	0.005	0.939
Agriculture	4.D1.4 Crop Residue	N_2O	0.361	0.005	0.945
Agriculture	4.D.2 Grassing animals	N_2O	0.311	0.005	0.949
Energy	Transport, Railways	CO_2	0.297	0.004	0.954
Energy	1.B.2. Flaring off-shore	CO_2	0.276	0.004	0.958
Agriculture	4.D1.3 N-fixing crops	N_2O	0.269	0.004	0.962
Energy	Transport, Civil aviation	CO_2	0.243	0.004	0.965
Industrial Proc.	2F Consumption of HFC	HFC	0.218	0.003	0.968
Agriculture	4.D1.5 Cultivation of histosols	N_2O	0.171	0.003	0.971
Energy	Stationary Combustion, LPG	CO_2	0.164	0.002	0.973
Energy	Stationary Combustion, Coke	CO_2	0.138	0.002	0.975
Energy	Transport, Military	CO_2	0.119	0.002	0.977
Industrial Proc.	2A2 Lime production	CO_2	0.116	0.002	0.979
Industrial Proc.	2F Consumption of SF6	SF6	0.107	0.002	0.980
Energy	Stationary Combustion, BIOMASS	CH_4	0.105	0.002	0.982
Energy	Transport, Road transport	N_2O	0.093	0.001	0.983
Solvent and Other Prod. Use	3D5 Other	CO_2	0.086	0.001	0.984
Waste	6 B. Wastewater Handling - Indirect	N_2O	0.082	0.001	0.986
Energy	Transport, Commercial/institutional	CO_2	0.074	0.001	0.987
Energy	Stationary Combustion, SOLID	N_2O	0.068	0.001	0.988

Continued					
Waste	6 B. Wastewater Handling	CH_4	0.066	0.001	0.989
Industrial Proc.	2A7 Glass and Glass wool	CO_2	0.055	0.001	0.990
Energy	Transport, Road transport	CH_4	0.053	0.001	0.990
Industrial Proc.	2G Lubricants	CO_2	0.050	0.001	0.991
Energy	Transport, Navigation (small boats)	CO_2	0.048	0.001	0.992
Energy	Stationary Combustion, LIQUID	N_2O	0.040	0.001	0.992
Energy	Transport, Residential	CO_2	0.039	0.001	0.993
Energy	Stationary Combustion, BIOMASS	N_2O	0.038	0.001	0.993
Energy	Transport, Forestry	CO_2	0.036	0.001	0.994
Industrial Proc.	2C1 Iron and steel production	CO_2	0.028	0.000	0.994
Agriculture	4.D1.6 Sewage sludge and Industrial waste used as fertiliser	N_2O	0.028	0.000	0.995
Waste	5 B. Wastewater Handling - Direct	N_2O	0.027	0.000	0.995
Waste	6.D Compost production	CH_4	0.027	0.000	0.996
Solvent and Other Prod. Use	3A Paint application	CO_2	0.026	0.000	0.996
Energy	1.B.2. Flaring in refinery	CO_2	0.024	0.000	0.996
Solvent and Other Prod. Use	3C Chemical products, manufacturing and processing	CO_2	0.023	0.000	0.997
Energy	1.B.2. Land based activities	CH_4	0.017	0.000	0.997
Energy	Stationary Combustion, GAS	N_2O	0.016	0.000	0.997
Waste	6.D Accidental fires, buildings	CO_2	0.015	0.000	0.997
Energy	Transport, Agriculture	N_2O	0.015	0.000	0.998
Energy	1.B.2. Off-shore activities	CH_4	0.015	0.000	0.998
Energy	Transport, Navigation (large vessels)	N_2O	0.015	0.000	0.998
Industrial Proc.	2A3 Limestone and dolomite use	CO_2	0.014	0.000	0.998
Energy	Stationary Combustion, SOLID	CH_4	0.013	0.000	0.998
Energy	Transport, Fisheries	N_2O	0.011	0.000	0.999
Waste	6.D Compost production	N_2O	0.011	0.000	0.999
Energy	Stationary Combustion, BKB	CO_2	0.011	0.000	0.999
Energy	Transport, Industry (mobile)	N_2O	0.011	0.000	0.999
Energy	Stationary Combustion, WASTE	N_2O	0.007	0.000	0.999
Waste	6.D Accidental fires, vehicles	CO_2	0.007	0.000	0.999
Energy	1.B.2. Distribution of natural gas	CH_4	0.005	0.000	0.999
Industrial Proc.	2D2 Food and Drink	CO_2	0.004	0.000	0.999
Energy	1.B.2. Transmission of natural gas	CH_4	0.004	0.000	0.999
Energy	Transport, Civil aviation	N_2O	0.003	0.000	1.000
Energy	Stationary Combustion, GAS	CH_4	0.003	0.000	1.000
Energy	Stationary Combustion, LIQUID	CH_4	0.003	0.000	1.000
Energy	Transport, Railways	N_2O	0.003	0.000	1.000
Waste	6.D Accidental fires, buildings	CH_4	0.002	0.000	1.000
Energy	Transport, Agriculture	CH_4	0.002	0.000	1.000
Energy	Transport, Commercial/institutional	CH_4	0.002	0.000	1.000
Agriculture	4F Field burning af agricultural residues	CH_4	0.002	0.000	1.000
Industrial Proc.	2A6 Road paving with asphalt	CO_2	0.002	0.000	1.000
Energy	Stationary Combustion, WASTE	CH_4	0.001	0.000	1.000
Energy	1.B.2. Flaring in refinery	CH_4	0.001	0.000	1.000
Energy	Transport, Industry (mobile)	CH_4	0.001	0.000	1.000
Energy	Transport, Military	N_2O	0.001	0.000	1.000
Energy	Transport, Residential	CH_4	0.001	0.000	1.000
Industrial Proc.	2B5 Catalysts/Fertilizers, Pesticides and Sulphuric acid	CO_2	0.001	0.000	1.000

Continued					
Energy	1.B.2. Refinery processes	CH_4	0.001	0.000	1.000
Solvent and Other Prod. Use	3D5 Consumption of fireworks	N_2O	0.001	0.000	1.000
Energy	1.B.2. Flaring off-shore	N_2O	0.001	0.000	1.000
Agriculture	4.F Field Burning of Agricultural Residues	N_2O	0.001	0.000	1.000
Energy	Natural gas fuelled engines, GAS	CH_4	0.001	0.000	1.000
Industrial Proc.	2F Consumption of PFC	PFC	0.001	0.000	1.000
Energy	1.B.2. Flaring off-shore	CH_4	0.000	0.000	1.000
Energy	Transport, Forestry	CH_4	0.000	0.000	1.000
Energy	Transport, Navigation (small boats)	N_2O	0.000	0.000	1.000
Energy	Transport, Navigation (small boats)	CH_4	0.000	0.000	1.000
Energy	Transport, Commercial/institutional	N_2O	0.000	0.000	1.000
Energy	Transport, Navigation (large vessels)	CH_4	0.000	0.000	1.000
Waste	6.D Accidental fires, vehicles	CH_4	0.000	0.000	1.000
Energy	Transport, Fisheries	CH_4	0.000	0.000	1.000
Energy	Transport, Railways	CH_4	0.000	0.000	1.000
Energy	Transport, Residential	N_2O	0.000	0.000	1.000
Waste	6.C Incineration of corpses	N_2O	0.000	0.000	1.000
Energy	Transport, Forestry	N_2O	0.000	0.000	1.000
Energy	Transport, Civil aviation	CH_4	0.000	0.000	1.000
Energy	1.B.2. Flaring in refinery	N_2O	0.000	0.000	1.000
Energy	Transport, Military	CH_4	0.000	0.000	1.000
Solvent and Other Prod. Use	3D5 Consumption of fireworks	CO_2	0.000	0.000	1.000
Industrial Proc.	2A5 Asphalt roofing	CO_2	0.000	0.000	1.000
Waste	6.C Incineration of carcasses	N_2O	0.000	0.000	1.000
Waste	6.C Incineration of corpses	CH_4	0.000	0.000	1.000
Waste	6.C Incineration of carcasses	CH_4	0.000	0.000	1.000
Solvent and Other Prod. Use	3B Degreasing and dry cleaning	CO_2	0.000	0.000	1.000
Energy	Biogas fuelled engines, BIOMASS	CH_4	0.000	0.000	1.000
Energy	1.B.2 Venting in gas storage	CH_4	0.000	0.000	1.000
Solvent and Other Prod. Use	3D5 Consumption of fireworks	CH_4	0.000	0.000	1.000
Solvent and Other Prod. Use	3D1 Other - Use of N2O for Anaesthesia	N_2O	0.000	0.000	1.000
Waste	6.D Accidental fires, buildings	N_2O	0.000	0.000	1.000
Waste	6.D Accidental fires, vehicles	N_2O	0.000	0.000	1.000
Total			**68.288**	**1.000**	

Table A1-13   KCA for Denmark, level assessment base year incl. LULUCF, tier 1.

Tier 1 Analysis IPCC Source Categories (LULUCF included)		**GHG**	**DK - inventory Base Year Estimate Ex,o Mt CO2-eq**	**Base Year Level Assessment Lx,o**	**Base Year Cumulative Total of Lx,o**
Energy	Stationary Combustion, Coal	CO_2	23.834	0.327	0.327
Energy	Transport, Road transport	CO_2	9.282	0.127	0.454
Energy	Stationary Combustion, Gas oil	CO_2	4.547	0.062	0.517
Energy	Stationary Combustion, Natural gas	CO_2	4.335	0.059	0.576
Agriculture	4A Enteric Fermentation	CH_4	3.249	0.045	0.621
Agriculture	4.D3 Leaching	N_2O	2.455	0.034	0.654
Energy	Stationary Combustion, Residual oil	CO_2	2.440	0.033	0.688
Agriculture	4.D1.1 Syntehetic Fertilizer	N_2O	2.395	0.033	0.721
LULUCF	5.B Cropland, Organic soils	CO_2	1.343	0.018	0.739
Energy	Transport, Agriculture	CO_2	1.272	0.017	0.757
Waste	6 A. Solid Waste Disposal on Land	CH_4	1.111	0.015	0.772
Agriculture	4.D1.2 Animal waste applied to soils	N_2O	1.097	0.015	0.787
LULUCF	5.B Cropland, Mineral soils	CO_2	1.054	0.014	0.801
Industrial Proc.	2B2 Nitric acid production	N_2O	1.043	0.014	0.816
Agriculture	4B Manure Management	CH_4	0.976	0.013	0.829
Industrial Proc.	2A1 Cement production	CO_2	0.882	0.012	0.841
Energy	Transport, Industry (mobile)	CO_2	0.842	0.012	0.853
Energy	Stationary Combustion, Refinery gas	CO_2	0.816	0.011	0.864
Energy	Transport, Navigation (large vessels)	CO_2	0.748	0.010	0.874
LULUCF	5.A.1 Broadleaves	CO_2	0.659	0.009	0.883
LULUCF	5IV Cropland Limestone	CO_2	0.623	0.009	0.892
Agriculture	4.B Manure Management	N_2O	0.604	0.008	0.900
Energy	Transport, Fisheries	CO_2	0.591	0.008	0.908
Agriculture	4.D3 Atmospheric deposition	N_2O	0.465	0.006	0.915
Energy	Stationary Combustion, Petroleum coke	CO_2	0.410	0.006	0.920
Energy	Stationary Combustion, Fosssil waste	CO_2	0.394	0.005	0.926
Energy	Stationary Combustion, Kerosene	CO_2	0.366	0.005	0.931
Agriculture	4.D1.4 Crop Residue	N_2O	0.361	0.005	0.936
Agriculture	4.D.2 Grassing animals	N_2O	0.311	0.004	0.940
LULUCF	5.C Grassland, Living biomass	CO_2	0.304	0.004	0.944
Energy	Transport, Railways	CO_2	0.297	0.004	0.948
Energy	1.B.2. Flaring off-shore	CO_2	0.276	0.004	0.952
Agriculture	4.D1.3 N-fixing crops	N_2O	0.269	0.004	0.956
Energy	Transport, Civil aviation	CO_2	0.243	0.003	0.959
Industrial Proc.	2F Consumption of HFC	HFC	0.218	0.003	0.962
LULUCF	5.B Cropland, Living biomass	CO_2	0.174	0.002	0.964
Agriculture	4.D1.5 Cultivation of histosols	N_2O	0.171	0.002	0.967
Energy	Stationary Combustion, LPG	CO_2	0.164	0.002	0.969
Energy	Stationary Combustion, Coke	CO_2	0.138	0.002	0.971
LULUCF	5.C Grassland, Organic soils	CO_2	0.137	0.002	0.973
Energy	Transport, Military	CO_2	0.119	0.002	0.974
Industrial Proc.	2A2 Lime production	CO_2	0.116	0.002	0.976

Continued					
Industrial Proc.	2F Consumption of SF6	SF6	0.107	0.001	0.977
Energy	Stationary Combustion, BIOMASS	CH_4	0.105	0.001	0.979
Energy	Transport, Road transport	N_2O	0.093	0.001	0.980
LULUCF	5.E Settlements, Living biomass	CO_2	0.090	0.001	0.981
LULUCF	5.D Wetlands, Soils	CO_2	0.086	0.001	0.982
Solvent and Other Prod. Use	3D5 Other	CO_2	0.086	0.001	0.984
Waste	6 B. Wastewater Handling - Indirect	N_2O	0.082	0.001	0.985
Energy	Transport, Commercial/institutional	CO_2	0.074	0.001	0.986
Energy	Stationary Combustion, SOLID	N_2O	0.068	0.001	0.987
Waste	6 B. Wastewater Handling	CH_4	0.066	0.001	0.988
LULUCF	5.A.1 Conifers	CO_2	0.066	0.001	0.988
Industrial Proc.	2A7 Glass and Glass wool	CO_2	0.055	0.001	0.989
Energy	Transport, Road transport	CH_4	0.053	0.001	0.990
Industrial Proc.	2G Lubricants	CO_2	0.050	0.001	0.991
Energy	Transport, Navigation (small boats)	CO_2	0.048	0.001	0.991
Energy	Stationary Combustion, LIQUID	N_2O	0.040	0.001	0.992
Energy	Transport, Residential	CO_2	0.039	0.001	0.992
Energy	Stationary Combustion, BIOMASS	N_2O	0.038	0.001	0.993
Energy	Transport, Forestry	CO_2	0.036	0.000	0.993
LULUCF	5.C Grassland, Dead organic matter	CO_2	0.032	0.000	0.994
Industrial Proc.	2C1 Iron and steel production	CO_2	0.028	0.000	0.994
Agriculture	4.D1.6 Sewage sludge and Industrial waste used as fertiliser	N_2O	0.028	0.000	0.995
Waste	5 B. Wastewater Handling - Direct	N_2O	0.027	0.000	0.995
Waste	6.D Compost production	CH_4	0.027	0.000	0.995
Solvent and Other Prod. Use	3A Paint application	CO_2	0.026	0.000	0.996
Energy	1.B.2. Flaring in refinery	CO_2	0.024	0.000	0.996
Solvent and Other Prod. Use	3C Chemical products, manufacturing and processing	CO_2	0.023	0.000	0.996
Energy	1.B.2. Land based activities	CH_4	0.017	0.000	0.997
Energy	Stationary Combustion, GAS	N_2O	0.016	0.000	0.997
LULUCF	5IID Forest Land.	N_2O	0.016	0.000	0.997
Waste	6.D Accidental fires, buildings	CO_2	0.015	0.000	0.997
Energy	Transport, Agriculture	N_2O	0.015	0.000	0.997
Energy	1.B.2. Off-shore activities	CH_4	0.015	0.000	0.998
Energy	Transport, Navigation (large vessels)	N_2O	0.015	0.000	0.998
Industrial Proc.	2A3 Limestone and dolomite use	CO_2	0.014	0.000	0.998
Energy	Stationary Combustion, SOLID	CH_4	0.013	0.000	0.998
Energy	Transport, Fisheries	N_2O	0.011	0.000	0.998
Waste	6.D Compost production	N_2O	0.011	0.000	0.999
Energy	Stationary Combustion, BKB	CO_2	0.011	0.000	0.999
Energy	Transport, Industry (mobile)	N_2O	0.011	0.000	0.999
Energy	Stationary Combustion, WASTE	N_2O	0.007	0.000	0.999
LULUCF	5.A.2 Conifers	CO_2	0.007	0.000	0.999
Waste	6.D Accidental fires, vehicles	CO_2	0.007	0.000	0.999
LULUCF	5.B Cropland, Dead organic matter	CO_2	0.006	0.000	0.999
Energy	1.B.2. Distribution of natural gas	CH_4	0.005	0.000	0.999
Industrial Proc.	2D2 Food and Drink	CO_2	0.004	0.000	0.999
Energy	1.B.2. Transmission of natural gas	CH_4	0.004	0.000	0.999
LULUCF	5.A.2 Broadleaves	CO_2	0.003	0.000	0.999

Continued					
LULUCF	5.B Disturbance, Land converted to cropland	N_2O	0.003	0.000	0.999
Energy	Transport, Civil aviation	N_2O	0.003	0.000	1.000
Energy	Stationary Combustion, GAS	CH_4	0.003	0.000	1.000
Energy	Stationary Combustion, LIQUID	CH_4	0.003	0.000	1.000
Energy	Transport, Railways	N_2O	0.003	0.000	1.000
Waste	6.D Accidental fires, buildings	CH_4	0.002	0.000	1.000
Energy	Transport, Agriculture	CH_4	0.002	0.000	1.000
Energy	Transport, Commercial/institutional	CH_4	0.002	0.000	1.000
Agriculture	4F Field burning af agricultural residues	CH_4	0.002	0.000	1.000
Industrial Proc.	2A6 Road paving with asphalt	CO_2	0.002	0.000	1.000
Energy	Stationary Combustion, WASTE	CH_4	0.001	0.000	1.000
Energy	1.B.2. Flaring in refinery	CH_4	0.001	0.000	1.000
Energy	Transport, Industry (mobile)	CH_4	0.001	0.000	1.000
Energy	Transport, Military	N_2O	0.001	0.000	1.000
Energy	Transport, Residential	CH_4	0.001	0.000	1.000
LULUCF	5.C Grassland, Mineral soils	CO_2	0.001	0.000	1.000
Industrial Proc.	2B5 Catalysts/Fertilizers, Pesticides and Sulphuric acid	CO_2	0.001	0.000	1.000
Energy	1.B.2. Refinery processes	CH_4	0.001	0.000	1.000
Solvent and Other Prod. Use	3D5 Consumption of fireworks	N_2O	0.001	0.000	1.000
Energy	1.B.2. Flaring off-shore	N_2O	0.001	0.000	1.000
Agriculture	4.F Field Burning of Agricultural Residues	N_2O	0.001	0.000	1.000
Energy	Natural gas fuelled engines, GAS	CH_4	0.001	0.000	1.000
Industrial Proc.	2F Consumption of PFC	PFC	0.001	0.000	1.000
Energy	1.B.2. Flaring off-shore	CH_4	0.000	0.000	1.000
Energy	Transport, Forestry	CH_4	0.000	0.000	1.000
Energy	Transport, Navigation (small boats)	N_2O	0.000	0.000	1.000
LULUCF	5.D Wetlands, Living biomass	CO_2	0.000	0.000	1.000
Energy	Transport, Navigation (small boats)	CH_4	0.000	0.000	1.000
Energy	Transport, Commercial/institutional	N_2O	0.000	0.000	1.000
Energy	Transport, Navigation (large vessels)	CH_4	0.000	0.000	1.000
Waste	6.D Accidental fires, vehicles	CH_4	0.000	0.000	1.000
Energy	Transport, Fisheries	CH_4	0.000	0.000	1.000
Energy	Transport, Railways	CH_4	0.000	0.000	1.000
Energy	Transport, Residential	N_2O	0.000	0.000	1.000
Waste	6.C Incineration of corpses	N_2O	0.000	0.000	1.000
Energy	Transport, Forestry	N_2O	0.000	0.000	1.000
Energy	Transport, Civil aviation	CH_4	0.000	0.000	1.000
LULUCF	5IID Wetlands. Peatland	N_2O	0.000	0.000	1.000
Energy	1.B.2. Flaring in refinery	N_2O	0.000	0.000	1.000
Energy	Transport, Military	CH_4	0.000	0.000	1.000
LULUCF	5.D Wetlands, Dead organic matter	CO_2	0.000	0.000	1.000
Solvent and Other Prod. Use	3D5 Consumption of fireworks	CO_2	0.000	0.000	1.000
Industrial Proc.	2A5 Asphalt roofing	CO_2	0.000	0.000	1.000
Waste	6.C Incineration of carcasses	N_2O	0.000	0.000	1.000
Waste	6.C Incineration of corpses	CH_4	0.000	0.000	1.000
Waste	6.C Incineration of carcasses	CH_4	0.000	0.000	1.000
Solvent and Other Prod. Use	3B Degreasing and dry cleaning	CO_2	0.000	0.000	1.000
Energy	Biogas fuelled engines, BIOMASS	CH_4	0.000	0.000	1.000

Continued					
Energy	1.B.2 Venting in gas storage	CH_4	0.000	0.000	1.000
Solvent and Other Prod. Use	3D5 Consumption of fireworks	CH_4	0.000	0.000	1.000
Solvent and Other Prod. Use	3D1 Other - Use of N2O for Anaesthesia	N_2O	0.000	0.000	1.000
Waste	6.D Accidental fires, buildings	N_2O	0.000	0.000	1.000
Waste	6.D Accidental fires, vehicles	N_2O	0.000	0.000	1.000
Total			**72.892**	**1.000**	

[1)] The Estimates include signs, where + : emission - : removal, although in the level analyses only the absolute values are used

Table A1-14 KCA for Denmark, level assessment 2009 excl. LULUCF, tier 1.

Tier 1 Analysis IPCC Source Categories (LULUCF excluded)		**GHG**	**DK - inventory Latest Year Estimate Ex,t Mt CO2-eq**	**Latest Year Level Assessment Lx,t**	**Latest Year Cumulative Total of Lx,t**
Energy	Stationary Combustion, Coal	CO_2	15.726	0.258	0.258
Energy	Transport, Road transport	CO_2	12.125	0.199	0.457
Energy	Stationary Combustion, Natural gas	CO_2	9.380	0.154	0.611
Agriculture	4A Enteric Fermentation	CH_4	2.859	0.047	0.657
Energy	Stationary Combustion, Gas oil	CO_2	1.792	0.029	0.687
Agriculture	4.D3 Leaching	N_2O	1.416	0.023	0.710
Energy	Transport, Agriculture	CO_2	1.268	0.021	0.731
Energy	Stationary Combustion, Fosssil waste	CO_2	1.266	0.021	0.752
Agriculture	4B Manure Management	CH_4	1.228	0.020	0.772
Agriculture	4.D1.1 Syntehetic Fertilizer	N_2O	1.196	0.020	0.791
Agriculture	4.D1.2 Animal waste applied to soils	N_2O	1.163	0.019	0.810
Energy	Stationary Combustion, Residual oil	CO_2	1.077	0.018	0.828
Waste	6 A. Solid Waste Disposal on Land	CH_4	1.039	0.017	0.845
Energy	Stationary Combustion, Refinery gas	CO_2	0.876	0.014	0.859
Energy	Transport, Industry (mobile)	CO_2	0.823	0.013	0.873
Industrial Proc.	2F Consumption of HFC	HFC	0.799	0.013	0.886
Industrial Proc.	2A1 Cement production	CO_2	0.764	0.013	0.899
Energy	Transport, Fisheries	CO_2	0.557	0.009	0.908
Energy	Stationary Combustion, Petroleum coke	CO_2	0.550	0.009	0.917
Energy	Transport, Navigation (large vessels)	CO_2	0.498	0.008	0.925
Agriculture	4.B Manure Management	N_2O	0.426	0.007	0.932
Agriculture	4.D1.4 Crop Residue	N_2O	0.312	0.005	0.937
Agriculture	4.D3 Atmospheric deposition	N_2O	0.296	0.005	0.942
Agriculture	4.D1.3 N-fixing crops	N_2O	0.248	0.004	0.946
Energy	1.B.2. Flaring off-shore	CO_2	0.241	0.004	0.950
Energy	Transport, Railways	CO_2	0.230	0.004	0.954
Agriculture	4.D.2 Grassing animals	N_2O	0.213	0.003	0.957
Energy	Natural gas fuelled engines, GAS	CH_4	0.192	0.003	0.960
Energy	Transport, Commercial/institutional	CO_2	0.174	0.003	0.963
Agriculture	4.D1.5 Cultivation of histosols	N_2O	0.164	0.003	0.966
Energy	Transport, Military	CO_2	0.160	0.003	0.968

Continued					
Energy	Transport, Civil aviation	CO_2	0.156	0.003	0.971
Energy	Stationary Combustion, BIOMASS	CH_4	0.148	0.002	0.973
Energy	Transport, Road transport	N_2O	0.119	0.002	0.975
Energy	Transport, Navigation (small boats)	CO_2	0.100	0.002	0.977
Energy	Stationary Combustion, LPG	CO_2	0.088	0.001	0.978
Energy	Stationary Combustion, Coke	CO_2	0.081	0.001	0.980
Agriculture	4.D1.6 Sewage sludge and Industrial waste used as fertiliser	N_2O	0.081	0.001	0.981
Energy	Stationary Combustion, BIOMASS	N_2O	0.081	0.001	0.982
Waste	6.D Compost production	CH_4	0.078	0.001	0.984
Waste	6 B. Wastewater Handling	CH_4	0.075	0.001	0.985
Energy	Transport, Residential	CO_2	0.063	0.001	0.986
Waste	5 B. Wastewater Handling - Direct	N_2O	0.047	0.001	0.987
Energy	1.B.2. Refinery processes	CH_4	0.045	0.001	0.987
Solvent and Other Prod. Use	3D5 Other	CO_2	0.044	0.001	0.988
Industrial Proc.	2A2 Lime production	CO_2	0.043	0.001	0.989
Energy	Stationary Combustion, SOLID	N_2O	0.043	0.001	0.990
Energy	Stationary Combustion, GAS	N_2O	0.041	0.001	0.990
Waste	6.D Compost production	N_2O	0.040	0.001	0.991
Industrial Proc.	2A3 Limestone and dolomite use	CO_2	0.038	0.001	0.992
Energy	1.B.2. Off-shore activities	CH_4	0.037	0.001	0.992
Industrial Proc.	2F Consumption of SF6	SF6	0.037	0.001	0.993
Solvent and Other Prod. Use	3D1 Other - Use of N2O for Anaesthesia	N_2O	0.034	0.001	0.993
Industrial Proc.	2A7 Glass and Glass wool	CO_2	0.034	0.001	0.994
Waste	6 B. Wastewater Handling - Indirect	N_2O	0.034	0.001	0.994
Industrial Proc.	2G Lubricants	CO_2	0.031	0.001	0.995
Energy	1.B.2. Land based activities	CH_4	0.029	0.000	0.995
Energy	Biogas fuelled engines, BIOMASS	CH_4	0.028	0.000	0.996
Waste	6.D Accidental fires, buildings	CO_2	0.018	0.000	0.996
Energy	Transport, Forestry	CO_2	0.017	0.000	0.996
Energy	1.B.2. Flaring in refinery	CO_2	0.017	0.000	0.997
Energy	Transport, Agriculture	N_2O	0.017	0.000	0.997
Energy	Stationary Combustion, WASTE	N_2O	0.016	0.000	0.997
Energy	Stationary Combustion, LIQUID	N_2O	0.016	0.000	0.997
Energy	Transport, Road transport	CH_4	0.015	0.000	0.998
Industrial Proc.	2F Consumption of PFC	PFC	0.014	0.000	0.998
Solvent and Other Prod. Use	3C Chemical products, manufacturing and processing	CO_2	0.012	0.000	0.998
Energy	Transport, Fisheries	N_2O	0.011	0.000	0.998
Energy	Transport, Industry (mobile)	N_2O	0.011	0.000	0.999
Waste	6.D Accidental fires, vehicles	CO_2	0.010	0.000	0.999
Energy	Transport, Navigation (large vessels)	N_2O	0.010	0.000	0.999
Solvent and Other Prod. Use	3A Paint application	CO_2	0.009	0.000	0.999
Energy	Stationary Combustion, Kerosene	CO_2	0.008	0.000	0.999
Energy	Stationary Combustion, GAS	CH_4	0.006	0.000	0.999
Energy	Stationary Combustion, SOLID	CH_4	0.004	0.000	0.999
Energy	Transport, Commercial/institutional	CH_4	0.004	0.000	0.999
Solvent and Other Prod. Use	3D5 Consumption of fireworks	N_2O	0.003	0.000	0.999
Agriculture	4F Field burning af agricultural residues	CH_4	0.003	0.000	0.999
Waste	6.D Accidental fires, buildings	CH_4	0.003	0.000	0.999

Continued					
Energy	1.B.2. Distribution of natural gas	CH_4	0.003	0.000	1.000
Energy	Transport, Civil aviation	N_2O	0.003	0.000	1.000
Industrial Proc.	2B5 Catalysts/Fertilizers, Pesticides and Sulphuric acid	CO_2	0.002	0.000	1.000
Energy	Transport, Agriculture	CH_4	0.002	0.000	1.000
Energy	Transport, Railways	N_2O	0.002	0.000	1.000
Industrial Proc.	2D2 Food and Drink	CO_2	0.002	0.000	1.000
Energy	Transport, Military	N_2O	0.002	0.000	1.000
Industrial Proc.	2A6 Road paving with asphalt	CO_2	0.002	0.000	1.000
Energy	Stationary Combustion, WASTE	CH_4	0.001	0.000	1.000
Energy	Transport, Residential	CH_4	0.001	0.000	1.000
Energy	Stationary Combustion, LIQUID	CH_4	0.001	0.000	1.000
Energy	1.B.2. Flaring off-shore	CH_4	0.001	0.000	1.000
Energy	1.B.2 Venting in gas storage	CH_4	0.001	0.000	1.000
Energy	Stationary Combustion, BKB	CO_2	0.001	0.000	1.000
Agriculture	4.F Field Burning of Agricultural Residues	N_2O	0.001	0.000	1.000
Energy	Transport, Navigation (small boats)	N_2O	0.001	0.000	1.000
Energy	Transport, Commercial/institutional	N_2O	0.001	0.000	1.000
Energy	Transport, Industry (mobile)	CH_4	0.001	0.000	1.000
Energy	1.B.2. Flaring off-shore	N_2O	0.001	0.000	1.000
Energy	Transport, Navigation (small boats)	CH_4	0.001	0.000	1.000
Waste	6.D Accidental fires, vehicles	CH_4	0.000	0.000	1.000
Energy	Transport, Residential	N_2O	0.000	0.000	1.000
Energy	Transport, Fisheries	CH_4	0.000	0.000	1.000
Solvent and Other Prod. Use	3D5 Consumption of fireworks	CO_2	0.000	0.000	1.000
Energy	Transport, Navigation (large vessels)	CH_4	0.000	0.000	1.000
Energy	Transport, Civil aviation	CH_4	0.000	0.000	1.000
Waste	6.C Incineration of corpses	N_2O	0.000	0.000	1.000
Energy	1.B.2. Transmission of natural gas	CH_4	0.000	0.000	1.000
Energy	Transport, Forestry	N_2O	0.000	0.000	1.000
Energy	Transport, Railways	CH_4	0.000	0.000	1.000
Energy	1.B.2. Flaring in refinery	CH_4	0.000	0.000	1.000
Energy	Transport, Military	CH_4	0.000	0.000	1.000
Waste	6.C Incineration of carcasses	N_2O	0.000	0.000	1.000
Energy	Transport, Forestry	CH_4	0.000	0.000	1.000
Energy	1.B.2. Flaring in refinery	N_2O	0.000	0.000	1.000
Total			**60.984**	**1.000**	

Table A1-15 KCA for Denmark, level assessment 2009 incl. LULUCF, tier 1.

Tier 1 Analysis IPCC Source Categories (LULUCF included)		GHG	DK - inventory Latest Year Estimate Ex,t Mt CO2-eq	Latest Year Level Assessment Lx,t	Latest Year Cumulative Total of Lx,t
Energy	Stationary Combustion, Coal	CO_2	15.726	0.239	0.239
Energy	Transport, Road transport	CO_2	12.125	0.184	0.424
Energy	Stationary Combustion, Natural gas	CO_2	9.380	0.143	0.566
Agriculture	4A Enteric Fermentation	CH_4	2.859	0.043	0.610
Energy	Stationary Combustion, Gas oil	CO_2	1.792	0.027	0.637
LULUCF	5.A.1 Conifers	CO_2	1.579	0.024	0.661
Agriculture	4.D3 Leaching	N_2O	1.416	0.022	0.682
LULUCF	5.B Cropland, Organic soils	CO_2	1.282	0.019	0.702
Energy	Transport, Agriculture	CO_2	1.268	0.019	0.721
Energy	Stationary Combustion, Fosssil waste	CO_2	1.266	0.019	0.740
Agriculture	4B Manure Management	CH_4	1.228	0.019	0.759
Agriculture	4.D1.1 Syntehetic Fertilizer	N_2O	1.196	0.018	0.777
Agriculture	4.D1.2 Animal waste applied to soils	N_2O	1.163	0.018	0.795
Energy	Stationary Combustion, Residual oil	CO_2	1.077	0.016	0.811
Waste	6 A. Solid Waste Disposal on Land	CH_4	1.039	0.016	0.827
LULUCF	5.A.1 Broadleaves	CO_2	1.012	0.015	0.843
Energy	Stationary Combustion, Refinery gas	CO_2	0.876	0.013	0.856
Energy	Transport, Industry (mobile)	CO_2	0.823	0.013	0.868
Industrial Proc.	2F Consumption of HFC	HFC	0.799	0.012	0.881
Industrial Proc.	2A1 Cement production	CO_2	0.764	0.012	0.892
Energy	Transport, Fisheries	CO_2	0.557	0.008	0.901
Energy	Stationary Combustion, Petroleum coke	CO_2	0.550	0.008	0.909
Energy	Transport, Navigation (large vessels)	CO_2	0.498	0.008	0.917
Agriculture	4.B Manure Management	N_2O	0.426	0.006	0.923
Agriculture	4.D1.4 Crop Residue	N_2O	0.312	0.005	0.928
Agriculture	4.D3 Atmospheric deposition	N_2O	0.296	0.005	0.932
Agriculture	4.D1.3 N-fixing crops	N_2O	0.248	0.004	0.936
Energy	1.B.2. Flaring off-shore	CO_2	0.241	0.004	0.940
Energy	Transport, Railways	CO_2	0.230	0.004	0.943
Agriculture	4.D.2 Grassing animals	N_2O	0.213	0.003	0.947
LULUCF	5.B Cropland, Mineral soils	CO_2	0.198	0.003	0.950
Energy	Natural gas fuelled engines, GAS	CH_4	0.192	0.003	0.952
LULUCF	5IV Cropland Limestone	CO_2	0.186	0.003	0.955
Energy	Transport, Commercial/institutional	CO_2	0.174	0.003	0.958
Agriculture	4.D1.5 Cultivation of histosols	N_2O	0.164	0.002	0.960
Energy	Transport, Military	CO_2	0.160	0.002	0.963
Energy	Transport, Civil aviation	CO_2	0.156	0.002	0.965
Energy	Stationary Combustion, BIOMASS	CH_4	0.148	0.002	0.967
LULUCF	5.C Grassland, Organic soils	CO_2	0.137	0.002	0.970
Energy	Transport, Road transport	N_2O	0.119	0.002	0.971
Energy	Transport, Navigation (small boats)	CO_2	0.100	0.002	0.973
Energy	Stationary Combustion, LPG	CO_2	0.088	0.001	0.974

Continued					
Energy	Stationary Combustion, Coke	CO_2	0.081	0.001	0.975
Agriculture	4.D1.6 Sewage sludge and Industrial waste used as fertiliser	N_2O	0.081	0.001	0.977
Energy	Stationary Combustion, BIOMASS	N_2O	0.081	0.001	0.978
LULUCF	5.A.2 Broadleaves	CO_2	0.078	0.001	0.979
Waste	6.D Compost production	CH_4	0.078	0.001	0.980
LULUCF	5.B Cropland, Living biomass	CO_2	0.076	0.001	0.981
Waste	6 B. Wastewater Handling	CH_4	0.075	0.001	0.983
LULUCF	5.A.2 Conifers	CO_2	0.067	0.001	0.984
Energy	Transport, Residential	CO_2	0.063	0.001	0.985
LULUCF	5.E Settlements, Living biomass	CO_2	0.055	0.001	0.985
Waste	5 B. Wastewater Handling - Direct	N_2O	0.047	0.001	0.986
Energy	1.B.2. Refinery processes	CH_4	0.045	0.001	0.987
Solvent and Other Prod. Use	3D5 Other	CO_2	0.044	0.001	0.987
Industrial Proc.	2A2 Lime production	CO_2	0.043	0.001	0.988
Energy	Stationary Combustion, SOLID	N_2O	0.043	0.001	0.989
Energy	Stationary Combustion, GAS	N_2O	0.041	0.001	0.989
Waste	6.D Compost production	N_2O	0.040	0.001	0.990
Industrial Proc.	2A3 Limestone and dolomite use	CO_2	0.038	0.001	0.991
Energy	1.B.2. Off-shore activities	CH_4	0.037	0.001	0.991
Industrial Proc.	2F Consumption of SF6	SF6	0.037	0.001	0.992
LULUCF	5.C Grassland, Living biomass	CO_2	0.035	0.001	0.992
Solvent and Other Prod. Use	3D1 Other - Use of N2O for Anaesthesia	N_2O	0.034	0.001	0.993
Industrial Proc.	2A7 Glass and Glass wool	CO_2	0.034	0.001	0.993
Waste	6 B. Wastewater Handling - Indirect	N_2O	0.034	0.001	0.994
Industrial Proc.	2G Lubricants	CO_2	0.031	0.000	0.994
Energy	1.B.2. Land based activities	CH_4	0.029	0.000	0.995
Energy	Biogas fuelled engines, BIOMASS	CH_4	0.028	0.000	0.995
LULUCF	5.C Grassland, Mineral soils	CO_2	0.024	0.000	0.995
Waste	6.D Accidental fires, buildings	CO_2	0.018	0.000	0.996
Energy	Transport, Forestry	CO_2	0.017	0.000	0.996
Energy	1.B.2. Flaring in refinery	CO_2	0.017	0.000	0.996
Energy	Transport, Agriculture	N_2O	0.017	0.000	0.997
LULUCF	5.D Wetlands, Soils	CO_2	0.016	0.000	0.997
Energy	Stationary Combustion, WASTE	N_2O	0.016	0.000	0.997
Energy	Stationary Combustion, LIQUID	N_2O	0.016	0.000	0.997
Energy	Transport, Road transport	CH_4	0.015	0.000	0.997
Industrial Proc.	2F Consumption of PFC	PFC	0.014	0.000	0.998
Solvent and Other Prod. Use	3C Chemical products, manufacturing and processing	CO_2	0.012	0.000	0.998
LULUCF	5IID Forest Land.	N_2O	0.012	0.000	0.998
LULUCF	5.D Wetlands, Living biomass	CO_2	0.011	0.000	0.998
Energy	Transport, Fisheries	N_2O	0.011	0.000	0.998
Energy	Transport, Industry (mobile)	N_2O	0.011	0.000	0.999
Waste	6.D Accidental fires, vehicles	CO_2	0.010	0.000	0.999
Energy	Transport, Navigation (large vessels)	N_2O	0.010	0.000	0.999
Solvent and Other Prod. Use	3A Paint application	CO_2	0.009	0.000	0.999
Energy	Stationary Combustion, Kerosene	CO_2	0.008	0.000	0.999
Energy	Stationary Combustion, GAS	CH_4	0.006	0.000	0.999
Energy	Stationary Combustion, SOLID	CH_4	0.004	0.000	0.999

Continued					
Energy	Transport, Commercial/institutional	CH_4	0.004	0.000	0.999
Solvent and Other Prod. Use	3D5 Consumption of fireworks	N_2O	0.003	0.000	0.999
Agriculture	4F Field burning af agricultural residues	CH_4	0.003	0.000	0.999
Waste	6.D Accidental fires, buildings	CH_4	0.003	0.000	0.999
Energy	1.B.2. Distribution of natural gas	CH_4	0.003	0.000	0.999
LULUCF	5.C Grassland, Dead organic matter	CO_2	0.003	0.000	1.000
Energy	Transport, Civil aviation	N_2O	0.003	0.000	1.000
Industrial Proc.	2B5 Catalysts/Fertilizers, Pesticides and Sulphuric acid	CO_2	0.002	0.000	1.000
Energy	Transport, Agriculture	CH_4	0.002	0.000	1.000
Energy	Transport, Railways	N_2O	0.002	0.000	1.000
Industrial Proc.	2D2 Food and Drink	CO_2	0.002	0.000	1.000
Energy	Transport, Military	N_2O	0.002	0.000	1.000
Industrial Proc.	2A6 Road paving with asphalt	CO_2	0.002	0.000	1.000
Energy	Stationary Combustion, WASTE	CH_4	0.001	0.000	1.000
Energy	Transport, Residential	CH_4	0.001	0.000	1.000
LULUCF	5.B Cropland, Dead organic matter	CO_2	0.001	0.000	1.000
Energy	Stationary Combustion, LIQUID	CH_4	0.001	0.000	1.000
Energy	1.B.2. Flaring off-shore	CH_4	0.001	0.000	1.000
Energy	1.B.2 Venting in gas storage	CH_4	0.001	0.000	1.000
Energy	Stationary Combustion, BKB	CO_2	0.001	0.000	1.000
Agriculture	4.F Field Burning of Agricultural Residues	N_2O	0.001	0.000	1.000
Energy	Transport, Navigation (small boats)	N_2O	0.001	0.000	1.000
Energy	Transport, Commercial/institutional	N_2O	0.001	0.000	1.000
Energy	Transport, Industry (mobile)	CH_4	0.001	0.000	1.000
Energy	1.B.2. Flaring off-shore	N_2O	0.001	0.000	1.000
Energy	Transport, Navigation (small boats)	CH_4	0.001	0.000	1.000
Waste	6.D Accidental fires, vehicles	CH_4	0.000	0.000	1.000
LULUCF	5.B Disturbance, Land converted to cropland	N_2O	0.000	0.000	1.000
Energy	Transport, Residential	N_2O	0.000	0.000	1.000
Energy	Transport, Fisheries	CH_4	0.000	0.000	1.000
Solvent and Other Prod. Use	3D5 Consumption of fireworks	CO_2	0.000	0.000	1.000
Energy	Transport, Navigation (large vessels)	CH_4	0.000	0.000	1.000
Energy	Transport, Civil aviation	CH_4	0.000	0.000	1.000
Waste	6.C Incineration of corpses	N_2O	0.000	0.000	1.000
Energy	1.B.2. Transmission of natural gas	CH_4	0.000	0.000	1.000
Energy	Transport, Forestry	N_2O	0.000	0.000	1.000
Energy	Transport, Railways	CH_4	0.000	0.000	1.000
LULUCF	5IID Wetlands. Peatland	N_2O	0.000	0.000	1.000
Energy	1.B.2. Flaring in refinery	CH_4	0.000	0.000	1.000
Energy	Transport, Military	CH_4	0.000	0.000	1.000
Total			**65.758**	**1.000**	

[1)] The Estimates include signs, where + : emission - : removal, although in the level analyses only the absolute values are used.

Table A1-16 KCA for Denmark, trend assessment 1990-2009 excl. LULUCF, tier 1.

Tier 1 Analysis IPCC Source Categories (LULUCF included)		**DK GHG**	**- inventory Base Year Estimate Ex,o Mt CO2-eq**	**Latest Year Estimate Ex,t Mt CO2-eq**	**Trend Assessment Tx,t**	**Contribution to Trend**	**Cumulative**
Energy	Stationary Combustion, Coal	CO_2	23.834	15.726	0.0814	0.213	0.213
Energy	Stationary Combustion, Natural gas	CO_2	4.335	9.380	0.0807	0.211	0.425
Energy	Transport, Road transport	CO_2	9.282	12.125	0.0562	0.147	0.572
Energy	Stationary Combustion, Gas oil	CO_2	4.547	1.792	0.0332	0.087	0.659
Energy	Stationary Combustion, Residual oil	CO_2	2.440	1.077	0.0161	0.042	0.701
Agriculture	4.D1.1 Syntehetic Fertilizer	N_2O	2.395	1.196	0.0138	0.036	0.737
Industrial Proc.	2B2 Nitric acid production	N_2O	1.043	0.000	0.0136	0.036	0.773
Energy	Stationary Combustion, Fosssil waste	CO_2	0.394	1.266	0.0134	0.035	0.808
Agriculture	4.D3 Leaching	N_2O	2.455	1.416	0.0114	0.030	0.838
Industrial Proc.	2F Consumption of HFC	HFC	0.218	0.799	0.0089	0.023	0.861
Agriculture	4B Manure Management	CH_4	0.976	1.228	0.0052	0.014	0.875
Energy	Stationary Combustion, Kerosene	CO_2	0.366	0.008	0.0047	0.012	0.887
Energy	Natural gas fuelled engines, GAS	CH_4	0.001	0.192	0.0028	0.007	0.894
Agriculture	4.D1.2 Animal waste applied to soils	N_2O	1.097	1.163	0.0027	0.007	0.901
Energy	Stationary Combustion, Petroleum coke	CO_2	0.410	0.550	0.0027	0.007	0.908
Energy	Transport, Navigation (large vessels)	CO_2	0.748	0.498	0.0025	0.007	0.915
Energy	Stationary Combustion, Refinery gas	CO_2	0.816	0.876	0.0022	0.006	0.920
Energy	Transport, Agriculture	CO_2	1.272	1.268	0.0019	0.005	0.926
Agriculture	4.D3 Atmospheric deposition	N_2O	0.465	0.296	0.0017	0.005	0.930
Agriculture	4.B Manure Management	N_2O	0.604	0.426	0.0017	0.004	0.934
Energy	Transport, Commercial/institutional	CO_2	0.074	0.174	0.0016	0.004	0.939
Energy	Transport, Industry (mobile)	CO_2	0.842	0.823	0.0010	0.003	0.941
Agriculture	4.D.2 Grassing animals	N_2O	0.311	0.213	0.0009	0.002	0.944
Energy	Transport, Civil aviation	CO_2	0.243	0.156	0.0009	0.002	0.946
Industrial Proc.	2A2 Lime production	CO_2	0.116	0.043	0.0009	0.002	0.948
Industrial Proc.	2F Consumption of SF6	SF6	0.107	0.037	0.0009	0.002	0.951
Energy	Stationary Combustion, LPG	CO_2	0.164	0.088	0.0009	0.002	0.953
Energy	Transport, Navigation (small boats)	CO_2	0.048	0.100	0.0008	0.002	0.955
Agriculture	4.D1.6 Sewage sludge and Industrial waste used as fertiliser	N_2O	0.028	0.081	0.0008	0.002	0.957
Waste	6.D Compost production	CH_4	0.027	0.078	0.0008	0.002	0.959
Energy	Transport, Military	CO_2	0.119	0.160	0.0008	0.002	0.961
Energy	Stationary Combustion, BIOMASS	CH_4	0.105	0.148	0.0008	0.002	0.964
Waste	6 A. Solid Waste Disposal on Land	CH_4	1.111	1.039	0.0007	0.002	0.965
Energy	Stationary Combustion, BIOMASS	N_2O	0.038	0.081	0.0007	0.002	0.967
Energy	1.B.2. Refinery processes	CH_4	0.001	0.045	0.0006	0.002	0.969
Agriculture	4A Enteric Fermentation	CH_4	3.249	2.859	0.0006	0.002	0.970
Energy	Stationary Combustion, Coke	CO_2	0.138	0.081	0.0006	0.002	0.972
Waste	6 B. Wastewater Handling - Indirect	N_2O	0.082	0.034	0.0006	0.002	0.974
Energy	Transport, Road transport	N_2O	0.093	0.119	0.0005	0.001	0.975
Energy	Transport, Railways	CO_2	0.297	0.230	0.0005	0.001	0.976
Solvent and Other Prod. Use	3D1 Other - Use of N2O for Anaesthesia	N_2O	0.000	0.034	0.0005	0.001	0.978
Solvent and Other Prod. Use	3D5 Other	CO_2	0.086	0.044	0.0005	0.001	0.979
Energy	Transport, Road transport	CH_4	0.053	0.015	0.0005	0.001	0.980

Continued							
Waste	6.D Compost production	N_2O	0.011	0.040	0.0004	0.001	0.981
Energy	Transport, Fisheries	CO_2	0.591	0.557	0.0004	0.001	0.982
Energy	Transport, Residential	CO_2	0.039	0.063	0.0004	0.001	0.983
Energy	Biogas fuelled engines, BIOMASS	CH_4	0.000	0.028	0.0004	0.001	0.985
Energy	Stationary Combustion, GAS	N_2O	0.016	0.041	0.0004	0.001	0.986
Industrial Proc.	2A3 Limestone and dolomite use	CO_2	0.014	0.038	0.0004	0.001	0.987
Industrial Proc.	2C1 Iron and steel production	CO_2	0.028	0.000	0.0004	0.001	0.987
Energy	1.B.2. Off-shore activities	CH_4	0.015	0.037	0.0004	0.001	0.988
Industrial Proc.	2A1 Cement production	CO_2	0.882	0.764	0.0003	0.001	0.989
Waste	5 B. Wastewater Handling - Direct	N_2O	0.027	0.047	0.0003	0.001	0.990
Energy	Stationary Combustion, LIQUID	N_2O	0.040	0.016	0.0003	0.001	0.991
Energy	Stationary Combustion, SOLID	N_2O	0.068	0.043	0.0003	0.001	0.992
Industrial Proc.	2A7 Glass and Glass wool	CO_2	0.055	0.034	0.0002	0.001	0.992
Waste	6 B. Wastewater Handling	CH_4	0.066	0.075	0.0002	0.001	0.993
Solvent and Other Prod. Use	3A Paint application	CO_2	0.026	0.009	0.0002	0.001	0.993
Energy	Transport, Forestry	CO_2	0.036	0.017	0.0002	0.001	0.994
Energy	1.B.2. Land based activities	CH_4	0.017	0.029	0.0002	0.001	0.995
Industrial Proc.	2F Consumption of PFC	PFC	0.001	0.014	0.0002	0.001	0.995
Industrial Proc.	2G Lubricants	CO_2	0.050	0.031	0.0002	0.001	0.996
Agriculture	4.D1.4 Crop Residue	N_2O	0.361	0.312	0.0002	0.000	0.996
Agriculture	4.D1.5 Cultivation of histosols	N_2O	0.171	0.164	0.0002	0.000	0.996
Energy	Stationary Combustion, WASTE	N_2O	0.007	0.016	0.0001	0.000	0.997
Energy	Stationary Combustion, BKB	CO_2	0.011	0.001	0.0001	0.000	0.997
Solvent and Other Prod. Use	3C Chemical products, manufacturing and processing	CO_2	0.023	0.012	0.0001	0.000	0.997
Energy	Stationary Combustion, SOLID	CH_4	0.013	0.004	0.0001	0.000	0.998
Agriculture	4.D1.3 N-fixing crops	N_2O	0.269	0.248	0.0001	0.000	0.998
Energy	1.B.2. Flaring off-shore	CO_2	0.276	0.241	0.0001	0.000	0.998
Energy	1.B.2. Flaring in refinery	CO_2	0.024	0.017	0.0001	0.000	0.998
Waste	6.D Accidental fires, vehicles	CO_2	0.007	0.010	0.0001	0.000	0.998
Waste	6.D Accidental fires, buildings	CO_2	0.015	0.018	0.0001	0.000	0.999
Energy	Transport, Navigation (large vessels)	N_2O	0.015	0.010	0.0000	0.000	0.999
Energy	Stationary Combustion, GAS	CH_4	0.003	0.006	0.0000	0.000	0.999
Energy	1.B.2. Transmission of natural gas	CH_4	0.004	0.000	0.0000	0.000	0.999
Energy	Transport, Agriculture	N_2O	0.015	0.017	0.0000	0.000	0.999
Solvent and Other Prod. Use	3D5 Consumption of fireworks	N_2O	0.001	0.003	0.0000	0.000	0.999
Industrial Proc.	2D2 Food and Drink	CO_2	0.004	0.002	0.0000	0.000	0.999
Energy	1.B.2. Distribution of natural gas	CH_4	0.005	0.003	0.0000	0.000	0.999
Energy	Transport, Commercial/institutional	CH_4	0.002	0.004	0.0000	0.000	0.999
Industrial Proc.	2B5 Catalysts/Fertilizers, Pesticides and Sulphuric acid	CO_2	0.001	0.002	0.0000	0.000	0.999
Energy	Transport, Industry (mobile)	N_2O	0.011	0.011	0.0000	0.000	1.000
Agriculture	4F Field burning af agricultural residues	CH_4	0.002	0.003	0.0000	0.000	1.000
Energy	Stationary Combustion, LIQUID	CH_4	0.003	0.001	0.0000	0.000	1.000
Energy	1.B.2 Venting in gas storage	CH_4	0.000	0.001	0.0000	0.000	1.000
Energy	1.B.2. Flaring in refinery	CH_4	0.001	0.000	0.0000	0.000	1.000
Energy	Transport, Navigation (small boats)	N_2O	0.000	0.001	0.0000	0.000	1.000
Energy	1.B.2. Flaring off-shore	CH_4	0.000	0.001	0.0000	0.000	1.000
Energy	Transport, Military	N_2O	0.001	0.002	0.0000	0.000	1.000
Energy	Transport, Fisheries	N_2O	0.011	0.011	0.0000	0.000	1.000

Continued								
Waste	6.D Accidental fires, buildings	CH_4	0.002	0.003	0.0000	0.000	1.000
Energy	Transport, Commercial/institutional	N_2O	0.000	0.001	0.0000	0.000	1.000
Energy	Transport, Industry (mobile)	CH_4	0.001	0.001	0.0000	0.000	1.000
Agriculture	4.F Field Burning of Agricultural Residues	N_2O	0.001	0.001	0.0000	0.000	1.000
Energy	Transport, Residential	CH_4	0.001	0.001	0.0000	0.000	1.000
Energy	Transport, Civil aviation	N_2O	0.003	0.003	0.0000	0.000	1.000
Energy	Transport, Forestry	CH_4	0.000	0.000	0.0000	0.000	1.000
Energy	Transport, Railways	N_2O	0.003	0.002	0.0000	0.000	1.000
Energy	Transport, Navigation (small boats)	CH_4	0.000	0.001	0.0000	0.000	1.000
Solvent and Other Prod. Use	3D5 Consumption of fireworks	CO_2	0.000	0.000	0.0000	0.000	1.000
Waste	6.D Accidental fires, vehicles	CH_4	0.000	0.000	0.0000	0.000	1.000
Energy	Transport, Residential	N_2O	0.000	0.000	0.0000	0.000	1.000
Energy	Stationary Combustion, WASTE	CH_4	0.001	0.001	0.0000	0.000	1.000
Energy	Transport, Railways	CH_4	0.000	0.000	0.0000	0.000	1.000
Waste	6.C Incineration of carcasses	N_2O	0.000	0.000	0.0000	0.000	1.000
Energy	Transport, Agriculture	CH_4	0.002	0.002	0.0000	0.000	1.000
Industrial Proc.	2A6 Road paving with asphalt	CO_2	0.002	0.002	0.0000	0.000	1.000
Energy	1.B.2. Flaring in refinery	N_2O	0.000	0.000	0.0000	0.000	1.000
Energy	Transport, Civil aviation	CH_4	0.000	0.000	0.0000	0.000	1.000
Energy	Transport, Navigation (large vessels)	CH_4	0.000	0.000	0.0000	0.000	1.000
Energy	1.B.2. Flaring off-shore	N_2O	0.001	0.001	0.0000	0.000	1.000
Energy	Transport, Fisheries	CH_4	0.000	0.000	0.0000	0.000	1.000
Waste	6.C Incineration of corpses	N_2O	0.000	0.000	0.0000	0.000	1.000
Total			**68.287**	**60.984**			

Table A1-17 KCA for Denmark, trend assessment 1990-2009 incl. LULUCF, tier 1.

Tier 1 Analysis IPCC Source Categories (LULUCF included)		DK GHG	- inventory Base Year Estimate Ex,o Mt CO2-eq	Latest Year Estimate Ex,t Mt CO2-eq	Trend Assessment Tx,t	Contribution to Trend	Cumulative
Energy	Stationary Combustion, Natural gas	CO_2	4.335	9.380	0.0788	0.198	0.198
Energy	Transport, Road transport	CO_2	9.282	12.125	0.0596	0.149	0.347
Energy	Stationary Combustion, Coal	CO_2	23.834	15.726	0.0582	0.146	0.493
Energy	Stationary Combustion, Gas oil	CO_2	4.547	1.792	0.0277	0.069	0.562
LULUCF	5.A.1 Conifers	CO_2	-0.066	-1.579	0.0206	0.052	0.614
LULUCF	5.B Cropland, Mineral soils	CO_2	1.054	-0.198	0.0148	0.037	0.651
Energy	Stationary Combustion, Residual oil	CO_2	2.440	1.077	0.0133	0.033	0.684
Energy	Stationary Combustion, Fosssil waste	CO_2	0.394	1.266	0.0128	0.032	0.717
Industrial Proc.	2B2 Nitric acid production	N_2O	1.043	0.000	0.0120	0.030	0.747
Agriculture	4.D1.1 Syntehetic Fertilizer	N_2O	2.395	1.196	0.0111	0.028	0.775
Agriculture	4.D3 Leaching	N_2O	2.455	1.416	0.0088	0.022	0.797
Industrial Proc.	2F Consumption of HFC	HFC	0.218	0.799	0.0085	0.021	0.818
Agriculture	4B Manure Management	CH_4	0.976	1.228	0.0056	0.014	0.832
LULUCF	5IV Cropland Limestone	CO_2	0.623	0.186	0.0046	0.012	0.843
Energy	Stationary Combustion, Kerosene	CO_2	0.366	0.008	0.0041	0.010	0.854
LULUCF	5.A.1 Broadleaves	CO_2	-0.659	-1.012	0.0034	0.008	0.862
Agriculture	4.D1.2 Animal waste applied to soils	N_2O	1.097	1.163	0.0034	0.008	0.871
LULUCF	5.C Grassland, Living biomass	CO_2	0.304	0.035	0.0030	0.008	0.878
Energy	Stationary Combustion, Petroleum coke	CO_2	0.410	0.550	0.0028	0.007	0.885
Energy	Transport, Agriculture	CO_2	1.272	1.268	0.0028	0.007	0.892
Energy	Stationary Combustion, Refinery gas	CO_2	0.816	0.876	0.0026	0.007	0.899
Energy	Natural gas fuelled engines, GAS	CH_4	0.001	0.192	0.0026	0.007	0.905
LULUCF	5.B Cropland, Organic soils	CO_2	1.343	1.282	0.0021	0.005	0.911
Agriculture	4A Enteric Fermentation	CH_4	3.249	2.859	0.0019	0.005	0.915
Energy	Transport, Navigation (large vessels)	CO_2	0.748	0.498	0.0018	0.004	0.920
Energy	Transport, Industry (mobile)	CO_2	0.842	0.823	0.0016	0.004	0.924
Energy	Transport, Commercial/institutional	CO_2	0.074	0.174	0.0015	0.004	0.928
Waste	6 A. Solid Waste Disposal on Land	CH_4	1.111	1.039	0.0015	0.004	0.931
Agriculture	4.D3 Atmospheric deposition	N_2O	0.465	0.296	0.0013	0.003	0.935
LULUCF	5.A.2 Broadleaves	CO_2	0.003	-0.078	0.0011	0.003	0.937
Agriculture	4.B Manure Management	N_2O	0.604	0.426	0.0011	0.003	0.940
LULUCF	5.A.2 Conifers	CO_2	0.007	-0.067	0.0010	0.003	0.943
LULUCF	5.B Cropland, Living biomass	CO_2	0.174	0.076	0.0010	0.002	0.945
Energy	Transport, Fisheries	CO_2	0.591	0.557	0.0009	0.002	0.947
Energy	Transport, Military	CO_2	0.119	0.160	0.0008	0.002	0.949
Energy	Transport, Navigation (small boats)	CO_2	0.048	0.100	0.0008	0.002	0.951
Energy	Stationary Combustion, BIOMASS	CH_4	0.105	0.148	0.0008	0.002	0.953
Agriculture	4.D1.6 Sewage sludge and Industrial waste used as fertiliser	N_2O	0.028	0.081	0.0008	0.002	0.955
LULUCF	5.D Wetlands, Soils	CO_2	0.086	0.016	0.0008	0.002	0.957
Waste	6.D Compost production	CH_4	0.027	0.078	0.0008	0.002	0.959
Industrial Proc.	2A2 Lime production	CO_2	0.116	0.043	0.0007	0.002	0.961
Industrial Proc.	2F Consumption of SF6	SF6	0.107	0.037	0.0007	0.002	0.963
Energy	Stationary Combustion, LPG	CO_2	0.164	0.088	0.0007	0.002	0.965

Continued							
Energy	Stationary Combustion, BIOMASS	N_2O	0.038	0.081	0.0007	0.002	0.966
Energy	Transport, Civil aviation	CO_2	0.243	0.156	0.0007	0.002	0.968
Agriculture	4.D.2 Grassing animals	N_2O	0.311	0.213	0.0007	0.002	0.970
Energy	1.B.2. Refinery processes	CH_4	0.001	0.045	0.0006	0.002	0.971
Energy	Transport, Road transport	N_2O	0.093	0.119	0.0006	0.001	0.973
Waste	6 B. Wastewater Handling - Indirect	N_2O	0.082	0.034	0.0005	0.001	0.974
Energy	Stationary Combustion, Coke	CO_2	0.138	0.081	0.0005	0.001	0.975
Solvent and Other Prod. Use	3D1 Other - Use of N2O for Anaesthesia	N_2O	0.000	0.034	0.0005	0.001	0.976
Waste	6.D Compost production	N_2O	0.011	0.040	0.0004	0.001	0.977
Energy	Transport, Residential	CO_2	0.039	0.063	0.0004	0.001	0.978
Energy	Transport, Road transport	CH_4	0.053	0.015	0.0004	0.001	0.979
Solvent and Other Prod. Use	3D5 Other	CO_2	0.086	0.044	0.0004	0.001	0.980
Energy	Biogas fuelled engines, BIOMASS	CH_4	0.000	0.028	0.0004	0.001	0.981
Energy	Stationary Combustion, GAS	N_2O	0.016	0.041	0.0004	0.001	0.982
Industrial Proc.	2A3 Limestone and dolomite use	CO_2	0.014	0.038	0.0004	0.001	0.983
Industrial Proc.	2A1 Cement production	CO_2	0.882	0.764	0.0003	0.001	0.984
Energy	1.B.2. Off-shore activities	CH_4	0.015	0.037	0.0003	0.001	0.985
Waste	5 B. Wastewater Handling - Direct	N_2O	0.027	0.047	0.0003	0.001	0.986
LULUCF	5.C Grassland, Dead organic matter	CO_2	0.032	0.003	0.0003	0.001	0.986
Industrial Proc.	2C1 Iron and steel production	CO_2	0.028	0.000	0.0003	0.001	0.987
LULUCF	5.C Grassland, Mineral soils	CO_2	0.001	0.024	0.0003	0.001	0.988
LULUCF	5.C Grassland, Organic soils	CO_2	0.137	0.137	0.0003	0.001	0.989
Agriculture	4.D1.3 N-fixing crops	N_2O	0.269	0.248	0.0003	0.001	0.989
LULUCF	5.E Settlements, Living biomass	CO_2	0.090	0.055	0.0003	0.001	0.990
Agriculture	4.D1.5 Cultivation of histosols	N_2O	0.171	0.164	0.0003	0.001	0.991
Waste	6 B. Wastewater Handling	CH_4	0.066	0.075	0.0003	0.001	0.992
Energy	Transport, Railways	CO_2	0.297	0.230	0.0003	0.001	0.992
Energy	Stationary Combustion, LIQUID	N_2O	0.040	0.016	0.0002	0.001	0.993
Energy	1.B.2. Land based activities	CH_4	0.017	0.029	0.0002	0.001	0.993
Energy	Stationary Combustion, SOLID	N_2O	0.068	0.043	0.0002	0.000	0.994
Industrial Proc.	2F Consumption of PFC	PFC	0.001	0.014	0.0002	0.000	0.994
Solvent and Other Prod. Use	3A Paint application	CO_2	0.026	0.009	0.0002	0.000	0.995
Energy	Transport, Forestry	CO_2	0.036	0.017	0.0002	0.000	0.995
Industrial Proc.	2A7 Glass and Glass wool	CO_2	0.055	0.034	0.0002	0.000	0.996
LULUCF	5.D Wetlands, Living biomass	CO_2	0.000	-0.011	0.0002	0.000	0.996
Industrial Proc.	2G Lubricants	CO_2	0.050	0.031	0.0001	0.000	0.996
Energy	Stationary Combustion, WASTE	N_2O	0.007	0.016	0.0001	0.000	0.997
Energy	1.B.2. Flaring off-shore	CO_2	0.276	0.241	0.0001	0.000	0.997
Agriculture	4.D1.4 Crop Residue	N_2O	0.361	0.312	0.0001	0.000	0.997
Energy	Stationary Combustion, BKB	CO_2	0.011	0.001	0.0001	0.000	0.998
Solvent and Other Prod. Use	3C Chemical products, manufacturing and processing	CO_2	0.023	0.012	0.0001	0.000	0.998
Energy	Stationary Combustion, SOLID	CH_4	0.013	0.004	0.0001	0.000	0.998
Waste	6.D Accidental fires, buildings	CO_2	0.015	0.018	0.0001	0.000	0.998
Waste	6.D Accidental fires, vehicles	CO_2	0.007	0.010	0.0001	0.000	0.998
Energy	Transport, Agriculture	N_2O	0.015	0.017	0.0001	0.000	0.999
LULUCF	5.B Cropland, Dead organic matter	CO_2	0.006	0.001	0.0001	0.000	0.999
Energy	Stationary Combustion, GAS	CH_4	0.003	0.006	0.0000	0.000	0.999
Energy	1.B.2. Flaring in refinery	CO_2	0.024	0.017	0.0000	0.000	0.999

Continued							
Energy	1.B.2. Transmission of natural gas	CH_4	0.004	0.000	0.0000	0.000	0.999
Solvent and Other Prod. Use	3D5 Consumption of fireworks	N_2O	0.001	0.003	0.0000	0.000	0.999
Energy	Transport, Navigation (large vessels)	N_2O	0.015	0.010	0.0000	0.000	0.999
LULUCF	5.B Disturbance, Land converted to cropland	N_2O	0.003	0.000	0.0000	0.000	0.999
Energy	Transport, Industry (mobile)	N_2O	0.011	0.011	0.0000	0.000	0.999
Industrial Proc.	2D2 Food and Drink	CO_2	0.004	0.002	0.0000	0.000	0.999
Energy	Transport, Commercial/institutional	CH_4	0.002	0.004	0.0000	0.000	0.999
Energy	1.B.2. Distribution of natural gas	CH_4	0.005	0.003	0.0000	0.000	0.999
Industrial Proc.	2B5 Catalysts/Fertilizers, Pesticides and Sulphuric acid	CO_2	0.001	0.002	0.0000	0.000	1.000
Agriculture	4F Field burning af agricultural residues	CH_4	0.002	0.003	0.0000	0.000	1.000
Energy	Transport, Fisheries	N_2O	0.011	0.011	0.0000	0.000	1.000
Energy	1.B.2 Venting in gas storage	CH_4	0.000	0.001	0.0000	0.000	1.000
LULUCF	5IID Forest Land.	N_2O	0.016	0.012	0.0000	0.000	1.000
Energy	Stationary Combustion, LIQUID	CH_4	0.003	0.001	0.0000	0.000	1.000
Energy	1.B.2. Flaring in refinery	CH_4	0.001	0.000	0.0000	0.000	1.000
Waste	6.D Accidental fires, buildings	CH_4	0.002	0.003	0.0000	0.000	1.000
Energy	Transport, Navigation (small boats)	N_2O	0.000	0.001	0.0000	0.000	1.000
Energy	Transport, Military	N_2O	0.001	0.002	0.0000	0.000	1.000
Energy	1.B.2. Flaring off-shore	CH_4	0.000	0.001	0.0000	0.000	1.000
Energy	Transport, Commercial/institutional	N_2O	0.000	0.001	0.0000	0.000	1.000
Agriculture	4.F Field Burning of Agricultural Residues	N_2O	0.001	0.001	0.0000	0.000	1.000
Energy	Transport, Residential	CH_4	0.001	0.001	0.0000	0.000	1.000
Energy	Transport, Industry (mobile)	CH_4	0.001	0.001	0.0000	0.000	1.000
Energy	Transport, Forestry	CH_4	0.000	0.000	0.0000	0.000	1.000
Energy	Stationary Combustion, WASTE	CH_4	0.001	0.001	0.0000	0.000	1.000
Energy	Transport, Navigation (small boats)	CH_4	0.000	0.001	0.0000	0.000	1.000
Waste	6.D Accidental fires, vehicles	CH_4	0.000	0.000	0.0000	0.000	1.000
Energy	Transport, Agriculture	CH_4	0.002	0.002	0.0000	0.000	1.000
Solvent and Other Prod. Use	3D5 Consumption of fireworks	CO_2	0.000	0.000	0.0000	0.000	1.000
Energy	Transport, Residential	N_2O	0.000	0.000	0.0000	0.000	1.000
Industrial Proc.	2A6 Road paving with asphalt	CO_2	0.002	0.002	0.0000	0.000	1.000
Energy	Transport, Civil aviation	N_2O	0.003	0.003	0.0000	0.000	1.000
Energy	Transport, Railways	N_2O	0.003	0.002	0.0000	0.000	1.000
Waste	6.C Incineration of carcasses	N_2O	0.000	0.000	0.0000	0.000	1.000
Energy	Transport, Civil aviation	CH_4	0.000	0.000	0.0000	0.000	1.000
Energy	Transport, Railways	CH_4	0.000	0.000	0.0000	0.000	1.000
Energy	1.B.2. Flaring in refinery	N_2O	0.000	0.000	0.0000	0.000	1.000
Energy	Transport, Fisheries	CH_4	0.000	0.000	0.0000	0.000	1.000
Energy	Transport, Navigation (large vessels)	CH_4	0.000	0.000	0.0000	0.000	1.000
Total			**71.441**	**59.865**			

Table A1-18 KCA for Denmark, level assessment base year excl. LULUCF, tier 2.

Tier 2 Analysis IPCC Source Categories (LULUCF excluded)		DK GHG	- inventory Base Year Estimate Ex,o Mt CO2-eq	Base Year Level Assessment Lx,o	Base Year Cumulative Total of Lx,o
Agriculture	4.D3 Leaching	N_2O	2.504	0.163	0.163
Agriculture	4.D1.1 Syntehetic Fertilizer	N_2O	2.469	0.161	0.324
Waste	6 A. Solid Waste Disposal on Land	CH4	1.314	0.086	0.409
Agriculture	4.D1.2 Animal waste applied to soils	N_2O	1.145	0.075	0.484
Agriculture	4A Enteric Fermentation	CH_4	0.653	0.043	0.526
Energy	Transport, Road transport	CO_2	0.500	0.033	0.559
Agriculture	4.D3 Atmospheric deposition	N_2O	0.473	0.031	0.590
Energy	Stationary Combustion, LIQUID	N_2O	0.403	0.026	0.616
Energy	Stationary Combustion, BIOMASS	N_2O	0.378	0.025	0.641
Agriculture	4.D1.4 Crop Residue	N_2O	0.368	0.024	0.665
Energy	Transport, Industry (mobile)	CO_2	0.348	0.023	0.687
Energy	Stationary Combustion, Coal	CO_2	0.339	0.022	0.709
Agriculture	4.B Manure Management	N_2O	0.331	0.022	0.731
Agriculture	4.D.2 Grassing animals	N_2O	0.321	0.021	0.752
Energy	Transport, Agriculture	CO_2	0.312	0.020	0.772
Agriculture	4.D1.3 N-fixing crops	N_2O	0.275	0.018	0.790
Energy	Stationary Combustion, SOLID	N_2O	0.272	0.018	0.808
Industrial Proc.	2B2 Nitric acid production	N_2O	0.262	0.017	0.825
Energy	Stationary Combustion, Gas oil	CO_2	0.215	0.014	0.839
Agriculture	4B Manure Management	CH_4	0.201	0.013	0.852
Agriculture	4.D1.5 Cultivation of histosols	N_2O	0.175	0.011	0.863
Energy	Transport, Agriculture	N_2O	0.153	0.010	0.873
Energy	Transport, Navigation (large vessels)	N_2O	0.146	0.010	0.883
Energy	Stationary Combustion, GAS	N_2O	0.121	0.008	0.890
Energy	Transport, Fisheries	N_2O	0.115	0.007	0.898
Industrial Proc.	2F Consumption of HFC	HFC	0.111	0.007	0.905
Energy	Stationary Combustion, BIOMASS	CH_4	0.107	0.007	0.912
Energy	Transport, Industry (mobile)	N_2O	0.106	0.007	0.919
Energy	Stationary Combustion, Fosssil waste	CO_2	0.100	0.007	0.926
Energy	Transport, Navigation (large vessels)	CO_2	0.090	0.006	0.931
Waste	6.D Accidental fires, buildings	CO_2	0.077	0.005	0.936
Waste	6 B. Wastewater Handling	CH_4	0.059	0.004	0.940
Waste	6 B. Wastewater Handling - Indirect	N_2O	0.058	0.004	0.944
Industrial Proc.	2F Consumption of SF6	SF6	0.055	0.004	0.948
Energy	Stationary Combustion, Residual oil	CO_2	0.053	0.003	0.951
Energy	Stationary Combustion, Natural gas	CO_2	0.047	0.003	0.954
Energy	Transport, Road transport	N_2O	0.047	0.003	0.957
Waste	6.D Accidental fires, vehicles	CO_2	0.033	0.002	0.959
Energy	Transport, Civil aviation	N_2O	0.032	0.002	0.962
Energy	Transport, Fisheries	CO_2	0.032	0.002	0.964
Energy	Stationary Combustion, WASTE	N_2O	0.030	0.002	0.966
Waste	6.D Compost production	CH_4	0.029	0.002	0.967

Continued					
Waste	5 B. Wastewater Handling - Direct	N_2O	0.029	0.002	0.969
Agriculture	4.D1.6 Sewage sludge and Industrial waste used as fertiliser	N_2O	0.028	0.002	0.971
Energy	Transport, Civil aviation	CO_2	0.027	0.002	0.973
Energy	Transport, Commercial/institutional	CO_2	0.026	0.002	0.975
Energy	Transport, Railways	N_2O	0.025	0.002	0.976
Energy	1.B.2. Flaring off-shore	CO_2	0.025	0.002	0.978
Energy	Stationary Combustion, Petroleum coke	CO_2	0.022	0.001	0.979
Energy	Transport, Road transport	CH_4	0.021	0.001	0.981
Energy	Stationary Combustion, Kerosene	CO_2	0.021	0.001	0.982
Energy	Transport, Navigation (small boats)	CO_2	0.020	0.001	0.983
Industrial Proc.	2A1 Cement production	CO_2	0.020	0.001	0.985
Solvent and Other Prod. Use	3D5 Other	CO_2	0.019	0.001	0.986
Energy	Stationary Combustion, Refinery gas	CO_2	0.018	0.001	0.987
Waste	6.D Accidental fires, buildings	CH_4	0.017	0.001	0.988
Energy	Transport, Railways	CO_2	0.016	0.001	0.989
Energy	Transport, Residential	CO_2	0.014	0.001	0.990
Energy	Stationary Combustion, SOLID	CH_4	0.013	0.001	0.991
Waste	6.D Compost production	N_2O	0.012	0.001	0.992
Energy	Transport, Military	N_2O	0.011	0.001	0.992
Energy	Transport, Forestry	CO_2	0.011	0.001	0.993
Energy	Stationary Combustion, LPG	CO_2	0.009	0.001	0.994
Industrial Proc.	2A2 Lime production	CO_2	0.008	0.001	0.994
Energy	Stationary Combustion, Coke	CO_2	0.007	0.000	0.995
Energy	1.B.2. Land based activities	CH_4	0.007	0.000	0.995
Energy	Transport, Military	CO_2	0.006	0.000	0.996
Solvent and Other Prod. Use	3A Paint application	CO_2	0.005	0.000	0.996
Energy	1.B.2. Off-shore activities	CH_4	0.004	0.000	0.996
Solvent and Other Prod. Use	3C Chemical products, manufacturing and processing	CO_2	0.004	0.000	0.996
Energy	Transport, Navigation (small boats)	N_2O	0.004	0.000	0.997
Energy	1.B.2. Flaring off-shore	N_2O	0.004	0.000	0.997
Energy	Transport, Commercial/institutional	N_2O	0.003	0.000	0.997
Energy	Stationary Combustion, GAS	CH_4	0.003	0.000	0.997
Industrial Proc.	2A7 Glass and Glass wool	CO_2	0.003	0.000	0.998
Energy	1.B.2. Flaring in refinery	CO_2	0.003	0.000	0.998
Energy	Stationary Combustion, LIQUID	CH_4	0.003	0.000	0.998
Industrial Proc.	2G Lubricants	CO_2	0.003	0.000	0.998
Solvent and Other Prod. Use	3D5 Consumption of fireworks	N_2O	0.002	0.000	0.998
Energy	Transport, Agriculture	CH_4	0.002	0.000	0.998
Energy	Transport, Commercial/institutional	CH_4	0.002	0.000	0.999
Waste	6.D Accidental fires, vehicles	CH_4	0.002	0.000	0.999
Industrial Proc.	2C1 Iron and steel production	CO_2	0.002	0.000	0.999
Energy	Transport, Residential	N_2O	0.002	0.000	0.999
Energy	Transport, Forestry	N_2O	0.002	0.000	0.999
Energy	1.B.2. Distribution of natural gas	CH_4	0.001	0.000	0.999
Energy	Stationary Combustion, WASTE	CH_4	0.001	0.000	0.999
Energy	Transport, Industry (mobile)	CH_4	0.001	0.000	0.999
Energy	Transport, Residential	CH_4	0.001	0.000	0.999
Agriculture	4F Field burning af agricultural residues	CH_4	0.001	0.000	0.999

Continued					
Energy	1.B.2. Refinery processes	CH_4	0.001	0.000	1.000
Industrial Proc.	2A3 Limestone and dolomite use	CO_2	0.001	0.000	1.000
Energy	Stationary Combustion, BKB	CO_2	0.001	0.000	1.000
Energy	1.B.2. Flaring in refinery	N_2O	0.001	0.000	1.000
Energy	1.B.2. Transmission of natural gas	CH_4	0.001	0.000	1.000
Energy	Transport, Forestry	CH_4	0.000	0.000	1.000
Industrial Proc.	2A6 Road paving with asphalt	CO_2	0.000	0.000	1.000
Agriculture	4.F Field Burning of Agricultural Residues	N_2O	0.000	0.000	1.000
Energy	Transport, Navigation (small boats)	CH_4	0.000	0.000	1.000
Energy	Transport, Navigation (large vessels)	CH_4	0.000	0.000	1.000
Industrial Proc.	2D2 Food and Drink	CO_2	0.000	0.000	1.000
Waste	6.C Incineration of corpses	N_2O	0.000	0.000	1.000
Energy	Transport, Fisheries	CH_4	0.000	0.000	1.000
Energy	Transport, Railways	CH_4	0.000	0.000	1.000
Industrial Proc.	2F Consumption of PFC	PFC	0.000	0.000	1.000
Energy	1.B.2. Flaring in refinery	CH_4	0.000	0.000	1.000
Solvent and Other Prod. Use	3D5 Consumption of fireworks	CO_2	0.000	0.000	1.000
Energy	Transport, Civil aviation	CH_4	0.000	0.000	1.000
Energy	Transport, Military	CH_4	0.000	0.000	1.000
Industrial Proc.	2B5 Catalysts/Fertilizers, Pesticides and Sulphuric acid	CO_2	0.000	0.000	1.000
Energy	1.B.2. Flaring off-shore	CH_4	0.000	0.000	1.000
Waste	6.C Incineration of carcasses	N_2O	0.000	0.000	1.000
Waste	6.C Incineration of corpses	CH_4	0.000	0.000	1.000
Energy	Natural gas fuelled engines, GAS	CH_4	0.000	0.000	1.000
Industrial Proc.	2A5 Asphalt roofing	CO_2	0.000	0.000	1.000
Waste	6.C Incineration of carcasses	CH_4	0.000	0.000	1.000
Solvent and Other Prod. Use	3B Degreasing and dry cleaning	CO_2	0.000	0.000	1.000
Energy	Biogas fuelled engines, BIOMASS	CH_4	0.000	0.000	1.000
Energy	1.B.2 Venting in gas storage	CH_4	0.000	0.000	1.000
Solvent and Other Prod. Use	3D5 Consumption of fireworks	CH_4	0.000	0.000	1.000
Solvent and Other Prod. Use	3D1 Other - Use of N2O for Anaesthesia	N_2O	0.000	0.000	1.000
Waste	6.D Accidental fires, buildings	N_2O	0.000	0.000	1.000
Waste	6.D Accidental fires, vehicles	N_2O	0.000	0.000	1.000
Total			15.360	1.000	

Table A1-19 KCA for Denmark, level assessment base year incl. LULUCF, tier 2.

Tier 2 Analysis **IPCC Source Categories (LULUCF included)**		**GHG**	**DK - inventory** **Base Year Estimate** **Ex,o** **Mt CO2-eq**	**Base Year Level Assessment** **Lx,o**	**Base Year Cumulative Total of Lx,o**
Agriculture	4.D3 Leaching	N_2O	2.504	0.137	0.137
Agriculture	4.D1.1 Syntehetic Fertilizer	N_2O	2.469	0.135	0.272
Waste	6 A. Solid Waste Disposal on Land	CH_4	1.314	0.072	0.344
LULUCF	5.B Cropland, Organic soils	CO_2	1.216	0.066	0.410
Agriculture	4.D1.2 Animal waste applied to soils	N_2O	1.145	0.063	0.473
LULUCF	5.B Cropland, Mineral soils	CO_2	0.797	0.044	0.516
Agriculture	4A Enteric Fermentation	CH_4	0.653	0.036	0.552
Energy	Transport, Road transport	CO_2	0.500	0.027	0.579
Agriculture	4.D3 Atmospheric deposition	N_2O	0.473	0.026	0.605
Energy	Stationary Combustion, LIQUID	N_2O	0.403	0.022	0.627
Energy	Stationary Combustion, BIOMASS	N_2O	0.378	0.021	0.648
Agriculture	4.D1.4 Crop Residue	N_2O	0.368	0.020	0.668
Energy	Transport, Industry (mobile)	CO_2	0.348	0.019	0.687
LULUCF	5.A.1 Broadleaves	CO_2	0.344	0.019	0.706
Energy	Stationary Combustion, Coal	CO_2	0.339	0.019	0.724
Agriculture	4.B Manure Management	N_2O	0.331	0.018	0.742
Agriculture	4.D.2 Grassing animals	N_2O	0.321	0.018	0.760
Energy	Transport, Agriculture	CO_2	0.312	0.017	0.777
Agriculture	4.D1.3 N-fixing crops	N_2O	0.275	0.015	0.792
Energy	Stationary Combustion, SOLID	N_2O	0.272	0.015	0.807
Industrial Proc.	2B2 Nitric acid production	N_2O	0.262	0.014	0.821
Energy	Stationary Combustion, Gas oil	CO_2	0.215	0.012	0.833
Agriculture	4B Manure Management	CH_4	0.201	0.011	0.844
Agriculture	4.D1.5 Cultivation of histosols	N_2O	0.175	0.010	0.854
LULUCF	5.C Grassland, Living biomass	CO_2	0.155	0.008	0.862
Energy	Transport, Agriculture	N_2O	0.153	0.008	0.870
Energy	Transport, Navigation (large vessels)	N_2O	0.146	0.008	0.878
LULUCF	5.C Grassland, Organic soils	CO_2	0.124	0.007	0.885
Energy	Stationary Combustion, GAS	N_2O	0.121	0.007	0.892
Energy	Transport, Fisheries	N_2O	0.115	0.006	0.898
Industrial Proc.	2F Consumption of HFC	HFC	0.111	0.006	0.904
Energy	Stationary Combustion, BIOMASS	CH_4	0.107	0.006	0.910
Energy	Transport, Industry (mobile)	N_2O	0.106	0.006	0.916
Energy	Stationary Combustion, Fosssil waste	CO_2	0.100	0.005	0.921
Energy	Transport, Navigation (large vessels)	CO_2	0.090	0.005	0.926
LULUCF	5.B Cropland, Living biomass	CO_2	0.089	0.005	0.931
LULUCF	5.D Wetlands, Soils	CO_2	0.087	0.005	0.936
Waste	6.D Accidental fires, buildings	CO_2	0.077	0.004	0.940
Waste	6 B. Wastewater Handling	CH_4	0.059	0.003	0.943
Waste	6 B. Wastewater Handling - Indirect	N_2O	0.058	0.003	0.946
Industrial Proc.	2F Consumption of SF6	SF6	0.055	0.003	0.949
Energy	Stationary Combustion, Residual oil	CO_2	0.053	0.003	0.952

Continued					
Energy	Stationary Combustion, Natural gas	CO_2	0.047	0.003	0.955
Energy	Transport, Road transport	N_2O	0.047	0.003	0.957
LULUCF	5.E Settlements, Living biomass	CO_2	0.046	0.002	0.960
LULUCF	5.A.1 Conifers	CO_2	0.034	0.002	0.962
Waste	6.D Accidental fires, vehicles	CO_2	0.033	0.002	0.964
Energy	Transport, Civil aviation	N_2O	0.032	0.002	0.965
Energy	Transport, Fisheries	CO_2	0.032	0.002	0.967
Energy	Stationary Combustion, WASTE	N_2O	0.030	0.002	0.969
Waste	6.D Compost production	CH_4	0.029	0.002	0.970
Waste	5 B. Wastewater Handling - Direct	N_2O	0.029	0.002	0.972
Agriculture	4.D1.6 Sewage sludge and Industrial waste used as fertiliser	N_2O	0.028	0.002	0.973
Energy	Transport, Civil aviation	CO_2	0.027	0.001	0.975
Energy	Transport, Commercial/institutional	CO_2	0.026	0.001	0.976
Energy	Transport, Railways	N_2O	0.025	0.001	0.978
Energy	1.B.2. Flaring off-shore	CO_2	0.025	0.001	0.979
Energy	Stationary Combustion, Petroleum coke	CO_2	0.022	0.001	0.980
Energy	Transport, Road transport	CH_4	0.021	0.001	0.981
Energy	Stationary Combustion, Kerosene	CO_2	0.021	0.001	0.983
Energy	Transport, Navigation (small boats)	CO_2	0.020	0.001	0.984
Industrial Proc.	2A1 Cement production	CO_2	0.020	0.001	0.985
Solvent and Other Prod. Use	3D5 Other	CO_2	0.019	0.001	0.986
Energy	Stationary Combustion, Refinery gas	CO_2	0.018	0.001	0.987
Waste	6.D Accidental fires, buildings	CH_4	0.017	0.001	0.988
LULUCF	5.C Grassland, Dead organic matter	CO_2	0.016	0.001	0.989
Energy	Transport, Railways	CO_2	0.016	0.001	0.990
Energy	Transport, Residential	CO_2	0.014	0.001	0.990
Energy	Stationary Combustion, SOLID	CH_4	0.013	0.001	0.991
LULUCF	5IID Forest Land.	N_2O	0.013	0.001	0.992
Waste	6.D Compost production	N_2O	0.012	0.001	0.992
Energy	Transport, Military	N_2O	0.011	0.001	0.993
Energy	Transport, Forestry	CO_2	0.011	0.001	0.994
Energy	Stationary Combustion, LPG	CO_2	0.009	0.000	0.994
Industrial Proc.	2A2 Lime production	CO_2	0.008	0.000	0.994
Energy	Stationary Combustion, Coke	CO_2	0.007	0.000	0.995
Energy	1.B.2. Land based activities	CH_4	0.007	0.000	0.995
Energy	Transport, Military	CO_2	0.006	0.000	0.996
Solvent and Other Prod. Use	3A Paint application	CO_2	0.005	0.000	0.996
Energy	1.B.2. Off-shore activities	CH_4	0.004	0.000	0.996
Solvent and Other Prod. Use	3C Chemical products, manufacturing and processing	CO_2	0.004	0.000	0.996
Energy	Transport, Navigation (small boats)	N_2O	0.004	0.000	0.997
LULUCF	5.A.2 Conifers	CO_2	0.004	0.000	0.997
Energy	1.B.2. Flaring off-shore	N_2O	0.004	0.000	0.997
Energy	Transport, Commercial/institutional	N_2O	0.003	0.000	0.997
Energy	Stationary Combustion, GAS	CH_4	0.003	0.000	0.997
LULUCF	5.B Cropland, Dead organic matter	CO_2	0.003	0.000	0.997
Industrial Proc.	2A7 Glass and Glass wool	CO_2	0.003	0.000	0.998
LULUCF	5.B Disturbance, Land converted to cropland	N_2O	0.003	0.000	0.998
Energy	1.B.2. Flaring in refinery	CO_2	0.003	0.000	0.998

Continued					
Energy	Stationary Combustion, LIQUID	CH_4	0.003	0.000	0.998
Industrial Proc.	2G Lubricants	CO_2	0.003	0.000	0.998
Solvent and Other Prod. Use	3D5 Consumption of fireworks	N_2O	0.002	0.000	0.998
Energy	Transport, Agriculture	CH_4	0.002	0.000	0.999
Energy	Transport, Commercial/institutional	CH_4	0.002	0.000	0.999
Waste	6.D Accidental fires, vehicles	CH_4	0.002	0.000	0.999
Industrial Proc.	2C1 Iron and steel production	CO_2	0.002	0.000	0.999
Energy	Transport, Residential	N_2O	0.002	0.000	0.999
LULUCF	5.A.2 Broadleaves	CO_2	0.002	0.000	0.999
Energy	Transport, Forestry	N_2O	0.002	0.000	0.999
Energy	1.B.2. Distribution of natural gas	CH_4	0.001	0.000	0.999
Energy	Stationary Combustion, WASTE	CH_4	0.001	0.000	0.999
Energy	Transport, Industry (mobile)	CH_4	0.001	0.000	0.999
Energy	Transport, Residential	CH_4	0.001	0.000	0.999
Agriculture	4F Field burning af agricultural residues	CH_4	0.001	0.000	0.999
Energy	1.B.2. Refinery processes	CH_4	0.001	0.000	1.000
Industrial Proc.	2A3 Limestone and dolomite use	CO_2	0.001	0.000	1.000
LULUCF	5.C Grassland, Mineral soils	CO_2	0.001	0.000	1.000
Energy	Stationary Combustion, BKB	CO_2	0.001	0.000	1.000
Energy	1.B.2. Flaring in refinery	N_2O	0.001	0.000	1.000
Energy	1.B.2. Transmission of natural gas	CH_4	0.001	0.000	1.000
Energy	Transport, Forestry	CH_4	0.000	0.000	1.000
Industrial Proc.	2A6 Road paving with asphalt	CO_2	0.000	0.000	1.000
Agriculture	4.F Field Burning of Agricultural Residues	N_2O	0.000	0.000	1.000
Energy	Transport, Navigation (small boats)	CH_4	0.000	0.000	1.000
Energy	Transport, Navigation (large vessels)	CH_4	0.000	0.000	1.000
Industrial Proc.	2D2 Food and Drink	CO_2	0.000	0.000	1.000
Waste	6.C Incineration of corpses	N_2O	0.000	0.000	1.000
Energy	Transport, Fisheries	CH_4	0.000	0.000	1.000
Energy	Transport, Railways	CH_4	0.000	0.000	1.000
Industrial Proc.	2F Consumption of PFC	PFC	0.000	0.000	1.000
Energy	1.B.2. Flaring in refinery	CH_4	0.000	0.000	1.000
LULUCF	5.D Wetlands, Living biomass	CO_2	0.000	0.000	1.000
Solvent and Other Prod. Use	3D5 Consumption of fireworks	CO_2	0.000	0.000	1.000
Energy	Transport, Civil aviation	CH_4	0.000	0.000	1.000
LULUCF	5IID Wetlands. Peatland	N_2O	0.000	0.000	1.000
Energy	Transport, Military	CH_4	0.000	0.000	1.000
LULUCF	5.D Wetlands, Dead organic matter	CO_2	0.000	0.000	1.000
Industrial Proc.	2B5 Catalysts/Fertilizers, Pesticides and Sulphuric acid	CO_2	0.000	0.000	1.000
Energy	1.B.2. Flaring off-shore	CH_4	0.000	0.000	1.000
Waste	6.C Incineration of carcasses	N_2O	0.000	0.000	1.000
Waste	6.C Incineration of corpses	CH_4	0.000	0.000	1.000
Energy	Natural gas fuelled engines, GAS	CH_4	0.000	0.000	1.000
Industrial Proc.	2A5 Asphalt roofing	CO_2	0.000	0.000	1.000
Waste	6.C Incineration of carcasses	CH_4	0.000	0.000	1.000
Solvent and Other Prod. Use	3B Degreasing and dry cleaning	CO_2	0.000	0.000	1.000
Energy	Biogas fuelled engines, BIOMASS	CH_4	0.000	0.000	1.000
Energy	1.B.2 Venting in gas storage	CH_4	0.000	0.000	1.000

Continued					
Solvent and Other Prod. Use	3D5 Consumption of fireworks	CH_4	0.000	0.000	1.000
Solvent and Other Prod. Use	3D1 Other - Use of N2O for Anaesthesia	N_2O	0.000	0.000	1.000
LULUCF	5IV Cropland Limestone	CO_2	0.000	0.000	1.000
Waste	6.D Accidental fires, buildings	N_2O	0.000	0.000	1.000
Waste	6.D Accidental fires, vehicles	N_2O	0.000	0.000	1.000
Total			18.293	1.000	

[1)] The Estimates include signs, where + : emission - : removal, although in the level analyses only the absolute values are used

Table A1-20 KCA for Denmark, level assessment 2009 excl. LULUCF, tier 2.

Tier 2 Analysis IPCC Source Categories (LULUCF excluded)		GHG	DK - inventory Latest Year Estimate Ex,t Mt CO2-eq	Latest Year Level Assessment Lx,t	Latest Year Cumulative Total of Lx,t
Agriculture	4.D3 Leaching	N_2O	1.444	0.109	0.109
Agriculture	4.D1.1 Syntehetic Fertilizer	N_2O	1.233	0.093	0.202
Waste	6 A. Solid Waste Disposal on Land	CH_4	1.230	0.093	0.295
Agriculture	4.D1.2 Animal waste applied to soils	N_2O	1.215	0.092	0.387
Energy	Stationary Combustion, BIOMASS	N_2O	0.807	0.061	0.448
Energy	Transport, Road transport	CO_2	0.653	0.049	0.497
Agriculture	4A Enteric Fermentation	CH_4	0.575	0.043	0.540
Industrial Proc.	2F Consumption of HFC	HFC	0.407	0.031	0.571
Energy	Transport, Industry (mobile)	CO_2	0.340	0.026	0.597
Energy	Stationary Combustion, Fosssil waste	CO_2	0.322	0.024	0.621
Agriculture	4.D1.4 Crop Residue	N_2O	0.318	0.024	0.645
Energy	Transport, Agriculture	CO_2	0.311	0.023	0.669
Energy	Stationary Combustion, GAS	N_2O	0.306	0.023	0.692
Agriculture	4.D3 Atmospheric deposition	N_2O	0.301	0.023	0.714
Agriculture	4B Manure Management	CH_4	0.253	0.019	0.734
Agriculture	4.D1.3 N-fixing crops	N_2O	0.253	0.019	0.753
Agriculture	4.B Manure Management	N_2O	0.234	0.018	0.770
Energy	Stationary Combustion, Coal	CO_2	0.224	0.017	0.787
Agriculture	4.D.2 Grassing animals	N_2O	0.220	0.017	0.804
Energy	Stationary Combustion, SOLID	N_2O	0.171	0.013	0.817
Agriculture	4.D1.5 Cultivation of histosols	N_2O	0.167	0.013	0.829
Energy	Transport, Agriculture	N_2O	0.166	0.013	0.842
Energy	Stationary Combustion, LIQUID	N_2O	0.158	0.012	0.854
Energy	Stationary Combustion, BIOMASS	CH_4	0.151	0.011	0.865
Energy	Transport, Fisheries	N_2O	0.109	0.008	0.873
Energy	Transport, Industry (mobile)	N_2O	0.108	0.008	0.881
Energy	Stationary Combustion, Natural gas	CO_2	0.102	0.008	0.889
Energy	Transport, Navigation (large vessels)	N_2O	0.097	0.007	0.896
Waste	6.D Accidental fires, buildings	CO_2	0.088	0.007	0.903
Energy	Stationary Combustion, Gas oil	CO_2	0.085	0.006	0.910
Waste	6.D Compost production	CH_4	0.084	0.006	0.916
Agriculture	4.D1.6 Sewage sludge and Industrial waste used as fertiliser	N_2O	0.083	0.006	0.922
Waste	6 B. Wastewater Handling	CH_4	0.067	0.005	0.927
Energy	Stationary Combustion, WASTE	N_2O	0.064	0.005	0.932
Energy	Transport, Commercial/institutional	CO_2	0.062	0.005	0.937
Energy	Transport, Navigation (large vessels)	CO_2	0.060	0.005	0.941
Energy	Transport, Road transport	N_2O	0.060	0.005	0.946
Energy	1.B.2. Refinery processes	CH_4	0.056	0.004	0.950
Waste	6.D Accidental fires, vehicles	CO_2	0.050	0.004	0.954
Waste	5 B. Wastewater Handling - Direct	N_2O	0.050	0.004	0.957
Waste	6.D Compost production	N_2O	0.044	0.003	0.961
Energy	Transport, Navigation (small boats)	CO_2	0.041	0.003	0.964

Continued					
Energy	Transport, Fisheries	CO_2	0.030	0.002	0.966
Energy	Stationary Combustion, Petroleum coke	CO_2	0.030	0.002	0.968
Energy	Transport, Civil aviation	N_2O	0.025	0.002	0.970
Waste	6 B. Wastewater Handling - Indirect	N_2O	0.024	0.002	0.972
Energy	Stationary Combustion, Residual oil	CO_2	0.024	0.002	0.974
Energy	Transport, Residential	CO_2	0.022	0.002	0.975
Energy	1.B.2. Flaring off-shore	CO_2	0.022	0.002	0.977
Waste	6.D Accidental fires, buildings	CH_4	0.020	0.002	0.979
Energy	Transport, Railways	N_2O	0.020	0.001	0.980
Energy	Stationary Combustion, Refinery gas	CO_2	0.020	0.001	0.982
Industrial Proc.	2F Consumption of SF6	SF6	0.019	0.001	0.983
Energy	Transport, Civil aviation	CO_2	0.017	0.001	0.984
Industrial Proc.	2A1 Cement production	CO_2	0.017	0.001	0.986
Energy	Transport, Military	N_2O	0.017	0.001	0.987
Energy	Transport, Railways	CO_2	0.012	0.001	0.988
Energy	1.B.2. Land based activities	CH_4	0.012	0.001	0.989
Energy	1.B.2. Off-shore activities	CH_4	0.011	0.001	0.990
Energy	Transport, Navigation (small boats)	N_2O	0.011	0.001	0.990
Solvent and Other Prod. Use	3D5 Other	CO_2	0.010	0.001	0.991
Solvent and Other Prod. Use	3D5 Consumption of fireworks	N_2O	0.010	0.001	0.992
Energy	Transport, Military	CO_2	0.009	0.001	0.992
Energy	Transport, Commercial/institutional	N_2O	0.008	0.001	0.993
Industrial Proc.	2F Consumption of PFC	PFC	0.007	0.001	0.994
Energy	Transport, Road transport	CH_4	0.006	0.000	0.994
Energy	Stationary Combustion, GAS	CH_4	0.006	0.000	0.995
Energy	Transport, Forestry	CO_2	0.005	0.000	0.995
Energy	Stationary Combustion, LPG	CO_2	0.005	0.000	0.995
Energy	Stationary Combustion, Coke	CO_2	0.004	0.000	0.996
Energy	Natural gas fuelled engines, GAS	CH_4	0.004	0.000	0.996
Energy	Stationary Combustion, SOLID	CH_4	0.004	0.000	0.996
Energy	Transport, Commercial/institutional	CH_4	0.004	0.000	0.997
Energy	Transport, Residential	N_2O	0.003	0.000	0.997
Waste	6.D Accidental fires, vehicles	CH_4	0.003	0.000	0.997
Industrial Proc.	2A2 Lime production	CO_2	0.003	0.000	0.997
Energy	Biogas fuelled engines, BIOMASS	CH_4	0.003	0.000	0.997
Energy	1.B.2. Flaring off-shore	N_2O	0.003	0.000	0.998
Industrial Proc.	2A3 Limestone and dolomite use	CO_2	0.003	0.000	0.998
Solvent and Other Prod. Use	3D1 Other - Use of N2O for Anaesthesia	N_2O	0.002	0.000	0.998
Solvent and Other Prod. Use	3C Chemical products, manufacturing and processing	CO_2	0.002	0.000	0.998
Energy	Transport, Agriculture	CH_4	0.002	0.000	0.998
Energy	1.B.2. Flaring in refinery	CO_2	0.002	0.000	0.999
Industrial Proc.	2A7 Glass and Glass wool	CO_2	0.002	0.000	0.999
Energy	Transport, Forestry	N_2O	0.002	0.000	0.999
Industrial Proc.	2G Lubricants	CO_2	0.002	0.000	0.999
Agriculture	4F Field burning af agricultural residues	CH_4	0.002	0.000	0.999
Solvent and Other Prod. Use	3A Paint application	CO_2	0.002	0.000	0.999
Energy	Transport, Residential	CH_4	0.001	0.000	0.999
Energy	Stationary Combustion, WASTE	CH_4	0.001	0.000	0.999

Continued					
Energy	Stationary Combustion, LIQUID	CH_4	0.001	0.000	1.000
Energy	1.B.2. Distribution of natural gas	CH_4	0.001	0.000	1.000
Solvent and Other Prod. Use	3D5 Consumption of fireworks	CO_2	0.001	0.000	1.000
Energy	Transport, Industry (mobile)	CH_4	0.001	0.000	1.000
Agriculture	4.F Field Burning of Agricultural Residues	N_2O	0.001	0.000	1.000
Energy	Transport, Navigation (small boats)	CH_4	0.001	0.000	1.000
Energy	Stationary Combustion, Kerosene	CO_2	0.000	0.000	1.000
Industrial Proc.	2A6 Road paving with asphalt	CO_2	0.000	0.000	1.000
Waste	6.C Incineration of corpses	N_2O	0.000	0.000	1.000
Energy	Transport, Fisheries	CH_4	0.000	0.000	1.000
Energy	Transport, Navigation (large vessels)	CH_4	0.000	0.000	1.000
Energy	1.B.2. Flaring in refinery	N_2O	0.000	0.000	1.000
Energy	Transport, Civil aviation	CH_4	0.000	0.000	1.000
Energy	1.B.2 Venting in gas storage	CH_4	0.000	0.000	1.000
Industrial Proc.	2B5 Catalysts/Fertilizers, Pesticides and Sulphuric acid	CO_2	0.000	0.000	1.000
Waste	6.C Incineration of carcasses	N_2O	0.000	0.000	1.000
Energy	Transport, Railways	CH_4	0.000	0.000	1.000
Industrial Proc.	2D2 Food and Drink	CO_2	0.000	0.000	1.000
Energy	Transport, Military	CH_4	0.000	0.000	1.000
Energy	1.B.2. Flaring off-shore	CH_4	0.000	0.000	1.000
Energy	Transport, Forestry	CH_4	0.000	0.000	1.000
Energy	Stationary Combustion, BKB	CO_2	0.000	0.000	1.000
Energy	1.B.2. Transmission of natural gas	CH_4	0.000	0.000	1.000
Energy	1.B.2. Flaring in refinery	CH_4	0.000	0.000	1.000
Waste	6.C Incineration of corpses	CH_4	0.000	0.000	1.000
Waste	6.C Incineration of carcasses	CH_4	0.000	0.000	1.000
Industrial Proc.	2A5 Asphalt roofing	CO_2	0.000	0.000	1.000
Solvent and Other Prod. Use	3B Degreasing and dry cleaning	CO_2	0.000	0.000	1.000
Industrial Proc.	2C1 Iron and steel production	CO_2	0.000	0.000	1.000
Industrial Proc.	2B2 Nitric acid production	N_2O	0.000	0.000	1.000
Solvent and Other Prod. Use	3D5 Consumption of fireworks	CH_4	0.000	0.000	1.000
Waste	6.D Accidental fires, buildings	N_2O	0.000	0.000	1.000
Waste	6.D Accidental fires, vehicles	N_2O	0.000	0.000	1.000
Total			13.243	1.000	

Table A1-21 KCA for Denmark, level assessment 2009 incl. LULUCF, tier 2.

Tier 2 Analysis **IPCC Source Categories (LULUCF included)**		**GHG**	**DK - inventory Latest Year Estimate Ex,t Mt CO2-eq**	**Latest Year Level Assessment Lx,t**	**Latest Year Cumulative Total of Lx,t**
Agriculture	4.D3 Leaching	N_2O	1.444	0.089	0.089
Agriculture	4.D1.1 Syntehetic Fertilizer	N_2O	1.233	0.076	0.165
Waste	6 A. Solid Waste Disposal on Land	CH_4	1.230	0.076	0.241
Agriculture	4.D1.2 Animal waste applied to soils	N_2O	1.215	0.075	0.315
LULUCF	5.B Cropland, Organic soils	CO_2	1.161	0.071	0.387
LULUCF	5.A.1 Conifers	CO_2	0.824	0.051	0.437
Energy	Stationary Combustion, BIOMASS	N_2O	0.807	0.050	0.487
Energy	Transport, Road transport	CO_2	0.653	0.040	0.527
Agriculture	4A Enteric Fermentation	CH_4	0.575	0.035	0.563
LULUCF	5.A.1 Broadleaves	CO_2	0.528	0.033	0.595
Industrial Proc.	2F Consumption of HFC	HFC	0.407	0.025	0.620
Energy	Transport, Industry (mobile)	CO_2	0.340	0.021	0.641
Energy	Stationary Combustion, Fosssil waste	CO_2	0.322	0.020	0.661
Agriculture	4.D1.4 Crop Residue	N_2O	0.318	0.020	0.681
Energy	Transport, Agriculture	CO_2	0.311	0.019	0.700
Energy	Stationary Combustion, GAS	N_2O	0.306	0.019	0.719
Agriculture	4.D3 Atmospheric deposition	N_2O	0.301	0.019	0.737
Agriculture	4B Manure Management	CH_4	0.253	0.016	0.753
Agriculture	4.D1.3 N-fixing crops	N_2O	0.253	0.016	0.768
Agriculture	4.B Manure Management	N_2O	0.234	0.014	0.783
Energy	Stationary Combustion, Coal	CO_2	0.224	0.014	0.796
Agriculture	4.D.2 Grassing animals	N_2O	0.220	0.014	0.810
Energy	Stationary Combustion, SOLID	N_2O	0.171	0.011	0.821
Agriculture	4.D1.5 Cultivation of histosols	N_2O	0.167	0.010	0.831
Energy	Transport, Agriculture	N_2O	0.166	0.010	0.841
Energy	Stationary Combustion, LIQUID	N_2O	0.158	0.010	0.851
Energy	Stationary Combustion, BIOMASS	CH_4	0.151	0.009	0.860
LULUCF	5.B Cropland, Mineral soils	CO_2	0.150	0.009	0.869
LULUCF	5.C Grassland, Organic soils	CO_2	0.124	0.008	0.877
Energy	Transport, Fisheries	N_2O	0.109	0.007	0.884
Energy	Transport, Industry (mobile)	N_2O	0.108	0.007	0.890
Energy	Stationary Combustion, Natural gas	CO_2	0.102	0.006	0.896
Energy	Transport, Navigation (large vessels)	N_2O	0.097	0.006	0.902
Waste	6.D Accidental fires, buildings	CO_2	0.088	0.005	0.908
Energy	Stationary Combustion, Gas oil	CO_2	0.085	0.005	0.913
Waste	6.D Compost production	CH_4	0.084	0.005	0.918
Agriculture	4.D1.6 Sewage sludge and Industrial waste used as fertiliser	N_2O	0.083	0.005	0.923
Waste	6 B. Wastewater Handling	CH_4	0.067	0.004	0.927
Energy	Stationary Combustion, WASTE	N_2O	0.064	0.004	0.931
Energy	Transport, Commercial/institutional	CO_2	0.062	0.004	0.935
Energy	Transport, Navigation (large vessels)	CO_2	0.060	0.004	0.939
Energy	Transport, Road transport	N_2O	0.060	0.004	0.943

Continued					
Energy	1.B.2. Refinery processes	CH_4	0.056	0.003	0.946
Waste	6.D Accidental fires, vehicles	CO_2	0.050	0.003	0.949
Waste	5 B. Wastewater Handling - Direct	N_2O	0.050	0.003	0.952
Waste	6.D Compost production	N_2O	0.044	0.003	0.955
Energy	Transport, Navigation (small boats)	CO_2	0.041	0.003	0.957
LULUCF	5.A.2 Broadleaves	CO_2	0.041	0.003	0.960
LULUCF	5.B Cropland, Living biomass	CO_2	0.039	0.002	0.962
LULUCF	5.A.2 Conifers	CO_2	0.035	0.002	0.964
Energy	Transport, Fisheries	CO_2	0.030	0.002	0.966
Energy	Stationary Combustion, Petroleum coke	CO_2	0.030	0.002	0.968
LULUCF	5.E Settlements, Living biomass	CO_2	0.028	0.002	0.970
Energy	Transport, Civil aviation	N_2O	0.025	0.002	0.971
Waste	6 B. Wastewater Handling - Indirect	N_2O	0.024	0.001	0.973
Energy	Stationary Combustion, Residual oil	CO_2	0.024	0.001	0.974
Energy	Transport, Residential	CO_2	0.022	0.001	0.976
Energy	1.B.2. Flaring off-shore	CO_2	0.022	0.001	0.977
Waste	6.D Accidental fires, buildings	CH_4	0.020	0.001	0.978
Energy	Transport, Railways	N_2O	0.020	0.001	0.979
Energy	Stationary Combustion, Refinery gas	CO_2	0.020	0.001	0.981
Industrial Proc.	2F Consumption of SF6	SF6	0.019	0.001	0.982
LULUCF	5.C Grassland, Mineral soils	CO_2	0.018	0.001	0.983
LULUCF	5.C Grassland, Living biomass	CO_2	0.018	0.001	0.984
Energy	Transport, Civil aviation	CO_2	0.017	0.001	0.985
Industrial Proc.	2A1 Cement production	CO_2	0.017	0.001	0.986
Energy	Transport, Military	N_2O	0.017	0.001	0.987
LULUCF	5.D Wetlands, Soils	CO_2	0.016	0.001	0.988
Energy	Transport, Railways	CO_2	0.012	0.001	0.989
Energy	1.B.2. Land based activities	CH_4	0.012	0.001	0.990
Energy	1.B.2. Off-shore activities	CH_4	0.011	0.001	0.990
Energy	Transport, Navigation (small boats)	N_2O	0.011	0.001	0.991
Solvent and Other Prod. Use	3D5 Other	CO_2	0.010	0.001	0.992
LULUCF	5IID Forest Land.	N_2O	0.010	0.001	0.992
Solvent and Other Prod. Use	3D5 Consumption of fireworks	N_2O	0.010	0.001	0.993
Energy	Transport, Military	CO_2	0.009	0.001	0.993
Energy	Transport, Commercial/institutional	N_2O	0.008	0.001	0.994
Industrial Proc.	2F Consumption of PFC	PFC	0.007	0.000	0.994
Energy	Transport, Road transport	CH_4	0.006	0.000	0.995
Energy	Stationary Combustion, GAS	CH_4	0.006	0.000	0.995
LULUCF	5.D Wetlands, Living biomass	CO_2	0.006	0.000	0.995
Energy	Transport, Forestry	CO_2	0.005	0.000	0.996
Energy	Stationary Combustion, LPG	CO_2	0.005	0.000	0.996
Energy	Stationary Combustion, Coke	CO_2	0.004	0.000	0.996
Energy	Natural gas fuelled engines, GAS	CH_4	0.004	0.000	0.997
Energy	Stationary Combustion, SOLID	CH_4	0.004	0.000	0.997
Energy	Transport, Commercial/institutional	CH_4	0.004	0.000	0.997
Energy	Transport, Residential	N_2O	0.003	0.000	0.997
Waste	6.D Accidental fires, vehicles	CH_4	0.003	0.000	0.997
Industrial Proc.	2A2 Lime production	CO_2	0.003	0.000	0.998

Continued					
Energy	Biogas fuelled engines, BIOMASS	CH_4	0.003	0.000	0.998
Energy	1.B.2. Flaring off-shore	N_2O	0.003	0.000	0.998
Industrial Proc.	2A3 Limestone and dolomite use	CO_2	0.003	0.000	0.998
Solvent and Other Prod. Use	3D1 Other - Use of N2O for Anaesthesia	N_2O	0.002	0.000	0.998
Solvent and Other Prod. Use	3C Chemical products, manufacturing and processing	CO_2	0.002	0.000	0.998
Energy	Transport, Agriculture	CH_4	0.002	0.000	0.999
Energy	1.B.2. Flaring in refinery	CO_2	0.002	0.000	0.999
Industrial Proc.	2A7 Glass and Glass wool	CO_2	0.002	0.000	0.999
Energy	Transport, Forestry	N_2O	0.002	0.000	0.999
Industrial Proc.	2G Lubricants	CO_2	0.002	0.000	0.999
Agriculture	4F Field burning af agricultural residues	CH_4	0.002	0.000	0.999
Solvent and Other Prod. Use	3A Paint application	CO_2	0.002	0.000	0.999
Energy	Transport, Residential	CH_4	0.001	0.000	0.999
Energy	Stationary Combustion, WASTE	CH_4	0.001	0.000	0.999
LULUCF	5.C Grassland, Dead organic matter	CO_2	0.001	0.000	0.999
Energy	Stationary Combustion, LIQUID	CH_4	0.001	0.000	1.000
Energy	1.B.2. Distribution of natural gas	CH_4	0.001	0.000	1.000
Solvent and Other Prod. Use	3D5 Consumption of fireworks	CO_2	0.001	0.000	1.000
Energy	Transport, Industry (mobile)	CH_4	0.001	0.000	1.000
LULUCF	5.B Cropland, Dead organic matter	CO_2	0.001	0.000	1.000
Agriculture	4.F Field Burning of Agricultural Residues	N_2O	0.001	0.000	1.000
Energy	Transport, Navigation (small boats)	CH_4	0.001	0.000	1.000
Energy	Stationary Combustion, Kerosene	CO_2	0.000	0.000	1.000
Industrial Proc.	2A6 Road paving with asphalt	CO_2	0.000	0.000	1.000
LULUCF	5.B Disturbance, Land converted to cropland	N_2O	0.000	0.000	1.000
Waste	6.C Incineration of corpses	N_2O	0.000	0.000	1.000
Energy	Transport, Fisheries	CH_4	0.000	0.000	1.000
Energy	Transport, Navigation (large vessels)	CH_4	0.000	0.000	1.000
Energy	1.B.2. Flaring in refinery	N_2O	0.000	0.000	1.000
Energy	Transport, Civil aviation	CH_4	0.000	0.000	1.000
Energy	1.B.2 Venting in gas storage	CH_4	0.000	0.000	1.000
Industrial Proc.	2B5 Catalysts/Fertilizers, Pesticides and Sulphuric acid	CO_2	0.000	0.000	1.000
Waste	6.C Incineration of carcasses	N_2O	0.000	0.000	1.000
Energy	Transport, Railways	CH_4	0.000	0.000	1.000
Industrial Proc.	2D2 Food and Drink	CO_2	0.000	0.000	1.000
LULUCF	5IID Wetlands. Peatland	N_2O	0.000	0.000	1.000
Energy	Transport, Military	CH_4	0.000	0.000	1.000
LULUCF	5.D Wetlands, Dead organic matter	CO_2	0.000	0.000	1.000
Energy	1.B.2. Flaring off-shore	CH_4	0.000	0.000	1.000
Energy	Transport, Forestry	CH_4	0.000	0.000	1.000
Energy	Stationary Combustion, BKB	CO_2	0.000	0.000	1.000
Energy	1.B.2. Transmission of natural gas	CH_4	0.000	0.000	1.000
Energy	1.B.2. Flaring in refinery	CH_4	0.000	0.000	1.000
Waste	6.C Incineration of corpses	CH_4	0.000	0.000	1.000
Waste	6.C Incineration of carcasses	CH_4	0.000	0.000	1.000
Industrial Proc.	2A5 Asphalt roofing	CO_2	0.000	0.000	1.000
Solvent and Other Prod. Use	3B Degreasing and dry cleaning	CO_2	0.000	0.000	1.000
Industrial Proc.	2C1 Iron and steel production	CO_2	0.000	0.000	1.000

Continued					
Industrial Proc.	2B2 Nitric acid production	N_2O	0.000	0.000	1.000
Solvent and Other Prod. Use	3D5 Consumption of fireworks	CH_4	0.000	0.000	1.000
LULUCF	5IV Cropland Limestone	CO_2	0.000	0.000	1.000
Waste	6.D Accidental fires, buildings	N_2O	0.000	0.000	1.000
Waste	6.D Accidental fires, vehicles	N_2O	0.000	0.000	1.000
Total			**16.244**	**1.000**	

[1)] The Estimates include signs, where + : emission - : removal, although in the level analyses only the absolute values are used.

Table A1-22 KCA for Denmark, trend assessment 1990-2009 excl. LULUCF, tier 2.

Tier 2 Analysis IPCC Source Categories (LULUCF included)		**DK GHG**	**- inventory Base Year Estimate Ex,o Mt CO2-eq**	**Latest Year Estimate Ex,t Mt CO2-eq**	**Trend Assessment Tx,t**	**Contribution to Trend**	**Cumulative**
Agriculture	4.D1.1 Syntehetic Fertilizer	N_2O	2.395	1.196	1.4237	0.179	0.179
Agriculture	4.D3 Leaching	N_2O	2.455	1.416	1.1596	0.146	0.324
Energy	Stationary Combustion, BIOMASS	N_2O	0.038	0.081	0.6896	0.087	0.411
Industrial Proc.	2F Consumption of HFC	HFC	0.218	0.799	0.4524	0.057	0.468
Industrial Proc.	2B2 Nitric acid production	N_2O	1.043	0.000	0.3425	0.043	0.511
Energy	Stationary Combustion, Fosssil waste	CO2	0.394	1.266	0.3416	0.043	0.553
Energy	Transport, Road transport	CO2	9.282	12.125	0.3037	0.038	0.592
Energy	Stationary Combustion, LIQUID	N_2O	0.040	0.016	0.2958	0.037	0.629
Energy	Stationary Combustion, GAS	N_2O	0.016	0.041	0.2895	0.036	0.665
Agriculture	4.D1.2 Animal waste applied to soils	N_2O	1.097	1.163	0.2833	0.036	0.701
Agriculture	4.D3 Atmospheric deposition	N_2O	0.465	0.296	0.1776	0.022	0.723
Energy	Stationary Combustion, Gas oil	CO_2	4.547	1.792	0.1569	0.020	0.743
Energy	Stationary Combustion, Coal	CO_2	23.834	15.726	0.1156	0.015	0.757
Agriculture	4B Manure Management	CH_4	0.976	1.228	0.1080	0.014	0.771
Energy	Stationary Combustion, SOLID	N_2O	0.068	0.043	0.1057	0.013	0.784
Agriculture	4.D.2 Grassing animals	N_2O	0.311	0.213	0.0978	0.012	0.796
Agriculture	4.B Manure Management	N_2O	0.604	0.426	0.0905	0.011	0.808
Energy	Stationary Combustion, Natural gas	CO_2	4.335	9.380	0.0876	0.011	0.819
Waste	6.D Compost production	CH_4	0.027	0.078	0.0852	0.011	0.829
Agriculture	4.D1.6 Sewage sludge and Industrial waste used as fertiliser	N_2O	0.028	0.081	0.0842	0.011	0.840
Waste	6 A. Solid Waste Disposal on Land	CH_4	1.111	1.039	0.0836	0.010	0.850
Energy	1.B.2. Refinery processes	CH_4	0.001	0.045	0.0811	0.010	0.861
Energy	Stationary Combustion, BIOMASS	CH_4	0.105	0.148	0.0802	0.010	0.871
Energy	Transport, Commercial/institutional	CO_2	0.074	0.174	0.0563	0.007	0.878
Energy	Stationary Combustion, WASTE	N_2O	0.007	0.016	0.0545	0.007	0.885
Energy	Transport, Navigation (large vessels)	N_2O	0.015	0.010	0.0484	0.006	0.891
Waste	6.D Compost production	N_2O	0.011	0.040	0.0482	0.006	0.897
Energy	Transport, Agriculture	CO_2	1.272	1.268	0.0478	0.006	0.903
Industrial Proc.	2F Consumption of SF6	SF6	0.107	0.037	0.0442	0.006	0.908
Energy	Transport, Agriculture	N_2O	0.015	0.017	0.0439	0.006	0.914
Energy	Transport, Industry (mobile)	CO_2	0.842	0.823	0.0436	0.005	0.919
Waste	6 B. Wastewater Handling - Indirect	N_2O	0.082	0.034	0.0414	0.005	0.924

Continued							
Waste	5 B. Wastewater Handling - Direct	N_2O	0.027	0.047	0.0354	0.004	0.929
Energy	Stationary Combustion, Residual oil	CO_2	2.440	1.077	0.0352	0.004	0.933
Energy	Transport, Navigation (small boats)	CO_2	0.048	0.100	0.0346	0.004	0.938
Waste	6.D Accidental fires, vehicles	CO_2	0.007	0.010	0.0302	0.004	0.941
Energy	Transport, Navigation (large vessels)	CO_2	0.748	0.498	0.0300	0.004	0.945
Waste	6.D Accidental fires, buildings	CO_2	0.015	0.018	0.0287	0.004	0.949
Energy	Stationary Combustion, Kerosene	CO_2	0.366	0.008	0.0264	0.003	0.952
Energy	Transport, Road transport	N_2O	0.093	0.119	0.0262	0.003	0.955
Waste	6 B. Wastewater Handling	CH_4	0.066	0.075	0.0205	0.003	0.958
Energy	Transport, Industry (mobile)	N_2O	0.011	0.011	0.0196	0.002	0.960
Energy	Transport, Road transport	CH_4	0.053	0.015	0.0188	0.002	0.963
Agriculture	4.D1.5 Cultivation of histosols	N_2O	0.171	0.164	0.0159	0.002	0.965
Agriculture	4.D1.4 Crop Residue	N_2O	0.361	0.312	0.0156	0.002	0.967
Energy	Transport, Residential	CO_2	0.039	0.063	0.0146	0.002	0.969
Energy	Stationary Combustion, Petroleum coke	CO_2	0.410	0.550	0.0145	0.002	0.970
Agriculture	4A Enteric Fermentation	CH_4	3.249	2.859	0.0117	0.001	0.972
Solvent and Other Prod. Use	3D5 Consumption of fireworks	N_2O	0.001	0.003	0.0112	0.001	0.973
Solvent and Other Prod. Use	3D5 Other	CO_2	0.086	0.044	0.0108	0.001	0.975
Agriculture	4.D1.3 N-fixing crops	N_2O	0.269	0.248	0.0108	0.001	0.976
Energy	Transport, Navigation (small boats)	N_2O	0.000	0.001	0.0107	0.001	0.977
Energy	Stationary Combustion, SOLID	CH_4	0.013	0.004	0.0106	0.001	0.979
Energy	1.B.2. Off-shore activities	CH_4	0.015	0.037	0.0106	0.001	0.980
Industrial Proc.	2F Consumption of PFC	PFC	0.001	0.014	0.0103	0.001	0.981
Energy	Transport, Military	N_2O	0.001	0.002	0.0100	0.001	0.983
Energy	Transport, Civil aviation	CO_2	0.243	0.156	0.0100	0.001	0.984
Energy	Transport, Fisheries	N_2O	0.011	0.011	0.0096	0.001	0.985
Energy	1.B.2. Land based activities	CH_4	0.017	0.029	0.0081	0.001	0.986
Energy	Transport, Commercial/institutional	N_2O	0.000	0.001	0.0076	0.001	0.987
Energy	Transport, Forestry	CO_2	0.036	0.017	0.0066	0.001	0.988
Waste	6.D Accidental fires, buildings	CH_4	0.002	0.003	0.0065	0.001	0.989
Energy	Natural gas fuelled engines, GAS	CH_4	0.001	0.192	0.0063	0.001	0.989
Industrial Proc.	2A2 Lime production	CO_2	0.116	0.043	0.0062	0.001	0.990
Energy	Transport, Civil aviation	N_2O	0.003	0.003	0.0049	0.001	0.991
Energy	Stationary Combustion, Refinery gas	CO_2	0.816	0.876	0.0049	0.001	0.991
Energy	Stationary Combustion, LPG	CO_2	0.164	0.088	0.0047	0.001	0.992
Energy	Stationary Combustion, GAS	CH_4	0.003	0.006	0.0046	0.001	0.993
Energy	Biogas fuelled engines, BIOMASS	CH_4	0.000	0.028	0.0044	0.001	0.993
Energy	Transport, Railways	N_2O	0.003	0.002	0.0043	0.001	0.994
Energy	Transport, Military	CO_2	0.119	0.160	0.0043	0.001	0.994
Solvent and Other Prod. Use	3A Paint application	CO_2	0.026	0.009	0.0039	0.000	0.995
Solvent and Other Prod. Use	3D1 Other - Use of N2O for Anaesthesia	N_2O	0.000	0.034	0.0035	0.000	0.995
Energy	Stationary Combustion, Coke	CO_2	0.138	0.081	0.0033	0.000	0.996
Energy	Transport, Railways	CO_2	0.297	0.230	0.0027	0.000	0.996
Industrial Proc.	2A3 Limestone and dolomite use	CO_2	0.014	0.038	0.0027	0.000	0.996
Industrial Proc.	2C1 Iron and steel production	CO_2	0.028	0.000	0.0026	0.000	0.997
Energy	Transport, Commercial/institutional	CH_4	0.002	0.004	0.0026	0.000	0.997
Energy	Transport, Residential	N_2O	0.000	0.000	0.0024	0.000	0.997
Energy	Transport, Fisheries	CO_2	0.591	0.557	0.0024	0.000	0.997

Continued							
Solvent and Other Prod. Use	3C Chemical products, manufacturing and processing	CO_2	0.023	0.012	0.0022	0.000	0.998
Waste	6.D Accidental fires, vehicles	CH_4	0.000	0.000	0.0018	0.000	0.998
Energy	Stationary Combustion, LIQUID	CH_4	0.003	0.001	0.0018	0.000	0.998
Industrial Proc.	2A7 Glass and Glass wool	CO_2	0.055	0.034	0.0012	0.000	0.998
Industrial Proc.	2G Lubricants	CO_2	0.050	0.031	0.0010	0.000	0.998
Agriculture	4F Field burning af agricultural residues	CH_4	0.002	0.003	0.0010	0.000	0.999
Solvent and Other Prod. Use	3D5 Consumption of fireworks	CO_2	0.000	0.000	0.0008	0.000	0.999
Energy	Transport, Industry (mobile)	CH_4	0.001	0.001	0.0008	0.000	0.999
Energy	1.B.2. Flaring in refinery	CO_2	0.024	0.017	0.0008	0.000	0.999
Energy	1.B.2. Distribution of natural gas	CH_4	0.005	0.003	0.0008	0.000	0.999
Industrial Proc.	2A1 Cement production	CO_2	0.882	0.764	0.0008	0.000	0.999
Energy	Stationary Combustion, BKB	CO_2	0.011	0.001	0.0007	0.000	0.999
Energy	1.B.2. Flaring off-shore	CO_2	0.276	0.241	0.0007	0.000	0.999
Energy	1.B.2. Transmission of natural gas	CH_4	0.004	0.000	0.0007	0.000	0.999
Energy	Transport, Residential	CH_4	0.001	0.001	0.0007	0.000	0.999
Energy	1.B.2. Flaring in refinery	N_2O	0.000	0.000	0.0005	0.000	1.000
Energy	Transport, Forestry	CH_4	0.000	0.000	0.0005	0.000	1.000
Energy	1.B.2. Flaring off-shore	N_2O	0.001	0.001	0.0005	0.000	1.000
Agriculture	4.F Field Burning of Agricultural Residues	N_2O	0.001	0.001	0.0004	0.000	1.000
Energy	Transport, Navigation (small boats)	CH_4	0.000	0.001	0.0003	0.000	1.000
Energy	1.B.2. Flaring in refinery	CH_4	0.001	0.000	0.0003	0.000	1.000
Energy	1.B.2 Venting in gas storage	CH_4	0.000	0.001	0.0003	0.000	1.000
Energy	Stationary Combustion, WASTE	CH_4	0.001	0.001	0.0002	0.000	1.000
Industrial Proc.	2D2 Food and Drink	CO_2	0.004	0.002	0.0002	0.000	1.000
Waste	6.C Incineration of carcasses	N_2O	0.000	0.000	0.0002	0.000	1.000
Energy	Transport, Forestry	N_2O	0.000	0.000	0.0002	0.000	1.000
Industrial Proc.	2B5 Catalysts/Fertilizers, Pesticides and Sulphuric acid	CO_2	0.001	0.002	0.0001	0.000	1.000
Energy	Transport, Railways	CH_4	0.000	0.000	0.0001	0.000	1.000
Energy	Transport, Agriculture	CH_4	0.002	0.002	0.0001	0.000	1.000
Energy	Transport, Civil aviation	CH_4	0.000	0.000	0.0001	0.000	1.000
Energy	Transport, Navigation (large vessels)	CH_4	0.000	0.000	0.0001	0.000	1.000
Energy	1.B.2. Flaring off-shore	CH_4	0.000	0.001	0.0001	0.000	1.000
Waste	6.C Incineration of corpses	N_2O	0.000	0.000	0.0001	0.000	1.000
Energy	Transport, Fisheries	CH_4	0.000	0.000	0.0001	0.000	1.000
Industrial Proc.	2A6 Road paving with asphalt	CO_2	0.002	0.002	0.0000	0.000	1.000
Energy	Transport, Military	CH_4	0.000	0.000	0.0000	0.000	1.000
Waste	6.C Incineration of carcasses	CH_4	0.000	0.000	0.0000	0.000	1.000
Waste	6.C Incineration of corpses	CH_4	0.000	0.000	0.0000	0.000	1.000
Industrial Proc.	2A5 Asphalt roofing	CO_2	0.000	0.000	0.0000	0.000	1.000
Solvent and Other Prod. Use	3B Degreasing and dry cleaning	CO_2	0.000	0.000	0.0000	0.000	1.000
Solvent and Other Prod. Use	3D5 Consumption of fireworks	CH_4	0.000	0.000	0.0000	0.000	1.000
Waste	6.D Accidental fires, buildings	N_2O	0.000	0.000	0.0000	0.000	1.000
Waste	6.D Accidental fires, vehicles	N_2O	0.000	0.000	0.0000	0.000	1.000
Total			68.288	60.985			

Table A1-23 KCA for Denmark, trend assessment 1990-2009 incl. LULUCF, tier 2.

Tier 2 Analysis IPCC Source Categories (LULUCF included)		**DK GHG**	**- inventory Base Year Estimate Ex,o Mt CO2-eq**	**Latest Year Estimate Ex,t Mt CO2-eq**	**Trend Assessment Tx,t**	**Contribution to Trend**	**Cumulative**
Agriculture	4.D1.1 Syntehetic Fertilizer	N_2O	2.395	1.196	1.1463	0.110	0.110
LULUCF	5.B Cropland, Mineral soils	CO_2	1.054	-0.198	1.1233	0.108	0.219
LULUCF	5.A.1 Conifers	CO_2	-0.066	-1.579	1.0783	0.104	0.322
Agriculture	4.D3 Leaching	N_2O	2.455	1.416	0.8964	0.086	0.409
Energy	Stationary Combustion, BIOMASS	N_2O	0.038	0.081	0.6746	0.065	0.474
Industrial Proc.	2F Consumption of HFC	HFC	0.218	0.799	0.4322	0.042	0.515
Agriculture	4.D1.2 Animal waste applied to soils	N_2O	1.097	1.163	0.3522	0.034	0.549
Energy	Stationary Combustion, Fosssil waste	CO_2	0.394	1.266	0.3276	0.032	0.581
Energy	Transport, Road transport	CO_2	9.282	12.125	0.3224	0.031	0.612
Industrial Proc.	2B2 Nitric acid production	N_2O	1.043	0.000	0.3010	0.029	0.641
Energy	Stationary Combustion, GAS	N_2O	0.016	0.041	0.2804	0.027	0.668
Energy	Stationary Combustion, LIQUID	N_2O	0.040	0.016	0.2465	0.024	0.691
LULUCF	5.B Cropland, Organic soils	CO_2	1.343	1.282	0.1957	0.019	0.710
Waste	6 A. Solid Waste Disposal on Land	CH_4	1.111	1.039	0.1779	0.017	0.727
LULUCF	5.A.1 Broadleaves	CO_2	-0.659	-1.012	0.1761	0.017	0.744
LULUCF	5.C Grassland, Living biomass	CO_2	0.304	0.035	0.1542	0.015	0.759
Energy	Stationary Combustion, Gas oil	CO_2	4.547	1.792	0.1307	0.013	0.772
Agriculture	4.D3 Atmospheric deposition	N_2O	0.465	0.296	0.1305	0.013	0.784
Agriculture	4B Manure Management	CH_4	0.976	1.228	0.1165	0.011	0.795
Energy	Stationary Combustion, Natural gas	CO_2	4.335	9.380	0.0856	0.008	0.804
Energy	Stationary Combustion, BIOMASS	CH_4	0.105	0.148	0.0833	0.008	0.812
Energy	Stationary Combustion, Coal	CO_2	23.834	15.726	0.0826	0.008	0.820
Waste	6.D Compost production	CH_4	0.027	0.078	0.0820	0.008	0.828
Agriculture	4.D1.6 Sewage sludge and Industrial waste used as fertiliser	N_2O	0.028	0.081	0.0810	0.008	0.835
Energy	Stationary Combustion, SOLID	N_2O	0.068	0.043	0.0784	0.008	0.843
LULUCF	5.D Wetlands, Soils	CO_2	0.086	0.016	0.0772	0.007	0.850
Energy	1.B.2. Refinery processes	CH_4	0.001	0.045	0.0760	0.007	0.858
Energy	Transport, Agriculture	CO_2	1.272	1.268	0.0685	0.007	0.864
Agriculture	4.D.2 Grassing animals	N_2O	0.311	0.213	0.0673	0.006	0.871
Energy	Transport, Industry (mobile)	CO_2	0.842	0.823	0.0672	0.006	0.877
Agriculture	4.B Manure Management	N_2O	0.604	0.426	0.0597	0.006	0.883
LULUCF	5.A.2 Broadleaves	CO_2	0.003	-0.078	0.0583	0.006	0.889
Energy	Transport, Commercial/institutional	CO_2	0.074	0.174	0.0547	0.005	0.894
Energy	Stationary Combustion, WASTE	N_2O	0.007	0.016	0.0533	0.005	0.899
Energy	Transport, Agriculture	N_2O	0.015	0.017	0.0527	0.005	0.904
LULUCF	5.A.2 Conifers	CO_2	0.007	-0.067	0.0523	0.005	0.909
LULUCF	5.B Cropland, Living biomass	CO_2	0.174	0.076	0.0490	0.005	0.914
Waste	6.D Compost production	N_2O	0.011	0.040	0.0460	0.004	0.918
Agriculture	4A Enteric Fermentation	CH_4	3.249	2.859	0.0385	0.004	0.922
Industrial Proc.	2F Consumption of SF6	SF6	0.107	0.037	0.0373	0.004	0.926
Waste	5 B. Wastewater Handling - Direct	N_2O	0.027	0.047	0.0354	0.003	0.929
Waste	6 B. Wastewater Handling - Indirect	N_2O	0.082	0.034	0.0344	0.003	0.932
Energy	Transport, Navigation (large vessels)	N_2O	0.015	0.010	0.0342	0.003	0.936

Continued							
Energy	Transport, Navigation (small boats)	CO_2	0.048	0.100	0.0340	0.003	0.939
Waste	6.D Accidental fires, buildings	CO_2	0.015	0.018	0.0327	0.003	0.942
Agriculture	4.D1.3 N-fixing crops	N_2O	0.269	0.248	0.0310	0.003	0.945
Waste	6.D Accidental fires, vehicles	CO_2	0.007	0.010	0.0308	0.003	0.948
Energy	Stationary Combustion, Residual oil	CO_2	2.440	1.077	0.0290	0.003	0.951
Agriculture	4.D1.5 Cultivation of histosols	N_2O	0.171	0.164	0.0281	0.003	0.953
Energy	Transport, Road transport	N_2O	0.093	0.119	0.0281	0.003	0.956
LULUCF	5.C Grassland, Organic soils	CO_2	0.137	0.137	0.0280	0.003	0.959
Energy	Transport, Industry (mobile)	N_2O	0.011	0.011	0.0264	0.003	0.961
LULUCF	5.C Grassland, Mineral soils	CO_2	0.001	0.024	0.0245	0.002	0.964
Waste	6 B. Wastewater Handling	CH_4	0.066	0.075	0.0237	0.002	0.966
Energy	Stationary Combustion, Kerosene	CO_2	0.366	0.008	0.0232	0.002	0.968
Energy	Transport, Navigation (large vessels)	CO_2	0.748	0.498	0.0213	0.002	0.970
Energy	Transport, Fisheries	N_2O	0.011	0.011	0.0177	0.002	0.972
LULUCF	5.C Grassland, Dead organic matter	CO_2	0.032	0.003	0.0168	0.002	0.974
Energy	Transport, Road transport	CH_4	0.053	0.015	0.0160	0.002	0.975
Energy	Stationary Combustion, Petroleum coke	CO_2	0.410	0.550	0.0153	0.001	0.977
Energy	Transport, Residential	CO_2	0.039	0.063	0.0147	0.001	0.978
LULUCF	5.E Settlements, Living biomass	CO_2	0.090	0.055	0.0141	0.001	0.979
Agriculture	4.D1.4 Crop Residue	N_2O	0.361	0.312	0.0133	0.001	0.981
Solvent and Other Prod. Use	3D5 Consumption of fireworks	N_2O	0.001	0.003	0.0107	0.001	0.982
Energy	Transport, Navigation (small boats)	N_2O	0.000	0.001	0.0103	0.001	0.983
Energy	1.B.2. Off-shore activities	CH_4	0.015	0.037	0.0103	0.001	0.984
Energy	Transport, Military	N_2O	0.001	0.002	0.0103	0.001	0.985
Industrial Proc.	2F Consumption of PFC	PFC	0.001	0.014	0.0096	0.001	0.986
Energy	Stationary Combustion, SOLID	CH_4	0.013	0.004	0.0090	0.001	0.986
Solvent and Other Prod. Use	3D5 Other	CO_2	0.086	0.044	0.0087	0.001	0.987
LULUCF	5.D Wetlands, Living biomass	CO_2	0.000	-0.011	0.0082	0.001	0.988
Energy	1.B.2. Land based activities	CH_4	0.017	0.029	0.0081	0.001	0.989
Energy	Transport, Commercial/institutional	N_2O	0.000	0.001	0.0074	0.001	0.990
Waste	6.D Accidental fires, buildings	CH_4	0.002	0.003	0.0074	0.001	0.990
Energy	Transport, Civil aviation	CO_2	0.243	0.156	0.0073	0.001	0.991
Energy	Stationary Combustion, Refinery gas	CO_2	0.816	0.876	0.0059	0.001	0.992
Energy	Natural gas fuelled engines, GAS	CH_4	0.001	0.192	0.0059	0.001	0.992
Energy	Transport, Forestry	CO_2	0.036	0.017	0.0053	0.001	0.993
Industrial Proc.	2A2 Lime production	CO_2	0.116	0.043	0.0052	0.001	0.993
Energy	Transport, Fisheries	CO_2	0.591	0.557	0.0046	0.000	0.994
Energy	Stationary Combustion, GAS	CH_4	0.003	0.006	0.0046	0.000	0.994
Energy	Transport, Military	CO_2	0.119	0.160	0.0045	0.000	0.994
Energy	Biogas fuelled engines, BIOMASS	CH_4	0.000	0.028	0.0041	0.000	0.995
Energy	Stationary Combustion, LPG	CO_2	0.164	0.088	0.0037	0.000	0.995
Solvent and Other Prod. Use	3A Paint application	CO_2	0.026	0.009	0.0033	0.000	0.996
Solvent and Other Prod. Use	3D1 Other - Use of N2O for Anaesthesia	N_2O	0.000	0.034	0.0033	0.000	0.996
LULUCF	5.B Disturbance, Land converted to cropland	N_2O	0.003	0.000	0.0028	0.000	0.996
LULUCF	5.B Cropland, Dead organic matter	CO_2	0.006	0.001	0.0026	0.000	0.996
Energy	Transport, Commercial/institutional	CH_4	0.002	0.004	0.0026	0.000	0.997
Industrial Proc.	2A3 Limestone and dolomite use	CO_2	0.014	0.038	0.0026	0.000	0.997
Energy	Stationary Combustion, Coke	CO_2	0.138	0.081	0.0025	0.000	0.997

Continued							
Energy	Transport, Residential	N_2O	0.000	0.000	0.0024	0.000	0.997
Industrial Proc.	2C1 Iron and steel production	CO_2	0.028	0.000	0.0023	0.000	0.998
Energy	Transport, Civil aviation	N_2O	0.003	0.003	0.0022	0.000	0.998
Energy	Transport, Railways	N_2O	0.003	0.002	0.0021	0.000	0.998
Waste	6.D Accidental fires, vehicles	CH_4	0.000	0.000	0.0019	0.000	0.998
Solvent and Other Prod. Use	3C Chemical products, manufacturing and processing	CO_2	0.023	0.012	0.0018	0.000	0.998
Energy	Stationary Combustion, LIQUID	CH_4	0.003	0.001	0.0015	0.000	0.998
Energy	Transport, Railways	CO_2	0.297	0.230	0.0013	0.000	0.999
Energy	1.B.2. Flaring off-shore	CO_2	0.276	0.241	0.0012	0.000	0.999
LULUCF	5IID Forest Land.	N_2O	0.016	0.012	0.0012	0.000	0.999
Agriculture	4F Field burning af agricultural residues	CH_4	0.002	0.003	0.0010	0.000	0.999
Industrial Proc.	2A7 Glass and Glass wool	CO_2	0.055	0.034	0.0009	0.000	0.999
Industrial Proc.	2A1 Cement production	CO_2	0.882	0.764	0.0008	0.000	0.999
Industrial Proc.	2G Lubricants	CO_2	0.050	0.031	0.0008	0.000	0.999
Solvent and Other Prod. Use	3D5 Consumption of fireworks	CO_2	0.000	0.000	0.0008	0.000	0.999
Energy	Transport, Residential	CH_4	0.001	0.001	0.0007	0.000	0.999
Energy	Stationary Combustion, BKB	CO_2	0.011	0.001	0.0006	0.000	0.999
Energy	Transport, Industry (mobile)	CH_4	0.001	0.001	0.0006	0.000	0.999
Energy	1.B.2. Transmission of natural gas	CH_4	0.004	0.000	0.0006	0.000	0.999
Energy	1.B.2. Distribution of natural gas	CH_4	0.005	0.003	0.0006	0.000	1.000
Energy	1.B.2. Flaring in refinery	CO_2	0.024	0.017	0.0005	0.000	1.000
Energy	1.B.2. Flaring in refinery	N_2O	0.000	0.000	0.0004	0.000	1.000
Energy	Transport, Forestry	CH_4	0.000	0.000	0.0004	0.000	1.000
Agriculture	4.F Field Burning of Agricultural Residues	N_2O	0.001	0.001	0.0004	0.000	1.000
Energy	Transport, Navigation (small boats)	CH_4	0.000	0.001	0.0003	0.000	1.000
Energy	Stationary Combustion, WASTE	CH_4	0.001	0.001	0.0003	0.000	1.000
Energy	Transport, Forestry	N_2O	0.000	0.000	0.0003	0.000	1.000
Energy	Transport, Agriculture	CH_4	0.002	0.002	0.0003	0.000	1.000
Energy	1.B.2. Flaring in refinery	CH_4	0.001	0.000	0.0003	0.000	1.000
Energy	1.B.2 Venting in gas storage	CH_4	0.000	0.001	0.0002	0.000	1.000
Waste	6.C Incineration of carcasses	N_2O	0.000	0.000	0.0002	0.000	1.000
Industrial Proc.	2D2 Food and Drink	CO_2	0.004	0.002	0.0002	0.000	1.000
Energy	1.B.2. Flaring off-shore	N_2O	0.001	0.001	0.0002	0.000	1.000
Industrial Proc.	2B5 Catalysts/Fertilizers, Pesticides and Sulphuric acid	CO_2	0.001	0.002	0.0001	0.000	1.000
Energy	Transport, Civil aviation	CH_4	0.000	0.000	0.0001	0.000	1.000
Energy	Transport, Railways	CH_4	0.000	0.000	0.0001	0.000	1.000
Energy	1.B.2. Flaring off-shore	CH_4	0.000	0.001	0.0001	0.000	1.000
Waste	6.C Incineration of corpses	N_2O	0.000	0.000	0.0001	0.000	1.000
Energy	Transport, Fisheries	CH_4	0.000	0.000	0.0001	0.000	1.000
Energy	Transport, Navigation (large vessels)	CH_4	0.000	0.000	0.0001	0.000	1.000
Industrial Proc.	2A6 Road paving with asphalt	CO_2	0.002	0.002	0.0001	0.000	1.000
LULUCF	5.D Wetlands, Dead organic matter	CO_2	0.000	0.000	0.0000	0.000	1.000
LULUCF	5IID Wetlands. Peatland	N_2O	0.000	0.000	0.0000	0.000	1.000
Energy	Transport, Military	CH_4	0.000	0.000	0.0000	0.000	1.000
Waste	6.C Incineration of carcasses	CH_4	0.000	0.000	0.0000	0.000	1.000
Waste	6.C Incineration of corpses	CH_4	0.000	0.000	0.0000	0.000	1.000
Industrial Proc.	2A5 Asphalt roofing	CO_2	0.000	0.000	0.0000	0.000	1.000
Solvent and Other Prod. Use	3B Degreasing and dry cleaning	CO_2	0.000	0.000	0.0000	0.000	1.000

Continued							
Solvent and Other Prod. Use	3D5 Consumption of fireworks	CH_4	0.000	0.000	0.0000	0.000	1.000
LULUCF	5IV Cropland Limestone	CO_2	0.623	0.186	0.0000	0.000	1.000
Waste	6.D Accidental fires, buildings	N_2O	0.000	0.000	0.0000	0.000	1.000
Waste	6.D Accidental fires, vehicles	N_2O	0.000	0.000	0.0000	0.000	1.000
Total			**71.442**	**59.867**			

1) The Estimates include signs, where + : emission - : removal, although in the level analyses only the absolute values are used.

Annex 2 Detailed discussion of methodology and data for estimation of CO_2 emission from fossil fuel combustion

Please refer to Annex 3A and 3B.

Annex 3 Other detailed methodological descriptions for individual source or sink categories (where relevant)

Annex 3A Stationary combustion

Annex 3A-1 IPCC/SNAP source correspondence list

Table 3A-1.1 Correspondence list for IPCC source categories 1A1, 1A2 and 1A4 and SNAP (EEA 2007).

SNAP_id	SNAP_name	IPCC source
01	Combustion in energy and transformation industries	
010100	Public power	1A1a
010101	Combustion plants >= 300 MW (boilers)	1A1a
010102	Combustion plants >= 50 and < 300 MW (boilers)	1A1a
010103	Combustion plants < 50 MW (boilers)	1A1a
010104	Gas turbines	1A1a
010105	Stationary engines	1A1a
010200	District heating plants	1A1a
010201	Combustion plants >= 300 MW (boilers)	1A1a
010202	Combustion plants >= 50 and < 300 MW (boilers)	1A1a
010203	Combustion plants < 50 MW (boilers)	1A1a
010204	Gas turbines	1A1a
010205	Stationary engines	1A1a
010300	Petroleum refining plants	1A1b
010301	Combustion plants >= 300 MW (boilers)	1A1b
010302	Combustion plants >= 50 and < 300 MW (boilers)	1A1b
010303	Combustion plants < 50 MW (boilers)	1A1b
010304	Gas turbines	1A1b
010305	Stationary engines	1A1b
010306	Process furnaces	1A1b
010400	Solid fuel transformation plants	1A1c
010401	Combustion plants >= 300 MW (boilers)	1A1c
010402	Combustion plants >= 50 and < 300 MW (boilers)	1A1c
010403	Combustion plants < 50 MW (boilers)	1A1c
010404	Gas turbines	1A1c
010405	Stationary engines	1A1c
010406	Coke oven furnaces	1A1c
010407	Other (coal gasification, liquefaction, ...)	1A1c
010500	Coal mining, oil/gas extraction, pipeline compressors	
010501	Combustion plants >= 300 MW (boilers)	1A1c
010502	Combustion plants >= 50 and < 300 MW (boilers)	1A1c
010503	Combustion plants < 50 MW (boilers)	1A1c
010504	Gas turbines	1A1c
010505	Stationary engines	1A1c
02	Non-industrial combustion plants	
020100	Commercial and institutional plants (t)	1A4a
020101	Combustion plants >= 300 MW (boilers)	1A4a
020102	Combustion plants >= 50 and < 300 MW (boilers)	1A4a
020103	Combustion plants < 50 MW (boilers)	1A4a
020104	Stationary gas turbines	1A4a
020105	Stationary engines	1A4a
020106	Other stationary equipments (n)	1A4a
020200	Residential plants	1A4b
020201	Combustion plants >= 50 MW (boilers)	1A4b
020202	Combustion plants < 50 MW (boilers)	1A4b
020203	Gas turbines	1A4b
020204	Stationary engines	1A4b
020205 [2)]	Other equipments (stoves, fireplaces, cooking,...) [2)]	1A4b
020300	Plants in agriculture, forestry and aquaculture	1A4c
020301	Combustion plants >= 50 MW (boilers)	1A4c
020302	Combustion plants < 50 MW (boilers)	1A4c
020303	Stationary gas turbines	1A4c
020304	Stationary engines	1A4c
020305	Other stationary equipments (n)	1A4c
03	Combustion in manufacturing industry	
030100	Comb. in boilers, gas turbines and stationary	1A2
030101	Combustion plants >= 300 MW (boilers)	1A2
030102	Combustion plants >= 50 and < 300 MW (boilers)	1A2
030103	Combustion plants < 50 MW (boilers)	1A2
030104	Gas turbines	1A2
030105	Stationary engines	1A2
030106	Other stationary equipments (n)	1A2
030200	Process furnaces without contact	
030203	Blast furnace cowpers	1A2a
030204	Plaster furnaces	1A2f
030205	Other furnaces	1A2f
0303	Processes with contact	
030301	Sinter and pelletizing plants	1A2a
030302	Reheating furnaces steel and iron	1A2a
030303	Gray iron foundries	1A2a
030304	Primary lead production	1A2b
030305	Primary zinc production	1A2b

SNAP_id	SNAP_name	IPCC source
030306	Primary copper production	1A2b
030307	Secondary lead production	1A2b
030308	Secondary zinc production	1A2b
030309	Secondary copper production	1A2b
030310	Secondary aluminium production	1A2b
030311	Cement (f)	1A2f
030312	Lime (includ. iron and steel and paper pulp industr.)(f)	1A2f
030313	Asphalt concrete plants	1A2f
030314	Flat glass (f)	1A2f
030315	Container glass (f)	1A2f
030316	Glass wool (except binding) (f)	1A2f
030317	Other glass (f)	1A2f
030318	Mineral wool (except binding)	1A2f
030319	Bricks and tiles	1A2f
030320	Fine ceramic materials	1A2f
030321	Paper-mill industry (drying processes)	1A2d
030322	Alumina production	1A2b
030323	Magnesium production (dolomite treatment)	1A2b
030324	Nickel production (thermal process)	1A2b
030325	Enamel production	1A2f
030326	Other	1A2f
08 1)	Other mobile sources and machinery	
0804 1)	Maritime activities	
080403 1)	National fishing	1A4c
0806 1)	Agriculture	1A4c
0807 1)	Forestry	1A4c
0808 1)	Industry	1A2f
0809 1)	Household and gardening	1A4b

[1)] Not stationary combustion. Included in a IPCC sector that also includes stationary combustion plants

[2)] Stoves, fireplaces and cooking is included in the sector 0202 or 020202 in the Danish inventory.

Annex 3A-2 Fuel rate

Table 3A-2.1 Fuel consumption rate of stationary combustion plants 2009, PJ.

fuel_type	fuel_gr_abbr	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
BIOMASS	BIO OIL	0.74	0.74	0.74	0.80	0.25	0.25	0.06	0.01	0.01	0.03
	BIO PROD GAS					0.08	0.02	0.03	0.04	0.04	0.05
	BIOGAS	0.75	0.75	0.75	0.75	1.28	1.75	1.99	2.39	2.64	2.61
	STRAW	12.48	13.31	13.88	13.37	12.66	12.97	12.94	13.17	13.90	13.67
	WOOD	18.25	20.04	21.03	22.22	21.86	21.82	23.36	23.42	22.95	24.38
WASTE	MUNICIP. WASTES	15.50	16.74	17.80	19.41	20.31	22.91	24.95	26.77	26.59	29.14
GAS	NATURAL GAS	76.10	86.11	90.48	102.48	114.60	132.71	156.26	164.50	178.72	187.95
LIQUID	GAS OIL	61.44	64.99	56.09	62.02	53.92	53.69	58.01	51.06	48.41	47.49
	KEROSENE	5.09	0.94	0.78	0.77	0.65	0.58	0.54	0.44	0.42	0.26
	LPG	2.60	2.55	2.32	2.56	2.60	2.74	2.98	2.49	2.54	2.21
	NAPHTA										
	ORIMULSION						19.91	36.77	40.49	32.58	34.19
	PETROLEUM COKE	4.46	4.40	4.31	5.68	7.55	5.27	5.88	6.02	5.30	6.78
	REFINERY GAS	14.17	14.54	14.87	15.41	16.36	20.84	21.44	16.91	15.23	15.72
	RESIDUAL OIL	31.39	37.52	37.78	32.09	45.50	32.28	37.04	25.85	29.26	22.97
SOLID	BROWN COAL BRI.	0.12	0.17	0.10	0.13	0.09	0.07	0.06	0.05	0.05	0.04
	COAL	253.44	344.30	286.84	300.80	323.40	270.35	371.91	276.28	234.28	196.47
	COKE OVEN COKE	1.28	1.45	1.18	1.15	1.23	1.27	1.23	1.25	1.35	1.42
Total		**497.80**	**608.57**	**548.94**	**579.64**	**622.33**	**599.44**	**755.43**	**651.14**	**614.27**	**585.38**

Continued

fuel_type	fuel_gr_abbr	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
BIOMASS	BIO OIL	0.05	0.19	0.13	0.42	0.65	0.76	1.13	1.21	1.84	1.66
	BIO PROD GAS	0.05	0.06	0.06	0.07	0.08	0.08	0.09	0.09	0.08	0.25
	BIOGAS	2.87	3.02	3.33	3.54	3.71	3.83	3.92	3.91	3.93	4.17
	STRAW	12.22	13.70	15.65	16.88	17.94	18.49	18.54	18.76	15.84	17.34
	WOOD	27.53	30.91	31.69	39.06	43.97	49.80	52.12	60.35	63.21	63.94
WASTE	MUNICIP. WASTES	30.39	32.70	35.12	36.60	37.27	37.79	38.43	39.75	40.94	38.62
GAS	NATURAL GAS	186.13	193.84	193.62	195.94	195.08	187.41	191.08	170.98	172.12	165.19
LIQUID	GAS OIL	41.25	43.63	38.60	38.83	35.76	31.65	26.52	21.53	20.71	24.19
	KEROSENE	0.17	0.29	0.26	0.34	0.21	0.28	0.22	0.12	0.12	0.11
	LPG	1.99	1.70	1.50	1.66	1.76	1.84	1.97	1.66	1.53	1.39
	NAPHTA										
	ORIMULSION	34.15	30.24	23.85	1.92	0.02					
	PETROLEUM COKE	6.79	7.81	7.78	7.96	8.38	8.08	8.46	9.16	6.92	5.92
	REFINERY GAS	15.56	15.76	15.20	16.55	15.89	15.35	16.12	15.92	14.78	15.42
	RESIDUAL OIL	18.11	20.36	25.43	27.35	23.33	20.76	24.72	18.42	14.29	13.72
SOLID	BROWN COAL BRI.	0.03	0.03	0.02	0.00					0.01	0.01
	COAL	164.71	174.31	174.65	238.97	182.50	154.01	231.97	194.13	170.74	168.00
	COKE OVEN COKE	1.19	1.11	1.07	1.00	1.14	0.98	1.01	1.12	1.04	0.75
Total		**543.18**	**569.65**	**567.96**	**627.11**	**567.69**	**531.11**	**616.29**	**557.11**	**528.09**	**520.68**

Table 3A-2.2 Detailed fuel consumption data for stationary combustion plants, PJ. 1990 – 2009

fuel_type	fuel_gr_abbr	NFR	nfr_name	snap_id	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
BIOMASS	BIOGAS	1A1	Electricity and heat production	010100	0.24	0.24								
				010101					0.02	0.00		0.02		
				010102					0.01		0.09	0.04	0.05	0.03
				010104					0.00	0.02				
				010105			0.27	0.27	0.49	0.58	0.65	0.82	0.98	1.06
				010200	0.03	0.03								
				010203					0.21	0.25	0.25	0.25	0.25	0.22
		1A2	Industry	030100	0.49	0.49	0.49	0.49	0.01	0.13	0.10	0.12	0.07	0.03
				030103					0.01	0.02	0.02	0.02	0.02	0.02
		1A4	Commercial/ Institutional	020100					0.11	0.17	0.17	0.27	0.23	0.29
				020103						0.00	0.01	0.04	0.07	0.07
				020105					0.41	0.57	0.54	0.77	0.90	0.81
			Agriculture/ Forestry	020300					0.00	0.00	0.13	0.03	0.03	0.03
				020304					0.01	0.02	0.02	0.02	0.03	0.05
	STRAW	1A1	Electricity and heat production	010100	0.48	0.99	1.49	1.64						
				010101					0.10	0.08	0.22	0.74	1.01	1.34
				010102					0.61	1.13	1.50	1.31	1.25	1.31
				010103					0.72	0.99	1.32	1.14	1.46	1.34
				010200	3.52	3.84	3.92	3.81						
				010203					3.87	3.97	3.83	3.49	3.88	3.92
		1A2	Industry	030103						0.00				
				030105									0.00	0.00
		1A4	Residential	020200	5.09	5.09	5.09	4.75	4.41	4.08	3.63	3.89	3.77	3.44
			Agriculture/ Forestry	020300	3.39	3.39	3.39	3.17	2.94	2.72	2.42	2.59	2.03	1.80
				020302					0.01	0.01	0.01	0.01	0.50	0.51
	WOOD	1A1	Electricity and heat production	010100			0.17	0.52						
				010101					0.04				0.26	
				010102					1.74	1.60	1.60	1.57	1.95	2.86
				010103					0.05	0.04	0.03	0.06	0.06	0.34

fuel_type	fuel_gr_abbr	NFR	nfr_name	snap_id	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
				010104						0.00				
				010200	3.22	3.65	4.10	3.75						
				010203					3.32	3.48	3.89	4.06	4.14	4.04
		1A2	Industry	030100	5.78	5.69	5.75	5.82	4.46	4.23	4.10	4.17	4.27	4.25
				030102									0.00	0.00
				030103					0.41	0.37	0.53	0.43	0.35	0.37
		1A4	Commercial/ Institutional	020100	0.20	0.20	0.20	0.20	0.22	0.27	0.45	0.47	0.49	0.64
				020105									0.00	0.00
			Residential	020200	8.95	10.41	10.72	11.86	11.56	11.76	12.67	12.57	11.13	11.62
			Agriculture/ Forestry	020300	0.09	0.09	0.09	0.07	0.07	0.07	0.09	0.10	0.23	0.23
				020302									0.06	0.03
	BIO PROD GAS	1A1	Electricity and heat production	010105					0.08	0.02	0.03	0.04	0.04	0.04
		1A4	Agriculture/ Forestry	020304								0.00	0.00	0.01
	BIO OIL	1A1	Electricity and heat production	010200	0.74	0.74	0.74	0.80						
				010203					0.25	0.25	0.06	0.01	0.01	0.03
WASTE	MUNICIP. WASTES	1A1	Electricity and heat production	010100		0.88	1.30	2.52						
				010101									0.76	0.75
				010102					3.20	2.67	3.72	4.54	4.76	8.54
				010103					2.62	3.20	3.54	3.30	2.78	0.67
				010104					0.37	0.54	1.14	1.10	0.91	0.91
				010200	9.20	8.23	7.18	6.21						
				010202						1.98	2.73	2.73	2.72	
				010203					5.85	4.71	2.79	3.35	3.27	5.38
		1A2	Industry	030100	0.69	1.55	2.33	2.83	0.02	0.02	0.02	0.01	0.02	0.02
		1A4	Commercial/ Institutional	020100	0.62	0.69	0.69	0.69	0.75	0.77	0.72	0.69	0.42	0.87
				020103					0.02	0.02	0.01	0.00	0.01	0.00
			Agriculture/ Forestry	020302									0.00	0.00
P_WASTE	FOSSIL WASTE	1A1	Electricity and heat production	010100		0.42	0.71	1.47						
				010101									0.53	0.53
				010102					1.87	1.73	2.61	3.18	3.34	5.98

fuel_type	fuel_gr_abbr	NFR	nfr_name	snap_id	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
				010103					1.53	2.07	2.48	2.31	1.95	0.47
				010104					0.21	0.35	0.80	0.77	0.64	0.64
				010200	4.37	3.91	3.93	3.63						
				010202						1.28	1.91	1.92	1.90	
				010203					3.42	3.05	1.96	2.35	2.29	3.77
		1A2	Industry	030100	0.33	0.74	1.28	1.65	0.01	0.01	0.01	0.01	0.01	0.01
		1A4	Commercial/ Institutional	020100	0.29	0.33	0.38	0.41	0.44	0.50	0.50	0.49	0.29	0.61
				020103					0.01	0.01	0.00	0.00	0.00	0.00
GAS	NATURAL GAS	1A1	Electricity and heat production	010100			0.80	3.21						
				010101	4.01	4.39	3.28	4.42	6.45	7.81	9.48	8.44	17.50	17.27
				010102					2.01	2.85	4.08	8.14	9.30	6.45
				010103					0.02	0.05				
				010104	2.51	3.95	5.67	7.52	7.59	8.23	13.94	15.81	12.76	21.45
				010105	0.09	0.18	0.25	0.41	8.59	16.78	21.93	23.46	26.39	26.61
				010200	10.92	13.13	12.35	11.42						
				010202					0.26	0.38	0.38	0.47	0.54	0.20
				010203					9.39	7.95	6.40	4.01	3.14	2.74
			Other energy industries	010504	9.18	9.44	11.05	11.24	12.26	12.91	15.24	19.87	22.05	23.97
		1A2	Industry	030100	22.78	24.34	25.15	27.18	29.24	29.66	28.82	29.18	28.66	31.02
				030102					0.71	2.66	2.46	2.97	2.96	3.10
				030103					0.77	0.81	1.07	0.98	1.09	0.90
				030104	0.51	0.61	0.66	0.73	0.76	0.91	2.15	3.04	4.77	6.14
				030105					0.02	0.19	0.88	0.97	1.17	1.17
				030106	0.14	0.03	0.05	0.07	0.06	0.03	0.02	0.01	0.05	0.11
				030315								0.92	0.90	1.01
				030318						0.62	0.59	0.62	0.67	0.69
		1A4	Commercial/ Institutional	020100	6.38	6.93	7.38	8.91	7.34	8.44	11.25	9.11	8.66	7.53
				020103					0.00	0.00	0.00	0.00	0.20	0.01
				020104						0.00		0.00		
				020105					0.58	0.71	0.79	0.97	1.04	1.08

fuel_type	fuel_gr_abbr	NFR	nfr_name	snap_id	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
			Residential	020200	17.36	20.43	21.44	24.90	24.74	26.95	30.41	28.36	29.14	28.98
				020202					0.05	0.01	0.05	0.04	0.03	0.04
				020204					0.96	1.04	1.41	1.46	1.53	1.52
			Agriculture/ Forestry	020300	2.22	2.68	2.39	2.46	2.49	2.56	2.67	2.64	2.48	2.24
				020304					0.28	1.16	2.22	3.03	3.71	3.72
LIQUID	GAS OIL	1A1	Electricity and heat production	010100	0.30	0.47	0.70	0.29						
				010101					0.01	0.05	0.04	0.09	0.11	0.26
				010102					0.01	0.01	0.03	0.03	0.03	0.05
				010103						0.00	0.04	0.03	0.01	0.03
				010104		0.02	0.02	0.03	0.04	0.08	0.05	0.03	0.14	0.03
				010105					0.12	0.14	0.10	0.10	0.12	0.11
				010200	1.94	0.81	0.74	0.95						
				010202					0.15	0.20	0.15	0.07	0.12	0.05
				010203					0.99	0.68	1.40	1.18	1.06	0.67
			Petroleum refining	010306		0.04	0.04	0.03	0.05	0.03	0.02	0.09		
		1A2	Industry	030100	0.54	1.37	1.43	0.95	0.81	1.46	2.25	1.90	1.80	2.48
				030102					0.00	0.00	0.00	0.00	0.00	0.00
				030103					0.00	0.00	0.01	0.00	0.00	0.00
				030104								0.00	0.00	0.01
				030105					0.00				0.00	0.00
				030315								0.00	0.00	0.00
		1A4	Commercial/ Institutional	020100	11.79	10.62	9.06	9.01	7.16	6.56	6.62	6.09	5.44	5.78
				020102					0.19		0.00		0.00	
				020103					0.00		0.06	0.06	0.06	0.04
				020105					0.00	0.02	0.00	0.00	0.00	0.00
			Residential	020200	46.46	50.64	42.91	49.97	43.68	43.29	45.30	39.60	37.85	35.68
			Agriculture/ Forestry	020300	0.41	1.01	1.18	0.79	0.71	1.18	1.94	1.80	1.68	2.29
				020302								0.00		
				020304							0.00	0.00		0.01
	KEROSENE	1A2	Industry	030100	0.07	0.05	0.04	0.04	0.03	0.02	0.03	0.03	0.02	0.01

fuel_type	fuel_gr_abbr	NFR	nfr_name	snap_id	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
		1A4	Commercial/ Institutional	020100	0.57	0.21	0.21	0.19	0.15	0.12	0.10	0.10	0.13	0.12
			Residential	020200	4.40	0.66	0.51	0.52	0.44	0.41	0.38	0.29	0.25	0.12
			Agriculture/ Forestry	020300	0.04	0.03	0.03	0.03	0.03	0.02	0.02	0.03	0.02	0.01
	LPG	1A1	Electricity and heat production	010100		0.00	0.00	0.00						
				010200	0.01	0.01	0.01							
				010203					0.00	0.00				0.00
			Petroleum refining	010306			0.00		0.01	0.02	0.02	0.02		
		1A2	Industry	030100	1.58	1.69	1.59	1.45	1.56	1.74	1.92	1.60	1.62	1.36
		1A4	Commercial/ Institutional	020100	0.08	0.08	0.08	0.12	0.13	0.13	0.14	0.13	0.12	0.11
				020105										0.00
			Residential	020200	0.67	0.52	0.44	0.86	0.79	0.73	0.77	0.64	0.68	0.66
			Agriculture/ Forestry	020300	0.26	0.25	0.19	0.12	0.12	0.13	0.14	0.11	0.13	0.09
	ORIMULSION	1A1	Electricity and heat production	010101						19.91	36.77	40.49	32.58	34.19
	PETROLEUM COKE	1A1	Electricity and heat production	010100				1.24						
				010102					3.18	0.92				
		1A2	Industry	030100	0.30		0.06	0.12		0.10	0.11	0.03	0.03	0.04
				030311	2.50	2.99	3.23	3.23	3.47	3.71	4.97	5.23	4.77	6.40
		1A4	Commercial/ Institutional	020100	0.06	0.10	0.09	0.10	0.09	0.07	0.09	0.10	0.07	0.05
			Residential	020200	0.76	0.70	0.46	0.49	0.40	0.23	0.43	0.34	0.22	0.20
			Agriculture/ Forestry	020300	0.84	0.61	0.47	0.50	0.41	0.24	0.29	0.32	0.20	0.09
	REFINERY GAS	1A1	Electricity and heat production	010203							0.03	0.04		
			Petroleum refining	010300	0.46	0.93	1.53	2.08						
				010304					2.36	2.29	2.67	2.28	2.48	2.65
				010306	13.52	13.49	13.24	13.21	14.00	18.55	18.70	14.54	12.71	13.07
		1A2	Industry	030100	0.19	0.13	0.10	0.11			0.03	0.05	0.03	
	RESIDUAL OIL	1A1	Electricity and heat production	010100	0.78	0.37	1.75	0.75						
				010101	6.51	9.63	8.26	7.78	21.50	8.49	11.61	5.15	8.87	6.00
				010102	0.70	0.44	0.45	0.66	0.76	2.53	4.57	2.63	2.78	1.58
				010103					0.21	0.36	0.04	0.20	0.16	

fuel_type	fuel_gr_abbr	NFR	nfr_name	snap_id	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
				010104										0.01
				010105					0.01	0.00	0.00	0.00	0.01	0.00
				010200	2.01	2.24	1.14	0.88						
				010202					0.24	0.46	0.52	0.41	0.23	0.28
				010203					1.19	1.29	1.66	1.33	1.54	1.43
			Petroleum refining	010306	1.31	2.04	3.57	3.49	3.34	2.33	2.24	1.62	1.11	1.09
		1A2	Industry	030100	15.80	18.27	17.83	13.80	11.86	9.48	9.88	8.49	8.39	7.95
				030102					0.79	0.85	0.77	0.68	0.55	0.58
				030103					0.15	0.22	0.10	0.14	0.07	0.24
				030104								0.05		
				030311	1.76	2.15	2.37	2.40	2.62	2.84	1.77	1.86	2.54	0.89
		1A4	Commercial/ Institutional	020100	1.07	0.87	0.60	0.52	0.72	0.68	0.72	0.73	0.38	0.45
				020103					0.09	0.08				
			Residential	020200	0.22	0.22	0.17	0.13	0.10	0.06	0.07	0.05	0.04	0.05
			Agriculture/ Forestry	020300	1.22	1.30	1.63	1.69	1.94	2.62	3.07	2.49	2.56	2.39
				020302									0.00	0.00
				020304									0.01	0.01
SOLID	BROWN COAL BRI.	1A2	Industry	030100	0.00	0.01	0.00	0.02	0.00	0.00	0.00	0.00		
		1A4	Commercial/ Institutional	020100	0.00	0.00		0.01	0.00	0.00	0.00	0.00		
			Residential	020200	0.05	0.07	0.04	0.08	0.08	0.06	0.05	0.05	0.04	0.04
			Agriculture/ Forestry	020300	0.06	0.09	0.05	0.02	0.01	0.01	0.01	0.00	0.00	
	COAL	1A1	Electricity and heat production	010100	8.52	12.89	10.18	8.22						
				010101	207.92	294.72	241.79	256.32	284.66	233.17	333.57	244.26	206.22	172.04
				010102	13.98	11.03	13.21	15.41	18.91	19.37	22.59	17.06	14.23	12.84
				010103					0.49	0.37	0.06			
				010104					0.27	0.27	0.30	0.07		
				010105					0.02					
				010200	6.02	6.64	5.17	3.58						
				010202					1.08	0.68				
				010203					1.38	0.95	0.65	0.15	0.09	0.04

fuel_type	fuel_gr_abbr	NFR	nfr_name	snap_id	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
		1A2	Industry	030100	8.85	8.98	6.75	7.70	5.87	4.63	4.24	4.14	4.40	3.52
				030102					0.47	1.05	1.45	1.47	1.41	1.41
				030103					0.34	0.39	0.41	0.55	0.27	0.19
				030311	5.02	6.05	6.58	6.60	6.91	7.22	7.07	7.21	6.63	5.64
		1A4	Commercial/ Institutional	020100	0.09	0.01	0.10	0.08	0.09	0.07	0.04	0.04	0.00	
			Residential	020200	0.59	1.13	0.87	0.79	0.62	0.38	0.09	0.09	0.13	0.08
			Agriculture/ Forestry	020300	2.46	2.85	2.20	2.11	2.29	1.80	1.45	1.24	0.90	0.71
	COKE OVEN COKE	1A2	Industry	030100	1.17	1.35	1.08	1.07	1.16	0.29	0.30	0.30	0.32	0.38
				030318						0.94	0.89	0.93	1.01	1.03
		1A4	Residential	020200	0.11	0.10	0.10	0.08	0.06	0.05	0.04	0.03	0.02	0.01
Grand Total					497.80	608.57	548.94	579.64	622.33	599.44	755.43	651.14	614.27	585.38

uel_type	fuel_gr_abbr	NFR	nfr_name	snap_id	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
BIOMASS	BIOGAS	1A1	Electricity and heat production	010102	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01
				010105	1.07	1.15	1.27	1.34	1.38	1.45	1.45	1.57	1.58	1.69
				010203	0.30	0.28	0.25	0.26	0.14	0.09	0.12	0.15	0.16	0.13
		1A2	Industry	030100	0.02	0.01	0.01	0.04	0.04	0.11	0.12	0.12	0.09	0.08
				030102	0.02	0.02	0.02	0.04	0.05	0.05	0.04	0.03	0.05	0.06
				030103	0.02	0.06	0.07	0.06	0.06	0.01	0.01	0.01	0.05	0.06
				030105		0.02	0.06	0.08	0.09	0.25	0.22	0.22	0.23	0.25
		1A4	Commercial/ Institutional	020100	0.31	0.35	0.43	0.32	0.44	0.44	0.47	0.37	0.36	0.31
				020103	0.09	0.08	0.07	0.09	0.11	0.11	0.14	0.10	0.11	0.11
				020105	0.87	0.83	0.82	0.79	0.79	0.76	0.59	0.58	0.56	0.62
			Agriculture/ Forestry	020300	0.08	0.08	0.10	0.13	0.17	0.08	0.33	0.28	0.27	0.34
				020304	0.08	0.11	0.20	0.37	0.42	0.46	0.41	0.47	0.46	0.51
	STRAW	1A1	Electricity and heat production	010101	1.12	1.59	2.64	3.16	3.66	3.33	3.69	3.59	2.42	2.82
				010102	1.33	1.26	1.17	1.29	2.06	2.04	1.70	1.87	1.74	1.89
				010103	0.73	2.09	1.94	2.07	2.11	2.13	2.06	2.14	2.13	2.16
				010104		0.10	1.22	1.71	1.86	2.45	2.54	2.51	0.82	1.52

uel_type	fuel_gr_abbr	NFR	nfr_name	snap_id	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
				010203	3.84	3.81	3.83	3.81	3.40	3.69	3.69	3.79	3.89	4.07
		1A2	Industry	030105	0.00	0.00								
		1A4	Residential	020200	3.11	2.90	2.90	2.90	2.90	2.90	2.90	2.90	2.90	2.90
			Agriculture/ Forestry	020300	1.59	1.46	1.48	1.48	1.48	1.48	1.43	1.49	1.46	1.47
				020302	0.50	0.48	0.47	0.47	0.47	0.47	0.52	0.46	0.48	0.50
	WOOD	1A1	Electricity and heat production	010101		0.00	0.07	0.31	0.23	0.17	0.29	0.17	0.26	0.52
				010102	2.73	2.52	3.19	5.36	5.43	6.62	6.49	6.29	5.80	7.11
				010103	0.44	0.53	0.64	0.60	0.67	0.57	0.51	0.56	0.56	0.66
				010104			0.12	1.58	4.49	4.48	2.61	3.77	5.96	6.26
				010203	3.90	4.49	4.96	5.62	6.15	6.55	7.02	7.07	7.86	8.59
		1A2	Industry	030100	4.45	4.60	3.31	3.53	3.43	3.67	4.26	4.35	5.48	4.51
				030102	0.00	0.00					0.01	1.06	1.18	1.21
				030103	0.39	0.39	0.40	0.28	0.40	0.34	0.44	0.39	0.45	0.48
		1A4	Commercial/ Institutional	020100	0.78	0.67	0.67	0.68	0.68	0.82	0.95	1.01	1.07	1.06
				020105		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00
			Residential	020200	14.62	17.48	18.07	20.86	22.27	26.40	29.42	35.51	34.45	33.38
				020202						0.00	0.00	0.00	0.00	0.00
				020204									0.00	0.00
			Agriculture/ Forestry	020300	0.17	0.15	0.15	0.11	0.10	0.09	0.08	0.08	0.08	0.08
				020302	0.06	0.10	0.13	0.13	0.12	0.09	0.03	0.09	0.06	0.07
	BIO PROD GAS	1A1	Electricity and heat production	010105	0.05	0.06	0.06	0.07	0.08	0.08	0.09	0.09	0.08	0.25
		1A2	Industry	030105								0.00	0.00	0.00
		1A4	Agriculture/ Forestry	020304	0.00	0.00								
	BIO OIL	1A1	Electricity and heat production	010101				0.10				0.01	0.01	
				010105					0.00			0.00	0.00	0.00
				010202				0.01	0.00	0.02	0.02	0.05	0.40	0.19
				010203	0.05	0.19	0.07	0.30	0.64	0.74	1.10	1.14	1.39	1.43
		1A2	Industry	030103			0.06							
				030105			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		1A4	Commercial/ Institutional	020105								0.00		

uel_type	fuel_gr_abbr	NFR	nfr_name	snap_id	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
			Residential	020200								0.00	0.04	0.04
			Agriculture/ Forestry	020304	0.00	0.00	0.00							
WASTE	MUNICIP. WASTES	1A1	Electricity and heat production	010101		0.11	0.52	0.08					0.02	0.03
				010102	7.09	7.66	8.17	8.30	9.77	11.33	11.71	11.93	12.31	12.18
				010103	5.30	5.28	5.42	5.37	5.36	5.16	5.62	5.56	5.66	5.16
				010104	1.30	1.45	1.54	1.75	1.71	1.52	1.81	1.95	1.95	1.91
				010203	3.78	3.88	3.89	4.36	3.81	2.55	2.25	2.79	2.92	2.38
		1A2	Industry	030102					0.00	0.00			0.02	
				030311	0.32	0.85	1.09	0.86	1.17	1.17	0.89	0.97	1.15	1.03
		1A4	Commercial/ Institutional	020100	0.07			0.77	0.06	0.39	0.21	0.15		
				020103	0.01	0.01	0.01	0.04	0.04	0.10	0.11	0.03	0.04	0.03
P_WASTE	FOSSIL WASTE	1A1	Electricity and heat production	010101		0.08	0.37	0.06					0.01	0.02
				010102	4.97	5.37	5.73	5.81	6.84	7.94	8.21	8.36	8.63	8.54
				010103	3.71	3.70	3.80	3.76	3.75	3.61	3.94	3.89	3.97	3.61
				010104	0.91	1.01	1.08	1.22	1.20	1.06	1.27	1.37	1.37	1.34
				010203	2.65	2.72	2.73	3.05	2.67	1.79	1.58	1.95	2.05	1.67
		1A2	Industry	030102					0.00	0.00			0.02	
				030311	0.22	0.59	0.76	0.60	0.82	0.82	0.62	0.68	0.81	0.72
		1A4	Commercial/ Institutional	020100	0.05			0.54	0.04	0.28	0.15	0.11		
				020103	0.01	0.01	0.01	0.03	0.03	0.07	0.08	0.02	0.03	0.02
GAS	NATURAL GAS	1A1	Electricity and heat production	010101	18.44	18.19	16.52	17.88	17.30	17.24	18.96	13.89	10.91	13.38
				010102	6.54	6.37	5.52	3.94	3.34	2.96	2.60	0.94	3.82	2.73
				010103	0.05	0.03	0.02	0.04	0.04	0.01	0.05	0.06	0.06	0.05
				010104	22.81	24.87	30.04	29.66	30.53	25.50	32.05	26.22	27.83	24.59
				010105	25.51	27.85	27.59	26.74	26.92	24.03	21.47	17.10	18.30	15.43
				010202	0.14	0.08	0.21	0.21	0.28	0.22	0.06	0.23	0.38	2.10
				010203	2.32	2.94	2.36	3.23	2.72	4.42	4.57	6.12	6.03	6.91
			Other energy industries	010504	25.36	24.76	26.56	26.57	27.42	28.11	28.72	28.48	28.33	26.93
		1A2	Industry	030100	28.53	30.89	28.91	27.88	26.40	26.65	26.54	27.08	27.27	25.74
				030102	2.69	2.87	1.19	2.27	2.30	2.20	2.29	1.57	1.50	0.81

uel_type	fuel_gr_abbr	NFR	nfr_name	snap_id	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
				030103	0.68	0.18	0.46	0.59	0.60	0.57	0.58	0.62	0.52	0.56
				030104	6.42	6.19	6.72	6.48	6.81	5.88	4.64	4.47	3.82	3.33
				030105	1.57	1.66	1.57	1.56	1.59	1.34	1.02	0.53	0.59	0.63
				030106	0.06	0.06	0.03	0.02	0.03	0.01	0.01	0.02	0.12	0.08
				030315	1.10	1.09	1.02	0.95	0.91	0.87	0.83	0.83	0.87	0.72
				030318	0.63	0.59	0.52	0.55	0.61	0.56	0.56	0.63	0.57	0.41
		1A4	Commercial/ Institutional	020100	7.23	7.32	7.62	9.22	9.20	9.74	10.76	10.10	9.73	9.21
				020103	0.16	0.19	0.17	0.01	0.09	0.01	0.08	0.02	0.05	0.03
				020104	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00		
				020105	1.11	1.14	1.17	1.14	1.10	1.02	1.03	0.92	0.88	0.85
			Residential	020200	27.57	29.26	28.08	30.02	29.86	29.52	28.59	26.57	26.52	26.84
				020202	0.06	0.08	0.03	0.07	0.07	0.03	0.06	0.07	0.10	0.10
				020204	1.40	1.41	1.36	1.38	1.42	1.41	1.44	1.31	1.20	1.15
			Agriculture/ Forestry	020300	2.38	2.69	2.54	2.32	2.26	2.25	2.24	1.87	1.66	1.71
				020304	3.34	3.12	3.39	3.20	3.30	2.85	1.92	1.33	1.06	0.90
LIQUID	GAS OIL	1A1	Electricity and heat production	010101	0.05	0.08	0.09	0.96	0.21	0.18	0.45	0.52	0.92	2.29
				010102	0.11	0.10	0.09	0.03	0.05	0.03	0.04	0.06	0.04	0.08
				010103	0.05	0.02	0.03	0.03	0.02	0.02	0.01	0.02	0.02	0.02
				010104	0.07	0.04	0.03	0.03	0.07	0.09	0.08	0.05	0.04	0.06
				010105	0.08	0.10	0.09	0.09	0.11	0.08	0.07	0.15	0.14	0.09
				010202	0.54	0.94	0.24	0.35	0.49	0.26	0.24	0.36	0.31	0.51
				010203	0.61	0.54	0.44	0.05	0.61	0.46	0.37	0.33	0.72	0.95
				010204				1.04						
			Petroleum refining	010306				0.00	0.01	0.00	0.01	0.01	0.00	0.01
		1A2	Industry	030100	2.18	2.99	2.34	2.61	2.47	1.58	0.52	0.00	0.00	0.00
				030102				0.00	0.00	0.00	0.01	0.01	0.02	0.00
				030103	0.08	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	
				030104	0.00		0.00			0.00	0.00	0.00	0.00	0.00
				030105	0.00	0.00							0.00	0.00
				030315	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00

uel_type	fuel_gr_abbr	NFR	nfr_name	snap_id	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
		1A4	Commercial/ Institutional	020100	4.96	4.69	4.04	4.30	4.41	3.75	3.03	2.61	2.80	2.78
				020103	0.07	0.05	0.04	0.03	0.02	0.05	0.03	0.02	0.03	0.06
				020105	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
			Residential	020200	30.28	31.51	29.00	27.03	25.29	23.86	21.20	17.38	15.61	17.28
				020204									0.01	0.02
			Agriculture/ Forestry	020300	2.15	2.55	2.15	2.25	1.97	1.22	0.45			
				020302	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00
				020304	0.01	0.01	0.02	0.02	0.01	0.03	0.02	0.02	0.03	0.02
	KEROSENE	1A2	Industry	030100	0.01	0.03	0.07	0.05	0.02	0.01	0.02	0.01	0.02	0.01
		1A4	Commercial/ Institutional	020100	0.06	0.08	0.07	0.07	0.08	0.10	0.06	0.02	0.01	0.02
			Residential	020200	0.09	0.16	0.11	0.21	0.11	0.16	0.14	0.09	0.09	0.07
			Agriculture/ Forestry	020300	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
	LPG	1A1	Electricity and heat production	010101							0.00		0.00	0.00
				010102									0.00	0.00
				010202						0.00	0.00	0.00		
				010203	0.00					0.00		0.00	0.00	0.00
		1A2	Industry	030100	1.02	0.76	0.68	0.73	0.75	0.74	0.77	0.49	0.45	0.39
		1A4	Commercial/ Institutional	020100	0.12	0.12	0.14	0.17	0.21	0.25	0.27	0.27	0.27	0.27
				020105						0.00	0.00	0.00	0.00	0.00
			Residential	020200	0.76	0.74	0.63	0.70	0.75	0.80	0.88	0.88	0.78	0.70
			Agriculture/ Forestry	020300	0.09	0.08	0.06	0.06	0.05	0.05	0.05	0.03	0.03	0.04
	ORIMULSION	1A1	Electricity and heat production	010101	34.15	30.24	23.85	1.92	0.02					
	PETROLEUM COKE	1A1	Electricity and heat production	010102					0.01	0.00				0.03
		1A2	Industry	030100	0.29	0.13	0.22	0.23	0.18	0.16	0.16			
				030311	6.47	7.66	7.54	7.71	8.19	7.80	8.28	9.11	6.84	5.89
		1A4	Commercial/ Institutional	020100	0.01	0.01	0.01	0.01		0.07	0.01	0.04	0.06	0.00
			Residential	020200	0.01	0.01	0.01	0.01		0.06	0.01	0.01	0.02	
			Agriculture/ Forestry	020300	0.01	0.00	0.00	0.00						
	REFINERY GAS	1A1	Petroleum refining	010304	2.40	2.45	2.46	2.67	2.44	2.00	2.25	2.31	1.83	1.94

uel_type	fuel_gr_abbr	NFR	nfr_name	snap_id	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
				010306	13.16	13.31	12.74	13.88	13.45	13.35	13.87	13.61	12.95	13.48
	RESIDUAL OIL	1A1	Electricity and heat production	010101	3.44	3.51	3.75	5.76	4.60	4.33	3.34	5.44	2.81	3.62
				010102	0.66	2.31	1.25	1.66	1.33	1.46	1.79	0.26	0.91	1.86
				010103	0.27	0.09	0.13	0.10	0.18	0.20	0.11	0.60	0.23	0.08
				010104		1.72	6.62	9.32	7.39	6.34	8.40	4.50	4.47	2.88
				010105	0.02	0.00	0.00	0.01	0.00	0.02	0.02	0.00	0.01	0.01
				010202										0.01
				010203	1.11	1.17	1.04	0.69	0.34	0.53	0.45		0.11	0.32
			Petroleum refining	010306	1.32	1.44	1.36	0.91	1.07	0.69	0.62	0.77	0.89	0.73
		1A2	Industry	030100	7.43	6.90	7.89	5.54	5.02	3.66	6.06	3.45	0.66	0.22
				030102	0.63	0.57	0.46	0.92	0.92	1.06	0.82	0.61	1.90	1.97
				030103	0.21	0.31	0.35	0.73	0.77	0.84	0.79	0.81	1.01	1.10
				030105		0.00	0.00	0.00	0.00	0.01	0.00		0.00	
				030311	0.86	0.50	0.59	0.59	0.82	0.69	0.98	1.06	0.51	0.25
		1A4	Commercial/ Institutional	020100	0.34	0.17	0.48	0.17	0.11	0.12	0.25	0.23	0.10	0.03
			Residential	020200	0.04	0.03	0.15	0.05	0.04	0.05	0.20	0.01	0.01	0.01
			Agriculture/ Forestry	020300	1.78	1.64	1.37	0.91	0.72	0.76	0.90	0.64	0.64	0.60
				020302				0.01	0.01	0.01	0.02	0.03	0.03	0.02
				020304	0.00	0.00	0.00	0.00						
SOLID	BROWN COAL BRI.	1A4	Residential	020200	0.03	0.03	0.02	0.00					0.01	0.01
	COAL	1A1	Electricity and heat production	010101	143.84	156.22	158.32	223.55	167.93	140.02	218.36	180.90	159.44	161.87
				010102	9.30	7.74	7.98	6.43	4.51	4.05	3.29	3.05	2.81	1.99
				010104										0.02
				010203	0.04	0.03	0.02	0.03	0.02	0.05		0.06	0.01	
		1A2	Industry	030100	3.23	3.12	2.01	2.72	3.25	2.58	2.52	2.66	1.60	0.14
				030102	1.06	1.00	1.00	1.57	1.50	1.50	1.23	1.16	1.22	1.21
				030103	0.43	0.44	0.12	0.10	0.09	0.10	0.20	0.21	0.25	0.32
				030311	5.71	4.52	4.35	3.37	3.75	3.92	4.36	4.03	3.54	1.14
		1A4	Commercial/ Institutional	020100					0.00					
			Residential	020200	0.01	0.01	0.02	0.00	0.00	0.01	0.00	0.01	0.01	0.01

uel_type	fuel_gr_abbr	NFR	nfr_name	snap_id	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
			Agriculture/ Forestry	020300	1.08	1.23	0.86	1.20	1.44	1.79	2.00	2.05	1.86	1.31
				020304					0.00	0.00				0.00
	COKE OVEN COKE	1A2	Industry	030100	0.24	0.22	0.28	0.28	0.30	0.24	0.25	0.21	0.15	0.02
				030102									0.06	0.06
				030103								0.04	0.05	0.06
				030318	0.94	0.88	0.79	0.69	0.81	0.74	0.76	0.88	0.78	0.61
		1A4	Residential	020200	0.01	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00
Grand Total					**543.18**	**569.65**	**567.96**	**627.11**	**567.69**	**531.11**	**616.29**	**557.11**	**528.09**	**520.68**

Annex 3A-3 Lower Calorific Value (LCV) of fuels and fuel correspondence list

Table 3A-3.1 Time-series for calorific values of fuels (DEA 2010b).

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Crude Oil, Average	GJ per tonne	42.40	42.40	42.40	42.70	42.70	42.70	42.70	43.00	43.00	43.00
Crude Oil, Golf	GJ per tonne	41.80	41.80	41.80	41.80	41.80	41.80	41.80	41.80	41.80	41.80
Crude Oil, North Sea	GJ per tonne	42.70	42.70	42.70	42.70	42.70	42.70	42.70	43.00	43.00	43.00
Refinery Feedstocks	GJ per tonne	41.60	41.60	41.60	41.60	41.60	41.60	41.60	42.70	42.70	42.70
Refinery Gas	GJ per tonne	52.00	52.00	52.00	52.00	52.00	52.00	52.00	52.00	52.00	52.00
LPG	GJ per tonne	46.00	46.00	46.00	46.00	46.00	46.00	46.00	46.00	46.00	46.00
Naphtha (LVN)	GJ per tonne	44.50	44.50	44.50	44.50	44.50	44.50	44.50	44.50	44.50	44.50
Motor Gasoline	GJ per tonne	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80
Aviation Gasoline	GJ per tonne	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80
JP4	GJ per tonne	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80
Other Kerosene	GJ per tonne	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50
JP1	GJ per tonne	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50
Gas/Diesel Oil	GJ per tonne	42.70	42.70	42.70	42.70	42.70	42.70	42.70	42.70	42.70	42.70
Fuel Oil	GJ per tonne	40.40	40.40	40.40	40.40	40.40	40.40	40.70	40.65	40.65	40.65
Orimulsion	GJ per tonne	27.60	27.60	27.60	27.60	27.60	28.13	28.02	27.72	27.84	27.58
Petroleum Coke	GJ per tonne	31.40	31.40	31.40	31.40	31.40	31.40	31.40	31.40	31.40	31.40
Waste Oil	GJ per tonne	41.90	41.90	41.90	41.90	41.90	41.90	41.90	41.90	41.90	41.90
White Spirit	GJ per tonne	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50
Bitumen	GJ per tonne	39.80	39.80	39.80	39.80	39.80	39.80	39.80	39.80	39.80	39.80
Lubricants	GJ per tonne	41.90	41.90	41.90	41.90	41.90	41.90	41.90	41.90	41.90	41.90
Natural Gas	GJ per 1000 Nm^3	39.00	39.00	39.00	39.30	39.30	39.30	39.30	39.60	39.90	40.00
Town Gas	GJ per 1000 m^3							17.00	17.00	17.00	17.00
Electricity Plant Coal	GJ per tonne	25.30	25.40	25.80	25.20	24.50	24.50	24.70	24.96	25.00	25.00
Other Hard Coal	GJ per tonne	26.10	26.50	26.50	26.50	26.50	26.50	26.50	26.50	26.50	26.50
Coke	GJ per tonne	31.80	29.30	29.30	29.30	29.30	29.30	29.30	29.30	29.30	29.30
Brown Coal Briquettes	GJ per tonne	18.30	18.30	18.30	18.30	18.30	18.30	18.30	18.30	18.30	18.30
Straw	GJ per tonne	14.50	14.50	14.50	14.50	14.50	14.50	14.50	14.50	14.50	14.50
Wood Chips	GJ per Cubic metre	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80
Wood Chips	GJ per m^3	9.30	9.30	9.30	9.30	9.30	9.30	9.30	9.30	9.30	9.30
Firewood, Hardwood	GJ per m^3	10.40	10.40	10.40	10.40	10.40	10.40	10.40	10.40	10.40	10.40
Firewood, Conifer	GJ per tonne	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60
Wood Pellets	GJ per tonne	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50
Wood Waste	GJ per Cubic metre	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
Wood Waste	GJ per 1000 m^3	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20
Biogas	GJ per tonne								23.00	23.00	23.00
Wastes	GJ per tonne	8.20	8.20	9.00	9.40	9.40	10.00	10.50	10.50	10.50	10.50
Bioethanol	GJ per tonne	26.70	26.70	26.70	26.70	26.70	26.70	26.70	26.70	26.70	26.70
Liquid Biofuels	GJ per tonne	37.60	37.60	37.60	37.60	37.60	37.60	37.60	37.60	37.60	37.60
Bio Oil	GJ per tonne	37.20	37.20	37.20	37.20	37.20	37.20	37.20	37.20	37.20	37.20
Continued		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Crude Oil, Average	GJ per tonne	43.00	43.00	43.00	43.00	43.00	43.00	43.00	43.00	43.00	43.00
Crude Oil, Golf	GJ per tonne	41.80	41.80	41.80	41.80	41.80	41.80	41.80	41.80	41.80	41.80
Crude Oil, North Sea	GJ per tonne	43.00	43.00	43.00	43.00	43.00	43.00	43.00	43.00	43.00	43.00
Refinery Feedstocks	GJ per tonne	42.70	42.70	42.70	42.70	42.70	42.70	42.70	42.70	42.70	42.70
Refinery Gas	GJ per tonne	52.00	52.00	52.00	52.00	52.00	52.00	52.00	52.00	52.00	52.00
LPG	GJ per tonne	46.00	46.00	46.00	46.00	46.00	46.00	46.00	46.00	46.00	46.00
Naphtha (LVN)	GJ per tonne	44.50	44.50	44.50	44.50	44.50	44.50	44.50	44.50	44.50	44.50
Motor Gasoline	GJ per tonne	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80
Aviation Gasoline	GJ per tonne	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80
JP4	GJ per tonne	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80
Other Kerosene	GJ per tonne	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50
JP1	GJ per tonne	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50
Gas/Diesel Oil	GJ per tonne	42.70	42.70	42.70	42.70	42.70	42.70	42.70	42.70	42.70	42.70
Fuel Oil	GJ per tonne	40.65	40.65	40.65	40.65	40.65	40.65	40.65	40.65	40.65	40.65
Orimulsion	GJ per tonne	27.62	27.64	27.71	27.65	27.65	27.65	27.65	27.65	27.65	27.65
Petroleum Coke	GJ per tonne	31.40	31.40	31.40	31.40	31.40	31.40	31.40	31.40	31.40	31.40
Waste Oil	GJ per tonne	41.90	41.90	41.90	41.90	41.90	41.90	41.90	41.90	41.90	41.90
White Spirit	GJ per tonne	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50
Bitumen	GJ per tonne	39.80	39.80	39.80	39.80	39.80	39.80	39.80	39.80	39.80	39.80
Lubricants	GJ per tonne	41.90	41.90	41.90	41.90	41.90	41.90	41.90	41.90	41.90	41.90
Natural Gas	GJ per 1000 Nm^3	40.15	39.99	40.06	39.94	39.77	39.67	39.54	39.59	39.48	39.46
Town Gas	GJ per 1000 m^3	17.01	16.88	17.39	16.88	17.58	17.51	17.20	17.14	15.50	21.29
Electricity Plant Coal	GJ per tonne	24.80	24.90	25.15	24.73	24.60	24.40	24.80	24.40	24.30	24.60
Other Hard Coal	GJ per tonne	26.50	26.50	26.50	26.50	26.50	26.50	26.50	26.50	26.50	26.50
Coke	GJ per tonne	29.30	29.30	29.30	29.30	29.30	29.30	29.30	29.30	29.30	29.30
Brown Coal Briquettes	GJ per tonne	18.30	18.30	18.30	18.30	18.30	18.30	18.30	18.30	18.30	18.30
Straw	GJ per tonne	14.50	14.50	14.50	14.50	14.50	14.50	14.50	14.50	14.50	14.50
Wood Chips	GJ per Cubic metre	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80
Wood Chips	GJ per m^3	9.30	9.30	9.30	9.30	9.30	9.30	9.30	9.30	9.30	9.30
Firewood, Hardwood	GJ per m^3	10.40	10.40	10.40	10.40	10.40	10.40	10.40	10.40	10.40	10.40
Firewood, Conifer	GJ per tonne	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60
Wood Pellets	GJ per tonne	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50
Wood Waste	GJ per Cubic metre	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
Wood Waste	GJ per 1000 m^3	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20

Continued											
Biogas	GJ per tonne	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00
Wastes	GJ per tonne	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50
Bioethanol	GJ per tonne	26.70	26.70	26.70	26.70	26.70	26.70	26.70	26.70	26.70	26.70
Liquid Biofuels	GJ per tonne	37.60	37.60	37.60	37.60	37.60	37.60	37.60	37.60	37.50	37.50
Bio Oil	GJ per tonne	37.20	37.20	37.20	37.20	37.20	37.20	37.20	37.20	37.20	37.20

Table 3A-3.2 Fuel category correspondence list, DEA, NERI and Climate Convention reportings (IPCC).

Danish Energy Agency	NERI Emission database	IPCC fuel category
Other Hard Coal	Coal	Solid
Coke	Coke oven coke	Solid
Electricity Plant Coal	Coal	Solid
Brown Coal Briquettes	Brown coal briq.	Solid
Orimulsion	Orimulsion	Liquid
Petroleum Coke	Petroleum coke	Liquid
Fuel Oil	Residual oil	Liquid
Waste Oil	Residual oil	Liquid
Gas/Diesel Oil	Gas oil	Liquid
Other Kerosene	Kerosene	Liquid
LPG	LPG	Liquid
Refinery Gas	Refinery gas	Liquid
Town Gas	Natural gas	Gas
Natural Gas	Natural gas	Gas
Straw	Straw	Biomass
Wood Waste	Wood and simil.	Biomass
Wood Pellets	Wood and simil.	Biomass
Wood Chips	Wood and simil.	Biomass
Firewood, Hardwood & Conifer	Wood and simil.	Biomass
Waste Combustion (biomass)	Municip. wastes	Biomass
Bio Oil	Bio oil	Biomass
Biogas	Biogas	Biomass
Biogas, other	Biogas	Biomass
Biogas, landfill	Biogas	Biomass
Biogas, sewage sludge	Biogas	Biomass
(Wood applied in gas engines)	Biomass producer gas	Biomass
Waste Combustion (fossil)	Fossil waste	Other fuel

Annex 3A-4 Emission factors

Table 3A-4.1 CO_2 emission factors 2009.

Fuel	Emission factor kg per GJ		Reference type	IPCC fuel
	Biomass	Fossil fuel		Category
Coal, source category 1A1a Public electricity and heat production		93.6 [1)]	Country specific	Solid
Coal, Other source categories		94.6[3)]	IPCC 1996	Solid
Brown coal briquettes		94.6	IPCC 1996	Solid
Coke oven coke		108	IPCC 1996	Solid
Petroleum coke		92 [3)]	Country specific	Liquid
Wood	102		EEA 2002	Biomass
Municipal waste	79.6 [3)4)]	+ 32.5[3)4)]	Country specific	Biomass and Other fuels
Straw	102		EEA 2002	Biomass
Residual oil, source category 1A1a Public electricity and heat production		78.9 [1)]	Country specific	Liquid
Residual oil, other source categories		77.4[3)]	IPCC 1996	Liquid
Gas oil		74 [1)]	EEA 2007	Liquid
Kerosene		71.9	IPCC 1996	Liquid
Bio oil	74		Country specific	Biomass
Orimulsion		80 [2)]	Country specific	Liquid
Natural gas		56.69	Country specific	Gas
LPG		63.1	IPCC 1996	Liquid
Refinery gas		56.814	Country specific	Liquid
Biogas	83.6		Country specific	Biomass
Biomass producer gas	142.9[5)]		Country specific	Biomass

1) Plant specific data from EU ETS incorporated for individual plants.

2) Not applied in 2009

3) Plant specific data from EU ETS incorporated for cement production.

4) The emission factor for municipal waste is (76.6+32.5) kg CO_2 per GJ municipal waste. The fuel consumption and the CO_2 emission have been disaggregated to the two IPCC fuel categories *Biomass* and *Other fuels* in CRF. The IEF for CO_2, Other fuels is 78.88 kg CO_2 per GJ fossil municipal waste.

5) Includes a high content of CO_2 in the gas.

For coal (1A1a), residual oil (1A1a), municipal waste, refinery gas, natural gas fuelled off shore gas turbines and other natural gas comsumption time-series have been estimated. For all other fuels the same emission factor has been applied for 1990-2009.

Table 3A-4.2 CO_2 emission factors, time-series.

Year	Natural gas, off shore gas turbines, kg per GJ	Natural gas, other, kg per GJ	Municipal waste, plastic part, kg per GJ	Municipal waste biomass part, kg per GJ	Coal, sector 1A1a, kg per GJ	Residual oil, sector 1A1a, kg per GJ	Refinery gas, kg per GJ
1990	**57.469**	**56.9**	**25.4**	**86.7**	**94.0**	**78.4**	**57.6**
1991	**57.469**	**56.9**	**25.4**	**86.7**	**94.0**	**78.4**	**57.6**
1992	**57.469**	**56.9**	**27.9**	**84.2**	**94.0**	**78.4**	**57.6**
1993	**57.469**	**56.9**	**29.1**	**83.0**	**94.0**	**78.4**	**57.6**
1994	**57.469**	**56.9**	**29.1**	**83.0**	**94.0**	**78.4**	**57.6**
1995	**57.469**	**56.9**	**31.0**	**81.1**	**94.0**	**78.4**	**57.6**
1996	**57.469**	**56.9**	**32.5**	**79.6**	**94.0**	**78.4**	**57.6**
1997	**57.469**	**56.9**	**32.5**	**79.6**	**94.0**	**78.4**	**57.6**
1998	**57.469**	**56.9**	**32.5**	**79.6**	**94.0**	**78.4**	**57.6**
1999	**57.469**	**56.9**	**32.5**	**79.6**	**94.0**	**78.4**	**57.6**
2000	**57.469**	**57.1**	**32.5**	**79.6**	**94.0**	**78.4**	**57.6**
2001	**57.469**	**57.25**	**32.5**	**79.6**	**94.0**	**78.4**	**57.6**
2002	**57.469**	**57.28**	**32.5**	**79.6**	**94.0**	**78.4**	**57.6**
2003	**57.469**	**57.19**	**32.5**	**79.6**	**94.0**	**78.4**	**57.6**
2004	**57.469**	**57.12**	**32.5**	**79.6**	**94.0**	**78.4**	**57.6**
2005	**57.469**	**56.96**	**32.5**	**79.6**	**94.0**	**78.4**	**57.6**
2006	**57.879**	**56.78**	**32.5**	**79.6**	**94.4**	**78.2**	**57.812**
2007	**57.784**	**56.78**	**32.5**	**79.6**	**94.3**	**78.1**	**57.848**
2008	**56.959**	**56.77**	**32.5**	**79.6**	**94.0**	**78.5**	**57.948**
2009	**57.254**	**56.69**	**32.5**	**79.6**	**93.6**	**78.9**	**56.814**

Table 3A-4.3 CH_4 emission factors and references 2009.

Fuel group	Fuel	CRF source category	CRF source category	SNAP	Emission factor, g per GJ	Reference
SOLID	COAL	1A1a	Electricity and heat production	010101	0.9	IPCC (1996), Tier 2, Table 1-15, Utility Boiler, Pulverised Bituminous Combustion, Wet bottom.
				010102	0.9	IPCC (1996), Tier 2, Table 1-15, Utility Boiler, Pulverised Bituminous Combustion, Wet bottom.
		1A2	Industry	030100	10	IPCC (1996), Tier 2, Table 1-19, Commercial coal boilers.
		1A4b i	Residential	020200	300	IPCC (1996), Tier 1, Table 1-7, Residential, coal.
		1A4c i	Agriculture/ Forestry	020300	10	IPCC (1996), Tier 2, Table 1-19, Commercial coal boilers.[1)]
				020304	10	IPCC (1996), Tier 2, Table 1-19, Commercial coal boilers.[1)]
	BROWN COAL BRI.	1A4b i	Residential	020200	300	IPCC (1996), Tier 1, Table 1-7, Residential, coal.
	COKE OVEN COKE	1A2	Industry	030100	10	IPCC (1996), Tier 2, Table 1-19, Commercial coal boilers.
		1A4b i	Residential	020200	300	IPCC (1996), Tier 1, Table 1-7, Residential, coal.
LIQUID	PETROLEUM COKE	1A4a	Commercial/ Institutional	020100	10	IPCC (1996), Tier 1, Table 1-7, Commercial, oil.
	RESIDUAL OIL	1A1a	Electricity and heat production	010101	0.9	IPCC (1996), Tier 2, Table 1-15, Utility Boiler, Residual fuel oil.
				010102	1.3	Nielsen et al. (2010)
				010103	1.3	Nielsen et al. (2010)
				010104	3	IPCC (1996), Tier 1, Table 1-7, Energy industries, oil.
				010105	4	IPCC (1996), Tier 2, Table 1-15, Utility, Large diesel engines.
				010202	0.9	IPCC (1996), Tier 2, Table 1-15, Utility Boiler, Residual fuel oil.
				010203	0.9	IPCC (1996), Tier 2, Table 1-15, Utility Boiler, Residual fuel oil.
		1A1b	Petroleum refining	010306	3	IPCC (1996), Tier 1, Table 1-7, Energy industries, oil.
		1A2	Industry	030100	1.3	Nielsen et al. (2010)
				030102	1.3	Nielsen et al. (2010)
				030103	1.3	Nielsen et al. (2010)
		1A4a	Commercial/ Institutional	020100	1.4	IPCC (1996), Tier 2, Table 1-19, Commercial, residual fuel oil.
		1A4b i	Residential	020200	1.4	IPCC (1996), Tier 2, Table 1-18, Residential, residual fuel oil.
		1A4c i	Agriculture/ Forestry	020300	1.4	IPCC (1996), Tier 2, Table 1-19, Commercial, residual fuel oil[1)].
				020302	1.4	IPCC (1996), Tier 2, Table 1-19, Commercial, residual fuel oil[1)].
	GAS OIL	1A1a	Electricity and heat production	010101	0.9	IPCC (1996), Tier 2, Table 1-15, Utility Boiler, distillate fuel oil.
				010102	0.9	IPCC (1996), Tier 2, Table 1-15, Utility Boiler, distillate fuel oil.
				010103	0.9	IPCC (1996), Tier 2, Table 1-15, Utility Boiler, distillate fuel oil.
				010104	3	IPCC (1996), Tier 1, Table 1-7, Energy industries, oil.
				010105	24	Nielsen et al. (2010)
				010202	0.9	IPCC (1996), Tier 2, Table 1-15, Utility Boiler, distillate fuel oil.
				010203	0.9	IPCC (1996), Tier 2, Table 1-15, Utility Boiler, distillate fuel oil.
		1A1b	Petroleum refining	010306	3	IPCC (1996), Tier 1, Table 1-7, Energy industries, oil.
		1A2	Industry	030100	0.2	IPCC (1996), Tier 2, Table 1-16, Industry, distillate fuel oil.
				030102	0.2	IPCC (1996), Tier 2, Table 1-16, Industry, distillate fuel oil.
				030104	2	IPCC (1996), Tier 1, Table 1-7, Industry, oil.
				030105	24	Nielsen et al. (2010)
		1A4a	Commercial/ Institutional	020100	0.7	IPCC (1996), Tier 2, Table 1-19, Commercial, distillate fuel oil.
				020103	0.7	IPCC (1996), Tier 2, Table 1-19, Commercial, distillate fuel oil.
				020105	24	Nielsen et al. (2010)
		1A4b i	Residential	020200	0.7	IPCC (1996), Tier 2, Table 1-18, Residential, distillate fuel oil.
				020204	24	Nielsen et al. (2010)
	KEROSENE	1A2	Industry	030100	0.2	IPCC (1996), Tier 2, Table 1-16, Industry, distillate fuel oil.
		1A4a	Commercial/ Institutional	020100	0.7	IPCC (1996), Tier 2, Table 1-19, Commercial, distillate fuel oil.
		1A4b i	Residential	020200	0.7	IPCC (1996), Tier 2, Table 1-18, Residential, distillate fuel oil.
		1A4c i	Agriculture/ Forestry	020300	0.7	IPCC (1996), Tier 2, Table 1-19, Commercial, distillate fuel oil[1)].
	LPG	1A1a	Electricity and heat production	010102	3	IPCC (1996), Tier 1, Table 1-7, Energy Industries, oil.
				010203	3	IPCC (1996), Tier 1, Table 1-7, Energy Industries, oil.
		1A2	Industry	030100	2	IPCC (1996), Tier 1, Table 1-7, Industry, oil
		1A4a	Commercial/ Institutional	020100	10	IPCC (1996), Tier 1, Table 1-7, Commercial, oil.
				020105	10	IPCC (1996), Tier 1, Table 1-7, Commercial, oil.
		1A4b i	Residential	020200	1.1	IPCC (1996), Tier 2, Table 1-18, Residiential propane/butane furnaces.
		1A4c i	Agriculture/ Forestry	020300	10	IPCC (1996), Tier 1, Table 1-7, Agriculture, oil.
	REFINERY GAS	1A1b	Petroleum refining	010304	1.7	Assumed equal to natural gas fuelled gas turbines. Nielsen et al. (2010)

Fuel group	Fuel	CRF source category	CRF source category	SNAP	Emission factor, g per GJ	Reference
				010306	1	Assumed equal to natural gas fuelled plants. IPCC (1996), Tier 1, Table 1-7, Natural gas
GAS	NATURAL GAS	1A1a	Electricity and heat production	010101	0.1	IPCC (1996), Tier 2, Table 1-15, Utility Boiler, natural gas.
				010102	0.1	IPCC (1996), Tier 2, Table 1-15, Utility Boiler, natural gas.
				010103	0.1	IPCC (1996), Tier 2, Table 1-15, Utility Boiler, natural gas.
				010104	1.7	Nielsen et al. (2010)
				010105	481	Nielsen et al. (2010)
				010202	0.1	IPCC (1996), Tier 2, Table 1-15, Utility Boiler, natural gas.
				010203	0.1	IPCC (1996), Tier 2, Table 1-15, Utility Boiler, natural gas.
		1A1c	Other energy industries	010504	1.7	Nielsen et al. (2010)
		1A2	Industry	030100	1.4	IPCC (1996), Tier 2, Table 1-16, Industry, natural gas boilers.
				030103	1.4	IPCC (1996), Tier 2, Table 1-16, Industry, natural gas boilers.
				030104	1.7	Nielsen et al. (2010)
				030105	481	Nielsen et al. (2010)
				030106	1.4	IPCC (1996), Tier 2, Table 1-16, Industry, natural gas boilers.
		1A4a	Commercial/ Institutional	020100	1.2	IPCC (1996), Tier 2, Table 1-19, Commercial, natural gas boilers.
				020103	1.2	IPCC (1996), Tier 2, Table 1-19, Commercial, natural gas boilers.
				020105	481	Nielsen et al. (2010)
		1A4b i	Residential	020200	5	IPCC (1996), Tier 1, Table 1-7, Residential, natural gas.
				020202	5	IPCC (1996), Tier 1, Table 1-7, Residential, natural gas.
				020204	481	Nielsen et al. (2010)
		1A4c i	Agriculture/ Forestry	020300	1.2	IPCC (1996), Tier 2, Table 1-19, Commercial, natural gas boilers[1)].
				020304	481	Nielsen et al. (2010)
WASTE	MUNICIP. WASTES	1A1a	Electricity and heat production	010101	0.34	Nielsen et al. (2010)
				010102	0.34	Nielsen et al. (2010)
				010103	0.34	Nielsen et al. (2010)
				010203	0.34	Nielsen et al. (2010)
		1A4a	Commercial/ Institutional	020103	30	IPCC (1996), Tier 1, Table 1-7, Industry, wastes.
BIOMASS	WOOD	1A1a	Electricity and heat production	010102	3.1	Nielsen et al. (2010)
				010103	3.1	Nielsen et al. (2010)
				010104	3.1	Nielsen et al. (2010)
				010203	30	IPCC (1996), Tier 1, Table 1-7, Energy industries, wood.
		1A2	Industry	030100	15	IPCC (1996), Tier 2, Table 1-16, Industry, wood stoker boilers.
				030102	15	IPCC (1996), Tier 2, Table 1-16, Industry, wood stoker boilers.
				030103	15	IPCC (1996), Tier 2, Table 1-16, Industry, wood stoker boilers.
		1A4a	Commercial/ Institutional	020100	30	IPCC (1996), Tier 1, Table 1-7, Industry, wood[2)].
				020105	30	IPCC (1996), Tier 1, Table 1-7, Industry, wood[2)].
		1A4b i	Residential	020200	154	NERI estimate based on technology distribution [3)]
				020202	154	NERI estimate based on technology distribution [3)]
				020204	154	NERI estimate based on technology distribution [3)]
		1A4c i	Agriculture/ Forestry	020300	30	IPCC (1996), Tier 1, Table 1-7, Industry, wood[2)].
	STRAW	1A1a	Electricity and heat production	010101	0.47	Nielsen et al. (2010)
				010102	0.47	Nielsen et al. (2010)
				010103	0.47	Nielsen et al. (2010)
				010104	0.47	Nielsen et al. (2010)
				010203	30	IPCC (1996), Tier 1, Table 1-7, Energy industries, other biomass
		1A4b i	Residential	020200	300	IPCC (1996), Tier 1, Table 1-7, Residential, other biomass.
		1A4c i	Agriculture/ Forestry	020300	300	IPCC (1996), Tier 1, Table 1-7, Agriculture, other biomass.
	BIO OIL	1A1a	Electricity and heat production	010105	24	Nielsen et al. (2010) assumed same emission factor as for gas oil fuelled engines.
				010202	0.7	IPCC (1996), Tier 2, Table 1-19, Commercial, distil-late fuel oil.
				010203	0.7	IPCC (1996), Tier 2, Table 1-19, Commercial, distil-late fuel oil.
		1A2	Industry	030105	24	Nielsen et al. (2010) assumed same emission factor as for gas oil fuelled engines.
		1A4b i	Residential	020200	0.7	IPCC (1996), Tier 2, Table 1-18, Residentail, distillate fuel oil.
	BIOGAS	1A1a	Electricity and heat production	010102	1	IPCC (1996), Tier 1, Table 1-7, Energy industries, natural gas. Assumed similar to natural gas (NERI assumption).
				010105	434	Nielsen et al. (2010)
				010203	1	IPCC (1996), Tier 1, Table 1-7, Energy industries, natural gas. Assumed similar to natural gas (NERI assumption).

Fuel group	Fuel	CRF source category	CRF source category	SNAP	Emission factor, g per GJ	Reference
		1A2	Industry	030100	5	IPCC (1996), Tier 1, Table 1-7, Industry, natural gas. Assumed similar to natural gas (NERI assumption).
				030102	5	IPCC (1996), Tier 1, Table 1-7, Industry, natural gas. Assumed similar to natural gas (NERI assumption).
				030103	5	IPCC (1996), Tier 1, Table 1-7, Industry, natural gas. Assumed similar to natural gas (NERI assumption).
				030105	434	Nielsen et al. (2010)
		1A4a	Commercial/ Institutional	020100	5	IPCC (1996), Tier 1, Table 1-7, Commercial, natural gas. Assumed similar to natural gas (NERI assumption).
				020103	5	IPCC (1996), Tier 1, Table 1-7, Commercial, natural gas. Assumed similar to natural gas (NERI assumption).
				020105	434	Nielsen et al. (2010)
		1A4c i	Agriculture/ Forestry	020300	5	IPCC (1996), Tier 1, Table 1-7, Agriculture, natural gas. Assumed similar to natural gas (NERI assumption).
				020304	434	Nielsen et al. (2010)
	BIO PROD GAS	1A1a	Electricity and heat production	010105	13	Nielsen et al. (2010)
		1A2	Industry	030105	13	Nielsen et al. (2010)

In general, the same emission factors have been applied for 1990-2009. However, time-series have been estimated for both natural gas fuelled engines and biogas fuelled engines, residential wood combustion, natural gas fuelled gas turbines[3] and MSW incineration plants[3].

Table 3A-4.4 CH_4 emission factors, time-series.

Year	Natural gas fuelled engines Emission factor, g per GJ	Biogas fuelled engines Emission factor, g per GJ	Residential wood combustion, g per GJ	MSW Incineration g per GJ	Natural gas fuelled gas turbines, g per GJ
1990	266	239	243	0.59	1.5
1991	309	251	243	0.59	1.5
1992	359	264	243	0.59	1.5
1993	562	276	243	0.59	1.5
1994	623	289	243	0.59	1.5
1995	632	301	243	0.59	1.5
1996	616	305	243	0.59	1.5
1997	551	310	243	0.59	1.5
1998	542	314	243	0.59	1.5
1999	541	318	243	0.59	1.5
2000	537	323	243	0.59	1.5
2001	522	342	217	0.59	1.5
2002	508	360	206	0.59	1.6
2003	494	379	204	0.59	1.6
2004	479	397	202	0.51	1.7
2005	465	416	193	0.42	1.7
2006	473	434	186	0.34	1.7
2007	481	434	184	0.34	1.7
2008	481	434	169	0.34	1.7
2009	481	434	154	0.34	1.7

[3] A minor emission source

Table 3A-4.5 N_2O emission factors and references 2009.

Fuel group	Fuel	CRF source catego-ry	CRF source category	SNAP	Emission factor, g per GJ	Reference
SOLID	COAL	1A1a	Electricity and heat production	010101	0.8	Elsam (2005)
				010102	0.8	Elsam (2005)
		1A2	Industry	030100	1.4	IPCC (1996), Tier 1, Table 1-8, Industry, coal
		1A4b i	Residential	020200	1.4	IPCC (1996), Tier 1, Table 1-8, Residential, coal
		1A4c i	Agriculture/ Forestry	020300	1.4	IPCC (1996), Tier 1, Table 1-8, Commerdial, coal
				020304	1.4	IPCC (1996), Tier 1, Table 1-8, Commerdial, coal
	BROWN COAL BRI.	1A4b i	Residential	020200	1.4	IPCC (1996), Tier 1, Table 1-8, Residential, coal
	COKE OVEN COKE	1A2	Industry	030100	1.4	IPCC (1996), Tier 1, Table 1-8, Industry, coal
		1A4b i	Residential	020200	1.4	IPCC (1996), Tier 1, Table 1-8, Residential, coal
LIQUID	PETROLEUM COKE	1A4a	Commercial/ Institutional	020100	0.6	IPCC (1996), Tier 1, Table 1-8, Commercial, oil
	RESIDUAL OIL	1A1a	Electricity and heat production	010101	0.3	IPCC (1996), Tier 2, Table 1-15, Utility, residual fuel oil
				010102	5	Nielsen et al. (2010)
				010103	5	Nielsen et al. (2010)
				010104	0.6	IPCC (1996), Tier 1, Table 1-8, Energy industries, oil
				010105	0.6	IPCC (1996), Tier 1, Table 1-8, Energy industries, oil
				010202	0.3	IPCC (1996), Tier 2, Table 1-15, Utility, residual fuel oil
				010203	0.3	IPCC (1996), Tier 2, Table 1-15, Utility, residual fuel oil
		1A1b	Petroleum refining	010306	0.6	IPCC (1996), Tier 1, Table 1-8, Energy industries, oil
		1A2	Industry	030100	5	Nielsen et al. (2010)
				030102	5	Nielsen et al. (2010)
				030103	5	Nielsen et al. (2010)
		1A4a	Commercial/ Institutional	020100	0.3	IPCC (1996), Tier 2, Table 1-19, Commercial, fuel oil
		1A4b i	Residential	020200	0.6	IPCC (1996), Tier 1, Table 1-8, Residential, oil
		1A4c i	Agriculture/ Forestry	020300	0.3	IPCC (1996), Tier 2, Table 1-19, Commercial, fuel oil
				020302	0.3	IPCC (1996), Tier 2, Table 1-19, Commercial, fuel oil
	GAS OIL	1A1a	Electricity and heat production	010101	0.4	IPCC (1996), Tier 2, Table 1-15, Utility, distillate fuel oil
				010102	0.4	IPCC (1996), Tier 2, Table 1-15, Utility, distillate fuel oil
				010103	0.4	IPCC (1996), Tier 2, Table 1-15, Utility, distillate fuel oil
				010104	0.6	IPCC (1996), Tier 1, Table 1-8, Energy industries, oil
				010105	2.1	Nielsen et al. (2010)
				010202	0.4	IPCC (1996), Tier 2, Table 1-15, Utility, distillate fuel oil
				010203	0.4	IPCC (1996), Tier 2, Table 1-15, Utility, distillate fuel oil
		1A1b	Petroleum refining	010306	0.6	IPCC (1996), Tier 1, Table 1-8, Energy industries, oil
		1A2	Industry	030100	0.4	IPCC (1996), Tier 2, Table 1-16, Industry, distillate fuel oil boilers
				030102	0.4	IPCC (1996), Tier 2, Table 1-16, Industry, distillate fuel oil boilers
				030104	0.6	IPCC (1996), Tier 1, Table 1-8, Industry, oil
				030105	2.1	Nielsen et al. (2010)
		1A4a	Commercial/ Institutional	020100	0.4	IPCC (1996), Tier 2, Table 1-19, Commercial, distillate fuel oil
				020103	0.4	IPCC (1996), Tier 2, Table 1-19, Commercial, distillate fuel oil
				020105	2.1	Nielsen et al. (2010)
		1A4b i	Residential	020200	0.6	IPCC (1996), Tier 1, Table 1-8, Residential, oil
				020204	2.1	Nielsen et al. (2010)
	KEROSENE	1A2	Industry	030100	0.4	IPCC (1996), Tier 2, Table 1-16, Industry, distillate fuel oil boilers
		1A4a	Commercial/ Institutional	020100	0.4	IPCC (1996), Tier 2, Table 1-19, Commercial, distillate fuel oil
		1A4b i	Residential	020200	0.6	IPCC (1996), Tier 1, Table 1-8, Residential, oil
		1A4c i	Agriculture/ Forestry	020300	0.4	IPCC (1996), Tier 2, Table 1-19, Commercial, distillate fuel oil[1)]
	LPG	1A1a	Electricity and heat production	010102	0.6	IPCC (1996), Tier 1, Table 1-8, Energy industries, oil
				010203	0.6	IPCC (1996), Tier 1, Table 1-8, Energy industries, oil
		1A2	Industry	030100	0.6	IPCC (1996), Tier 1, Table 1-8, Industry, oil
		1A4a	Commercial/ Institutional	020100	0.6	IPCC (1996), Tier 1, Table 1-8, Commercial, oil
				020105	0.6	IPCC (1996), Tier 1, Table 1-8, Commercial, oil
		1A4b i	Residential	020200	0.6	IPCC (1996), Tier 1, Table 1-8, Residential, oil
		1A4c i	Agriculture/ Forestry	020300	0.6	IPCC (1996), Tier 1, Table 1-8, Agriculture, oil
	REFINERY GAS	1A1b	Petroleum refining	010304	1	Assumed equal to natural gas fuelled turbines. Based on Nielsen et al. (2010).
				010306	0.1	IPCC (1996), Tier 1, Table 1-8, Energy industries, natural gas
GAS	NATURAL GAS	1A1a	Electricity and heat production	010101	0.1	IPCC (1996), Tier 1, Table 1-8, Energy industries, natural gas
				010102	0.1	IPCC (1996), Tier 1, Table 1-8, Energy industries, natural gas
				010103	0.1	IPCC (1996), Tier 1, Table 1-8, Energy industries, natural gas
				010104	1	Nielsen et al. (2010)
				010105	0.58	Nielsen et al. (2010)
				010202	0.1	IPCC (1996), Tier 1, Table 1-8, Energy industries, natural gas
				010203	0.1	IPCC (1996), Tier 1, Table 1-8, Energy industries, natural gas
		1A1c	Other energy industries	010504	2.2	Nielsen & Illerup (2003) [2)]
		1A2	Industry	030100	0.1	IPCC (1996), Tier 1, Table 1-8, Industry, natural gas
				030103	0.1	IPCC (1996), Tier 1, Table 1-8, Industry, natural gas
				030104	1	Nielsen et al. (2010)
				030105	0.58	Nielsen et al. (2010)

Fuel group	Fuel	CRF source category	CRF source category	SNAP	Emission factor, g per GJ	Reference
				030106	0.1	IPCC (1996), Tier 1, Table 1-8, Industry, natural gas
		1A4a	Commercial/ Institutional	020100	2.3	IPCC (1996), Tier 2, Table 1-19, Commercial, natural gas boilers
				020103	2.3	IPCC (1996), Tier 2, Table 1-19, Commercial, natural gas boilers
				020105	0.58	Nielsen et al. (2010)
		1A4b i	Residential	020200	0.1	IPCC (1996), Tier 1, Table 1-8, Residential, natural gas
				020202	0.1	IPCC (1996), Tier 1, Table 1-8, Residential, natural gas
				020204	0.58	Nielsen et al. (2010)
		1A4c i	Agriculture/ Forestry	020300	2.3	IPCC (1996), Tier 2, Table 1-19, Commercial, natural gas boilers[1)]
				020304	0.58	Nielsen et al. (2010)
WASTE	MUNICIP. WASTES	1A1a	Electricity and heat production	010101	1.2	Nielsen et al. (2010)
				010102	1.2	Nielsen et al. (2010)
				010103	1.2	Nielsen et al. (2010)
				010203	1.2	Nielsen et al. (2010)
		1A4a	Commercial/ Institutional	020103	4	IPCC (1996), Tier 1, Table 1-8, Commercial, wastes
BIO-MASS	WOOD	1A1a	Electricity and heat production	010102	0.8	Nielsen et al. (2010)
				010103	0.8	Nielsen et al. (2010)
				010104	0.8	Nielsen et al. (2010)
				010203	4	IPCC (1996), Tier 1, Table 1-8, Energy industries, wood
		1A2	Industry	030100	4	IPCC (1996), Tier 1, Table 1-8, Industry, wood
				030102	4	IPCC (1996), Tier 1, Table 1-8, Industry, wood
				030103	4	IPCC (1996), Tier 1, Table 1-8, Industry, wood
		1A4a	Commercial/ Institutional	020100	4	IPCC (1996), Tier 1, Table 1-8, Commercial, wood
				020105	4	IPCC (1996), Tier 1, Table 1-8, Commercial, wood
		1A4b i	Residential	020200	4	IPCC (1996), Tier 1, Table 1-8, Residential, wood
				020202	4	IPCC (1996), Tier 1, Table 1-8, Residential, wood
				020204	4	IPCC (1996), Tier 1, Table 1-8, Residential, wood
		1A4c i	Agriculture/ Forestry	020300	4	IPCC (1996), Tier 1, Table 1-8, Agriculture, wood
	STRAW	1A1a	Electricity and heat production	010101	1.1	Nielsen et al. (2010)
				010102	1.1	Nielsen et al. (2010)
				010103	1.1	Nielsen et al. (2010)
				010104	1.1	Nielsen et al. (2010)
				010203	4	IPCC (1996), Tier 1, Table 1-8, Energy industries, other biomass
		1A4b i	Residential	020200	4	IPCC (1996), Tier 1, Table 1-8, Residential, other biomass
		1A4c i	Agriculture/ Forestry	020300	4	IPCC (1996), Tier 1, Table 1-8, Agriculture, other biomass
	BIO OIL	1A1a	Electricity and heat production	010105	2.1	Assumed equal to gas oil. Based on Nielsen et al. (2010)
				010202	0.4	IPCC (1996), Tier 2, Table 1-15, Utility, distillate fuel oil
				010203	0.4	IPCC (1996), Tier 2, Table 1-15, Utility, distillate fuel oil
		1A2	Industry	030105	2.1	Assumed equal to gas oil. Based on Nielsen et al. (2010)
		1A4b i	Residential	020200	0.6	IPCC (1996), Tier 1, Table 1-8, Residential, oil
	BIOGAS	1A1a	Electricity and heat production	010102	0.1	IPCC (1996), Tier 1, Table 1-8, Energy industries, natural gas
				010105	1.6	Nielsen et al. (2010)
				010203	0.1	IPCC (1996), Tier 1, Table 1-8, Energy industries, natural gas
		1A2	Industry	030100	0.1	IPCC (1996), Tier 1, Table 1-8, Industry, natural gas
				030102	0.1	IPCC (1996), Tier 1, Table 1-8, Industry, natural gas
				030103	0.1	IPCC (1996), Tier 1, Table 1-8, Industry, natural gas
				030105	1.6	Nielsen et al. (2010)
		1A4a	Commercial/ Institutional	020100	0.1	IPCC (1996), Tier 1, Table 1-8, Commercial, natural gas
				020103	0.1	IPCC (1996), Tier 1, Table 1-8, Commercial, natural gas
				020105	1.6	Nielsen et al. (2010)
		1A4c i	Agriculture/ Forestry	020300	0.1	IPCC (1996), Tier 1, Table 1-8, Agriculture, natural gas
				020304	1.6	Nielsen et al. (2010)
	BIO PROD GAS	1A1a	Electricity and heat production	010105	2.7	Nielsen et al. (2010)
		1A2	Industry	030105	2.7	Nielsen et al. (2010)

1) In Denmark plants in Agriculture/Forestry are similar to Commercial plants.

2) The emission factor 1 g/GJ, referring to Nielsen et al. (2010), will be applied in the next inventory.

Time-series have been estimated for natural gas fuelled gas turbines. All other emission factors have been applied unchanged for 1990-2009.

Table 3A-4.6 N_2O emission factors, time-series.

Year	Natural gas fuelled gas turbines Emission factor, g per GJ
1990	2.2
1991	2.2
1992	2.2
1993	2.2
1994	2.2
1995	2.2
1996	2.2
1997	2.2
1998	2.2
1999	2.2
2000	2.2
2001	2.0
2002	1.9
2003	1.7
2004	1.5
2005	1.4
2006	1.2
2007	1.0
2008	1.0
2009	1.0

Table 3A-4.7 SO_2, NO_x, NMVOC and CO emission factors and references 2009.

Fuel type	Fuel	NFR	NFR_name	SNAP	SO_2 g/GJ	SO_2 Ref.	NO_x g/GJ	NO_x Ref.	NMVOC g/GJ	NMVOC Ref.	CO g/GJ	CO Ref.
BIO-MASS	WOOD	1A1a	Electricity and heat production	010102	1.9	*12*	81	*12*	5.1	*12*	90	*12*
				010103	1.9	*12*	81	*12*	5.1	*12*	90	*12*
				010104	1.9	*12*	81	*12*	5.1	*12*	90	*12*
				010203	25	*22, 21*	90	*22, 21, 4*	7.3	*13*	240	*4*
		1A2	Industry	030100	25	*22, 21*	90	*22, 21, 4*	10	*13*	240	*4*
				030102	25	*22, 21*	90	*22, 21, 4*	10	*13*	240	*4*
				030103	25	*22, 21*	90	*22, 21, 4*	10	*13*	240	*4*
		1A4a	Commercial/ Institutional	020100	25	*22, 21*	90	*22, 21, 4*	146	*13*	240	*4*
				020105	25	*22, 21*	90	*22, 21, 4*	146	*13*	240	*4*
		1A4b i	Residential	020200	25	*22, 21*	120	*22*	437	*39*	3165	*39*
				020202	25	*22, 21*	120	*22*	437	*39*	3165	*39*
				020205	25	*22, 21*	120	*22*	437	*39*	3165	*39*
		1A4c i	Agriculture/ Forestry	020300	25	*22, 21*	90	*22, 21, 4*	146	*13*	240	*4*
	STRAW	1A1a	Electricity and heat production	010101	49	*12*	125	*12*	0.78	*12*	67	*12*
				010102	49	*12*	125	*12*	0.78	*12*	67	*12*
				010103	49	*12*	125	*12*	0.78	*12*	67	*12*
				010104	49	*12*	125	*12*	0.78	*12*	67	*12*
				010203	130	*5*	90	*4, 28*	7.3	*13*	325	*4, 5*
		1A4b i	Residential	020200	130	*5*	90	*4, 28*	400	*13*	4000	*1, 6, 7*
		1A4c i	Agriculture/ Forestry	020300	130	*5*	90	*4, 28*	146	*13*	4000	*1, 6, 7*
	BIO OIL	1A1a	Electricity and heat production	010105	1	*37*	700	*15*	37	*13*	15	*15*
				010202	1	*37*	65	*15*	0.8	*13*	15	*15*
				010203	1	*37*	65	*15*	0.8	*13*	15	*15*
		1A2	Industry	030105	1	*37*	700	*15*	37	*13*	100	*15*
		1A4b i	Residential	020200	1	*37*	65	*15*	15	*13*	100	*15*
	BIOGAS	1A1a	Electricity and heat production	010102	25	*26*	28	*4*	2	*16*	36	*4*
				010105	19.2	*31*	202	*12*	10	*12*	310	*12*
				010203	25	*26*	28	*4*	2	*16*	36	*4*
		1A2	Industry	030100	25	*26*	28	*4*	2	*16*	36	*4*
				030102	25	*26*	59	*4*	2	*16*	36	*4*
				030103	25	*26*	59	*4*	2	*16*	36	*4*
				030105	19.2	*31*	202	*12*	10	*12*	310	*12*
		1A4a	Commercial/ Institutional	020100	25	*26*	28	*4*	2	*16*	36	*4*
				020103	25	*26*	28	*4*	2	*16*	36	*4*
				020105	19.2	*31*	202	*12*	10	*12*	310	*12*
		1A4c i	Agriculture/ Forestry	020300	25	*26*	28	*4*	2	*16*	36	*4*
				020304	19.2	*31*	202	*12*	10	*12*	310	*12*
	BIO PROD GAS	1A1a	Electricity and heat production	010105	1.9	*12*	173	*12*	2	*12*	586	*12*
		1A2	Industry	030105	1.9	*12*	173	*12*	2	*12*	586	*12*
WASTE	MUNICIP. WASTES	1A1a	Electricity and heat production	010101	8.3	*12*	102	*12*	0.56	*12*	3.9	*12*
				010102	8.3	*12*	102	*12*	0.56	*12*	3.9	*12*
				010103	8.3	*12*	102	*12*	0.56	*12*	3.9	*12*
				010203	15	*34*	164	*9*	2	*13*	10	*9*
		1A4a	Commercial/ Institutional	020103	15	*34*	164	*9*	2	*13*	10	*9*
GAS	NATURAL GAS	1A1a	Electricity and heat production	010101	0.3	*17*	97	*9*	2	*14*	15	*3*
				010102	0.3	*17*	97	*9*	2	*14*	15	*3*
				010103	0.3	*17*	42	*9*	2	*14*	28	*4*
				010104	0.3	*17*	48	*12*	1.6	*12*	4.8	*12*
				010105	0.3	*17*	135	*12*	92	*12*	58	*12*
				010202	0.3	*17*	42	*36*	2	*14*	28	*4*
				010203	0.3	*17*	42	*36*	2	*14*	28	*4*
		1A1c	Other energy industries	010504	0.3	*17*	250	*1, 8, 32*	1.4	*31*	6.2	*31*
		1A2	Industry	030100	0.3	*17*	42	*36*	2	*14*	28	*4*
				030103	0.3	*17*	42	*36*	2	*14*	28	*4*
				030104	0.3	*17*	48	*12*	1.6	*12*	4.8	*12*
				030105	0.3	*17*	135	*12*	92	*12*	58	*12*
				030106	0.3	*17*	42	*36*	2	*14*	28	*4*
		1A4a	Commercial/ Institutional	020100	0.3	*17*	30	*1,4,11*	2	*14*	28	*4*
				020103	0.3	*17*	30	*1,4,11*	2	*14*	28	*4*
				020105	0.3	*17*	135	*12*	92	*12*	58	*12*
		1A4b i	Residential	020200	0.3	*17*	30	*1,4,11*	4	*11*	20	*11*
				020202	0.3	*17*	30	*1,4,11*	4	*11*	20	*11*
				020204	0.3	*17*	135	*12*	92	*12*	58	*12*
		1A4c i	Agriculture/ Forestry	020300	0.3	*17*	30	*1,4,11*	2	*14*	28	*4*
				020304	0.3	*17*	135	*12*	92	*12*	58	*12*
LIQUID	PETROLEUM COKE	1A4a	Commercial/ Institutional	020100	605	*20*	50	*1*	88.8	*13*	1000	*1*
	RESIDUAL OIL	1A1a	Electricity and heat production	010101	119	*18*	1347	*18*	2.3	*13*	15	*3*
				010102	119	*18*	1347	*18*	0.8	*12*	2.8	*12*
				010103	119	*18*	1347	*18*	0.8	*12*	2.8	*12*
				010104	119	*18*	1347	*18*	2.3	*13*	15	*3*
				010105	119	*18*	1347	*18*	2.3	*13*	15	*3*
				010202	344	*25,10, 24*	142	*4*	2.3	*13*	30	*1*
				010203	344	*25,10,*	142	*4*	2.3	*13*	30	*1*

Fuel type	Fuel	NFR	NFR_name	SNAP	SO_2 g/GJ	Ref.	NO_x g/GJ	Ref.	NMVOC g/GJ	Ref.	CO g/GJ	Ref.
						24						
		1A1b	Petroleum refining	010306	537	33	142	4	2.3	13	30	1
		1A2	Industry	030100	344	25,10, 24	130	28	0.8	12	2.8	12
				030102	344	25,10, 24	136	12	0.8	12	2.8	12
				030103	344	25,10, 24	136	12	0.8	12	2.8	12
		1A4a	Commercial/ Institutional	020100	344	25,10, 24	142	4	5	13	30	1
		1A4b i	Residential	020200	344	25,10, 24	142	4	15	13	30	1
		1A4c i	Agriculture/ Forestry	020300	344	25,10, 24	142	4	5	13	30	1
				020302	344	25,10, 24	142	4	5	13	30	1
	GAS OIL	1A1a	Electricity and heat production	010101	23	27	249	18	0.8	13	15	3
				010102	23	27	249	18	0.8	13	15	3
				010103	23	27	65	28	0.8	13	15	3
				010104	23	27	350	9	0.2	13	15	3
				010105	23	27	942	12	37	13	130	12
				010202	23	27	65	28	0.8	13	30	1
				010203	23	27	65	28	0.8	13	30	1
		1A1b	Petroleum refining	010306	23	27	65	28	0.8	13	30	1
		1A2	Industry	030100	23	27	65	28	10	13	30	1
				030102	23	27	65	28	5	13	30	1
				030104	23	27	350	9	0.2	13	15	3
				030105	23	27	942	12	37	13	130	12
		1A4a	Commercial/ Institutional	020100	23	27	52	4	5	13	30	1
				020103	23	27	52	4	5	13	30	1
				020105	23	27	942	12	37	13	130	12
		1A4b i	Residential	020200	23	27	52	4	15	13	43	1
				020204	23	27	942	12	37	13	130	12
	KEROSENE	1A2	Industry	030100	5	30	50	1	10	13	20	1
		1A4a	Commercial/ Institutional	020100	5	30	50	1	5	13	20	1
		1A4b i	Residential	020200	5	30	50	1	15	13	20	1
		1A4c i	Agriculture/ Forestry	020300	5	30	50	1	5	13	20	1
	LPG	1A1a	Electricity and heat production	010102	0.13	23	96	32	0.8	13	25	1
				010203	0.13	23	96	32	0.8	13	25	1
		1A2	Industry	030100	0.13	23	96	32	5	13	25	1
		1A4a	Commercial/ Institutional	020100	0.13	23	71	32	5	13	25	1
				020105	0.13	23	71	32	5	13	25	1
		1A4b i	Residential	020200	0.13	23	47	32	10	13	25	1
		1A4c i	Agriculture/ Forestry	020300	0.13	23	71	32	5	13	25	1
	REFINERY GAS	1A1b	Petroleum refining	010304	1	2	170	9	1.4	35	6.2	35
				010306	1	2	80	40	1.4	35	6.2	35
SOLID	COAL	1A1a	Electricity and heat production	010101	14	18	39	18	1.2	13	10	3
				010102	14	18	39	18	1.2	13	10	3
		1A2	Industry	030100	574	19	95	4	10	13	10	3
		1A4b i	Residential	020200	574	19	95	4	484	13	2000	32
		1A4c i	Agriculture/ Forestry	020300	574	19	95	4	88.8	13	931	13
				020304	574	19	95	4	88.8	13	931	13
	BROWN COAL BRI.	1A4b i	Residential	020200	574	19	95	4	484	13	2000	29
	COKE OVEN COKE	1A2	Industry	030100	574	19	95	4	10	13	10	29
		1A4b i	Residential	020200	574	19	95	4	484	13	2000	29

1. European Environment Agency (EEA), 2007: EMEP/CORINAIR Atmospheric Emission Inventory Guidebook – 2007, prepared by the UNECE/EMEP Task Force on Emissions Inventories and Projections. Technical Report No 16/2007. Available at: http://www.eea.europa.eu/publications/EMEPCORINAIR5 (2010-02-03).
2. NERI calculation based on plant specific data 1995-2002.
3. Sander, B. 2002. Elsam, personal communication, e-mail 17-05-2002.
4. Miljøstyrelsen, 2001. Luftvejledningen, Begrænsning af luftforurening fra virksomheder, Vejledning fra Miljøstyrelsen Nr. 2 2001 (Danish legislation).
5. Nikolaisen L., Nielsen C., Larsen M.G., Nielsen V. Zielke U., Kristensen J.K. & Holm-Christensen B. 1998 Halm til energiformål, Teknik – Miljø – Økonomi, 2. udgave, 1998, Videncenter for halm og flisfyring (In Danish).
6. Jensen L. & Nielsen P.A. 1990. Emissioner fra halm- og flisfyr, dk-Teknik & Levnedsmiddelstyrelsen 1990 (In Danish).
7. Bjerrum M., 2002. Danish Technological Institute, personal communication 09-10-2002.
8. Kristensen, P. (2004) Danish Gas Technology Centre, e-mail 31-03-2004 .
9. NERI calculation based on annual environmental reports of Danish plants year 2000.
10. Risø National Laboratory home page – http://www.risoe.dk/sys/esy/emiss_e/emf25082000.xls.
11. Gruijthuijsen L.v. & Jensen J.K., 2000. Energi- og miljøoversigt, Danish Gas Technology Centre 2000 (In Danish).
12. Nielsen, M., Nielsen, O.K. & Thomsen, M. 2010c: Emissionskortlægning for decentral kraftvarme, Energinet.dk miljøprojekt nr. 07/1882. Delrapport 5. Emissionsfaktorer og emissionsopgørelse for decentral kraftvarme, 2006. National Environmental Research Institute, University of Aarhus.
13. European Environment Agency (EEA), 2009: EMEP/EEA air pollutant emission inventory guidebook 2009. Technical guidance to prepare national emission inventories. EEA Technical Report 9/2009 http://www.eea.europa.eu/publications/emep-eea-emission-inventory-guidebook-2009 (2010-02-03)
14. Danish Gas Technology Centre 2001, Naturgas – Energi og miljø (In Danish).
15. Same emission factors as for gas oil is assumed (NERI assumption).
16. Ref. no 13: EEA 2009 assuming same emission factor as for natural gas.

17. NERI calculation based on S content of natural gas 6mg(S)/m_n^3 gas. The S content refers to the former Danish natural gas transmission company Gastra.
18. Estimated by NERI based on 2009 data reported by the plant owners to the electricity transmission companies and the Danish Energy Agency. NERI calculations are based on data forwarded to NERI by the Danish Energy Agency, 2010.
19. NERI calculation based on a sulphur content of 0.8 % and a retention of sulphur in ash of 5 %. The sulphur content has been assumed just below the limit value of 0.9 % (reference no. 24).
20. NERI calculation based on a sulphur content of 1 % (reference no. 24) and a retention of sulphur in ash of 5 %.
21. Christiansen, B.H., Evald, A., Baadsgaard-Jensen, J. Bülow, K. 1997. Fyring med biomassebaserede restprodukter, Miljøprojekt nr. 358, 1997, Miljøstyrelsen.
22. Serup H., Falster H., Gamborg C., Gundersen P., Hansen L. Heding N., Jacobsen H.H., Kofman P., Nikolaisen L., Thomsen I.M. 1999. Træ til energiformål, Teknik – Miljø – Økonomi, 2. udgave, 1999, Videncenter for halm og flisfyring (In Danish).
23. NERI calculation based on a sulphur content of 0.0003 %. The approximate sulphur content is stated by Danish refineries.
24. Miljøstyrelsen, 2001.Bekendtgørelseom begrænsning af svovlindholdet i visse flydende og faste brændstoffer, Bekendtgørelse 532 af 25/05/2001 (Danish legislation).
25. NERI calculation based on a sulphur content of 0.7 %. The sulhpur content refer to product data from Shell and Statoil available at the internet at: http://www.statoil.dk/mar/svg01185.nsf/fs/erhverv-produkt (13-05-2004).
26. NERI calculation based on a H_2S content of 200 ppm. The H_2S content refer to Christiansen J. 2003, Personal communication and to Hjort-Gregersen K., 1999 Centralised Biogas Plants, Danish Institute of Agricultural and Fisheries Economics, 1999.
27. NERI calculation based on a sulphur content of 0.05 % S. The sulphur content refers to Bilag 750, Kom 97/0105 (http://www.folketinget.dk/?/samling/20041/MENU/00000002.htm) and to product sheets from Q8, Shell and Statoil.
28. Miljøstyrelsen 1990. Bekendtgørelse om begrænsning af emissioner af svovldioxid, kvælstofoxider og støv fra store fyringsanlæg, Bekendtgørelse 689 af 15/10/1990 (Danish legislation).
29. Same emission factor as for coal is assumed (NERI assumption).
30. Product sheet from Shell. Available on the internet at: http://www.shell.com/home/dk-da/html/iwgen/app_profile/app_products_0310_1510.html (13-05-2004).
31. Nielsen, M. & Illerup, J.B: 2003. Emissionsfaktorer og emissionsopgørelse for decentral kraftvarme. Eltra PSO projekt 3141. Kortlægning af emissioner fra decentrale kraftvarmeværker. Delrapport 6. Danmarks Miljøundersøgelser. 116 s. –Faglig rapport fra DMU nr. 442.(In Danish, whith an english summary). Available on the Internet at : http://www2.dmu.dk/1_viden/2_Publikationer/3_fagrapporter/rapporter/FR442.pdf (25-02-2009).
32. Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual, 1996. Available on the Internet at http://www.ipcc-nggip.iges.or.jp/public/gl/invs6.htm (25-02-2009).
33. NERI calculation based on plant specific data 2003.
34. NERI calculation based on plant specific data for MSW incineration, district heating plants, 2009.
35. Same emission factor as for natural gas fuelled gas turbines is assumed.
36. Wit, J. d & Andersen, S. D. 2003. Emissioner fra større gasfyrede kedler, Dansk Gasteknisk Center 2003. The emission factor have been assumed to be the average value of the stated interval (NERI assumption).
37. Folkecenter for Vedvarende Energi, 2000. http://www.folkecenter.dk/plant-oil/emission/emission_rapsolie.pdf.
38. -
39. Aggregated emission factor based on the technology distribution in the sector and guidebook (EEA 2009) emission factors. Technology distribution based on: (Illerup, J. B., Henriksen, T. C., Lundhede, T., Breugel C. v., Jensen, N. Z. (2009) "Brændeovne og små kedler - partikelemissioner og reduktionstiltag". Miljøprojekt nr. 1164 2009. Miljøstyrelsen. Available on the Internet at: http://www2.mst.dk/common/Udgivramme/Frame.asp?pg=http://www2.mst.dk/Udgiv/publikationer/2009/978-87-7052-451-3/html/default.htm.
40. NERI calculation based on plant specific data.

Table 3A-4.8 SO_2, NO_x, NMVOC and CO emission factors time-series, g per GJ.

pollutant	fuel_type	fuel	nfr	nfr_name	snap	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
SO_2	WASTE	MUNICIP. WASTES	1A1a	Electricity and heat production	010100		116	95	73						
					010102					52	30	29	28	26	25
					010103					52	30	29	28	26	25
					010104					52	30	29	28	26	25
					010200	138	131	124	117						
					010203					110	103	95	88	81	74
			1A2	Industry	030100	138	131	124	117	110	103	95	88	81	74
					030102										
			1A4a	Commercial/ Institutional	020100	138	131	124	117	110	103	95	88	81	74
					020103					110	103	95	88	81	74
	LIQUID	GAS OIL	1A1a	Electricity and heat production	010101					94	23	23	23	23	23
					010102					94	23	23	23	23	23
					010104		94	94	94	94	23	23	23	23	23
					010105					94	23	23	23	23	23
					010202					94	23	23	23	23	23
					010203					94	23	23	23	23	23
			1A1b	Petroleum refining	010306		94	94	94	94	23	23	23		
			1A2	Industry	030100	94	94	94	94	94	23	23	23	23	23
					030102					94	23	23	23	23	23
					030103					94	23	23	23	23	23
					030105					94				94	94
			1A4a	Commercial/ Institutional	020100	94	94	94	94	94	23	23	23	23	23
					020102					94		23		23	
					020103					94		23	23	23	23
					020105					94	23	23	23	23	23
			1A4b i	Residential	020200	94	94	94	94	94	23	23	23	23	23
			1A4c i	Agriculture/ Forestry	020300	94	94	94	94	94	23	23	23	23	23
		ORIMULSION	1A1a	Electricity and heat production	010101						149	147	149	149	
		PETROLEUM COKE	1A2	Industry	030100	787		787	787		787	787	787	787	787
			1A4a	Commercial/ Institutional	020100	787	787	787	787	787	787	787	787	787	787
			1A4b i	Residential	020200	787	787	787	787	787	787	787	787	787	787
			1A4c i	Agriculture/ Forestry	020300	787	787	787	787	787	787	787	787	787	787
		REFINERY GAS	1A1b	Petroleum refining	010306	190	190	190	190			1	1	1	1
		RESIDUAL OIL	1A1a	Electricity and heat production	010100	446	470	490	475						
					010101						351	408	344	369	369
					010102	446	470	490	475	543	351	408	344	369	369
					010103					543	351	408	344	369	
					010104										369
					010105					543	351	408	344	369	369
					010202					495	495	495	344	344	344
					010203					495	495	495	344	344	344
			1A1b	Petroleum refining	010306	643	38	222	389				537	537	537
			1A2	Industry	030100	495	495	495	495	495	495	495	344	344	344
					030102					495	495	495	344	344	344
					030103					495	495	495	344	344	344
			1A4a	Commercial/ Institutional	020100	495	495	495	495	495	495	495	344	344	344

pollutant	fuel_type	fuel	nfr	nfr_name	snap	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
			1A4b i	Residential	020200	495	495	495	495	495	495	495	344	344	344
			1A4c i	Agriculture/ Forestry	020300	495	495	495	495	495	495	495	344	344	344
	SOLID	COAL	1A1a	Electricity and heat production	010100	506	571	454	386						
					010101	506	571	454	386	343	312	420	215	263	193
					010102	506	571	454	386	343	312	420	215	263	193
					010103					343	312	420			
					010104					343	312	420	215		
NO_X	BIOMASS	BIOGAS	1A1a	Electricity and heat production	010105			681	665	650	635	616	597	578	559
			1A2	Industry	030103					28	28	28	28	28	28
					030105										
			1A4a	Commercial/ Institutional	020105					650	635	616	597	578	559
			1A4c i	Agriculture/ Forestry	020304					650	635	616	597	578	559
		WOOD	1A1a	Electricity and heat production	010203					130	130	130	130	130	90
			1A2	Industry	030100	130	130	130	130	130	130	130	130	130	90
					030102									130	90
					030103					130	130	130	130	130	90
			1A4a	Commercial/ Institutional	020100	130	130	130	130	130	130	130	130	130	90
					020105									130	90
			1A4c i	Agriculture/ Forestry	020300	130	130	130	130	130	130	130	130	130	90
		BIO OIL	1A1a	Electricity and heat production	010200	100	95	90	85						
					010203					80	75	70	65	65	65
	WASTE	MUNICIP. WASTES	1A1a	Electricity and heat production	010102					134	134	134	134	134	129
					010103					134	134	134	134	134	129
					010104					134	134	134	134	134	129
	GAS	NATURAL GAS	1A1a	Electricity and heat production	010101					115	115		115		
					010102					115	115			115	115
					010104	161	157	153	149	145	141	138	134	131	127
					010105	276	241	235	214	199	194	193	170	167	167
			1A2	Industry	030104	161				145	141	138	134	131	127
					030105					199	194	193	170	167	167
			1A4a	Commercial/ Institutional	020104						141		134		
					020105					199	194	193	170	167	167
			1A4b i	Residential	020204					199	194	193	170	167	167
			1A4c i	Agriculture/ Forestry	020304					199	194	193	170	167	167
	LIQUID	GAS OIL	1A1a	Electricity and heat production	010103						75	65	65	65	65
					010105					1247	1196	1145	1094	1044	993
					010200	100	95	90	85						
					010202					80	75	70	65	65	65
					010203					80	75	70	65	65	65
			1A1b	Petroleum refining	010306		95	90	85	80	75	70	65		
			1A2	Industry	030100	100	95	90	85	80	75	70	65	65	65
					030102					75	75	70	65	65	65
					030103					80	75	70	65	65	65
					030105					1247				1247	1247
			1A4a	Commercial/ Institutional	020105					1247	1196	1145	1094	1044	993
			1A4c i	Agriculture/ Forestry	020304							1145	1094		

pollutant	fuel_type	fuel	nfr	nfr_name	snap	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
		ORIMULSION	1A1a	Electricity and heat production	010101						138	139	138	138	
		PETROLEUM COKE	1A2	Industry	030100	200		200	200		200	200	200	200	200
		REFINERY GAS	1A1b	Petroleum refining	010306	100	100	100	100			80	80	80	80
		RESIDUAL OIL	1A1a	Electricity and heat production	010100	342	384	294	289						
					010101						239	250	200	177	152
					010102	342	384	294	289	267	239	250	200	177	152
					010103					267	239	250	200	177	
					010104										152
					010105					267	239	250	200	177	152
	SOLID	BROWN COAL BRI.	1A4b i	Residential	020200	200	200	200	200	200	200	200	200	200	200
		COAL	1A1a	Electricity and heat production	010100	342	384	294	289						
					010101	342	384	294	289	267	239	250	200	177	152
					010102	342	384	294	289	267	239	250	200	177	152
					010103					267	239	250			
					010104					267	239	250	200		
					010203					200	200	200	200	200	200
			1A2	Industry	030100	200	200	200	200	200	200	200	200	200	200
					030103					200	200	200	200	200	200
			1A4a	Commercial/ Institutional	020100	200	200	200	200	200	200	200	200	200	
			1A4b i	Residential	020200	200	200	200	200	200	200	200	200	200	200
			1A4c i	Agriculture/ Forestry	020300	200	200	200	200	200	200	200	200	200	200
		COKE OVEN COKE	1A2	Industry	030100	200	200	200	200	200	200	200	200	200	200
			1A4b i	Residential	020200	200	200	200	200	200	200	200	200	200	200
NMVOC	BIOMASS	BIOGAS	1A1a	Electricity and heat production	010105			14	14	14	14	14	14	14	14
			1A2	Industry	030105										
			1A4a	Commercial/ Institutional	020105					14	14	14	14	14	14
			1A4c i	Agriculture/ Forestry	020304					14	14	14	14	14	14
		STRAW	1A4b i	Residential	020200	925	872.5	820	767	715	663	610	558	505	453
		WOOD	1A2	Industry	030100	146	132	119	105	92	78	64	51	37	24
					030103					92	78	64	51	37	24
			1A4b i	Residential	020200	650	650	650	650	650	650	650	650	650	650
					020202										
					020204										
	WASTE	MUNICIP. WASTES	1A1a	Electricity and heat production	010102					0.98	0.98	0.98	0.98	0.98	0.98
					010103					0.98	0.98	0.98	0.98	0.98	0.98
					010104					0.98	0.98	0.98	0.98	0.98	0.98
	GAS	NATURAL GAS	1A1a	Electricity and heat production	010104	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
					010105	60	69	81	127	140	142	138	124	122	122
			1A2	Industry	030104	1.4				1.4	1.4	1.4	1.4	1.4	1.4
					030105					140	142	138	124	122	122
			1A4a	Commercial/ Institutional	020104						1.4		1.4		
					020105					140	142	138	124	122	122
			1A4b i	Residential	020204					140	142	138	124	122	122
			1A4c i	Agriculture/ Forestry	020304					140	142	138	124	122	122
	LIQUID	REFINERY GAS	1A1b	Petroleum refining	010306	4	4	4	4			1.4	1.4	1.4	1.4
CO	BIOMASS	BIOGAS	1A1a	Electricity and heat production	010105			239	243	248	252	256	260	265	269

pollutant	fuel_type	fuel	nfr	nfr_name	snap	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
			1A2	Industry	030105										
			1A4a	Commercial/ Institutional	020105					248	252	256	260	265	269
			1A4c i	Agriculture/ Forestry	020304					248	252	256	260	265	269
		STRAW	1A1a	Electricity and heat production	010200	600	554	508	463						
					010203					417	371	325	325	325	325
			1A2	Industry	030105									371	371
			1A4b i	Residential	020200	8500	8500	8500	8500	8500	7500	6500	5500	4500	4000
			1A4c i	Agriculture/ Forestry	020300	8500	8500	8500	8500	8500	7500	6500	5500	4500	4000
		WOOD	1A1a	Electricity and heat production	010200	400	373	347	320						
					010203					293	267	240	240	240	240
			1A2	Industry	030100	400	373	347	320	293	267	240	240	240	240
					030103					293	267	240	240	240	240
			1A4a	Commercial/ Institutional	020100	400	373	347	320	293	267	240	240	240	240
			1A4b i	Residential	020200	4146	4146	4146	4146	4146	4146	4146	4146	4146	4146
					020202										
					020204										
			1A4c i	Agriculture/ Forestry	020300	400	373	347	320	293	267	240	240	240	240
		BIO OIL	1A2	Industry	030105										
			1A4b i	Residential	020200										
	WASTE	MUNICIP. WASTES	1A1a	Electricity and heat production	010102					7.4	7.4	7.4	7.4	7.4	7.4
					010103					7.4	7.4	7.4	7.4	7.4	7.4
					010104					7.4	7.4	7.4	7.4	7.4	7.4
					010200	100	85	70	55						
					010203					40	25	10	10	10	10
			1A2	Industry	030100	100	85	70	55	40	25	10	10	10	10
			1A4a	Commercial/ Institutional	020100	100	85	70	55	40	25	10	10	10	10
					020103					40	25	10	10	10	10
	GAS	NATURAL GAS	1A1a	Electricity and heat production	010104	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
					010105	189	211	212	227	226	222	221	182	182	182
			1A2	Industry	030104	6.2				6.2	6.2	6.2	6.2	6.2	6.2
					030105					226	222	221	182	182	182
			1A4a	Commercial/ Institutional	020104						6.2		6.2		
					020105					226	222	221	182	182	182
			1A4b i	Residential	020204					226	222	221	182	182	182
			1A4c i	Agriculture/ Forestry	020304					226	222	221	182	182	182
	LIQUID	REFINERY GAS	1A1b	Petroleum refining	010306	15	15	15	15			6.2	6.2	6.2	6.2

Continued

pollutant	fuel_type	fuel	nfr	nfr_name	snap	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
SO_2	WASTE	MUNICIP. WASTES	1A1a	Electricity and heat production	010100										
					010102	24	24	24	24	19	14	8.3	8.3	8.3	8.3
					010103	24	24	24	24	19	14	8.3	8.3	8.3	8.3
					010104	24			24			8.3			
					010200										
					010203	67	60	52	45	37	30	22	15	15	15
			1A2	Industry	030100										
					030102					37	30			15	
			1A4a	Commercial/ Institutional	020100	67			45	37	30	22	15		
					020103	67	60	52	45	37	30	22	15	15	15
	LIQUID	GAS OIL	1A1a	Electricity and heat production	010101	23	23	23	23	23	23	23	23	23	23
					010102	23	23	23	23	23	23	23	23	23	23
					010104	23	23	23	23	23	23	23	23	23	23
					010105	23	23	23	23	23	23	23	23	23	23
					010202	23	23	23	23	23	23	23	23	23	23
					010203	23	23	23	23	23	23	23	23	23	23
			1A1b	Petroleum refining	010306				23	23	23	23	23	23	23
			1A2	Industry	030100	23	23	23	23	23	23	23	23	23	23
					030102				23	23	23	23	23	23	23
					030103	23	23	23	23	23	23	23	23	23	
					030105	23	23							23	23
			1A4a	Commercial/ Institutional	020100	23	23	23	23	23	23	23	23	23	23
					020102										
					020103	23	23	23	23	23	23	23	23	23	23
					020105	23	23	23	23	23	23	23	23	23	23
			1A4b i	Residential	020200	23	23	23	23	23	23	23	23	23	23
			1A4c i	Agriculture/ Forestry	020300	23	23	23	23	23	23	23			
		ORIMULSION	1A1a	Electricity and heat production	010101		10	12	12	12					
		PETROLEUM COKE	1A2	Industry	030100	787	605	605	605	605	605	605			
			1A4a	Commercial/ Institutional	020100	787	605	605	605		605	605	605	605	605
			1A4b i	Residential	020200	787	605	605	605		605	605	605	605	
			1A4c i	Agriculture/ Forestry	020300	787	605	605	605						
		REFINERY GAS	1A1b	Petroleum refining	010306	1	1	1	1	1	1	1	1	1	1
		RESIDUAL OIL	1A1a	Electricity and heat production	010100										
					010101	403	315	290	334	349	283	308	206	82	119
					010102	403	315	290	334	349	283	308	206	82	119
					010103	403	315	290	334	349				82	119
					010104		315	290	334	349	283	308	206	82	119
					010105	403	315	290	334	349	283	308	206	82	119
					010202										344
					010203	344	344	344	344	344	344	344		344	344

pollutant	fuel_type	fuel	nfr	nfr_name	snap	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
			1A1b	Petroleum refining	010306	537	537	537	537	537	537	537	537	537	537
			1A2	Industry	030100	344	344	344	344	344	344	344	344	344	344
					030102	344	344	344	344	344	344	344	344	344	344
					030103	344	344	344						344	344
			1A4a	Commercial/ Institutional	020100	344	344	344	344	344	344	344	344	344	344
			1A4b i	Residential	020200	344	344	344	344	344	344	344	344	344	344
			1A4c i	Agriculture/ Forestry	020300	344	344	344	344	344	344	344	344	344	344
	SOLID	COAL	1A1a	Electricity and heat production	010100										
					010101	64	47	45	61	42	41	37	40	26	14
					010102	64	47	45	61	42	41	37	40	26	14
					010103										
					010104										
NO_x	BIOMASS	BIOGAS	1A1a	Electricity and heat production	010105	540	484	427	371	315	259	202	202	202	202
			1A2	Industry	030103	28	28	28			28	28	28	59	59
					030105		484	427	371	315	259	202	202	202	202
			1A4a	Commercial/ Institutional	020105	540	484	427	371	315	259	202	202	202	202
			1A4c i	Agriculture/ Forestry	020304	540	484	427	371	315	259	202	202	202	202
		WOOD	1A1a	Electricity and heat production	010203	90	90	90	90	90	90	90	90	90	90
			1A2	Industry	030100	90	90	90	90	90	90	90	90	90	90
					030102	90	90					90	90	90	90
					030103	90	90	90	90	90	90	90	90	90	90
			1A4a	Commercial/ Institutional	020100	90	90	90	90	90	90	90	90	90	90
					020105		90	90		90	90	90	90	90	90
			1A4c i	Agriculture/ Forestry	020300	90	90	90	90	90	90	90	90	90	90
		BIO OIL	1A1a	Electricity and heat production	010200										
					010203	65	65	65	65	65	65	65	65	65	65
	WASTE	MUNICIP. WASTES	1A1a	Electricity and heat production	010102	124	124	124	124	117	110	102	102	102	102
					010103	124	124	124	124	117	110	102	102	102	102
					010104	124			124			102			
	GAS	NATURAL GAS	1A1a	Electricity and heat production	010101		115	115	115	97	97	97	97	97	97
					010102	115	115	115	115	97	97	97	97	97	97
					010104	124	119	113	108	103	98	73	48	48	48
					010105	168	163	158	153	148	143	139	135	135	135
			1A2	Industry	030104	124	119	113	108	103	98	73	48	48	48
					030105	168	163	158	153	148	143	139	135	135	135
			1A4a	Commercial/ Institutional	020104	124	119	113	108	103	98	73	48		
					020105	168	163	158	153	148	143	139	135	135	135
			1A4b i	Residential	020204	168	163	158	153	148	143	139	135	135	135
			1A4c i	Agriculture/ Forestry	020304	168	163	158	153	148	143	139	135	135	135
	LIQUID	GAS OIL	1A1a	Electricity and heat production	010103		65	65	65	65	65	65	65	65	65
					010105	942	942	942	942	942	942	942	942	942	942
					010200										
					010202	65	65	65	65	65	65	65	65	65	65

pollutant	fuel_type	fuel	nfr	nfr_name	snap	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
					010203	65	65	65	65	65	65	65	65	65	65
			1A1b	Petroleum refining	010306				65	65	65	65	65	65	65
			1A2	Industry	030100	65	65	65	65	65	65	65	65	65	65
					030102				65	65	65	65	65	65	65
					030103	65	65	65	65	65	65	65	65	65	
					030105	942	942							942	942
			1A4a	Commercial/ Institutional	020105	942	942	942	942	942	942	942	942	942	942
			1A4c i	Agriculture/ Forestry	020304	942	942	942	942		942	942	942		
		ORIMULSION	1A1a	Electricity and heat production	010101		88	86	86	86					
		PETROLEUM CO-KE	1A2	Industry	030100	95	95	95	95	95	95	95			
		REFINERY GAS	1A1b	Petroleum refining	010306	80	80	80	80	80	80	80	80	80	80
		RESIDUAL OIL	1A1a	Electricity and heat production	010100										
					010101	129	122	130	144	131	127	109	98	1717	1347
					010102	129	122	130	144	131	127	109	98	1717	1347
					010103	129	122	130	144	131				1717	1347
					010104		122	130	144	131	127	109	98	1717	1347
					010105	129	122	130	144	131	127	109	98	1717	1347
	SOLID	BROWN COAL BRI.	1A4b i	Residential	020200	95	95	95	95					95	95
		COAL	1A1a	Electricity and heat production	010100										
					010101	129	122	130	144	131	127	109	98	59	39
					010102	129	122	130	144	131	127	109	98	59	39
					010103										
					010104										
					010203	95	95	95	95	95	95		95	95	
			1A2	Industry	030100	95	95	95	95	95	95	95	95	95	95
					030103	95	95	95	95	95	95				
			1A4a	Commercial/ Institutional	020100					95					
			1A4b i	Residential	020200	95	95	95	95	95	95	95	95	95	95
			1A4c i	Agriculture/ Forestry	020300	95	95	95	95	95	95	95	95	95	95
		COKE OVEN COKE	1A2	Industry	030100	95	95	95	95	95	95	95	95	95	95
			1A4b i	Residential	020200	95	95	95	95	95	95	95	95	95	95
NMVOC	BIOMASS	BIOGAS	1A1a	Electricity and heat production	010105	14	13	13	12	11	10	10	10	10	10
			1A2	Industry	030105		13	13	12	11	10	10	10	10	10
			1A4a	Commercial/ Institutional	020105	14	13	13	12	11	10	10	10	10	10
			1A4c i	Agriculture/ Forestry	020304	14	13	13	12	11	10	10	10	10	10
		STRAW	1A4b i	Residential	020200	400	400	400	400	400	400	400	400	400	400
		WOOD	1A2	Industry	030100	10	10	10	10	10	10	10	10	10	10
					030103	10	10	10	10	10	10	10	10	10	10
			1A4b i	Residential	020200	650	582	557	554	550	528	508	508	472	437
					020202						528	508	508	472	437
					020204									472	437
	WASTE	MUNICIP. WASTES	1A1a	Electricity and heat production	010102	0.98	0.98	0.98	0.98	0.84	0.7	0.56	0.56	0.56	0.56

pollutant	fuel_type	fuel	nfr	nfr_name	snap	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
					010103	0.98	0.98	0.98	0.98	0.84	0.7	0.56	0.56	0.56	0.56
					010104	0.98			0.98			0.56			
	GAS	NATURAL GAS	1A1a	Electricity and heat production	010104	1.4	1.4	1.5	1.5	1.6	1.6	1.6	1.6	1.6	1.6
					010105	121	114	108	101	95	88	90	92	92	92
			1A2	Industry	030104	1.4	1.4	1.5	1.5	1.6	1.6	1.6	1.6	1.6	1.6
					030105	121	114	108	101	95	88	90	92	92	92
			1A4a	Commercial/ Institutional	020104	1.4	1.4	1.5	1.5	1.6	1.6	1.6	1.6		
					020105	121	114	108	101	95	88	90	92	92	92
			1A4b i	Residential	020204	121	114	108	101	95	88	90	92	92	92
			1A4c i	Agriculture/ Forestry	020304	121	114	108	101	95	88	90	92	92	92
	LIQUID	REFINERY GAS	1A1b	Petroleum refining	010306	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
CO	BIOMASS	BIOGAS	1A1a	Electricity and heat production	010105	273	279	285	292	298	304	310	310	310	310
			1A2	Industry	030105		279	285	292	298	304	310	310	310	310
			1A4a	Commercial/ Institutional	020105	273	279	285	292	298	304	310	310	310	310
			1A4c i	Agriculture/ Forestry	020304	273	279	285	292	298	304	310	310	310	310
		STRAW	1A1a	Electricity and heat production	010200										
					010203	325	325	325	325	325	325	325	325	325	325
			1A2	Industry	030105	325	325								
			1A4b i	Residential	020200	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
			1A4c i	Agriculture/ Forestry	020300	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
		WOOD	1A1a	Electricity and heat production	010200										
					010203	240	240	240	240	240	240	240	240	240	240
			1A2	Industry	030100	240	240	240	240	240	240	240	240	240	240
					030103	240	240	240	240	240	240	240	240	240	240
			1A4a	Commercial/ Institutional	020100	240	240	240	240	240	240	240	240	240	240
			1A4b i	Residential	020200	4146	3779	3656	3659	3657	3546	3436	3491	3326	3165
					020202						3546	3436	3491	3326	3165
					020204									3326	3165
			1A4c i	Agriculture/ Forestry	020300	240	240	240	240	240	240	240	240	240	240
		BIO OIL	1A2	Industry	030105			100	100	15	100	100	100	100	100
			1A4b i	Residential	020200								15	100	100
	WASTE	MUNICIP. WASTES	1A1a	Electricity and heat production	010102	8	8	8	8	6.6	5.3	3.9	3.9	3.9	3.9
					010103	8	8	8	8	6.6	5.3	3.9	3.9	3.9	3.9
					010104	8			8			3.9			
					010200										
					010203	10	10	10	10	10	10	10	10	10	10
			1A2	Industry	030100										
			1A4a	Commercial/ Institutional	020100	10			10	10	10	10	10		
					020103	10	10	10	10	10	10	10	10	10	10
	GAS	NATURAL GAS	1A1a	Electricity and heat production	010104	6.2	6.2	6.2	6.2	6.2	6.2	5.5	4.8	4.8	4.8
					010105	183	163	142	122	101	81	70	58	58	58
			1A2	Industry	030104	6.2	6.2	6.2	6.2	6.2	6.2	5.5	4.8	4.8	4.8
					030105	183	163	142	122	101	81	70	58	58	58

pollutant	fuel_type	fuel	nfr	nfr_name	snap	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
			1A4a	Commercial/ Institutional	020104	6.2	6.2	6.2	6.2	6.2	6.2	5.5	4.8		
					020105	183	163	142	122	101	81	70	58	58	58
			1A4b i	Residential	020204	183	163	142	122	101	81	70	58	58	58
			1A4c i	Agriculture/ Forestry	020304	183	163	142	122	101	81	70	58	58	58
	LIQUID	REFINERY GAS	1A1b	Petroleum refining	010306	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2

Annex 3A-5 Large point sources

Table 3A-5.1 Large point sources, fuel consumption in 2009 (1A1, 1A2 and 1A4).

nfr_id_EA	nfr_name	lps_name	fuel_gr_abbr	Fuel consumption, PJ
1A1a	Electricity and heat production	Amagervaerket	COAL	16.781
			WOOD	0.461
			STRAW	0.582
			RESIDUAL OIL	1.295
		Svanemoellevaerket	GAS OIL	0.025
			NATURAL GAS	3.134
		H.C.Oerstedsvaerket	RESIDUAL OIL	1.376
			GAS OIL	0.092
			NATURAL GAS	5.203
		Kyndbyvaerket	GAS OIL	0.842
		Stigsnaesvaerket	COAL	1.566
			RESIDUAL OIL	0.821
			GAS OIL	0.006
		Asnaesvaerket	COAL	25.455
			RESIDUAL OIL	0.484
			GAS OIL	0.018
		Avedoerevaerket	COAL	12.037
			WOOD	6.251
			STRAW	1.517
			RESIDUAL OIL	3.106
			GAS OIL	0.010
			NATURAL GAS	6.948
		Fynsvaerket	COAL	20.819
			STRAW	0.503
			RESIDUAL OIL	0.145
		Studstrupvaerket	COAL	27.730
			STRAW	1.285
			RESIDUAL OIL	0.317
		Nordjyllandsvaerket	COAL	25.506
			RESIDUAL OIL	0.100
		Skaerbaekvaerket	GAS OIL	1.404
			NATURAL GAS	12.791
		Enstedvaerket	COAL	18.123
			WOOD	0.373
			STRAW	1.374
			RESIDUAL OIL	0.088
			GAS OIL	0.009
		Esbjergvaerket	COAL	13.868
			MUNICIP. WASTES	0.045
			RESIDUAL OIL	0.227
			LPG	0.000
		Oestkraft	COAL	0.637
			WOOD	0.051
			RESIDUAL OIL	0.135
		Horsens Kraftvarmevaerk	MUNICIP. WASTES	1.055
			NATURAL GAS	0.802
		Herningvaerket	WOOD	2.680
			RESIDUAL OIL	0.368
			NATURAL GAS	0.611
		I/S Vestforbraending	MUNICIP. WASTES	5.668
			GAS OIL	0.015
			NATURAL GAS	0.010
		Amagerforbraending	MUNICIP. WASTES	4.386
		Energi Randers Produktion	COAL	0.883
			PETROLEUM COKE	0.030
			WOOD	2.317
			GAS OIL	0.007
			BIO OIL	0.113
			BIOGAS	0.013
		Grenaa Kraftvarmevaerk	COAL	0.472
			STRAW	0.574
			RESIDUAL OIL	0.038
			GAS OIL	0.006
		Hilleroed Kraftvarmevaerk	NATURAL GAS	2.428

nfr_id_EA	nfr_name	lps_name	fuel_gr_abbr	Fuel consumption, PJ
		Helsingoer Kraftvarmevaerk	NATURAL GAS	1.178
		Kolding Forbraendingsanlaeg	WOOD	0.015
			MUNICIP. WASTES	1.265
		Maabjergvaerket	WOOD	0.471
			MUNICIP. WASTES	1.698
			STRAW	0.396
			NATURAL GAS	0.065
		Soenderborg Kraftvarmevaerk	WOOD	0.008
			MUNICIP. WASTES	0.710
			NATURAL GAS	0.951
		I/S Kara Affaldsforbraendingsanlaeg	WOOD	0.034
			MUNICIP. WASTES	1.818
			NATURAL GAS	0.009
		Viborg Kraftvarme	NATURAL GAS	1.760
		I/S Nordforbraending	WOOD	0.418
			MUNICIP. WASTES	1.039
		Affaldscenter aarhus - Forbraend-sanlaegget	MUNICIP. WASTES	2.290
		I/S Reno Nord	MUNICIP. WASTES	1.899
			GAS OIL	0.006
		Silkeborg Kraftvarmevaerk	NATURAL GAS	3.447
		Fasan+Naestved Kraftvarmevaerk	MUNICIP. WASTES	1.064
		AVV Forbraendingsanlaeg	MUNICIP. WASTES	0.802
		Affaldsforbraendingsanlaeg I/S REFA	MUNICIP. WASTES	1.213
		Svendborg Kraftvarmevaerk	WOOD	0.010
			MUNICIP. WASTES	0.470
			NATURAL GAS	0.006
		Kommunekemi	MUNICIP. WASTES	1.650
			RESIDUAL OIL	0.082
			GAS OIL	0.023
		I/S Faelles Forbraending	MUNICIP. WASTES	0.276
		I/S Reno Syd	MUNICIP. WASTES	0.599
		I/S Kraftvarmevaerk Thisted	WOOD	0.016
			MUNICIP. WASTES	0.537
			STRAW	0.015
		Knudmosevaerket	WOOD	0.006
			MUNICIP. WASTES	0.509
			NATURAL GAS	0.034
		Affaldplus I/S Slagelse Forbr.+Slagelse KVV	MUNICIP. WASTES	0.254
			STRAW	0.025
		Haderslev Kraftvarmevaerk	MUNICIP. WASTES	0.616
			NATURAL GAS	0.007
		Frederiskhavn Affaldskraftvarmevaerk	MUNICIP. WASTES	0.414
			GAS OIL	0.002
		Vejen Kraftvarmevaerk	MUNICIP. WASTES	0.393
		Bofa I/S	MUNICIP. WASTES	0.208
		DTU	NATURAL GAS	1.183
		Naestved Kraftvarmevaerk	NATURAL GAS	0.172
		Hjoerring Varmeforsyning	WOOD	0.385
			NATURAL GAS	0.048
		L90 Affaldsforbraending	MUNICIP. WASTES	2.202
			GAS OIL	0.011
		Hammel Fjernvarme	MUNICIP. WASTES	0.316

nfr_id_EA	nfr_name	lps_name	fuel_gr_abbr	Fuel consumption, PJ
			BIO OIL	0.008
		Koege Kraftvarmevaerk	WOOD	1.241
			RESIDUAL OIL	0.008
		Skagen Forbraendingen	MUNICIP. WASTES	0.125
		Odense Kraftvarmevaerk	MUNICIP. WASTES	2.872
			GAS OIL	0.041
1A1b	Petroleum refining	Statoil Raffinaderi	GAS OIL	0.003
			REFINERY GAS	8.783
		Shell Raffinaderi	RESIDUAL OIL	0.726
			REFINERY GAS	6.236
1A1c	Other energy industries	Nybro Gasbehandlingsanlaeg	NATURAL GAS	0.393
1A2	Industry	Danisco Grindsted	COAL	0.439
			RESIDUAL OIL	0.009
			NATURAL GAS	0.037
		DanSteel	NATURAL GAS	0.687
		Dalum Papir	WOOD	1.180
			NATURAL GAS	0.087
		Aalborg Portland	COAL	1.144
			PETROLEUM COKE	5.888
			MUNICIP. WASTES	1.745
			RESIDUAL OIL	0.252
		Maricogen	NATURAL GAS	0.228
		Rockwool A/S Vamdrup	COKE OVEN COKE	0.315
			NATURAL GAS	0.210
		Rockwool A/S Doense	COKE OVEN COKE	0.298
			NATURAL GAS	0.199
		Rexam Glass Holmegaard A/S	GAS OIL	0.001
			NATURAL GAS	0.717
		Haldor Topsoee	GAS OIL	0.002
			NATURAL GAS	0.509
			LPG	0.000
		Danisco Sugar Nakskov	COAL	0.767
			COKE OVEN COKE	0.062
			RESIDUAL OIL	0.695
			GAS OIL	0.004
			BIOGAS	0.062
		Danisco Sugar Nykoebing	COAL	0.315
			COKE OVEN COKE	0.057
			RESIDUAL OIL	1.097
			BIOGAS	0.056
		Cheminova	GAS OIL	0.000
			NATURAL GAS	1.133
		AarhusKarlshamn Denmark A/S	WOOD	0.027
			RESIDUAL OIL	1.267
			GAS OIL	0.000
1A4a	Commercial/ Institutional	Rensningsanlaegget Lynetten	MUNICIP. WASTES	0.052
			GAS OIL	0.017
			BIOGAS	0.107
1A4c i	Agriculture/ Forestry	Masnedoevaerket	WOOD	0.074
			STRAW	0.498
			GAS OIL	0.024
Grand Total				309.744

Table 3A-5.2 Large point sources, plant specific emissions (IPCC 1A1, 1A2 and 1A4)[1].

LPS id	LPS name	NFR	SNAP	SO_2	NO_x	NMVOC	CO
001	Amagervaerket	1A1a	010101	x	x		
			010102	x	x		
002	Svanemoellevaerket	1A1a	010104		x		
003	H.C.Oerstedsvaerket	1A1a	010101	x	x		
			010102	x	x		
			010104		x		
004	Kyndbyvaerket	1A1a	010101	x	x		
			010105		x		
005	Masnedoevaerket	1A4c i	020302	x	x		
			020304	x	x		
007	Stigsnaesvaerket	1A1a	010101	x	x		
008	Asnaesvaerket	1A1a	010101	x	x		
009	Statoil Raffinaderi	1A1b	010306	x	x		
010	Avedoerevaerket	1A1a	010101	x	x		
			010104	x	x		
011	Fynsvaerket	1A1a	010101	x	x		
012	Studstrupvaerket	1A1a	010101	x	x		
014	Nordjyllandsvaerket	1A1a	010101	x	x		
017	Shell Raffinaderi	1A1b	010304	x	x		
			010306	x	x		
018	Skaerbaekvaerket	1A1a	010101	x	x		x
019	Enstedvaerket	1A1a	010101	x	x		
020	Esbjergvaerket	1A1a	010101	x	x		
022	Oestkraft	1A1a	010102	x	x		
023	Danisco Grindsted	1A2	030102	x	x		
024	Nybro Gasbehandlingsanlaeg	1A1c	010504		x		
025	Horsens Kraftvarmevaerk	1A1a	010104	x	x		
026	Herningvaerket	1A1a	010102	x	x		x
027	I/S Vestforbraending	1A1a	010102	x	x		
			010203				
028	Amagerforbraending	1A1a	010102	x	x		x
029	Energi Randers Produktion	1A1a	010102	x	x		
030	Grenaa Kraftvarmevaerk	1A1a	010102	x	x		x
031	Hilleroed Kraftvarmevaerk	1A1a	010104		x		
032	Helsingoer Kraftvarmevaerk	1A1a	010104		x		
			010105				
034	Dalum Papir	1A2	030102		x		
036	Kolding Forbraendingsanlaeg	1A1a	010103	x	x	x	x
			010203	x	x	x	x
037	Maabjergvaerket	1A1a	010102	x	x		
038	Soenderborg Kraftvarmevaerk	1A1a	010104	x	x		x
039	I/S Kara Affaldsforbraendingsanlaeg	1A1a	010102	x			x
040	Viborg Kraftvarme	1A1a	010104		x		
042	I/S Nordforbraending	1A1a	010103	x	x		x
045	Aalborg Portland	1A2	030311	x	x		x
046	Affaldscenter aarhus - Forbraendsanlaegget	1A1a	010203	x	x	x	
047	I/S Reno Nord	1A1a	010102	x	x		x
048	Silkeborg Kraftvarmevaerk	1A1a	010104		x		
049	Rensningsanlaegget Lynetten	1A4a	020103	x	x		
050	Fasan+Naestved Kraftvarmevaerk	1A1a	010104	x	x		x
051	AVV Forbraendingsanlaeg	1A1a	010103	x	x		x
052	Affaldsforbraendingsanlaeg I/S REFA	1A1a	010103	x	x		x
053	Svendborg Kraftvarmevaerk	1A1a	010103	x	x		x
054	Kommunekemi	1A1a	010103	x	x		x
055	I/S Faelles Forbraending	1A1a	010203				x
058	I/S Reno Syd	1A1a	010103	x			x
059	I/S Kraftvarmevaerk Thisted	1A1a	010103	x	x		x
061	Affaldplus I/S Slagelse Forbr.+Slagelse KVV	1A1a	010103	x	x		x
065	Haderslev Kraftvarmevaerk	1A1a	010103	x	x		
066	Frederiskhavn Affaldskraftvarmevaerk	1A1a	010104	x	x		x
067	Vejen Kraftvarmevaerk	1A1a	010103	x	x	x	x
068	Bofa I/S	1A1a	010203	x	x		x
069	DTU	1A1a	010104		x		
070	Naestved Kraftvarmevaerk	1A1a	010104		x		x
071	Maricogen	1A2	030104	x	x		
072	Hjoerring Varmeforsyning	1A1a	010104		x		x
076	Rockwool A/S Vamdrup	1A2	030318	x		x	x
077	Rockwool A/S Doense	1A2	030318	x		x	x
078	Rexam Glass Holmegaard A/S	1A2	030315		x		x
080	Saint-Gobain Isover A/S	1A2	030316		x		
082	Danisco Sugar Nakskov	1A2	030102	x			
083	Danisco Sugar Nykoebing	1A2	030103	x			
084	Cheminova	1A2	030104		x		x
085	L90 Affaldsforbraending	1A1a	010102	x	x		x
086	Hammel Fjernvarme	1A1a	010203	x	x		x
087	Koege Kraftvarmevaerk	1A1a	010102	x	x	x	x

Continued							
088	Skagen Forbraendingen	1A1a	010203	x		x	
089	AarhusKarlshamn Denmark A/S	1A2	030102	x	x		
090	Odense Kraftvarmevaerk	1A1a	010102	x	x		x
Grand total, Mg				6337	20821	15	8302
Share of total emission from stationary combustion, %				60%	20%	0.1%	3%

1) Emissions of the pollutants marked with “x” are plant specific. Emission of other pollutants is estimated based on emission factors. The total shown *in this table* only includes plant specific data.

Annex 3A-6 Adjustment of CO_2 emission

Table 3A-6.1 Adjustment of CO_2 emission (ref. DEA, 2010b).

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Actual Degree Days	Degree days	2857	3284	3022	3434	3148	3297	3837	3236	3217	3056
Normal Degree Days	Degree days	3379	3380	3 359	3 365	3 366	3 378	3 395	3 389	3 375	3 339
Net electricity import	PJ	25	-7	13	4	-17	-3	-55	-26	-16	-8
Actual CO_2 emission	1 000 000 tonnes	37.5	47.1	41.3	43.5	47.1	43.8	56.9	47.1	43.2	40.0
Adjusted CO_2 emission	1 000 000 tonnes	43.7	45.5	44.2	44.6	43.3	43.1	43.9	41.2	39.6	38.1
Continued		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Actual Degree Days	Degree days	2902	3279	3011	3150	3113	3068	2908	2807	2853	3061
Normal Degree Days	Degree days	3 304	3 289	3 273	3 271	3 261	3 224	3 188	3 136	3 120	3 131
Net electricity import	PJ	2	-2	-7	-31	-10	5	-25	-3	5.2	1.2
Actual CO_2 emission	1 000 000 tonnes	36.1	37.7	37.2	41.9	35.9	32.2	39.9	34.4	31.5	30.8
Adjusted CO_2 emission	1 000 000 tonnes	36.7	37.3	35.6	35.1	33.7	33.4	34.3	33.6	32.7	31.1

Annex 3A-7 Uncertainty estimates

Table 3A-7.1 Uncertainty estimation, tier 1.

IPCC Source category	Gas	Base year emission	Year t emission	Activity data uncer-tainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total na-tional emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty i trend in national emissions introduced by emission factor uncertarinty	Uncertainty in trend in na-tional emis-sions intro-duced by activity data uncertainty	Uncertainty introduced into the trend in total na-tional emissions
		Input data	Input data	Input data	Input data							
		Gg CO_2 eq	Gg CO_2 eq	%	%	%	%	%	%	%	%	%
Stationary Combustion, Coal	CO_2	23834	15726	0.9	1.1	1.421	0.711	-0.108	0.417	-0.119	0.530	0.543
Stationary Combustion, BKB	CO_2	11	1	3.0	5	5.831	0.000	-0.000	0.000	-0.001	0.000	0.001
Stationary Combustion, Coke	CO_2	138	81	2.0	5	5.385	0.014	-0.001	0.002	-0.004	0.006	0.008
Stationary Combustion, Fosssil waste	CO_2	394	1266	4.8	25	25.452	1.025	0.025	0.034	0.621	0.226	0.661
Stationary Combustion, Petroleum coke	CO_2	410	550	2.0	5	5.381	0.094	0.006	0.015	0.028	0.041	0.049
Stationary Combustion, Residual oil	CO_2	2440	1077	0.9	2	2.184	0.075	-0.025	0.029	-0.050	0.035	0.062
Stationary Combustion, Gas oil	CO_2	4547	1792	2.5	4	4.721	0.269	-0.053	0.047	-0.211	0.168	0.270
Stationary Combustion, Kerosene	CO_2	366	8	2.6	5	5.657	0.001	-0.008	0.000	-0.039	0.001	0.039
Stationary Combustion, LPG	CO_2	164	88	2.2	5	5.477	0.015	-0.001	0.002	-0.006	0.007	0.010
Stationary Combustion, Refinery gas	CO_2	816	876	1.0	2	2.236	0.062	0.005	0.023	0.010	0.033	0.034
Stationary Combustion, Natural gas	CO_2	4335	9380	1.0	0	1.083	0.323	0.153	0.248	0.061	0.354	0.359
Stationary Combustion, SOLID, CH4	CH_4	13	4	1.0	100	100.005	0.014	-0.000	0.000	-0.017	0.000	0.017
Stationary Combustion, LIQUID, CH4	CH_4	3	1	1.1	100	100.006	0.004	-0.000	0.000	-0.003	0.000	0.003
Stationary Combustion, GAS, CH4	CH_4	3	6	1.0	100	100.005	0.019	0.000	0.000	0.009	0.000	0.009
Natural gas fuelled engines, GAS, CH4	CH_4	1	192	1.0	2	2.236	0.014	0.005	0.005	0.010	0.007	0.012
Stationary Combustion, WASTE, CH4	CH_4	1	1	5.0	100	100.125	0.004	0.000	0.000	0.001	0.000	0.001
Stationary Combustion, BIOMASS, CH4	CH_4	105	148	19.8	100	101.948	0.479	0.002	0.004	0.159	0.110	0.193
Biogas fuelled engines, BIOMASS, CH4	CH_4		28	3.7	10	10.673	0.010	0.001	0.001	0.007	0.004	0.008
Stationary Combustion, SOLID, N2O	N_2O	68	43	1.0	400	400.001	0.544	-0.000	0.001	-0.148	0.002	0.148
Stationary Combustion, LIQUID, N2O	N_2O	40	16	1.1	1000	1000.001	0.502	-0.000	0.000	-0.470	0.001	0.470
Stationary Combustion, GAS, N2O	N_2O	16	41	1.0	750	750.001	0.972	0.001	0.001	0.542	0.002	0.542
Stationary Combustion, WASTE, N2O	N_2O	7	16	5.0	400	400.031	0.203	0.000	0.000	0.103	0.003	0.103
Stationary Combustion, BIOMASS, N2O	N_2O	38	81	19.1	400	400.458	1.029	0.001	0.002	0.522	0.058	0.525
Total		37749.792	31421.164				4.577					1.804
Total uncertainties				Overall uncertainty i the year (%):			2.139				Trend uncertainty (%):	1.343

Continued												
IPCC Source category	Gas	Base year emission	Year t emission	Activity data uncer-tainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total na-tional emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty i trend in na-tional emis-sions intro-duced by emis-sion factor uncertainty	Uncertainty in trend in na-tional emis-sions intro-duced by activity data uncertainty	Uncertainty introduced into the trend in total na-tional emissions
		Input data	Input data	Input data	Input data							
		Gg CO_2	Gg CO_2	%	%	%	%	%	%	%	%	%
Stationary Combustion, Coal	CO_2	23834	15726	0.9	1.1	1.421	0.725	-0.104	0.420	-0.114	0.534	0.546
Stationary Combustion, BKB	CO_2	11	1	3.0	5	5.831	0.000	-0.000	0.000	-0.001	0.000	0.001
Stationary Combustion, Coke	CO_2	138	81	2.0	5	5.385	0.014	-0.001	0.002	-0.004	0.006	0.007
Stationary Combustion, Petroleum coke	CO_2	394	1266	4.8	25	25.452	1.045	0.025	0.034	0.628	0.228	0.669
Stationary Combustion, Fosssil waste	CO_2	410	550	2.0	5	5.381	0.096	0.006	0.015	0.028	0.041	0.050
Stationary Combustion, Residual oil	CO_2	2440	1077	0.9	2	2.184	0.076	-0.025	0.029	-0.050	0.036	0.061
Stationary Combustion, Gas oil	CO_2	4547	1792	2.5	4	4.721	0.274	-0.052	0.048	-0.208	0.170	0.269
Stationary Combustion, Kerosene	CO_2	366	8	2.6	5	5.657	0.001	-0.008	0.000	-0.039	0.001	0.039
Stationary Combustion, Natural gas	CO_2	164	88	2.2	5	5.477	0.016	-0.001	0.002	-0.006	0.007	0.010
Stationary Combustion, LPG	CO_2	816	876	1.0	2	2.236	0.064	0.005	0.023	0.011	0.033	0.035
Stationary Combustion, Refinery gas	CO_2	4335	9380	1.0	0	1.083	0.329	0.155	0.250	0.062	0.356	0.362
Total	CO_2	37454	30845				1.819					0.958
Total uncertainties				Overall uncertainty i the year (%):			1.349			Trend uncertainty (%):		0.979

IPCC Source category	Gas	Base year emission	Year t emission	Activity data uncer-tainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total na-tional emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty i trend in na-tional emis-sions intro-duced by emis-sion factor uncertainty	Uncertainty in trend in na-tional emis-sions intro-duced by activity data uncertainty	Uncertainty introduced into the trend in total na-tional emissions
		Input data	Input data	Input data	Input data							
		Mg CH_4	Mg CH_4	%	%	%	%	%	%	%	%	%
Stationary Combustion, SOLID, CH4	CH_4	613	203	1.0	100	100.005	1.119	-0.274	0.034	-27.353	0.046	27.353
Stationary Combustion, LIQUID, CH4	CH_4	134	62	1.1	100	100.006	0.341	-0.057	0.010	-5.682	0.016	5.682
Stationary Combustion, GAS, CH4	CH_4	149	283	1.0	100	100.005	1.565	-0.028	0.047	-2.758	0.067	2.759
Natural gas fuelled engines, GAS, CH4	CH_4	25	9122	1.0	2	2.236	1.127	1.506	1.518	3.011	2.147	3.698
Stationary Combustion, WASTE, CH4	CH_4	66	66	5.0	100	100.125	0.367	-0.022	0.011	-2.203	0.078	2.204
Stationary Combustion, BIOMASS, CH4	CH_4	5021	7034	19.8	100	101.948	39.612	-1.336	1.171	-133.617	32.844	137.594
Biogas fuelled engines, BIOMASS, CH4	CH_4		1333	3.7	10	10.673	0.786	0.222	0.222	2.219	1.170	2.508
Total	CH_4	6008	18103				1574.935					19745.060
Total uncertainties				Overall uncertainty i the year (%):			39.685			Trend uncertainty (%):		140.517

Continued												
IPCC Source category	Gas	Base year emission	Year t emission	Activity data uncer-tainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total na-tional emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty i trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in na-tional emis-sions intro-duced by activity data uncertainty	Uncertainty introduced into the trend in total na-tional emissions
		Input data	Input data	Input data	Input data							
		Mg N_2O	Mg N_2O	%	%	%	%	%	%	%	%	%
Stationary Combustion, SOLID, N2O	N_2O	220	138	1.0	400	400.001	87.317	-0.210	0.252	-84.075	0.346	84.076
Stationary Combustion, LIQUID, N2O	N_2O	130	51	1.1	1000	1000.001	80.480	-0.180	0.093	-180.324	0.140	180.324
Stationary Combustion, GAS, N2O	N_2O	52	131	1.0	750	750.001	155.974	0.130	0.240	97.425	0.339	97.425
Stationary Combustion, WASTE, N2O	N_2O	24	51	5.0	400	400.031	32.519	0.043	0.094	17.279	0.663	17.292
Stationary Combustion, BIOMASS, N2O	N_2O	122	260	19.1	400	400.458	164.977	0.218	0.475	87.223	12.867	88.167
Total	N_2O	548	632				66704.156					57149.558
Total uncertainties				Overall uncertainty i the year (%):			258.271				Trend uncertainty (%):	239.060

SNAP	Gas	Base year emission	Year t emission	Activity data uncer-tainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total na-tional emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty i trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in na-tional emis-sions intro-duced by activity data uncertainty	Uncertainty introduced into the trend in total na-tional emissions
		Input data	Input data	Input data	Input data							
		Mg SO_2	Mg SO_2	%	%	%	%	%	%	%	%	%
01	SO_2	129466	4939	2	10	10.198	4.676	-0.025	0.031	-0.248	0.089	0.263
02	SO_2	11481	2985	2	20	20.100	5.570	0.014	0.019	0.279	0.054	0.285
03	SO_2	16296	2847	2	10	10.198	2.695	0.011	0.018	0.110	0.051	0.121
Total	SO_2	157242	10771				60.163					0.165
Total uncertainties				Overall uncertainty i the year (%):			7.757			Trend uncertainty (%):		0.406

Continued												
SNAP	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty i trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		Mg NO_x	Mg NO_x	%	%	%	%	%	%	%	%	%
01	NO_x	94393	28092	2	20	20.100	13.266	-0.059	0.244	-1.184	0.691	1.371
02	NO_x	7271	7706	2	50	50.040	9.060	0.044	0.067	2.180	0.190	2.188
03	NO_x	13277	6764	2	20	20.100	3.194	0.016	0.059	0.321	0.166	0.362
Total	NO_x	114941	42563				268.281					6.798
Total uncertainties				Overall uncertainty i the year (%):			16.379			Trend uncertainty (%):		2.607

SNAP	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty i trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		Mg NMVOC	Mg NMVOC	%	%	%	%	%	%	%	%	%
01	NMVOC	495	1977	2	50	50.040	5.143	0.090	0.135	4.523	0.381	4.539
02	NMVOC	13043	16964	2	50	50.040	44.129	-0.009	1.156	-0.472	3.271	3.305
03	NMVOC	1131	295	2	50	50.040	0.768	-0.081	0.020	-4.045	0.057	4.046
Total	NMVOC	14669	19236				1974.413					47.897
Total uncertainties				Overall uncertainty i the year (%):			44.434			Trend uncertainty (%):		6.921

SNAP	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty i trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		Mg CO	Mg CO	%	%	%	%	%	%	%	%	%
01	CO	8123	9372	2	20	20.100	1.284	0.007	0.066	0.136	0.187	0.231
02	CO	118073	127012	2	50	50.040	43.320	0.034	0.896	1.682	2.534	3.042
03	CO	15560	10330	2	20	20.100	1.415	-0.041	0.073	-0.814	0.206	0.840
Total	CO	141756	146714				1880.293					10.011
Total uncertainties				Overall uncertainty i the year (%):			43.362			Trend uncertainty (%):		3.164

Table 3A-7.2 Uncertainty estimation for GHG 2009, tier 2.

		Activity			Emission Factor			Emissions			
Category	Parameter	Below 2.5%	Above 97.5%	Differ-ence	Below 2.5%	Above 97.5%	Differ-ence	Median	Below 2.5%	Above 97.5%	Differ-ence
all	all							31582.1	31067.9	32263.6	1195.7
1A1+1A2+1A4 St.comb, CO2	all							30849.6	30464.2	31284.1	819.9
1A1+1A2+1A4 St.comb, N2O	all							291.3	75.7	862.4	786.7
1A1+1A2+1A4 St.comb, CH4	all							381.5	290.8	621.2	330.4
1A1+1A2+1A4 St.comb, CO2	Stationary Combustion, Fossil waste, CO2	15.2	16.7	1.5	62.2	101.5	39.2	1263.7	983.8	1620.3	636.5
1A1+1A2+1A4 St.comb, N2O	Stationary Combustion, BIOMASS, N2O	72.3	104.9	32.6	0.1	6.2	6.2	74.2	6.6	545.3	538.7
1A1+1A2+1A4 St.comb, N2O	Stationary Combustion, GAS, N2O	163.6	166.8	3.2	0.0	2.8	2.8	36.2	1.6	457.6	456.0
1A1+1A2+1A4 St.comb, CO2	Stationary Combustion, Coal, CO2	166.5	169.5	3.0	92.6	94.6	2.0	15725.9	15510.3	15941.0	430.7
1A1+1A2+1A4 St.comb, CH4	Stationary Combustion, BIOMASS, CH4	69.4	102.3	32.9	0.7	4.4	3.7	147.6	57.8	388.1	330.2
1A1+1A2+1A4 St.comb, N2O	Stationary Combustion, SOLID, N2O	167.1	170.4	3.2	0.0	1.7	1.7	38.8	3.5	289.0	285.4
1A1+1A2+1A4 St.comb, N2O	Stationary Combustion, LIQUID, N2O	60.1	61.4	1.3	0.0	3.8	3.8	14.3	0.4	228.7	228.3
1A1+1A2+1A4 St.comb, CO2	Stationary Combustion, Natural gas, CO2	163.6	166.8	3.2	56.6	57.0	0.4	9380.0	9281.5	9480.0	198.6
1A1+1A2+1A4 St.comb, CO2	Stationary Combustion, Gas oil, CO2	23.6	24.8	1.2	71.3	77.0	5.7	1791.9	1710.2	1878.2	167.9
1A1+1A2+1A4 St.comb, N2O	Stationary Combustion, WASTE, N2O	36.7	40.6	3.8	0.0	2.8	2.7	15.0	1.3	107.4	106.2
1A1+1A2+1A4 St.comb, CO2	Stationary Combustion, Refinery gas, CO2	15.3	15.6	0.3	54.2	59.7	5.5	876.0	834.2	920.5	86.3
1A1+1A2+1A4 St.comb, CO2	Stationary Combustion, Petroleum coke, CO2	5.8	6.0	0.2	88.5	97.6	9.1	549.8	521.7	579.5	57.8
1A1+1A2+1A4 St.comb, CO2	Stationary Combustion, Residual oil, CO2	13.6	13.8	0.2	77.0	80.1	3.1	1077.2	1055.0	1100.7	45.7
1A1+1A2+1A4 St.comb, CH4	Stationary Combustion, GAS, CH4	144.8	147.7	2.8	0.0	0.1	0.1	6.0	2.3	15.0	12.6
1A1+1A2+1A4 St.comb, CO2	Stationary Combustion, LPG, CO2	1.4	1.4	0.1	60.1	66.2	6.2	87.6	83.0	92.4	9.4
1A1+1A2+1A4 St.comb, CH4	Stationary Combustion, SOLID, CH4	167.2	170.4	3.2	0.0	0.1	0.1	4.2	1.6	10.7	9.1
1A1+1A2+1A4 St.comb, CH4	Natural gas fuelled engines, GAS, CH4	18.8	19.2	0.4	9.9	10.3	0.4	191.6	187.4	195.9	8.5
1A1+1A2+1A4 St.comb, CO2	Stationary Combustion, Coke, CO2	0.7	0.8	0.0	102.8	113.4	10.6	81.2	77.1	85.5	8.5
1A1+1A2+1A4 St.comb, CH4	Biogas fuelled engines, BIOMASS, CH4	3.0	3.2	0.2	8.3	10.1	1.8	28.0	25.3	31.1	5.9
1A1+1A2+1A4 St.comb, CH4	Stationary Combustion, WASTE, CH4	36.8	40.5	3.8	0.0	0.1	0.1	1.4	0.5	3.5	3.0
1A1+1A2+1A4 St.comb, CH4	Stationary Combustion, LIQUID, CH4	60.1	61.4	1.3	0.0	0.1	0.0	1.3	0.5	3.2	2.7
1A1+1A2+1A4 St.comb, CO2	Stationary Combustion, Kerosene, CO2	0.1	0.1	0.0	68.4	75.5	7.1	7.9	7.4	8.3	0.9
1A1+1A2+1A4 St.comb, CO2	Stationary Combustion, BKB, CO2	0.0	0.0	0.0	90.1	99.2	9.1	1.1	1.0	1.2	0.1

Annex 3A-8 Emission inventory 2009 based on SNAP sectors

Table 3A-8.1 Emission inventory 2009 based on SNAP sectors.

SNAP[2]	SO_2 [Mg]	NO_X [Mg]	NMVOC [Mg]	CH_4 [Mg]	CO [Mg]	CO_2[1] [Gg]	N_2O [Mg]
Total, SNAP 01-03	10771	42563	19236	18103	146714	42706	632
1	4939	28092	1977	8866	9372	30571	364
10100	0	0	0	0	0	0	0
10101	2366	7683	236	155	1953	16710	136
10102	920	3697	55	35	724	3740	44
10103	181	1347	10	6	223	1282	14
10104	160	2282	81	72	847	2783	37
10105	43	2576	1441	8164	1580	1061	13
10200	0	0	0	0	0	0	0
10201	0	0	0	0	0	0	0
10202	16	135	5	1	77	172	0
10203	905	2075	111	384	3674	2349	57
10204	0	0	0	0	0	0	0
10205	0	0	0	0	0	0	0
10300	0	0	0	0	0	0	0
10301	0	0	0	0	0	0	0
10302	0	0	0	0	0	0	0
10303	0	0	0	0	0	0	0
10304	5	298	0	3	12	110	2
10305	0	0	0	0	0	0	0
10306	336	1312	1	0	106	823	2
10400	0	0	0	0	0	0	0
10401	0	0	0	0	0	0	0
10402	0	0	0	0	0	0	0
10403	0	0	0	0	0	0	0
10404	0	0	0	0	0	0	0
10405	0	0	0	0	0	0	0
10406	0	0	0	0	0	0	0
10407	0	0	0	0	0	0	0
10500	0	0	0	0	0	0	0
10501	0	0	0	0	0	0	0
10502	0	0	0	0	0	0	0
10503	0	0	0	0	0	0	0
10504	8	6686	38	46	176	1542	59
10505	0	0	0	0	0	0	0
10506	0	0	0	0	0	0	0
2	2985	7706	16964	8581	127012	8246	204
20100	112	550	190	49	616	884	27
20101	0	0	0	0	0	0	0
20102	0	0	0	0	0	0	0
20103	5	20	1	2	7	21	0
20104	0	0	0	0	0	0	0
20105	12	242	85	678	242	100	1
20106	0	0	0	0	0	0	0
20200	1635	6014	16137	6166	118626	6557	159
20201	0	0	0	0	0	0	0
20202	0	3	2	1	11	6	0
20203	0	0	0	0	0	0	0
20204	1	175	107	555	70	67	1
20205	0	0	0	0	0	0	0
20300	1161	412	349	460	7188	456	12
20301	0	0	0	0	0	0	0
20302	47	60	6	15	41	60	2
20303	0	0	0	0	0	0	0
20304	11	230	88	654	212	95	1
20305	0	0	0	0	0	0	0
3	2847	6764	295	656	10330	3889	64
30100	287	1570	101	107	1817	1983	22
30101	0	0	0	0	0	0	0
30102	933	509	28	35	343	450	17
30103	370	254	11	13	140	206	8
30104	1	137	9	6	13	189	3
30105	5	136	61	412	114	57	1
30106	0	3	0	0	2	5	0
30200	0	0	0	0	0	0	0
30203	0	0	0	0	0	0	0
30204	0	0	0	0	0	0	0
30205	0	0	0	0	0	0	0
30300	0	0	0	0	0	0	0
30301	0	0	0	0	0	0	0
30302	0	0	0	0	0	0	0
30303	0	0	0	0	0	0	0
30304	0	0	0	0	0	0	0
30305	0	0	0	0	0	0	0
30306	0	0	0	0	0	0	0
30307	0	0	0	0	0	0	0
30308	0	0	0	0	0	0	0
30309	0	0	0	0	0	0	0
30310	0	0	0	0	0	0	0
30311	877	3881	76	76	1244	869	12
30312	0	0	0	0	0	0	0
30313	0	0	0	0	0	0	0

Continued							
30314	0	0	0	0	0	0	0
30315	0	155	1	1	31	41	0
30316	0	43	0	0	0	0	0
30317	0	0	0	0	0	0	0
30318	374	75	8	7	6625	89	1
30319	0	0	0	0	0	0	0
30320	0	0	0	0	0	0	0
30321	0	0	0	0	0	0	0
30322	0	0	0	0	0	0	0
30323	0	0	0	0	0	0	0
30324	0	0	0	0	0	0	0
30325	0	0	0	0	0	0	0
30326	0	0	0	0	0	0	0

1) Including CO_2 emission from biomass

2) SNAP sector codes are shown in appendix 3

Annex 3A-9 Description of the Danish energy statistics

This description of the Danish energy statistics has been prepared by Denmark's National Environmental Research Institute (NERI) in cooperation with the Danish Energy Agency (DEA) as background information to the Danish National Inventory Report (NIR).

The Danish energy statistics system

DEA is responsible for the Danish energy balance. Main contributors to the energy statistics outside DEA are Statistics Denmark and Danish Energy Association (before Association of Danish Energy Companies). The statistics is performed using an integrated statistical system building on an Access database and Excel spreadsheets.

The DEA follows the recommendations of the International Energy Agency as well as Eurostat.

The national energy statistics is updated annually and all revisions are immediately included in the published statistics, which can be found on the DEA homepage[4]. It is an easy task to check for breaks in a series because the statistics is 100% time-series oriented.

The national energy statistics does not include Greenland and Faroe Islands.

For historical reasons, DEA receive monthly information from the Danish oil companies regarding Danish deliveries of oil products to Greenland and Faroe Islands. However, the monthly (MOS) and annual (AOS) reporting of oil statistics to Eurostat and IEA exclude Greenland and Faroe Islands. For all other energy products, the Danish figures are also excluding Greenland and Faroe Islands.

Reporting to the Danish Energy Agency

The Danish Energy Agency receives monthly statistics for the following fuel groups:

- Crude oil and oil products.
  - Monthly data from 46 oil companies, the main purpose is monitoring oil stocks according to the oil preparedness system.
- Natural gas.
  - Fuel/flare from platforms in the North Sea.

[4] http://www.ens.dk/EN-US/INFO/FACTSANDFIGURES/ENERGY_STATISTICS_AND_INDICATORS/ANNUAL%20STATISTICS/Sider/Forside.aspx

    - Natural gas balance from the regulator Energinet.dk (National monopoly).
- Coal and coke.
    - Power plants (94 %).
    - Industry companies (4 %).
    - Coal and coke traders (2 %).
- Electricity.
    - Monthly reporting by e-mail from the regulator Energinet.dk (National monopoly).
        - The statistics covers:
        - Production by type of producer.
        - Own use of electricity.
        - Import and export by country.
        - Domestic supply (consumption + distribution loss).
- Town gas (quarterly) from two town gas producers.
-
- The large central power plants also report monthly consumption of biomass.

Annual data includes renewable energy including waste. The DEA conducts a biannual survey on wood pellets and wood fuel. Statistics Denmark conducts biannual surveys on the energy consumption in the service and industrial sectors. Statistics Denmark prepares annual surveys on forest (wood fuel) & straw.

Other annual data sources include:

- DEA.
    - Survey on production of electricity and heat and fuels used.
    - Survey on end use of oil.
    - Survey on end use of natural gas.
    - Survey on end use of coal and coke.
- National Environmental Research Institute (NERI), Aarhus University.
    - Energy consumption for domestic air transport.
- Danish Energy Association (Association of Danish Energy companies).
    - Survey on electricity consumption.
- Ministry of Taxation.
    - Border trade.
- Centre for Biomass Technology.
    - Annual estimates of final consumption of straw and wood chips.

Annual revisions

In general, DEA follows the same procedures as in the Danish national account. This means that normally only figures for the last two years are revised.

Aggregating the energy statistics on SNAP level

The sectors used in the official energy statistics have been mapped to SNAP categories, used in the Danish emission database. NERI aggregates the official energy statistics to SNAP level based on a source correspondence table.

In cooperation between DEA and NERI, a fuel correspondence table has been developed mapping the fuels used by the DEA in the official energy statistics with the fuel codes used in the Danish national emission database. The fuel correspondence table between fuel categories used by the DEA, NERI and IPCC is presented in Annex 2A-3.

The mapping between the energy statistics and the SNAP and fuel codes used by NERI can be seen in the table below.

Table 105 Correspondence between the Danish national energy statistics and the SNAP nomenclature (only stationary combustion part shown).

Unit: TJ		End-use		Transformation 1980-1993	
	SNAP	Fuel *(in Danish)*	Fuel-code	SNAP	Fuel-code
Foreign Trade					
- *Border Trade*					
- - Motor Gasoline					
- - Gas-/Diesel Oil					
- - Petroleum Coke	0202	Petrokoks	110A		
Vessels in Foreign Trade					
- *International Marine Bunkers*					
- - Gas-/Diesel Oil					
- - Fuel Oil					
- - Lubricants					
Energy Sector					
Extraction and Gasification					
- *Extraction*					
- - Natural Gas	010504	Naturgas	301A		
- *Gasification*					
- - Biogas, Landfill	091006	Biogas	309A		
- - Biogas, Other	091006	Biogas	309A		
Refineries					
- Own Use					
- - Refinery Gas	010306	Raffinaderigas	308A		
- - LPG	010306	LPG	303A		
- - Gas-/Diesel Oil	010306	Gas & Dieselolie	204A		
- - Fuel Oil	010306	Fuelolie & Spildolie	203A		
Transformation Sector					
Large-scale Power Units					
- *Fuels Used for Power Production*					
- - Gas-/Diesel Oil				0101	204A
- - Fuel Oil				0101	203A
- - Electricity Plant Coal				0101	102A
- - Straw				0101	117A
Large-Scale CHP Units					
- *Fuels Used for Power Production*					
- - Refinery Gas				0103	308A
- - LPG				0101	303A
- - Naphtha (LVN)				0101	210A
- - Gas-/Diesel Oil				0101	204A
- - Fuel Oil				0101	203A
- - Petroleum Coke				0101	110A
- - Orimulsion				0101	225A
- - Natural Gas				0101	301A
- - Electricity Plant Coal				0101	102A
- - Straw				0101	117A
- - Wood Chips				0101	111A
- - Wood Pellets				0101	111A
- - Wood Waste				0101	111A
- - Biogas, Landfill				0101	309A
- - Biogas, Others				0101	309A
- - Waste, Non-renewable				0101	114A
- - Wastes, Renewable				0101	114A
- *Fuels Used for Heat Production*					
- - Refinery Gas				0103	308A
- - LPG				0101	303A
- - Naphtha (LVN)				0101	210A
- - Gas-/Diesel Oil				0101	204A
- - Fuel Oil				0101	203A
- - Petroleum Coke				0101	110A
- - Orimulsion				0101	225A
- - Natural Gas				0101	301A
- - Electricity Plant Coal				0101	102A
- - Straw				0101	117A
- - Wood Chips				0101	111A
- - Wood Pellets				0101	111A
- - Wood Waste				0101	111A
- - Biogas, Landfill				0101	309A
- - Biogas, Other				0101	309A
- - Waste, Non-renewable				0101	114A
- - Wastes, Renewable				0101	114A
Small-Scale CHP Units					
- *Fuels Used for Power Production*					

Unit: TJ		End-use		Transformation 1980-1993	
	SNAP	Fuel *(in Danish)*	Fuel-code	SNAP	Fuel-code
- - Gas-/Diesel Oil				0101	204A
- - Fuel Oil				0101	203A
- - Natural Gas				0101	301A
- - Hard Coal				0101	102A
- - Straw				0101	117A
- - Wood Chips				0101	111A
- - Wood Pellets				0101	111A
- - Wood Waste				0101	111A
- - Biogas, Landfill				0101	309A
- - Biogas, Other				0101	309A
- - Waste, Non-renewable				0101	114A
- - Wastes, Renewable				0101	114A
- *Fuels Used for Heat Production*					
- - Gas-/Diesel Oil				0101	204A
- - Fuel Oil				0101	203A
- - Natural Gas				0101	301A
- - Coal				0101	102A
- - Straw				0101	117A
- - Wood Chips				0101	111A
- - Wood Pellets				0101	111A
- - Wood Waste				0101	111A
- - Biogas, Landfill				0101	309A
- - Biogas, Other				0101	309A
- - Waste, Non-renewable				0101	114A
- - Wastes, Renewable				0101	114A
District Heating Units					
- *Fuels Used for Heat Production*					
- - Refinery Gas				0103	308A
- - LPG				0102	303A
- - Gas-/Diesel Oil				0102	204A
- - Fuel Oil				0102	203A
- - Waste Oil				0102	203A
- - Petroleum Coke				0102	110A
- - Natural Gas				0102	301A
- - Electricity Plant Coal				0102	102A
- - Coal				0102	102A
- - Straw				0102	117A
- - Wood Chips				0102	111A
- - Wood Pellets				0102	111A
- - Wood Waste				0102	111A
- - Biogas, Landfill				0102	309A
- - Biogas, Sludge				0102	309A
- - Biogas, Other				0102	309A
- - Waste, Non-renewable				0102	114A
- - Wastes, Renewable				0102	114A
- - Fish Oil				0102	215A
Autoproducers, Electricity Only					
- Fuels Used for Power Production					
- - Natural Gas				0301	301A
- - Biogas, Landfill				0301	309A
- - Biogas, Sewage Sludge				0301	309A
- - Biogas, Other				0301	309A
Autoproducers, CHP Units					
- *Fuels Used for Power Production*					
- - Refinery Gas				0103	308A
- - Gas-/Diesel Oil				0301	204A
- - Fuel Oil				0301	203A
- - Waste Oil				0301	203A
- - Natural Gas				0301	301A
- - Coal				0301	102A
- - Straw				0301	117A
- - Wood Chips				0301	111A
- - Wood Pellets				0301	111A
- - Wood Waste				0301	111A
- - Biogas, Landfill				0301	309A
- - Biogas, Sludge				0301	309A
- - Biogas, Other				0301	309A
- - Fish Oil				0301	215A
- - Waste, Non-renewable				0301	114A
- - Wastes, Renewable				0301	114A
- *Fuels Used for Heat Production*					
- - Refinery Gas				0103	308A
- - Gas-/Diesel Oil				0301	204A
- - Fuel Oil				0301	203A
- - Waste Oil				0301	203A
- - Natural Gas				0301	301A
- - Coal				0301	102A
- - Wood Chips				0301	111A
- - Wood Waste				0301	111A
- - Biogas, Landfill				0301	309A
- - Biogas, Sludge				0301	309A
- - Biogas, Other				0301	309A
- - Waste, Non-renewable				0301	114A
- - Wastes, Renewable				0301	114A
Autoproducers, Heat Only					
- *Fuels Used for Heat Production*					

Unit: TJ	SNAP	End-use Fuel *(in Danish)*	Fuel-code	Transformation 1980-1993 SNAP	Fuel-code
- - Gas-/Diesel Oil				0301	204A
- - Fuel Oil				0301	203A
- - Waste Oil				0301	203A
- - Natural Gas				0301	301A
- - Straw				0301	117A
- - Wood Chips				0301	111A
- - Wood Chips				0301	111A
- - Wood Waste				0301	111A
- - Biogas, Landfill				0301	309A
- - Biogas, Sludge				0301	309A
- - Biogas, Other				0301	309A
- - Waste, Non-renewable				0102	114A
- - Wastes, Renewable				0102	114A
Town Gas Units	030106	Naturgas	301A		
- Fuels Used for Production of District Heating	030106	Kul (-83) / Gasolie (84-)	102A / 204A		
Transport					
Military Transport					
- Aviation Gasoline					
- Motor Gasoline					
- JP4					
- JP1					
- Gas-/Diesel Oil					
Road					
- LPG					
- Motor Gasoline					
- Other Kerosene	0202	Petroleum	206A		
- Gas-/Diesel Oil					
- Fuel Oil					
Rail					
- Motor Gasoline					
- Other Kerosene					
- Gas-/Diesel Oil					
- Electricity					
Domestic Sea Transport					
- LPG					
- Other Kerosene					
- Gas-/Diesel Oil					
- Fuel Oil					
Air Transport, Domestic					
- LPG					
- Aviation Gasoline					
- Motor Gasoline					
- Other Kerosene	0201	Petroleum	206A		
- JP1					
Air Transport, International					
- Aviation Gasoline					
- JP1					
Agriculture and Forestry					
- LPG					
- Motor Gasoline					
- Other Kerosene	0203	Petroleum	206A		
- Gas-/Diesel Oil					
- Fuel Oil	0203	Fuelolie & Spildolie	203A		
- Petroleum Coke	0203	Petrokoks	110A		
- Natural Gas	0203	Naturgas	301A		
- Coal	0203	Kul	102A		
- Brown Coal Briquettes	0203	Brunkul	106A		
- Straw	0203	Halm	117A		
- Wood Chips	0203	Træ	111A		
- Wood Waste	0203	Træ	111A		
- Biogas, Other	0203	Biogas	309A		
Horticulture					
- LPG					
- Motor Gasoline					
- Gas-/Diesel Oil					
- Fuel Oil	0203	Fuelolie & Spildolie	203A		
- Petroleum Coke	0203	Petrokoks	110A		
- Natural Gas	0203	Naturgas	301A		
- Coal	0203	Kul	102A		
- Wood Waste	0203	Træ	111A		
Fishing					
- LPG					
- Motor Gasoline					
- Other Kerosene					
- Gas-/Diesel Oil					
- Fuel Oil					
Manufacturing Industry					
- Refinery Gas	0301	Raffinaderigas	308A		
- LPG					
- Naphtha (LVN)					
- Motor Gasoline					
- Other Kerosene	0301	Petroleum	206A		
- Gas-/Diesel Oil					
- Fuel Oil	0301	Fuelolie & Spildolie	203A		
- Waste Oil	0301	Fuelolie & Spildolie	203A		

Unit: TJ		End-use		Transformation 1980-1993	
	SNAP	**Fuel *(in Danish)***	**Fuel-code**	**SNAP**	**Fuel-code**
- Petroleum Coke	0301	Petrokoks	110A		
- Natural Gas	0301	Naturgas	301A		
- Coal	0301	Kul	102A		
- Coke	0301	Koks	107A		
- Brown Coal Briquettes	0301	Brunkul	106A		
- Wood Pellets	0301	Træ	111A		
- Wood Waste	0301	Træ	111A		
- Biogas, Landfill	0301	Biogas	309A		
- Biogas, Other	0301	Biogas	309A		
- Wastes, Non-renewable	0301	Affald	114A		
- Wastes, Renewable	0301	Affald	114A		
- Town Gas	0301	Naturgas	301A		
Construction					
- LPG	0301	LPG	303A		
- Motor Gasoline					
- Other Kerosene	0301	Petroleum	206A		
- Gas-/Diesel Oil					
- Fuel Oil	0301	Fuelolie & Spildolie	203A		
- Natural Gas	0301	Naturgas	301A		
Wholesale					
- LPG	0201	LPG	303A		
- Motor Gasoline	0201	Petroleum	206A		
- Other Kerosene	0201	Gas & Dieselolie	204A		
- Gas-/Diesel Oil	0201	Fuelolie & Spildolie	203A		
- Petroleum Coke	0201	Petrokoks	110A		
- Natural Gas	0201	Naturgas	301A		
- Wood Waste	0201	Træ	111A		
Retail Trade					
- LPG	0201	LPG	303A		
- Other Kerosene	0201	Petroleum	206A		
- Gas-/Diesel Oil	0201	Gas & Dieselolie	204A		
- Fuel Oil	0201	Fuelolie & Spildolie	203A		
- Petroleum Coke	0201	Petrokoks	110A		
- Natural Gas	0201	Naturgas	301A		
Private Service					
- LPG	0201	LPG	303A		
- Other Kerosene	0201	Petroleum	206A		
- Gas-/Diesel Oil	0201	Gas & Dieselolie	204A		
- Fuel Oil	0201	Fuelolie & Spildolie	203A		
- Waste Oil	0201	Fuelolie & Spildolie	203A		
- Petroleum Coke	0201	Petrokoks	110A		
- Natural Gas	0201	Naturgas	301A		
- Wood Chips	0201	Træ	111A		
- Wood Waste	0201	Træ	111A		
- Biogas, Landfill	0201	Biogas	309A		
- Biogas, Sludge	0201	Biogas	309A		
- Biogas, Other	0201	Biogas	309A		
- Wastes, Non-renewable	0201	Affald	114A		
- Wastes, Renewable	0201	Affald	114A		
- Town Gas	0201	Naturgas	301A		
Public Service					
- LPG	0201	LPG	303A		
- Other Kerosene	0201	Petroleum	206A		
- Gas-/Diesel Oil	0201	Gas & Dieselolie	204A		
- Fuel Oil	0201	Fuelolie & Spildolie	203A		
- Petroleum Coke	0201	Petrokoks	110A		
- Natural Gas	0201	Naturgas	301A		
- Coal	0201	Kul	102A		
- Brown Coal Briquettes	0201	Brunkul	106A		
- Wood Chips	0201	Træ	111A		
- Wood Pellets	0201	Træ	111A		
- Town Gas	0201	Naturgas	301A		
Single Family Houses					
- LPG	0202	LPG	303A		
- Motor Gasoline					
- Other Kerosene	0202	Petroleum	206A		
- Gas-/Diesel Oil	0202	Gas & Dieselolie	204A		
- Fuel Oil	0202	Fuelolie & Spildolie	203A		
- Petroleum Coke	0202	Petrokoks	110A		
- Natural Gas	0202	Naturgas	301A		
- Coal	0202	Kul	102A		
- Coke	0202	koks	107A		
- Brown Coal Briquettes	0202	Brunkul	106A		
- Straw	0202	Halm	117A		
- Firewood	0202	Træ	111A		
- Wood Chips	0202	Træ	111A		
- Wood Pellets	0202	Træ	111A		
- Town Gas	0202	Naturgas	301A		
Multi-family Houses					
- LPG	0202	LPG	303A		
- Other Kerosene	0202	Petroleum	206A		
- Gas-/Diesel Oil	0202	Gas & Dieselolie	204A		
- Fuel Oil	0202	Fuelolie & Spildolie	203A		
- Petroleum Coke	0202	Petrokoks	110A		
- Natural Gas	0202	Naturgas	301A		
- Coal	0202	Kul	102A		

Unit: TJ	SNAP	End-use Fuel *(in Danish)*	Fuel-code	Transformation 1980-1993 SNAP	Fuel-code
- Coke	0202	Koks	107A		
- Brown Coal Briquettes	0202	Brunkul	106A		
- Town Gas	0202	Naturgas	301A		

Annex 3A-10 EU ETS data for coal

EU ETS data are available for the years 2006-2009. Corresponding values for lower calorific value (LCV) and implied emission factor (IEF) for CO_2 are shown in Figure 3A-10.1. The IEF factors include the oxidation factors.

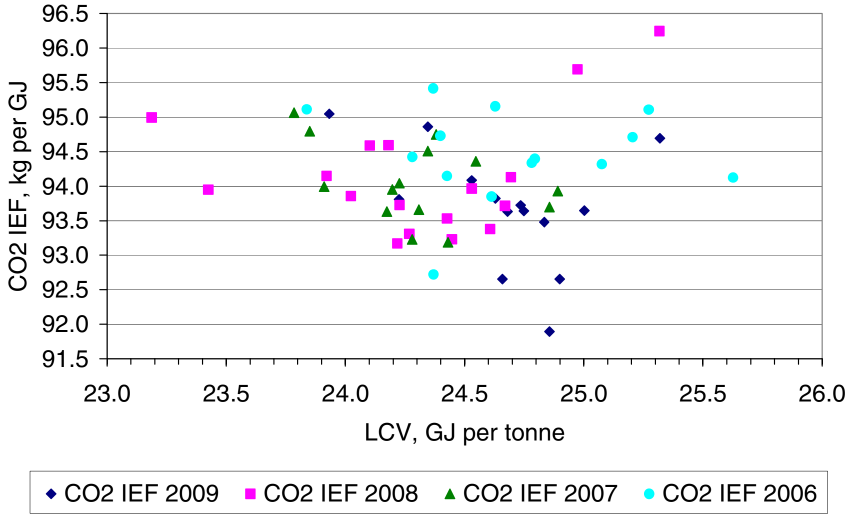


Figure 3A-10.1 EU ETS data for LCV and CO_2 IEF (including oxidation factor) for coal. Data for the years 2006-2009.

Annex 3B Transport

List of content

Annex 3B-1: Fleet data 1985-2009 for road transport (No. vehicles)

Sector	Subsector	Tech 2	FYear	LYear	1985	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Passenger Cars	Gasoline <1,4 l	PRE ECE	0	1969	75564	16627	13368	10706	8571	7246	6992	6618	6159	5646	5194
Passenger Cars	Gasoline <1,4 l	ECE 15/00-01	1970	1978	404441	179963	156167	134583	102209	66638	55669	43359	30440	19722	12950
Passenger Cars	Gasoline <1,4 l	ECE 15/02	1979	1980	97500	87416	63723	53008	61799	45282	38690	30726	21910	14275	8539
Passenger Cars	Gasoline <1,4 l	ECE 15/03	1981	1985	152241	318622	330062	307289	254029	235152	221928	204914	179982	150784	119474
Passenger Cars	Gasoline <1,4 l	ECE 15/04	1986	1990		165103	178393	209260	261580	258381	253651	249450	243072	232062	220895
Passenger Cars	Gasoline <1,4 l	Euro I	1991	1996			28375	60724	96923	141546	180780	219477	218990	216002	214711
Passenger Cars	Gasoline <1,4 l	Euro II	1997	2000									39547	74071	107025
Passenger Cars	Gasoline <1,4 l	Euro III	2001	2005											
Passenger Cars	Gasoline <1,4 l	Euro IV	2006	2010											
Passenger Cars	Gasoline 1,4 - 2,0 l	PRE ECE	0	1969	90872	28856	23474	19524	15744	13167	12527	11642	10624	9570	8659
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/00-01	1970	1978	344505	171158	152919	137410	110812	76213	63961	50125	35583	23605	15800
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/02	1979	1980	87587	74393	54644	44813	52998	40866	35395	28785	21181	14516	9144
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/03	1981	1985	210664	276842	281144	261222	218176	205239	196225	184150	165329	142253	115689
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/04	1986	1990		221807	211098	215194	242499	240697	238039	236139	232642	225250	217019
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro I	1991	1996			51521	101611	148509	235536	319571	414973	413070	407030	404816
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro II	1997	2000									105322	217501	303709
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro III	2001	2005											
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro IV	2006	2010											
Passenger Cars	Gasoline >2,0 l	PRE ECE	0	1969	3246	1388	1186	1033	897	911	945	971	986	987	989
Passenger Cars	Gasoline >2,0 l	ECE 15/00-01	1970	1978	3113	3661	3581	3373	3096	2800	2589	2352	2039	1657	1381
Passenger Cars	Gasoline >2,0 l	ECE 15/02	1979	1980	1078	564	531	687	859	865	865	846	773	702	599
Passenger Cars	Gasoline >2,0 l	ECE 15/03	1981	1985	4087	2263	2037	1700	1575	1659	1801	1950	2055	2081	2018
Passenger Cars	Gasoline >2,0 l	ECE 15/04	1986	1990		4323	3630	3161	2668	2810	3052	3331	3638	3874	4089
Passenger Cars	Gasoline >2,0 l	Euro I	1991	1996			1263	2350	3350	5384	7888	10682	11000	11250	11334
Passenger Cars	Gasoline >2,0 l	Euro II	1997	2000									3980	8667	14011
Passenger Cars	Gasoline >2,0 l	Euro III	2001	2005											
Passenger Cars	Gasoline >2,0 l	Euro IV	2006	2010											
Passenger Cars	Diesel <2,0 l	Conventional	0	1990	69406	71018	70198	69500	68720	65169	62762	59117	54631	50590	48238
Passenger Cars	Diesel <2,0 l	Euro I	1991	1996			979	2163	3799	6613	9919	13122	13689	14318	15305
Passenger Cars	Diesel <2,0 l	Euro II	1997	2000									3064	8535	18568
Passenger Cars	Diesel <2,0 l	Euro III	2001	2005											
Passenger Cars	Diesel <2,0 l	Euro IV	2006	2010											
Passenger Cars	Diesel >2,0 l	Conventional	0	1990	14055	14871	13888	13012	12136	11757	11413	10708	10043	9269	8435
Passenger Cars	Diesel >2,0 l	Euro I	1991	1996			1017	1988	3035	4323	5638	7401	7600	7595	7716

Continued															
Passenger Cars	Diesel >2,0 l	Euro II	1997	2000									2079	5072	9087
Passenger Cars	Diesel >2,0 l	Euro III	2001	2005											
Passenger Cars	Diesel >2,0 l	Euro IV	2006	2010											
Passenger Cars	LPG cars	Conventional	0	1990	1136	1163	1166	1173	1184	734	495	310	171	96	56
Passenger Cars	LPG cars	Euro I	1991	1996				1	4	4	3	1	1	1	3
Passenger Cars	LPG cars	Euro II	1997	2000											
Passenger Cars	LPG cars	Euro III	2001	2005											
Passenger Cars	LPG cars	Euro IV	2006	2010											
Passenger Cars	2-Stroke	Conventional	0	9999	4823	5417	4804	4308	3747	3029	2443	1824	1248	761	400
Passenger Cars	Electric cars	Conventional	0	9999	130	133	133	134	136	155	163	187	230	292	298
Light Duty Vehicles	Gasoline <3,5t	Conventional	0	1994	34172	44442	45625	46865	48934	49865	46712	42710	37987	34274	30224
Light Duty Vehicles	Gasoline <3,5t	Euro I	1995	1998							3773	7509	12025	17550	17352
Light Duty Vehicles	Gasoline <3,5t	Euro II	1999	2001											5272
Light Duty Vehicles	Gasoline <3,5t	Euro III	2002	2006											
Light Duty Vehicles	Gasoline <3,5t	Euro IV	2007	2011											
Light Duty Vehicles	Diesel <3,5t	Conventional	0	1994	113019	146986	150898	154999	161842	169142	160228	148520	133718	120795	105967
Light Duty Vehicles	Diesel <3,5t	Euro I	1995	1998							16899	35370	56836	76717	75753
Light Duty Vehicles	Diesel <3,5t	Euro II	1999	2001											24555
Light Duty Vehicles	Diesel <3,5t	Euro III	2002	2006											
Light Duty Vehicles	Diesel <3,5t	Euro IV	2007	2011											
Light Duty Vehicles	LPG <3,5t	Conventional	0	1994	684	889	913	938	979	632	462	295	196	125	90
Light Duty Vehicles	LPG <3,5t	Euro I	1995	1998										1	1
Light Duty Vehicles	LPG <3,5t	Euro II	1999	2001											
Light Duty Vehicles	LPG <3,5t	Euro III	2002	2006											
Light Duty Vehicles	LPG <3,5t	Euro IV	2007	2011											
Light Duty Vehicles	Electric <3,5t	Conventional	0	9999	3	4	4	4	4	3	2	2	1	1	1
Heavy Duty Vehicles	Gasoline >3,5t	Conventional	0	9999	621	530	510	497	503	455	412	365	326	336	318
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Conventional	0	1993	8686	7049	6675	6430	6419	6194	5738	5137	4646	4156	3518
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Euro I	1994	1996					66	376	711	976	973	967	906
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Euro II	1997	2001								89	521	1236	1782
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Euro III	2002	2006											
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Euro IV	2007	2009											
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Euro V	2010	2014											
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Conventional	0	1993	7266	5897	5584	5379	5375	5316	5373	5207	4854	4491	4116
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Euro I	1994	1996					51	298	671	968	1002	1081	1102
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Euro II	1997	2001								94	429	798	1200
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Euro III	2002	2006											

Continued

Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Euro IV	2007	2009											
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Euro V	2010	2014											
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Conventional	0	1993	4984	4519	4461	4388	4454	3991	3248	2731	2360	1984	1623
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Euro I	1994	1996					37	156	234	285	283	286	289
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Euro II	1997	2001								21	126	216	262
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Euro III	2002	2006											
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Euro IV	2007	2009											
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Euro V	2010	2014											
Heavy Duty Vehicles	Diesel RT 14 - 20t	Conventional	0	1993	5171	4689	4628	4552	4601	4348	4047	3669	3316	2924	2537
Heavy Duty Vehicles	Diesel RT 14 - 20t	Euro I	1994	1996					58	334	708	1001	1007	985	963
Heavy Duty Vehicles	Diesel RT 14 - 20t	Euro II	1997	2001								98	535	937	1371
Heavy Duty Vehicles	Diesel RT 14 - 20t	Euro III	2002	2006											
Heavy Duty Vehicles	Diesel RT 14 - 20t	Euro IV	2007	2009											
Heavy Duty Vehicles	Diesel RT 14 - 20t	Euro V	2010	2014											
Heavy Duty Vehicles	Diesel RT 20 - 26t	Conventional	0	1993	4307	5179	5237	5326	5315	5031	4565	4059	3536	3067	2596
Heavy Duty Vehicles	Diesel RT 20 - 26t	Euro I	1994	1996					67	469	1003	1452	1442	1400	1322
Heavy Duty Vehicles	Diesel RT 20 - 26t	Euro II	1997	2001								152	748	1330	1898
Heavy Duty Vehicles	Diesel RT 20 - 26t	Euro III	2002	2006											
Heavy Duty Vehicles	Diesel RT 20 - 26t	Euro IV	2007	2009											
Heavy Duty Vehicles	Diesel RT 20 - 26t	Euro V	2010	2014											
Heavy Duty Vehicles	Diesel RT 26 - 28t	Conventional	0	1993	7	8	8	9	9	7	6	6	6	6	6
Heavy Duty Vehicles	Diesel RT 26 - 28t	Euro I	1994	1996							0	1	1	1	1
Heavy Duty Vehicles	Diesel RT 26 - 28t	Euro II	1997	2001								0	1	2	3
Heavy Duty Vehicles	Diesel RT 26 - 28t	Euro III	2002	2006											
Heavy Duty Vehicles	Diesel RT 26 - 28t	Euro IV	2007	2009											
Heavy Duty Vehicles	Diesel RT 26 - 28t	Euro V	2010	2014											
Heavy Duty Vehicles	Diesel RT 28 - 32t	Conventional	0	1993	271	326	329	335	327	326	329	321	300	262	231
Heavy Duty Vehicles	Diesel RT 28 - 32t	Euro I	1994	1996					11	62	152	239	246	252	253
Heavy Duty Vehicles	Diesel RT 28 - 32t	Euro II	1997	2001								28	147	289	455
Heavy Duty Vehicles	Diesel RT 28 - 32t	Euro III	2002	2006											
Heavy Duty Vehicles	Diesel RT 28 - 32t	Euro IV	2007	2009											
Heavy Duty Vehicles	Diesel RT 28 - 32t	Euro V	2010	2014											
Heavy Duty Vehicles	Diesel RT >32t	Conventional	0	1993	0	0	0	0	0	0	1	0	0	1	1
Heavy Duty Vehicles	Diesel RT >32t	Euro I	1994	1996							0	1	1	1	1
Heavy Duty Vehicles	Diesel RT >32t	Euro II	1997	2001								0	1	0	0
Heavy Duty Vehicles	Diesel RT >32t	Euro III	2002	2006											
Heavy Duty Vehicles	Diesel RT >32t	Euro IV	2007	2009											

Continued

Heavy Duty Vehicles	Diesel RT >32t	Euro V	2010	2014											
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Conventional	0	1993	5617	5132	5080	5011	5065	4783	4448	4025	3645	3208	2772
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Euro I	1994	1996					63	356	759	1069	1076	1051	1028
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Euro II	1997	2001								104	570	1000	1467
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Euro III	2002	2006											
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Euro IV	2007	2009											
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Euro V	2010	2014											
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Conventional	0	1993	8359	10252	10740	11202	11174	10480	8917	7262	5877	4730	3842
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Euro I	1994	1996					204	1616	3609	4958	4683	4110	3555
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Euro II	1997	2001								495	2223	4240	5939
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Euro III	2002	2006											
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Euro IV	2007	2009											
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Euro V	2010	2014											
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Conventional	0	1993	1672	2083	2242	2382	2379	2398	2257	2045	1799	1469	1240
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Euro I	1994	1996					49	333	888	1316	1327	1314	1305
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Euro II	1997	2001								143	778	1564	2540
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Euro III	2002	2006											
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Euro IV	2007	2009											
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Euro V	2010	2014											
Heavy Duty Vehicles	Diesel TT/AT 50 - 60t	Euro I	1994	1996								1	1	1	1
Heavy Duty Vehicles	Diesel TT/AT 50 - 60t	Euro II	1997	2001										1	1
Heavy Duty Vehicles	Diesel TT/AT 50 - 60t	Euro IV	2007	2009											
Heavy Duty Vehicles	Diesel TT/AT >60t	Euro V	2010	2014											
Buses	Gasoline Urban Buses	Conventional	0	9999	8	8	9	11	14	11	11	16	17	17	15
Buses	Diesel Urban Buses <15t	Conventional	0	1993	347	352	433	488	639	558	494	411	335	281	250
Buses	Diesel Urban Buses <15t	Euro I	1994	1996						49	81	122	130	132	124
Buses	Diesel Urban Buses <15t	Euro II	1997	2001									103	295	438
Buses	Diesel Urban Buses <15t	Euro III	2002	2006											
Buses	Diesel Urban Buses <15t	Euro IV	2007	2009											
Buses	Diesel Urban Buses 15 - 18t	Conventional	0	1993	2083	2109	2597	2928	3833	3475	3205	2861	2691	2353	2012
Buses	Diesel Urban Buses 15 - 18t	Euro I	1994	1996						397	632	985	989	891	891
Buses	Diesel Urban Buses 15 - 18t	Euro II	1997	2001									183	568	817
Buses	Diesel Urban Buses 15 - 18t	Euro III	2002	2006											
Buses	Diesel Urban Buses 15 - 18t	Euro IV	2007	2009											

Continued

Buses	Diesel Urban Buses >18t	Conventional	0	1993	5	5	6	7	9	8	6	7	6	3	2
Buses	Diesel Urban Buses >18t	Euro I	1994	1996						1	1	3	3	3	2
Buses	Diesel Urban Buses >18t	Euro II	1997	2001										6	20
Buses	Diesel Urban Buses >18t	Euro III	2002	2006											
Buses	Diesel Urban Buses >18t	Euro IV	2007	2009											
Buses	Gasoline Coaches	Conventional	0	9999	931	942	1161	1309	1508	1762	1775	1786	1791	1808	1810
Buses	Diesel Coaches <15t	Conventional	0	1993	3710	3756	4627	5215	6010	5926	5739	5506	5208	4941	4629
Buses	Diesel Coaches <15t	Euro I	1994	1996						420	682	1113	1103	1091	1056
Buses	Diesel Coaches <15t	Euro II	1997	2001									370	695	1039
Buses	Diesel Coaches <15t	Euro III	2002	2006											
Buses	Diesel Coaches <15t	Euro IV	2007	2009											
Buses	Diesel Coaches 15 - 18t	Conventional	0	1993	804	814	1003	1131	1303	1389	1393	1342	1253	1241	1184
Buses	Diesel Coaches 15 - 18t	Euro I	1994	1996						35	89	153	162	163	159
Buses	Diesel Coaches 15 - 18t	Euro II	1997	2001									44	77	119
Buses	Diesel Coaches 15 - 18t	Euro III	2002	2006											
Buses	Diesel Coaches 15 - 18t	Euro IV	2007	2009											
Buses	Diesel Coaches >18t	Conventional	0	1993	122	123	152	171	197	210	221	211	193	193	206
Buses	Diesel Coaches >18t	Euro I	1994	1996						20	42	78	84	82	81
Buses	Diesel Coaches >18t	Euro II	1997	2001									25	54	99
Buses	Diesel Coaches >18t	Euro III	2002	2006											
Buses	Diesel Coaches >18t	Euro IV	2007	2009											
Mopeds	<50 cm^3	Conventional	0	1999	151000	120000	118000	113000	109000	105000	114167	123333	132500	141667	150833
Mopeds	<50 cm^3	Euro I	2000	2003											
Mopeds	<50 cm^3	Euro II	2004	9999											
Motorcycles	2-stroke >50 cm^3	Conventional	0	1999	6209	6617	6804	6904	7111	7406	7672	8214	8980	9598	10385
Motorcycles	4-stroke <250 cm^3	Conventional	0	1999	7037	7499	7712	7824	8059	8394	8695	9310	10177	10878	11769
Motorcycles	4-stroke <250 cm^3	Euro I	2000	2003											
Motorcycles	4-stroke <250 cm^3	Euro II	2004	2006											
Motorcycles	4-stroke <250 cm^3	Euro III	2007	9999											
Motorcycles	4-stroke 250 - 750 cm^3	Conventional	0	1999	19352	20622	21207	21516	22162	23083	23911	25602	27986	29914	32365
Motorcycles	4-stroke 250 - 750 cm^3	Euro I	2000	2003											
Motorcycles	4-stroke 250 - 750 cm^3	Euro II	2004	2006											
Motorcycles	4-stroke 250 - 750 cm^3	Euro III	2007	9999											
Motorcycles	4-stroke >750 cm^3	Conventional	0	1999	8796	9374	9639	9780	10074	10492	10869	11637	12721	13597	14712
Motorcycles	4-stroke >750 cm^3	Euro I	2000	2003											
Motorcycles	4-stroke >750 cm^3	Euro II	2004	2006											
Motorcycles	4-stroke >750 cm^3	Euro III	2007	9999											

Sector	Subsector	Tech 2	FYear	LYear	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Passenger Cars	Gasoline <1,4 l	PRE ECE	0	1969	5194	4994	4949	4963	5045	5223	5417	5720	6082	6467	6725
Passenger Cars	Gasoline <1,4 l	ECE 15/00-01	1970	1978	12950	9402	7791	6441	5527	4770	4352	4074	4103	4094	4147
Passenger Cars	Gasoline <1,4 l	ECE 15/02	1979	1980	8539	5582	4146	3061	2228	1672	1270	1027	857	728	634
Passenger Cars	Gasoline <1,4 l	ECE 15/03	1981	1985	119474	95486	78149	62695	47507	35638	25239	18617	13047	9408	6534
Passenger Cars	Gasoline <1,4 l	ECE 15/04	1986	1990	220895	203911	188827	166452	145685	119764	96438	73966	56842	40817	29940
Passenger Cars	Gasoline <1,4 l	Euro I	1991	1996	214711	212883	211037	207661	203273	197813	189161	177736	161965	144902	127481
Passenger Cars	Gasoline <1,4 l	Euro II	1997	2000	107025	132974	131683	130255	129818	128942	127649	126013	122908	119230	116047
Passenger Cars	Gasoline <1,4 l	Euro III	2001	2005			20508	43702	64814	94621	136765	135422	134549	133140	132632
Passenger Cars	Gasoline <1,4 l	Euro IV	2006	2010								46184	87915	132696	172453
Passenger Cars	Gasoline 1,4 - 2,0 l	PRE ECE	0	1969	8659	8291	8215	8200	8321	8638	9068	9589	10256	10936	11399
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/00-01	1970	1978	15800	11566	9555	7938	6866	5944	5373	5149	5260	5419	5580
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/02	1979	1980	9144	6258	4775	3690	2780	2170	1670	1386	1183	1020	895
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/03	1981	1985	115689	94495	78552	64108	49671	37838	27501	20744	15212	11502	8468
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/04	1986	1990	217019	203364	190772	171667	153308	129613	107638	85474	67960	51210	39584
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro I	1991	1996	404816	402938	402008	397847	391775	383212	370014	348949	317429	286209	256600
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro II	1997	2000	303709	363267	359633	355644	355739	352843	349396	344681	334040	320023	310538
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro III	2001	2005			51628	107387	148845	196878	250957	248647	251018	247684	246743
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro IV	2006	2010								55169	101832	129710	145252
Passenger Cars	Gasoline >2,0 l	PRE ECE	0	1969	989	1024	1079	1128	1237	1391	1600	2060	2628	3224	3589
Passenger Cars	Gasoline >2,0 l	ECE 15/00-01	1970	1978	1381	1181	1034	936	859	830	841	1031	1314	1735	2009
Passenger Cars	Gasoline >2,0 l	ECE 15/02	1979	1980	599	520	479	444	399	369	318	311	330	319	297
Passenger Cars	Gasoline >2,0 l	ECE 15/03	1981	1985	2018	1904	1798	1696	1572	1431	1299	1182	1129	1031	935
Passenger Cars	Gasoline >2,0 l	ECE 15/04	1986	1990	4089	4161	4188	4196	4099	3992	3847	3772	3641	3404	3151
Passenger Cars	Gasoline >2,0 l	Euro I	1991	1996	11334	11470	11572	11776	11983	12425	12702	13039	13204	12844	12336
Passenger Cars	Gasoline >2,0 l	Euro II	1997	2000	14011	18867	18776	18757	18984	19326	19848	20510	21171	20918	20652
Passenger Cars	Gasoline >2,0 l	Euro III	2001	2005			4628	9892	14692	21393	29899	30850	32713	33204	33810
Passenger Cars	Gasoline >2,0 l	Euro IV	2006	2010								7690	14232	17902	19391
Passenger Cars	Diesel <2,0 l	Conventional	0	1990	48238	46384	44480	41523	38006	34340	30089	26006	22027	17996	14360
Passenger Cars	Diesel <2,0 l	Euro I	1991	1996	15305	16471	17245	18106	19220	20895	21616	21549	20568	19152	17776
Passenger Cars	Diesel <2,0 l	Euro II	1997	2000	18568	30074	30082	30026	30342	30592	30774	31125	33912	32640	32025
Passenger Cars	Diesel <2,0 l	Euro III	2001	2005			12723	30100	46644	70013	100191	102310	119573	119892	121697
Passenger Cars	Diesel <2,0 l	Euro IV	2006	2010								35637	97621	163452	211200
Passenger Cars	Diesel >2,0 l	Conventional	0	1990	8435	7728	7120	6345	5723	5039	4460	3895	3402	2906	2515
Passenger Cars	Diesel >2,0 l	Euro I	1991	1996	7716	7698	7640	7463	7353	7287	7147	6943	6586	6016	5573
Passenger Cars	Diesel >2,0 l	Euro II	1997	2000	9087	13139	13250	13151	13303	13569	13890	13944	14951	14421	14008
Passenger Cars	Diesel >2,0 l	Euro III	2001	2005			3892	8650	12988	18896	25773	26255	31305	31519	32057
Passenger Cars	Diesel >2,0 l	Euro IV	2006	2010								7152	18381	24262	30134

Continued															
Passenger Cars	LPG cars	Conventional	0	1990	56	30	24	17	11	10	10	10	7	8	7
Passenger Cars	LPG cars	Euro I	1991	1996	3	2	2	3	2	4	4	3	2	2	2
Passenger Cars	LPG cars	Euro II	1997	2000				1	2	1	1	1			1
Passenger Cars	LPG cars	Euro III	2001	2005									1	2	4
Passenger Cars	LPG cars	Euro IV	2006	2010											1
Passenger Cars	2-Stroke	Conventional	0	9999	400	300	200	150	100	50					
Passenger Cars	Electric cars	Conventional	0	9999	298	322	301	280	250	211	183	183	188	191	273
Light Duty Vehicles	Gasoline <3,5t	Conventional	0	1994	30224	27140	23832	21083	18787	16405	14063	11895	9932	7990	6333
Light Duty Vehicles	Gasoline <3,5t	Euro I	1995	1998	17352	17103	16862	16703	16454	16011	15464	14728	13331	12214	11199
Light Duty Vehicles	Gasoline <3,5t	Euro II	1999	2001	5272	9655	14319	14153	14012	13791	13616	13420	10302	9608	8984
Light Duty Vehicles	Gasoline <3,5t	Euro III	2002	2006				3784	8014	13934	20623	26271	18997	18312	17579
Light Duty Vehicles	Gasoline <3,5t	Euro IV	2007	2011									3184	3811	4024
Light Duty Vehicles	Diesel <3,5t	Conventional	0	1994	105967	94102	80466	67925	56940	46624	37412	29736	24088	18849	14736
Light Duty Vehicles	Diesel <3,5t	Euro I	1995	1998	75753	74373	72684	71182	69081	66775	63284	58501	52343	46832	41793
Light Duty Vehicles	Diesel <3,5t	Euro II	1999	2001	24555	49951	74831	73532	72069	70326	68384	65625	55257	49899	45253
Light Duty Vehicles	Diesel <3,5t	Euro III	2002	2006				27192	54236	92157	139815	194261	167940	158600	150016
Light Duty Vehicles	Diesel <3,5t	Euro IV	2007	2011									47073	72419	83205
Light Duty Vehicles	LPG <3,5t	Conventional	0	1994	90	60	36	27	21	14	10	9	7	5	4
Light Duty Vehicles	LPG <3,5t	Euro I	1995	1998	1	1	1								
Light Duty Vehicles	LPG <3,5t	Euro II	1999	2001		1				1	3	3	2	2	3
Light Duty Vehicles	LPG <3,5t	Euro III	2002	2006								5	7	7	8
Light Duty Vehicles	LPG <3,5t	Euro IV	2007	2011									1	3	4
Light Duty Vehicles	Electric <3,5t	Conventional	0	9999	1	1								1	7
Heavy Duty Vehicles	Gasoline >3,5t	Conventional	0	9999	318	307	295	291	283	268	287	296	328	324	340
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Conventional	0	1993	3518	3011	2552	2088	1709	1430	1244	1075	937	793	653
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Euro I	1994	1996	906	834	769	715	656	594	492	437	360	290	234
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Euro II	1997	2001	1782	2136	2254	2161	2078	2003	1901	1722	1504	1386	1189
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Euro III	2002	2006			166	460	755	1049	1437	1677	1662	1576	1448
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Euro IV	2007	2009								53	364	758	911
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Euro V	2010	2014									2	5	27
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Conventional	0	1993	4116	3782	3406	3069	2766	2503	2241	2077	1899	1682	1418
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Euro I	1994	1996	1102	1099	1070	1040	985	948	885	827	747	666	544
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Euro II	1997	2001	1200	1575	1783	1840	1884	1858	1838	1706	1587	1525	1359
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Euro III	2002	2006			155	443	713	1061	1501	1936	1996	1908	1784
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Euro IV	2007	2009			2	2	2	2	3	93	427	823	890
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Euro V	2010	2014					1	1	1	2	42	180	345
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Conventional	0	1993	1623	1368	1094	896	734	612	500	435	367	295	224

Continued															
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Euro I	1994	1996	289	278	274	248	203	174	152	138	113	99	85
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Euro II	1997	2001	262	298	312	291	285	278	273	267	239	203	159
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Euro III	2002	2006			10	32	46	58	82	99	108	107	103
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Euro IV	2007	2009						1	1	2	25	49	63
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Euro V	2010	2014										8	11
Heavy Duty Vehicles	Diesel RT 14 - 20t	Conventional	0	1993	2537	2143	1897	1382	1158	1003	884	895	724	531	427
Heavy Duty Vehicles	Diesel RT 14 - 20t	Euro I	1994	1996	963	905	983	787	701	638	562	574	461	334	246
Heavy Duty Vehicles	Diesel RT 14 - 20t	Euro II	1997	2001	1371	1642	1926	1653	1586	1587	1564	1711	1454	1187	942
Heavy Duty Vehicles	Diesel RT 14 - 20t	Euro III	2002	2006			194	389	665	919	1245	1740	1655	1464	1326
Heavy Duty Vehicles	Diesel RT 14 - 20t	Euro IV	2007	2009			4	4	6	7	14	101	457	697	747
Heavy Duty Vehicles	Diesel RT 14 - 20t	Euro V	2010	2014							3	21	106	255	414
Heavy Duty Vehicles	Diesel RT 20 - 26t	Conventional	0	1993	2596	2097	1769	1231	984	797	655	623	463	306	217
Heavy Duty Vehicles	Diesel RT 20 - 26t	Euro I	1994	1996	1322	1204	1206	935	815	728	643	654	515	361	271
Heavy Duty Vehicles	Diesel RT 20 - 26t	Euro II	1997	2001	1898	2179	2589	2176	2053	1970	1846	1969	1668	1353	1074
Heavy Duty Vehicles	Diesel RT 20 - 26t	Euro III	2002	2006			197	487	803	1143	1583	2273	2160	1903	1747
Heavy Duty Vehicles	Diesel RT 20 - 26t	Euro IV	2007	2009			3	3	3	3	26	126	593	907	985
Heavy Duty Vehicles	Diesel RT 20 - 26t	Euro V	2010	2014							7	24	124	292	490
Heavy Duty Vehicles	Diesel RT 26 - 28t	Conventional	0	1993	6	4	4	4	4	4	4	4	4	3	2
Heavy Duty Vehicles	Diesel RT 26 - 28t	Euro I	1994	1996	1	1	2	1	1	1	0	1	1	1	0
Heavy Duty Vehicles	Diesel RT 26 - 28t	Euro II	1997	2001	3	3	3	2	2	2	2	2	2	1	1
Heavy Duty Vehicles	Diesel RT 26 - 28t	Euro III	2002	2006					0	2	2	3	3	3	3
Heavy Duty Vehicles	Diesel RT 26 - 28t	Euro IV	2007	2009									3	3	1
Heavy Duty Vehicles	Diesel RT 26 - 28t	Euro V	2010	2014									1	1	1
Heavy Duty Vehicles	Diesel RT 28 - 32t	Conventional	0	1993	231	185	139	93	70	50	42	36	22	12	9
Heavy Duty Vehicles	Diesel RT 28 - 32t	Euro I	1994	1996	253	239	241	190	157	134	114	95	68	41	27
Heavy Duty Vehicles	Diesel RT 28 - 32t	Euro II	1997	2001	455	618	792	670	641	637	639	702	590	504	383
Heavy Duty Vehicles	Diesel RT 28 - 32t	Euro III	2002	2006			82	193	341	509	747	1189	1157	1025	932
Heavy Duty Vehicles	Diesel RT 28 - 32t	Euro IV	2007	2009				0	1	1	21	86	400	606	661
Heavy Duty Vehicles	Diesel RT 28 - 32t	Euro V	2010	2014								10	69	157	254
Heavy Duty Vehicles	Diesel RT >32t	Conventional	0	1993	1	2	2	1	2	2	2	1	1	1	
Heavy Duty Vehicles	Diesel RT >32t	Euro I	1994	1996	1	0	1	1	1	1	1	1	1	1	1
Heavy Duty Vehicles	Diesel RT >32t	Euro II	1997	2001	0	1	1	0							
Heavy Duty Vehicles	Diesel RT >32t	Euro III	2002	2006			1	1	2	1	2	3	3	3	3
Heavy Duty Vehicles	Diesel RT >32t	Euro IV	2007	2009									1	1	1
Heavy Duty Vehicles	Diesel RT >32t	Euro V	2010	2014											1
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Conventional	0	1993	2772	2481	1887	1804	1515	1250	1033	756	655	548	442
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Euro I	1994	1996	1028	1025	954	1006	898	781	648	475	407	337	248

Continued

Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Euro II	1997	2001	1467	1862	1872	2119	2035	1942	1802	1407	1275	1190	944
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Euro III	2002	2006			188	497	852	1123	1432	1434	1454	1468	1329
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Euro IV	2007	2009			3	6	8	8	15	83	402	701	751
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Euro V	2010	2014							3	17	93	256	415
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Conventional	0	1993	3842	3173	2250	1980	1585	1255	973	705	576	453	328
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Euro I	1994	1996	3555	2884	2100	1834	1472	1214	979	713	596	466	346
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Euro II	1997	2001	5939	7098	7055	6586	5636	4638	3653	2744	2272	1947	1478
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Euro III	2002	2006			1009	2342	3625	4439	5378	5558	4873	4142	3372
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Euro IV	2007	2009			4	7	6	10	76	213	992	1630	1718
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Euro V	2010	2014			1	1	1		27	151	672	1159	1543
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Conventional	0	1993	1240	1029	708	549	388	287	219	170	123	94	67
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Euro I	1994	1996	1305	1215	1060	967	781	616	482	352	286	177	115
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Euro II	1997	2001	2540	3548	4062	4016	3731	3293	2841	2248	1798	1422	961
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Euro III	2002	2006			552	1706	3011	4472	6217	7584	7031	5987	4774
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Euro IV	2007	2009			1	5	6	6	82	328	2117	3548	3677
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Euro V	2010	2014			1	2	2	2	1	68	722	1421	1894
Heavy Duty Vehicles	Diesel TT/AT 50 - 60t	Euro I	1994	1996	1	1	1	1	1	1	1				
Heavy Duty Vehicles	Diesel TT/AT 50 - 60t	Euro II	1997	2001	1	1	1	1	1	1	1	1	1	1	1
Heavy Duty Vehicles	Diesel TT/AT 50 - 60t	Euro IV	2007	2009									1	1	1
Heavy Duty Vehicles	Diesel TT/AT >60t	Euro V	2010	2014										1	3
Buses	Gasoline Urban Buses	Conventional	0	9999	15	11	9	7	1	2	2	2	4	7	9
Buses	Diesel Urban Buses <15t	Conventional	0	1993	250	200	183	154	123	101	80	68	56	49	33
Buses	Diesel Urban Buses <15t	Euro I	1994	1996	124	118	118	96	106	88	84	75	57	53	28
Buses	Diesel Urban Buses <15t	Euro II	1997	2001	438	525	542	553	569	535	545	494	427	367	221
Buses	Diesel Urban Buses <15t	Euro III	2002	2006				56	155	248	378	461	438	433	416
Buses	Diesel Urban Buses <15t	Euro IV	2007	2009									119	261	433
Buses	Diesel Urban Buses 15 - 18t	Conventional	0	1993	2012	1701	1506	1175	1030	880	758	621	538	451	329
Buses	Diesel Urban Buses 15 - 18t	Euro I	1994	1996	891	845	810	749	691	620	561	476	399	338	296
Buses	Diesel Urban Buses 15 - 18t	Euro II	1997	2001	817	1049	1165	1156	1136	1066	1061	1032	1002	919	851
Buses	Diesel Urban Buses 15 - 18t	Euro III	2002	2006				288	456	596	733	991	992	989	962
Buses	Diesel Urban Buses 15 - 18t	Euro IV	2007	2009									107	327	624
Buses	Diesel Urban Buses >18t	Conventional	0	1993	2	37	47	45	25	24	23	16	7	6	5
Buses	Diesel Urban Buses >18t	Euro I	1994	1996	2	28	44	52	51	42	44	44	23	6	4
Buses	Diesel Urban Buses >18t	Euro II	1997	2001	20	106	220	225	224	218	217	215	213	161	147

Continued															
Buses	Diesel Urban Buses >18t	Euro III	2002	2006				135	228	337	388	448	439	414	398
Buses	Diesel Urban Buses >18t	Euro IV	2007	2009									124	247	338
Buses	Gasoline Coaches	Conventional	0	9999	1810	1796	1788	1763	1722	1663	1586	1521	1422	1306	1186
Buses	Diesel Coaches <15t	Conventional	0	1993	4629	4340	3989	3649	3360	3029	2726	2438	2162	1928	1661
Buses	Diesel Coaches <15t	Euro I	1994	1996	1056	1079	1053	1031	982	956	920	873	814	732	664
Buses	Diesel Coaches <15t	Euro II	1997	2001	1039	1347	1658	1694	1740	1908	2023	2144	2144	2078	2010
Buses	Diesel Coaches <15t	Euro III	2002	2006				253	482	751	1052	1351	1423	1439	1463
Buses	Diesel Coaches <15t	Euro IV	2007	2009									227	478	790
Buses	Diesel Coaches 15 - 18t	Conventional	0	1993	1184	1133	1061	1013	957	914	847	758	682	598	520
Buses	Diesel Coaches 15 - 18t	Euro I	1994	1996	159	148	161	173	176	176	184	177	177	176	184
Buses	Diesel Coaches 15 - 18t	Euro II	1997	2001	119	173	208	221	220	230	240	238	236	226	245
Buses	Diesel Coaches 15 - 18t	Euro III	2002	2006				19	46	61	71	90	81	99	106
Buses	Diesel Coaches 15 - 18t	Euro IV	2007	2009									11	38	69
Buses	Diesel Coaches >18t	Conventional	0	1993	206	192	177	157	142	138	121	92	77	56	49
Buses	Diesel Coaches >18t	Euro I	1994	1996	81	78	76	79	74	70	65	60	56	49	46
Buses	Diesel Coaches >18t	Euro II	1997	2001	99	145	190	196	201	192	192	202	199	173	164
Buses	Diesel Coaches >18t	Euro III	2002	2006				32	92	152	230	293	302	312	321
Buses	Diesel Coaches >18t	Euro IV	2007	2009									55	114	180
Mopeds	<50 cm^3	Conventional	0	1999	150833	143607	136249	128209	120305	112262	103829	94855	86621	78814	71067
Mopeds	<50 cm^3	Euro I	2000	2003		16393	28751	42791	48695	46069	43455	40746	37826	35231	32572
Mopeds	<50 cm^3	Euro II	2004	9999						10669	21715	33399	44553	50954	56361
Motorcycles	2-stroke >50 cm^3	Conventional	0	1999	10385	11054	11367	11582	11850	12326	13158	14241	15400	15790	15474
Motorcycles	4-stroke <250 cm^3	Conventional	0	1999	11769	11909	12331	12662	13098	13716	14486	15411	16311	16873	17111
Motorcycles	4-stroke <250 cm^3	Euro I	2000	2003		619	1074	1568	2088	2087	2144	2240	2373	2462	2488
Motorcycles	4-stroke <250 cm^3	Euro II	2004	2006						694	1791	3236	3221	3196	3132
Motorcycles	4-stroke <250 cm^3	Euro III	2007	9999									1798	3021	3649
Motorcycles	4-stroke 250 - 750 cm^3	Conventional	0	1999	32365	32749	33910	34821	36019	37720	39837	42380	44855	46402	47054
Motorcycles	4-stroke 250 - 750 cm^3	Euro I	2000	2003		1703	2953	4311	5742	5739	5897	6159	6527	6769	6843
Motorcycles	4-stroke 250 - 750 cm^3	Euro II	2004	2006						1910	4925	8898	8857	8788	8614
Motorcycles	4-stroke 250 - 750 cm^3	Euro III	2007	9999									4945	8307	10034
Motorcycles	4-stroke >750 cm^3	Conventional	0	1999	14712	14886	15414	15828	16372	17146	18108	19264	20388	21092	21388
Motorcycles	4-stroke >750 cm^3	Euro I	2000	2003		774	1342	1960	2610	2609	2681	2800	2967	3077	3110
Motorcycles	4-stroke >750 cm^3	Euro II	2004	2006						868	2239	4045	4026	3995	3915
Motorcycles	4-stroke >750 cm^3	Euro III	2007	9999									2248	3776	4561

Annex 2B-2: Mileage data 1985-2008 for road transport (km)

Sector	Subsector	Tech 2	FYear	LYear	1985	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Passenger Cars	Gasoline <1,4 l	PRE ECE	0	1969	6907	5043	5026	4950	4679	4510	4050	3625	3339	3054	2747
Passenger Cars	Gasoline <1,4 l	ECE 15/00-01	1970	1978	11968	9137	9327	9478	9117	8947	8066	7255	6696	6094	5471
Passenger Cars	Gasoline <1,4 l	ECE 15/02	1979	1980	15850	12204	12142	11974	11354	11114	10033	9045	8392	7711	7039
Passenger Cars	Gasoline <1,4 l	ECE 15/03	1981	1985	18179	15219	15478	15584	14975	14720	13316	12044	11235	10415	9514
Passenger Cars	Gasoline <1,4 l	ECE 15/04	1986	1990		19323	21341	20854	19640	19212	17350	15653	14556	13449	12243
Passenger Cars	Gasoline <1,4 l	Euro I	1991	1996			13096	20237	22145	22169	22091	21178	21989	20253	18402
Passenger Cars	Gasoline <1,4 l	Euro II	1997	2000									13680	19685	20308
Passenger Cars	Gasoline <1,4 l	Euro III	2001	2005											
Passenger Cars	Gasoline <1,4 l	Euro IV	2006	2010											
Passenger Cars	Gasoline 1,4 - 2,0 l	PRE ECE	0	1969	8172	6123	6124	6108	5833	5622	5042	4506	4142	3783	3396
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/00-01	1970	1978	14483	10984	11174	11359	10900	10716	9667	8703	8046	7336	6599
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/02	1979	1980	19318	14872	14796	14633	13850	13560	12245	11045	10250	9423	8597
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/03	1981	1985	21865	18617	18862	18978	18232	17905	16193	14643	13653	12640	11528
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/04	1986	1990		23276	26553	25869	24262	23731	21429	19332	17974	16600	15108
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro I	1991	1996			16068	24258	26466	26596	26680	25610	27384	25212	22891
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro II	1997	2000									16692	23292	25175
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro III	2001	2005											
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro IV	2006	2010											
Passenger Cars	Gasoline >2,0 l	PRE ECE	0	1969	9819	7341	7282	7174	6790	6622	5947	5324	4906	4494	4048
Passenger Cars	Gasoline >2,0 l	ECE 15/00-01	1970	1978	16756	12973	13275	13434	13043	12744	11488	10349	9573	8824	7995
Passenger Cars	Gasoline >2,0 l	ECE 15/02	1979	1980	24176	18448	18271	18062	17294	16929	15298	13790	12813	11805	10719
Passenger Cars	Gasoline >2,0 l	ECE 15/03	1981	1985	27345	23861	23772	23416	22198	21735	19605	17677	16447	15178	13812
Passenger Cars	Gasoline >2,0 l	ECE 15/04	1986	1990		28892	34037	33006	30993	30349	27364	24628	22878	21130	19226
Passenger Cars	Gasoline >2,0 l	Euro I	1991	1996			20267	30098	32800	33759	32656	31714	33886	31144	28248
Passenger Cars	Gasoline >2,0 l	Euro II	1997	2000									20682	28448	29808
Passenger Cars	Gasoline >2,0 l	Euro III	2001	2005											
Passenger Cars	Gasoline >2,0 l	Euro IV	2006	2010											
Passenger Cars	Diesel <2,0 l	Conventional	0	1990	29011	34689	35526	33499	32324	33027	30452	28522	26903	24831	22984
Passenger Cars	Diesel <2,0 l	Euro I	1991	1996			58705	75310	68926	59883	55674	53640	53892	45454	39745
Passenger Cars	Diesel <2,0 l	Euro II	1997	2000									36205	45397	43665
Passenger Cars	Diesel <2,0 l	Euro III	2001	2005											
Passenger Cars	Diesel <2,0 l	Euro IV	2006	2010											
Passenger Cars	Diesel >2,0 l	Conventional	0	1990	41740	47927	47979	41188	36786	36554	33125	30707	28615	26354	24470
Passenger Cars	Diesel >2,0 l	Euro I	1991	1996			66364	88552	85830	86568	81054	74707	73714	56528	45889

Continued															
Passenger Cars	Diesel >2,0 l	Euro II	1997	2000									57092	75623	69126
Passenger Cars	Diesel >2,0 l	Euro III	2001	2005											
Passenger Cars	Diesel >2,0 l	Euro IV	2006	2010											
Passenger Cars	LPG cars	Conventional	0	1990	19464	20345	21568	22731	23108	22963	20947	19087	17931	16544	15320
Passenger Cars	LPG cars	Euro I	1991	1996				50914	46268	45030	44086	39075	36267	33419	34913
Passenger Cars	LPG cars	Euro II	1997	2000											
Passenger Cars	LPG cars	Euro III	2001	2005											
Passenger Cars	LPG cars	Euro IV	2006	2010											
Passenger Cars	2-Stroke	Conventional	0	9999	17848	15403	15367	15207	14524	14218	12830	11561	10731	9888	8983
Passenger Cars	Electric cars	Conventional	0	9999	11674	12362	13128	13863	14135	17181	16301	14937	14412	13477	13754
Light Duty Vehicles	Gasoline <3,5t	Conventional	0	1994	17906	16929	17341	18014	18128	18991	18769	17601	16819	16116	15223
Light Duty Vehicles	Gasoline <3,5t	Euro I	1995	1998							15012	20957	21784	21913	24279
Light Duty Vehicles	Gasoline <3,5t	Euro II	1999	2001											14138
Light Duty Vehicles	Gasoline <3,5t	Euro III	2002	2006											
Light Duty Vehicles	Gasoline <3,5t	Euro IV	2007	2011											
Light Duty Vehicles	Diesel <3,5t	Conventional	0	1994	26193	28584	28610	27369	26659	27465	27145	25694	24311	22747	21465
Light Duty Vehicles	Diesel <3,5t	Euro I	1995	1998							21254	29902	31637	32234	34863
Light Duty Vehicles	Diesel <3,5t	Euro II	1999	2001											20419
Light Duty Vehicles	Diesel <3,5t	Euro III	2002	2006											
Light Duty Vehicles	Diesel <3,5t	Euro IV	2007	2011											
Light Duty Vehicles	LPG <3,5t	Conventional	0	1994	16938	16004	16392	17027	17134	17053	15936	15341	14676	13975	13056
Light Duty Vehicles	LPG <3,5t	Euro I	1995	1998										18616	34065
Light Duty Vehicles	LPG <3,5t	Euro II	1999	2001											
Light Duty Vehicles	LPG <3,5t	Euro III	2002	2006											
Light Duty Vehicles	LPG <3,5t	Euro IV	2007	2011											
Light Duty Vehicles	Electric <3,5t	Conventional	0	9999	8358	7906	8099	8414	8467	8721	6946	6326	8444	7860	7192
Heavy Duty Vehicles	Gasoline >3,5t	Conventional	0	9999	21185	19218	20687	21192	19552	18714	18826	17889	16872	15945	16019
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Conventional	0	1993	28489	27516	29674	26423	22217	21568	23078	21294	19711	18515	16946
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Euro I	1994	1996					18543	21249	30004	31328	33438	31008	28133
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Euro II	1997	2001								19896	22230	26001	28933
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Euro III	2002	2006											
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Euro IV	2007	2009											
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Euro V	2010	2014											
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Conventional	0	1993	31961	30806	33214	29580	24874	24239	26079	24008	22252	20992	19211
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Euro I	1994	1996					21299	24364	33019	35847	38609	35795	32401
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Euro II	1997	2001								22851	26526	32326	32922
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Euro III	2002	2006											

Continued															
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Euro IV	2007	2009											
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Euro V	2010	2014											
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Conventional	0	1993	25877	28475	30802	29330	24928	27370	27560	22693	21569	21360	23180
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Euro I	1994	1996					20135	27131	37510	34109	36256	35361	37717
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Euro II	1997	2001								21162	24109	33196	42058
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Euro III	2002	2006											
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Euro IV	2007	2009											
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Euro V	2010	2014											
Heavy Duty Vehicles	Diesel RT 14 - 20t	Conventional	0	1993	43123	47463	51343	48889	41597	46256	46862	38626	36833	36540	39384
Heavy Duty Vehicles	Diesel RT 14 - 20t	Euro I	1994	1996					32702	42814	55395	53902	59953	58503	62305
Heavy Duty Vehicles	Diesel RT 14 - 20t	Euro II	1997	2001								34370	39917	53206	62992
Heavy Duty Vehicles	Diesel RT 14 - 20t	Euro III	2002	2006											
Heavy Duty Vehicles	Diesel RT 14 - 20t	Euro IV	2007	2009											
Heavy Duty Vehicles	Diesel RT 14 - 20t	Euro V	2010	2014											
Heavy Duty Vehicles	Diesel RT 20 - 26t	Conventional	0	1993	68020	74853	70503	74452	71279	70963	69361	67502	59893	59066	52034
Heavy Duty Vehicles	Diesel RT 20 - 26t	Euro I	1994	1996					54333	61972	79388	90107	94480	92004	80208
Heavy Duty Vehicles	Diesel RT 20 - 26t	Euro II	1997	2001								58025	63576	82755	81264
Heavy Duty Vehicles	Diesel RT 20 - 26t	Euro III	2002	2006											
Heavy Duty Vehicles	Diesel RT 20 - 26t	Euro IV	2007	2009											
Heavy Duty Vehicles	Diesel RT 20 - 26t	Euro V	2010	2014											
Heavy Duty Vehicles	Diesel RT 26 - 28t	Conventional	0	1993	69652	76490	72488	76202	73014	75843	73940	73891	64235	62130	53609
Heavy Duty Vehicles	Diesel RT 26 - 28t	Euro I	1994	1996							104447	80548	100483	96533	83881
Heavy Duty Vehicles	Diesel RT 26 - 28t	Euro II	1997	2001								60568	72633	74350	84741
Heavy Duty Vehicles	Diesel RT 26 - 28t	Euro III	2002	2006											
Heavy Duty Vehicles	Diesel RT 26 - 28t	Euro IV	2007	2009											
Heavy Duty Vehicles	Diesel RT 26 - 28t	Euro V	2010	2014											
Heavy Duty Vehicles	Diesel RT 28 - 32t	Conventional	0	1993	77080	84647	80218	84328	81593	83975	80793	77637	68838	68165	60141
Heavy Duty Vehicles	Diesel RT 28 - 32t	Euro I	1994	1996					58007	67906	80845	92147	98676	95441	82968
Heavy Duty Vehicles	Diesel RT 28 - 32t	Euro II	1997	2001								60568	65681	83341	81390
Heavy Duty Vehicles	Diesel RT 28 - 32t	Euro III	2002	2006											
Heavy Duty Vehicles	Diesel RT 28 - 32t	Euro IV	2007	2009											
Heavy Duty Vehicles	Diesel RT 28 - 32t	Euro V	2010	2014											
Heavy Duty Vehicles	Diesel RT >32t	Conventional	0	1993	56514	62062	58815	61828	59241	56136	74920	50562	43948	70726	61456
Heavy Duty Vehicles	Diesel RT >32t	Euro I	1994	1996							59737	90679	102604	99241	80050
Heavy Duty Vehicles	Diesel RT >32t	Euro II	1997	2001								60568	72981	101839	54129
Heavy Duty Vehicles	Diesel RT >32t	Euro III	2002	2006											
Heavy Duty Vehicles	Diesel RT >32t	Euro IV	2007	2009											

Continued															
Heavy Duty Vehicles	Diesel RT >32t	Euro V	2010	2014											
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Conventional	0	1993	56367	62687	68231	64989	56316	62646	63493	52517	50375	49967	53295
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Euro I	1994	1996					44090	57832	75090	72818	81104	79511	84078
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Euro II	1997	2001								46341	53919	72247	84966
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Euro III	2002	2006											
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Euro IV	2007	2009											
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Euro V	2010	2014											
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Conventional	0	1993	90452	96878	92986	89230	90636	94470	88445	89361	83697	79698	72073
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Euro I	1994	1996					63260	73977	87341	107949	124745	114681	107365
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Euro II	1997	2001								69102	84745	99437	107874
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Euro III	2002	2006											
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Euro IV	2007	2009											
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Euro V	2010	2014											
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Conventional	0	1993	179307	183696	178227	163726	167408	170494	149580	140464	131102	116618	104431
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Euro I	1994	1996					122670	140305	150612	173364	191900	167697	148315
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Euro II	1997	2001								112336	126762	144731	144062
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Euro III	2002	2006											
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Euro IV	2007	2009											
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Euro V	2010	2014											
Heavy Duty Vehicles	Diesel TT/AT 50 - 60t	Euro I	1994	1996								200011	188890	160987	146272
Heavy Duty Vehicles	Diesel TT/AT 50 - 60t	Euro II	1997	2001										98475	178948
Heavy Duty Vehicles	Diesel TT/AT 50 - 60t	Euro IV	2007	2009											
Heavy Duty Vehicles	Diesel TT/AT >60t	Euro V	2010	2014											
Buses	Gasoline Urban Buses	Conventional	0	9999	28159	27652	22943	21032	16607	24925	22599	18797	20979	20295	17881
Buses	Diesel Urban Buses <15t	Conventional	0	1993	160776	181917	147471	124484	95132	103097	95437	90536	84863	81528	72794
Buses	Diesel Urban Buses <15t	Euro I	1994	1996						81399	121211	123538	135479	127203	112832
Buses	Diesel Urban Buses <15t	Euro II	1997	2001									77522	102227	114891
Buses	Diesel Urban Buses <15t	Euro III	2002	2006											
Buses	Diesel Urban Buses <15t	Euro IV	2007	2009											
Buses	Diesel Urban Buses 15 - 18t	Conventional	0	1993	153193	173553	140699	118773	90772	98878	91592	88390	82130	78165	71412
Buses	Diesel Urban Buses 15 - 18t	Euro I	1994	1996						81399	121740	118929	135400	127434	112378
Buses	Diesel Urban Buses 15 - 18t	Euro II	1997	2001									77522	99858	115558
Buses	Diesel Urban Buses 15 - 18t	Euro III	2002	2006											
Buses	Diesel Urban Buses 15 - 18t	Euro IV	2007	2009											

Continued

Buses	Diesel Urban Buses >18t	Conventional	0	1993	195753	221769	179787	151771	115990	127646	112591	102807	101414	83892	65303
Buses	Diesel Urban Buses >18t	Euro I	1994	1996						81399	147469	98792	138888	129877	119572
Buses	Diesel Urban Buses >18t	Euro II	1997	2001										77532	92231
Buses	Diesel Urban Buses >18t	Euro III	2002	2006											
Buses	Diesel Urban Buses >18t	Euro IV	2007	2009											
Buses	Gasoline Coaches	Conventional	0	9999	17020	17278	14388	13247	12255	13317	16473	18291	17701	17003	15971
Buses	Diesel Coaches <15t	Conventional	0	1993	28681	33618	27356	23196	20774	21886	25445	29138	28175	26656	25368
Buses	Diesel Coaches <15t	Euro I	1994	1996						15520	29058	34127	40990	38089	35548
Buses	Diesel Coaches <15t	Euro II	1997	2001									23371	33700	35523
Buses	Diesel Coaches <15t	Euro III	2002	2006											
Buses	Diesel Coaches <15t	Euro IV	2007	2009											
Buses	Diesel Coaches 15 - 18t	Conventional	0	1993	38594	45259	36830	31230	27970	26208	31086	36029	34942	33063	31667
Buses	Diesel Coaches 15 - 18t	Euro I	1994	1996						25531	43047	56568	67683	62822	58714
Buses	Diesel Coaches 15 - 18t	Euro II	1997	2001									38448	57217	58225
Buses	Diesel Coaches 15 - 18t	Euro III	2002	2006											
Buses	Diesel Coaches 15 - 18t	Euro IV	2007	2009											
Buses	Diesel Coaches >18t	Conventional	0	1993	82792	97099	79016	67004	60009	58557	67805	78201	74964	70678	65934
Buses	Diesel Coaches >18t	Euro I	1994	1996						40618	68552	88070	108218	100521	93954
Buses	Diesel Coaches >18t	Euro II	1997	2001									61166	84308	87891
Buses	Diesel Coaches >18t	Euro III	2002	2006											
Buses	Diesel Coaches >18t	Euro IV	2007	2009											
Mopeds	<50 cm^3	Conventional	0	1999	2335	2213	2312	2430	2498	2549	2499	2463	2487	2510	2137
Mopeds	<50 cm^3	Euro I	2000	2003											
Mopeds	<50 cm^3	Euro II	2004	9999											
Motorcycles	2-stroke >50 cm^3	Conventional	0	1999	6703	6564	6578	6930	7126	7258	7214	6820	6522	6313	5944
Motorcycles	4-stroke <250 cm^3	Conventional	0	1999	6703	6564	6578	6930	7126	7258	7214	6820	6522	6313	5944
Motorcycles	4-stroke <250 cm^3	Euro I	2000	2003											
Motorcycles	4-stroke <250 cm^3	Euro II	2004	2006											
Motorcycles	4-stroke <250 cm^3	Euro III	2007	9999											
Motorcycles	4-stroke 250 - 750 cm^3	Conventional	0	1999	6703	6564	6578	6930	7126	7258	7214	6820	6522	6313	5944
Motorcycles	4-stroke 250 - 750 cm^3	Euro I	2000	2003											
Motorcycles	4-stroke 250 - 750 cm^3	Euro II	2004	2006											
Motorcycles	4-stroke 250 - 750 cm^3	Euro III	2007	9999											
Motorcycles	4-stroke >750 cm^3	Conventional	0	1999	6703	6564	6578	6930	7126	7258	7214	6820	6522	6313	5944
Motorcycles	4-stroke >750 cm^3	Euro I	2000	2003											
Motorcycles	4-stroke >750 cm^3	Euro II	2004	2006											
Motorcycles	4-stroke >750 cm^3	Euro III	2007	9999											

Sector	Subsector	Tech 2	FYear	LYear	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Passenger Cars	Gasoline <1,4 l	PRE ECE	0	1969	2747	2508	2308	2206	2090	1973	1771	1613	1507	1381	1253
Passenger Cars	Gasoline <1,4 l	ECE 15/00-01	1970	1978	5471	4961	4521	4262	3989	3700	3271	2921	2690	2426	2183
Passenger Cars	Gasoline <1,4 l	ECE 15/02	1979	1980	7039	6473	5981	5707	5425	5104	4580	4151	3879	3548	3224
Passenger Cars	Gasoline <1,4 l	ECE 15/03	1981	1985	9514	8803	8151	7828	7420	7006	6266	5693	5302	4867	4412
Passenger Cars	Gasoline <1,4 l	ECE 15/04	1986	1990	12243	11311	10483	10099	9625	9146	8245	7523	7051	6484	5908
Passenger Cars	Gasoline <1,4 l	Euro I	1991	1996	18402	16935	15653	15004	14254	13464	12103	11030	10353	9538	8728
Passenger Cars	Gasoline <1,4 l	Euro II	1997	2000	20308	20524	21381	20475	19421	18335	16437	14932	13949	12779	11605
Passenger Cars	Gasoline <1,4 l	Euro III	2001	2005			12721	18243	20383	20163	19063	20966	19575	17930	16273
Passenger Cars	Gasoline <1,4 l	Euro IV	2006	2010								12435	18035	18618	18574
Passenger Cars	Gasoline 1,4 - 2,0 l	PRE ECE	0	1969	3396	3096	2846	2719	2575	2432	2185	1990	1864	1710	1553
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/00-01	1970	1978	6599	5998	5479	5176	4851	4509	3979	3550	3262	2933	2639
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/02	1979	1980	8597	7909	7310	6985	6640	6254	5612	5091	4758	4352	3956
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/03	1981	1985	11528	10654	9858	9466	8972	8472	7578	6885	6412	5876	5323
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/04	1986	1990	15108	13948	12926	12450	11866	11269	10156	9257	8665	7951	7233
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro I	1991	1996	22891	21062	19466	18653	17711	16726	15025	13684	12828	11798	10774
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro II	1997	2000	25175	25429	26034	24922	23634	22309	20002	18171	16964	15545	14120
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro III	2001	2005			15584	22459	25515	25407	24109	25057	23273	21331	19381
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro IV	2006	2010								15234	22188	23974	23613
Passenger Cars	Gasoline >2,0 l	PRE ECE	0	1969	4048	3681	3393	3255	3096	2941	2666	2458	2321	2141	1949
Passenger Cars	Gasoline >2,0 l	ECE 15/00-01	1970	1978	7995	7349	6808	6488	6122	5767	5072	4423	3968	3538	3174
Passenger Cars	Gasoline >2,0 l	ECE 15/02	1979	1980	10719	9886	9151	8763	8332	7851	7024	6366	5925	5410	4915
Passenger Cars	Gasoline >2,0 l	ECE 15/03	1981	1985	13812	12722	11770	11280	10707	10116	9072	8230	7676	7014	6360
Passenger Cars	Gasoline >2,0 l	ECE 15/04	1986	1990	19226	17731	16405	15739	14961	14156	12721	11574	10816	9916	9015
Passenger Cars	Gasoline >2,0 l	Euro I	1991	1996	28248	25969	23960	22908	21710	20509	18405	16728	15615	14301	12991
Passenger Cars	Gasoline >2,0 l	Euro II	1997	2000	29808	30484	32802	31384	29749	28083	25183	22869	21222	19458	17674
Passenger Cars	Gasoline >2,0 l	Euro III	2001	2005			19295	27607	30706	30611	29412	31355	28981	26568	24157
Passenger Cars	Gasoline >2,0 l	Euro IV	2006	2010								18820	27581	29879	29664
Passenger Cars	Diesel <2,0 l	Conventional	0	1990	22984	20413	18555	17390	17181	16617	14973	13554	12722	11207	9841
Passenger Cars	Diesel <2,0 l	Euro I	1991	1996	39745	34340	30595	28254	27539	26366	23619	21295	19869	17354	15089
Passenger Cars	Diesel <2,0 l	Euro II	1997	2000	43665	42519	46889	42625	41323	39699	35609	32143	29276	25588	22193
Passenger Cars	Diesel <2,0 l	Euro III	2001	2005			27291	36640	42493	43100	41210	44239	39807	34780	30202
Passenger Cars	Diesel <2,0 l	Euro IV	2006	2010								26589	34964	35682	35554
Passenger Cars	Diesel >2,0 l	Conventional	0	1990	24470	21664	19592	18431	18260	17829	16157	14671	13649	11926	10314
Passenger Cars	Diesel >2,0 l	Euro I	1991	1996	45889	38625	34189	31506	30675	29398	26321	23743	22169	19313	16694
Passenger Cars	Diesel >2,0 l	Euro II	1997	2000	69126	62306	62300	50218	44733	41577	36785	32952	29888	26016	22503
Passenger Cars	Diesel >2,0 l	Euro III	2001	2005			41466	56508	61814	58099	53205	53089	42785	35851	30811
Passenger Cars	Diesel >2,0 l	Euro IV	2006	2010								35507	47027	49665	44936

Continued

Passenger Cars	LPG cars	Conventional	0	1990	15320	14866	14422	13285	11658	11539	10337	9384	8024	6750	5934
Passenger Cars	LPG cars	Euro I	1991	1996	34913	28799	29589	27081	26832	27566	24709	21526	19252	17628	15994
Passenger Cars	LPG cars	Euro II	1997	2000				31455	33289	27200	24121	21713			18936
Passenger Cars	LPG cars	Euro III	2001	2005									28390	25717	27475
Passenger Cars	LPG cars	Euro IV	2006	2010											23424
Passenger Cars	2-Stroke	Conventional	0	9999	8983	8258	7623	7303	6929	6541					
Passenger Cars	Electric cars	Conventional	0	9999	13754	13359	13003	12725	12090	11361	10275	9463	9006	8918	9285
Light Duty Vehicles	Gasoline <3,5t	Conventional	0	1994	15223	14636	14079	13500	12822	11941	10679	9634	8959	8265	7575
Light Duty Vehicles	Gasoline <3,5t	Euro I	1995	1998	24279	22857	21458	20231	18958	17534	15569	14030	13102	12280	11476
Light Duty Vehicles	Gasoline <3,5t	Euro II	1999	2001	14138	20924	21951	25211	23599	21798	19327	17406	16229	15197	14174
Light Duty Vehicles	Gasoline <3,5t	Euro III	2002	2006				14417	20347	20918	20541	20359	21701	20334	18950
Light Duty Vehicles	Gasoline <3,5t	Euro IV	2007	2011									13013	22320	22316
Light Duty Vehicles	Diesel <3,5t	Conventional	0	1994	21465	19584	18243	16981	16697	15920	14286	12811	11990	10680	9492
Light Duty Vehicles	Diesel <3,5t	Euro I	1995	1998	34863	31247	28518	26174	25416	24038	21412	19209	17984	16041	14268
Light Duty Vehicles	Diesel <3,5t	Euro II	1999	2001	20419	27851	29308	32873	31896	30141	26794	24024	22470	20038	17787
Light Duty Vehicles	Diesel <3,5t	Euro III	2002	2006				18744	27845	28927	28021	27155	30323	27096	24061
Light Duty Vehicles	Diesel <3,5t	Euro IV	2007	2011									17908	26542	27222
Light Duty Vehicles	LPG <3,5t	Conventional	0	1994	13056	12728	12258	11299	10099	8366	6532	6312	5536	4387	4201
Light Duty Vehicles	LPG <3,5t	Euro I	1995	1998	34065	32069	30119								
Light Duty Vehicles	LPG <3,5t	Euro II	1999	2001		18341				30037	25519	23977	22403	20975	18732
Light Duty Vehicles	LPG <3,5t	Euro III	2002	2006								24719	27787	26732	25224
Light Duty Vehicles	LPG <3,5t	Euro IV	2007	2011									16765	26525	30280
Light Duty Vehicles	Electric <3,5t	Conventional	0	9999	7192	6770								9275	8787
Heavy Duty Vehicles	Gasoline >3,5t	Conventional	0	9999	16019	15493	16676	17806	16919	16518	14653	15671	17689	16019	14957
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Conventional	0	1993	16946	16153	16989	15554	15174	15045	11466	10078	9612	7771	6040
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Euro I	1994	1996	28133	26535	27670	25270	24653	24420	18721	16791	16297	13484	10784
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Euro II	1997	2001	28933	30173	33976	32474	31683	31361	24133	21676	20953	17649	14125
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Euro III	2002	2006			20988	26565	32250	35054	28231	27689	28887	24013	19227
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Euro IV	2007	2009								17575	20478	22672	22594
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Euro V	2010	2014									18145	21620	16183
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Conventional	0	1993	19211	18423	19271	17738	17318	17223	13049	11550	10970	8863	7110
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Euro I	1994	1996	32401	30753	31801	29193	28211	28040	21302	19089	18427	15361	12723
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Euro II	1997	2001	32922	34378	38552	37442	36459	36375	27765	24933	24097	20575	17052
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Euro III	2002	2006			24498	31333	38240	40030	32128	31075	33068	28004	23326
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Euro IV	2007	2009			23979	43961	37542	37294	25898	20599	24897	27003	28163
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Euro V	2010	2014					37206	36959	28085	22668	21305	22281	23758
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Conventional	0	1993	23180	17709	17743	16172	15830	15326	13791	12346	11754	9723	7609

Continued															
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Euro I	1994	1996	37717	28471	28400	25660	25163	24249	21873	19696	18690	15540	12253
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Euro II	1997	2001	42058	33239	35046	32043	31499	30428	27607	24972	23909	20175	15805
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Euro III	2002	2006			22052	27914	34134	34579	32312	32899	34142	28620	22578
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Euro IV	2007	2009						37505	33839	25324	22896	26712	25936
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Euro V	2010	2014										19230	26178
Heavy Duty Vehicles	Diesel RT 14 - 20t	Conventional	0	1993	39384	29954	29942	27217	26890	25963	23558	21080	19988	16510	12869
Heavy Duty Vehicles	Diesel RT 14 - 20t	Euro I	1994	1996	62305	46987	46696	42342	41766	40384	36436	32750	31223	25877	20380
Heavy Duty Vehicles	Diesel RT 14 - 20t	Euro II	1997	2001	62992	52561	57348	54322	53522	51752	46827	42199	40418	34116	26940
Heavy Duty Vehicles	Diesel RT 14 - 20t	Euro III	2002	2006			36816	47376	54021	58042	55288	53433	56311	47025	37105
Heavy Duty Vehicles	Diesel RT 14 - 20t	Euro IV	2007	2009			35496	55294	56391	62520	47694	38317	41350	47116	44909
Heavy Duty Vehicles	Diesel RT 14 - 20t	Euro V	2010	2014							35955	39286	40909	41332	39078
Heavy Duty Vehicles	Diesel RT 20 - 26t	Conventional	0	1993	52034	48784	42643	39593	39050	37481	33324	29756	28873	23604	18829
Heavy Duty Vehicles	Diesel RT 20 - 26t	Euro I	1994	1996	80208	74190	64232	59346	58498	55750	49488	44263	43129	35448	28621
Heavy Duty Vehicles	Diesel RT 20 - 26t	Euro II	1997	2001	81264	83315	78717	75696	74690	71344	63391	56807	55509	46407	37555
Heavy Duty Vehicles	Diesel RT 20 - 26t	Euro III	2002	2006			50076	63427	76848	79855	74740	72241	79086	65449	53105
Heavy Duty Vehicles	Diesel RT 20 - 26t	Euro IV	2007	2009			48983	84353	88921	79153	51634	56409	57100	64341	62710
Heavy Duty Vehicles	Diesel RT 20 - 26t	Euro V	2010	2014							49022	59839	57144	57196	54311
Heavy Duty Vehicles	Diesel RT 26 - 28t	Conventional	0	1993	53609	50997	43580	41765	39906	37863	34287	29658	28641	23599	18292
Heavy Duty Vehicles	Diesel RT 26 - 28t	Euro I	1994	1996	83881	76507	64409	60665	58979	54944	53762	46227	44643	36492	31114
Heavy Duty Vehicles	Diesel RT 26 - 28t	Euro II	1997	2001	84741	91344	79662	74674	72598	69481	63108	54264	52064	44479	34695
Heavy Duty Vehicles	Diesel RT 26 - 28t	Euro III	2002	2006					52319	64639	86216	83003	80157	65522	53315
Heavy Duty Vehicles	Diesel RT 26 - 28t	Euro IV	2007	2009									48987	71594	67431
Heavy Duty Vehicles	Diesel RT 26 - 28t	Euro V	2010	2014									48987	80087	65166
Heavy Duty Vehicles	Diesel RT 28 - 32t	Conventional	0	1993	60141	55679	48588	45446	43906	42120	38430	33582	31783	26181	20948
Heavy Duty Vehicles	Diesel RT 28 - 32t	Euro I	1994	1996	82968	75768	65876	62280	60792	57511	52159	44818	43114	35113	28729
Heavy Duty Vehicles	Diesel RT 28 - 32t	Euro II	1997	2001	81390	80921	80349	81290	79404	75568	68757	59408	57589	48115	39423
Heavy Duty Vehicles	Diesel RT 28 - 32t	Euro III	2002	2006			50491	67114	77491	81130	77643	71417	80573	66822	54663
Heavy Duty Vehicles	Diesel RT 28 - 32t	Euro IV	2007	2009				50317	67491	97129	53964	59067	57411	64566	63325
Heavy Duty Vehicles	Diesel RT 28 - 32t	Euro V	2010	2014								47429	54934	57646	55456
Heavy Duty Vehicles	Diesel RT >32t	Conventional	0	1993	61456	56930	52272	49233	29506	28060	25562	20218	19525	15960	
Heavy Duty Vehicles	Diesel RT >32t	Euro I	1994	1996	80050	70560	62408	63010	61258	58122	52791	45392	43836	35833	29157
Heavy Duty Vehicles	Diesel RT >32t	Euro II	1997	2001	54129	68116	90370	87977							
Heavy Duty Vehicles	Diesel RT >32t	Euro III	2002	2006			49949	94093	80937	85041	71024	64141	65351	57129	58102
Heavy Duty Vehicles	Diesel RT >32t	Euro IV	2007	2009									48987	80087	65166
Heavy Duty Vehicles	Diesel RT >32t	Euro V	2010	2014											65166
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Conventional	0	1993	53295	38922	32473	29422	29713	30166	27179	26616	26748	24973	16784
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Euro I	1994	1996	84078	60543	50244	45450	45881	46687	41913	41040	41616	39171	26799

Continued

Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Euro II	1997	2001	84966	67786	61810	58394	58854	59841	53827	52537	53512	51220	35156
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Euro III	2002	2006			39585	50819	59298	67034	63515	66578	74674	70642	48414
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Euro IV	2007	2009			38166	59313	61899	72154	54666	47802	54884	70940	58707
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Euro V	2010	2014							41211	48818	54042	62039	51085
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Conventional	0	1993	72073	64558	48148	43681	44268	44431	40409	40900	41052	40311	28023
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Euro I	1994	1996	107365	95799	72582	65656	66419	66426	60475	60901	61035	58983	40743
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Euro II	1997	2001	107874	104806	90497	85887	87511	87889	81043	82961	81406	80188	55173
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Euro III	2002	2006			60313	75055	89898	98531	98018	113777	123585	123680	85543
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Euro IV	2007	2009			54704	82664	104198	82680	70426	83526	85356	118021	98205
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Euro V	2010	2014			56776	103364	105168		65024	87663	91138	122131	99175
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Conventional	0	1993	104431	101476	114926	102603	94962	85488	75662	67070	59053	48131	46129
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Euro I	1994	1996	148315	142311	161568	144626	134519	121881	108658	96350	86720	71181	71682
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Euro II	1997	2001	144062	151404	198320	190450	178242	162017	145438	128386	114063	93609	93015
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Euro III	2002	2006			126193	152220	171833	171463	166125	162178	165279	138141	140174
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Euro IV	2007	2009			123985	140693	195700	197102	111866	121519	111377	130173	161836
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Euro V	2010	2014			123985	170490	214023	195058	171983	106655	108526	125989	150541
Heavy Duty Vehicles	Diesel TT/AT 50 - 60t	Euro I	1994	1996	146272	140321	165680	148443	138194	125949	114909				
Heavy Duty Vehicles	Diesel TT/AT 50 - 60t	Euro II	1997	2001	178948	171668	202691	181603	169066	154085	140579	126501	111773	94269	96292
Heavy Duty Vehicles	Diesel TT/AT 50 - 60t	Euro IV	2007	2009									102330	172609	176313
Heavy Duty Vehicles	Diesel TT/AT >60t	Euro V	2010	2014										92304	130083
Buses	Gasoline Urban Buses	Conventional	0	9999	17881	15823	15743	15595	15006	13286	18347	18359	34570	31935	34782
Buses	Diesel Urban Buses <15t	Conventional	0	1993	72794	66146	60826	57543	55307	52192	48496	44291	41096	38348	32610
Buses	Diesel Urban Buses <15t	Euro I	1994	1996	112832	101749	92253	86054	82570	78273	71818	66943	63750	57120	49227
Buses	Diesel Urban Buses <15t	Euro II	1997	2001	114891	113814	110138	107090	103339	98231	89952	84302	80381	71816	63223
Buses	Diesel Urban Buses <15t	Euro III	2002	2006				67351	90904	107019	104611	106855	115870	103738	88843
Buses	Diesel Urban Buses <15t	Euro IV	2007	2009									70060	92204	92610
Buses	Diesel Urban Buses 15 - 18t	Conventional	0	1993	71412	65164	59597	56622	54814	52082	47901	45699	43693	39704	34659
Buses	Diesel Urban Buses 15 - 18t	Euro I	1994	1996	112378	100729	90853	84448	80724	76708	70404	66159	63196	56534	48811
Buses	Diesel Urban Buses 15 - 18t	Euro II	1997	2001	115558	110687	108855	109189	104975	99787	91374	85628	81892	73730	63603
Buses	Diesel Urban Buses 15 - 18t	Euro III	2002	2006				67351	107300	112453	108690	102169	114521	102938	88672
Buses	Diesel Urban Buses 15 - 18t	Euro IV	2007	2009									70060	86788	88600
Buses	Diesel Urban Buses >18t	Conventional	0	1993	65303	76734	70006	66212	63926	60217	56266	53110	49067	46046	36574
Buses	Diesel Urban Buses >18t	Euro I	1994	1996	119572	97997	89234	85077	81698	77586	71230	66673	65034	53661	45872
Buses	Diesel Urban Buses >18t	Euro II	1997	2001	92231	87827	98878	118634	113907	107934	99049	92507	88522	79220	68713

Continued															
Buses	Diesel Urban Buses >18t	Euro III	2002	2006				67351	104529	107817	112631	108029	111653	100667	86922
Buses	Diesel Urban Buses >18t	Euro IV	2007	2009									70060	96699	98283
Buses	Gasoline Coaches	Conventional	0	9999	15971	15352	14868	14682	14149	13766	12926	12319	12174	11966	11288
Buses	Diesel Coaches <15t	Conventional	0	1993	25368	23169	21846	20959	20959	20726	19195	18144	17813	16610	14778
Buses	Diesel Coaches <15t	Euro I	1994	1996	35548	32129	29743	28216	27895	27396	25265	23752	23240	21691	19341
Buses	Diesel Coaches <15t	Euro II	1997	2001	35523	35631	35048	36620	36063	35348	32646	30780	30214	28259	25223
Buses	Diesel Coaches <15t	Euro III	2002	2006				22561	35324	38161	38371	38544	42168	39304	35027
Buses	Diesel Coaches <15t	Euro IV	2007	2009									25744	35854	36765
Buses	Diesel Coaches 15 - 18t	Conventional	0	1993	31667	29443	27570	26749	26784	26555	25037	23851	23664	22357	20308
Buses	Diesel Coaches 15 - 18t	Euro I	1994	1996	58714	53172	49088	46384	45870	44966	41451	38812	37965	35286	31526
Buses	Diesel Coaches 15 - 18t	Euro II	1997	2001	58225	57318	58475	60333	59741	58474	53620	50232	49157	45992	40988
Buses	Diesel Coaches 15 - 18t	Euro III	2002	2006				37115	53241	67461	65797	63728	67781	62845	55764
Buses	Diesel Coaches 15 - 18t	Euro IV	2007	2009									42351	53830	59674
Buses	Diesel Coaches >18t	Conventional	0	1993	65934	60505	56275	53918	53742	53378	49253	46460	45915	43254	38132
Buses	Diesel Coaches >18t	Euro I	1994	1996	93954	84867	78697	75015	73828	72136	66165	62616	61049	57094	50839
Buses	Diesel Coaches >18t	Euro II	1997	2001	87891	91117	90487	98678	97645	95875	87814	81921	79821	74718	67123
Buses	Diesel Coaches >18t	Euro III	2002	2006				59047	81754	98907	98849	102820	110819	103359	92172
Buses	Diesel Coaches >18t	Euro IV	2007	2009									67375	97429	102033
Mopeds	<50 cm³	Conventional	0	1999	2137	1942	1555	1584	1593	1579	1563	1571	1604	1624	1619
Mopeds	<50 cm³	Euro I	2000	2003		1942	1555	1584	1593	1579	1563	1571	1604	1624	1619
Mopeds	<50 cm³	Euro II	2004	9999						1579	1563	1571	1604	1624	1619
Motorcycles	2-stroke >50 cm³	Conventional	0	1999	5944	5738	5503	5340	5087	4776	4450	4203	4008	3770	3481
Motorcycles	4-stroke <250 cm³	Conventional	0	1999	5944	5738	5503	5340	5087	4776	4450	4203	4008	3770	3481
Motorcycles	4-stroke <250 cm³	Euro I	2000	2003		5738	5503	5340	5087	4776	4450	4203	4008	3770	3481
Motorcycles	4-stroke <250 cm³	Euro II	2004	2006						4776	4450	4203	4008	3770	3481
Motorcycles	4-stroke <250 cm³	Euro III	2007	9999									4008	3770	3481
Motorcycles	4-stroke 250 - 750 cm³	Conventional	0	1999	5944	5738	5503	5340	5087	4776	4450	4203	4008	3770	3481
Motorcycles	4-stroke 250 - 750 cm³	Euro I	2000	2003		5738	5503	5340	5087	4776	4450	4203	4008	3770	3481
Motorcycles	4-stroke 250 - 750 cm³	Euro II	2004	2006						4776	4450	4203	4008	3770	3481
Motorcycles	4-stroke 250 - 750 cm³	Euro III	2007	9999									4008	3770	3481
Motorcycles	4-stroke >750 cm³	Conventional	0	1999	5944	5738	5503	5340	5087	4776	4450	4203	4008	3770	3481
Motorcycles	4-stroke >750 cm³	Euro I	2000	2003		5738	5503	5340	5087	4776	4450	4203	4008	3770	3481
Motorcycles	4-stroke >750 cm³	Euro II	2004	2006						4776	4450	4203	4008	3770	3481
Motorcycles	4-stroke >750 cm³	Euro III	2007	9999									4008	3770	3481

Annex 2B-3: EU directive emission limits for road transportation vehicles

Private cars and light duty vehicles I (<1305 kg).

G prkm		EURO 1	EURO 2	EURO 3[1)]	EURO 4	EURO 5	EURO 6
Normal temp.							
CO	Gasoline	2.72	2.2	2.3	1.0	1.0	1.0
	Diesel	2.72	1.0	0.64	0.5	0.5	0.5
HC	Gasoline	-	-	0.20	0.10	0.1	0.1
NMHC	Gasoline	-	-	-	-	0.068	0.068
NO_x	Gasoline	-	-	0.15	0.08	0.06	0.06
	Diesel	-	-	0.5	0.25	0.18	0.08
HC+NO_x	Gasoline	0.97	0.5	-	-		-
	Diesel	0.97	0.7/0.9[2)]	0.56	0.30	0.23	0.17
Particulates	Diesel	0.14	0.08/0.10[2)]	0.05	0.025	0.005	0.005
Low temp.							
CO	Gasoline	-	-	-	15	15	15
HC	Gasoline	-	-	-	1.8	1.8	1.8
Evaporation							
HC[3)]	Gasoline	2.0	2.0	2.0	2.0	2.0	2.0

1) Changed test procedure at normal temperatures (40 s warm-up phase omitted) and for evaporation measurements.

2) Less stringent emission limits for direct injection diesel engines.

3) Unit: g/test.

Light duty vehicles II (1305-1760 kg)

G pr km		EURO 1	EURO 2	EURO 3[1)]	EURO 4	EURO 5	EURO 6
Normal temp.							
CO	Gasoline	5.17	4.0	4.17	1.81	1.81	1.81
	Diesel	5.17	1.25	0.80	0.63	0.63	0.63
HC	Gasoline	-	-	0.25	0.13	0.13	0.13
NMHC	Gasoline	-	-	-	-	0.9	0.9
NO_x	Gasoline	-	-	0.18	0.10	0.75	0.75
	Diesel	-	-	0.65	0.33	0.235	0.105
HC+NO_x	Gasoline	1.4	0.6	-	-	-	-
	Diesel	1.4	1.0/1.3[2)]	0.72	0.39	0.295	0.195
Particulates	Gasoline					0.005	0.005
	Diesel	0.19	0.12/0.14[2)]	0.07	0.04	0.005	0.005
Low temp.							
CO	Gasoline	-	-	-	24	24	24
HC	Gasoline	-	-		2.7	2.7	2.7
Evaporation							
HC[3)]	Gasoline	2.0	2.0	2.0	2.0	2.0	2.0

1) Changed test procedure at normal temperatures (40 s warm-up phase omitted) and for evaporation measurements

2) Less stringent emission limits for direct injection diesel engines

3) Unit: g/test

Light duty vehicles III (>1760 kg)

G pr km		EURO 1	EURO 2	EURO 3[1)]	EURO 4	EURO 5	EURO 6
Normal temp.							
CO	Gasoline	6.9	5.0	5.22	2.27	2.27	2.27
	Diesel	6.9	1.5	0.95	0.74	0.74	0.74
HC	Gasoline	-	-	0.29	0.16	0.16	0.16
NMHC	Gasoline					0.108	0.108
NO_x	Gasoline	-	-	0.21	0.11	0.082	0.082
	Diesel	-	-	0.78	0.39	0.28	0.125
HC+NO_x	Gasoline	1.7	0.7	-	-	-	-
	Diesel	1.7	1.2/1.6[2)]	0.86	0.46	0.35	0.215
Particulates	Gasoline					0.005	0.005
	Diesel	0.25	0.17/0.20[2)]	0.10	0.06	0.005	0.005
Low temp.							
CO	Gasoline	-	-	-	30	30	30
HC	Gasoline	-	-	-	3.2	3.2	3.2
Evaporation							
HC[3)]	Gasoline	2.0	2.0	2.0	2.0	2.0	2.0

1) Changed test procedure at normal temperatures (40 s warm-up phase omitted) and for evaporation measurements

2) Less stringent emission limits for direct injection diesel engines

3) Unit: g/test

Heavy duty diesel vehicles

(g pr kWh)		EURO 1	EURO 2	EURO 3	EURO 4	EURO 5	EEV[2)]
	Test[1)]	1993	1996	2001	2006	2009	2000
CO	ECE/ESC	4.5	4.0	2.1	1.5	1.5	1.5
	ETC	-	-	(5.45)	4.0	4.0	3.0
HC	ECE/ESC	1.1	1.1	0.66	0.46	0.46	0.25
	ETC	-	-	(0.78)	0.55	0.55	0.40
NO_x	ECE/ESC	8.0	7.0	5.0	3.5	2.0	2.0
	ETC	-	-	(5.0)	3.5	2.0	2.0
Particulates[3)]	ECE/ESC	0.36/0.61	0.15/0.25	0.10/0.13	0.02	0.02	0.02
	ETC	-	-	(0.16/0.21)	0.03	0.03	0.02
	ELR	-	-	0.8	0.5	0.5	0.15

1) Test procedure: Euro 1 og Euro 2: ECE (stationary)
Euro 3: ESC (stationary) + ELR (load response)
Euro 4, Euro 5 og EEV: ESC (stationary) + ETC (transient) + ELR (load response)

2) EEV: Emission limits for extra environmental friendly vehicles, used as a basis for economical incitaments (gas fueled vehicles).

3) For Euro 1, Euro 2 og Euro 3 less stringent emission limits apply for small engines:
Euro 1: <85 kW
Euro 2: <0,7 l
Euro 3: <0,75 l

Annex 2B-4: Basis emission factors (g pr km)

Sector	Subsector	Tech 2	FYear	LYear	FCu	FCr	FCh	COu	COr	COh	PMu	PMr	PMh	NOxu	NOxr	NOxh
Passenger Cars	Gasoline <1,4 l	PRE ECE	0	1969	67,499	55,000	62,743	27,505	19,333	15,520	0,063	0,044	0,041	1,849	2,062	2,023
Passenger Cars	Gasoline <1,4 l	ECE 15/00-01	1970	1978	58,240	44,460	48,600	18,966	14,480	18,620	0,063	0,044	0,041	1,849	2,062	2,023
Passenger Cars	Gasoline <1,4 l	ECE 15/02	1979	1980	53,248	45,170	51,200	15,859	8,200	8,260	0,063	0,044	0,041	1,619	2,102	2,909
Passenger Cars	Gasoline <1,4 l	ECE 15/03	1981	1985	53,248	45,170	51,200	16,752	8,793	7,620	0,042	0,029	0,029	1,680	2,253	3,276
Passenger Cars	Gasoline <1,4 l	ECE 15/04	1986	1990	51,420	43,440	47,700	9,087	4,956	4,292	0,030	0,020	0,020	1,691	2,089	2,662
Passenger Cars	Gasoline <1,4 l	Euro I	1991	1996	47,399	41,954	46,055	1,765	1,372	1,765	0,003	0,002	0,002	0,273	0,281	0,458
Passenger Cars	Gasoline <1,4 l	Euro II	1997	2000	46,486	39,509	44,016	0,659	0,575	0,749	0,003	0,002	0,002	0,154	0,154	0,181
Passenger Cars	Gasoline <1,4 l	Euro III	2001	2005	48,687	42,255	45,323	0,519	0,691	1,148	0,001	0,001	0,001	0,076	0,060	0,052
Passenger Cars	Gasoline <1,4 l	Euro IV	2006	2010	50,038	44,193	48,285	0,195	0,287	0,529	0,001	0,001	0,001	0,054	0,030	0,019
Passenger Cars	Gasoline 1,4 - 2,0 l	PRE ECE	0	1969	79,277	67,000	76,386	27,505	19,333	15,520	0,063	0,044	0,041	2,164	2,683	3,130
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/00-01	1970	1978	67,779	51,090	60,300	18,966	14,480	18,620	0,063	0,044	0,041	2,164	2,683	3,130
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/02	1979	1980	61,731	50,686	59,680	15,859	8,200	8,260	0,063	0,044	0,041	1,831	2,377	3,283
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/03	1981	1985	61,731	50,686	59,680	16,752	8,793	7,620	0,042	0,029	0,029	1,917	2,580	3,472
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/04	1986	1990	61,652	49,112	52,052	9,087	4,956	4,292	0,030	0,020	0,020	2,122	2,757	3,524
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro I	1991	1996	57,521	48,522	51,518	1,765	1,372	1,765	0,003	0,002	0,002	0,273	0,281	0,458
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro II	1997	2000	56,324	47,687	48,786	0,659	0,575	0,749	0,003	0,002	0,002	0,154	0,154	0,181
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro III	2001	2005	58,259	49,897	53,092	0,519	0,691	1,148	0,001	0,001	0,001	0,076	0,060	0,052
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro IV	2006	2010	60,486	52,793	55,293	0,195	0,287	0,529	0,001	0,001	0,001	0,054	0,030	0,019
Passenger Cars	Gasoline >2,0 l	PRE ECE	0	1969	96,536	80,000	88,267	27,505	19,333	15,520	0,063	0,044	0,041	2,860	4,090	5,500
Passenger Cars	Gasoline >2,0 l	ECE 15/00-01	1970	1978	73,798	57,090	66,300	18,966	14,480	18,620	0,063	0,044	0,041	2,860	4,090	5,500
Passenger Cars	Gasoline >2,0 l	ECE 15/02	1979	1980	75,270	63,260	70,700	15,859	8,200	8,260	0,063	0,044	0,041	2,066	2,675	3,680
Passenger Cars	Gasoline >2,0 l	ECE 15/03	1981	1985	75,270	63,260	70,700	16,752	8,793	7,620	0,042	0,029	0,029	2,806	3,441	4,604
Passenger Cars	Gasoline >2,0 l	ECE 15/04	1986	1990	71,055	58,080	69,900	9,087	4,956	4,292	0,030	0,020	0,020	2,293	2,750	3,687
Passenger Cars	Gasoline >2,0 l	Euro I	1991	1996	74,616	61,902	65,020	1,765	1,372	1,765	0,003	0,002	0,002	0,273	0,281	0,458
Passenger Cars	Gasoline >2,0 l	Euro II	1997	2000	76,837	65,226	66,732	0,659	0,575	0,749	0,003	0,002	0,002	0,154	0,154	0,181
Passenger Cars	Gasoline >2,0 l	Euro III	2001	2005	70,798	57,424	56,826	0,519	0,691	1,148	0,001	0,001	0,001	0,076	0,060	0,052
Passenger Cars	Gasoline >2,0 l	Euro IV	2006	2010	86,099	67,877	65,859	0,195	0,287	0,529	0,001	0,001	0,001	0,054	0,030	0,019
Passenger Cars	Diesel <2,0 l	Conventional	0	1990	57,529	41,209	50,089	0,651	0,472	0,384	0,199	0,132	0,170	0,520	0,433	0,528
Passenger Cars	Diesel <2,0 l	Euro I	1991	1996	47,836	42,807	48,388	0,419	0,215	0,208	0,057	0,062	0,107	0,603	0,562	0,663
Passenger Cars	Diesel <2,0 l	Euro II	1997	2000	50,442	44,117	48,779	0,343	0,110	0,035	0,047	0,039	0,050	0,651	0,555	0,665
Passenger Cars	Diesel <2,0 l	Euro III	2001	2005	48,920	43,427	45,585	0,099	0,041	0,012	0,029	0,030	0,045	0,716	0,665	0,750
Passenger Cars	Diesel <2,0 l	Euro IV	2006	2010	48,920	43,427	45,585	0,083	0,034	0,021	0,029	0,024	0,026	0,539	0,424	0,576
Passenger Cars	Diesel >2,0 l	Conventional	0	1990	57,529	41,209	50,089	0,651	0,472	0,384	0,199	0,132	0,170	0,824	0,723	0,861
Passenger Cars	Diesel >2,0 l	Euro I	1991	1996	65,267	58,299	64,360	0,419	0,215	0,208	0,057	0,062	0,107	0,603	0,562	0,663

Continued

Passenger Cars	Diesel >2,0 l	Euro II	1997	2000	65,267	58,299	64,360	0,343	0,110	0,035	0,047	0,039	0,050	0,651	0,555	0,665
Passenger Cars	Diesel >2,0 l	Euro III	2001	2005	65,267	58,299	64,360	0,099	0,041	0,012	0,029	0,030	0,045	0,716	0,665	0,750
Passenger Cars	Diesel >2,0 l	Euro IV	2006	2010	65,267	58,299	64,360	0,083	0,034	0,021	0,029	0,024	0,026	0,539	0,424	0,576
Passenger Cars	LPG cars	Conventional	0	1990	59,000	45,000	54,000	2,043	2,373	9,723	0,040	0,030	0,025	2,203	2,584	2,861
Passenger Cars	LPG cars	Euro I	1991	1996	49,145	45,155	54,125	1,310	1,445	3,560	0,040	0,030	0,025	0,340	0,283	0,298
Passenger Cars	LPG cars	Euro III	2001	2005	49,145	45,155	54,125	0,733	0,809	1,993	0,040	0,030	0,025	0,082	0,068	0,071
Light Duty Vehicles	Gasoline <3,5t	Conventional	0	1994	82,270	59,883	56,470	14,925	6,075	7,389	0,040	0,040	0,040	2,671	3,118	3,387
Light Duty Vehicles	Gasoline <3,5t	Euro I	1995	1998	96,450	70,388	66,450	4,187	0,862	1,087	0,003	0,002	0,002	0,427	0,400	0,429
Light Duty Vehicles	Gasoline <3,5t	Euro II	1999	2001	96,450	70,388	66,450	2,554	0,526	0,663	0,003	0,002	0,002	0,145	0,136	0,146
Light Duty Vehicles	Gasoline <3,5t	Euro III	2002	2006	96,450	70,388	66,450	2,177	0,448	0,565	0,001	0,001	0,001	0,090	0,084	0,090
Light Duty Vehicles	Gasoline <3,5t	Euro IV	2007	2011	96,450	70,388	66,450	1,172	0,241	0,304	0,001	0,001	0,001	0,043	0,040	0,043
Light Duty Vehicles	Diesel <3,5t	Conventional	0	1994	76,718	65,934	72,142	1,124	1,009	1,060	0,285	0,303	0,322	1,673	0,843	0,834
Light Duty Vehicles	Diesel <3,5t	Euro I	1995	1998	68,860	58,185	63,660	0,393	0,328	0,423	0,070	0,066	0,090	1,138	0,975	1,022
Light Duty Vehicles	Diesel <3,5t	Euro II	1999	2001	68,860	58,185	63,660	0,393	0,328	0,423	0,070	0,066	0,090	1,138	0,975	1,022
Light Duty Vehicles	Diesel <3,5t	Euro III	2002	2006	68,860	58,185	63,660	0,322	0,269	0,347	0,047	0,044	0,061	0,740	0,634	0,664
Light Duty Vehicles	Diesel <3,5t	Euro IV	2007	2011	68,860	58,185	63,660	0,255	0,213	0,275	0,024	0,023	0,032	0,319	0,273	0,286
Light Duty Vehicles	LPG <3,5t	Conventional	0	1994	88,500	67,500	81,000	3,064	3,559	14,584	0,060	0,045	0,038	3,305	3,876	4,291
Light Duty Vehicles	LPG <3,5t	Euro II	1999	2001	73,718	67,733	81,188	1,336	1,474	3,631	0,060	0,045	0,038	0,183	0,153	0,161
Light Duty Vehicles	LPG <3,5t	Euro III	2002	2006	73,718	67,733	81,188	1,100	1,214	2,990	0,060	0,045	0,038	0,122	0,102	0,107
Light Duty Vehicles	LPG <3,5t	Euro IV	2007	2011	73,718	67,733	81,188	0,668	0,737	1,815	0,060	0,045	0,038	0,066	0,055	0,058
Heavy Duty Vehicles	Gasoline >3,5t	Conventional	0	9999	225,000	150,000	165,000	70,000	55,000	55,000	0,400	0,400	0,400	4,500	7,500	7,500
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Conventional	0	1993	126,126	110,262	121,098	2,122	1,540	1,405	0,379	0,278	0,257	4,427	4,351	4,894
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Euro I	1994	1996	101,649	94,975	107,022	0,701	0,528	0,551	0,146	0,107	0,100	3,084	3,162	3,555
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Euro II	1997	2001	95,904	91,415	103,765	0,581	0,461	0,462	0,062	0,054	0,059	3,288	3,262	3,568
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Euro III	2002	2006	102,401	96,395	107,651	0,695	0,471	0,416	0,067	0,047	0,041	2,573	2,401	2,585
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Euro IV	2007	2009	96,010	90,427	101,100	0,055	0,038	0,034	0,013	0,008	0,007	1,561	1,528	1,686
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Euro V	2010	2014	97,564	91,551	102,095	0,055	0,038	0,034	0,013	0,009	0,007	0,922	0,886	0,978
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Conventional	0	1993	185,930	153,512	158,158	2,458	1,717	1,564	0,391	0,273	0,248	8,414	7,702	8,114
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Euro I	1994	1996	159,000	135,529	144,405	1,152	0,821	0,748	0,231	0,161	0,148	4,989	4,616	4,790
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Euro II	1997	2001	151,797	131,067	140,716	0,950	0,725	0,693	0,100	0,081	0,090	5,284	4,799	4,879
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Euro III	2002	2006	160,444	137,265	146,295	1,135	0,758	0,675	0,105	0,071	0,064	4,188	3,656	3,585
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Euro IV	2007	2009	151,058	128,558	136,547	0,085	0,058	0,051	0,020	0,013	0,011	2,544	2,280	2,313
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Euro V	2010	2014	154,061	130,592	138,157	0,086	0,059	0,051	0,020	0,013	0,011	1,503	1,347	1,330
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Conventional	0	1993	203,004	165,090	167,652	2,673	1,889	1,720	0,421	0,298	0,271	9,438	8,311	8,445
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Euro I	1994	1996	174,591	145,586	151,052	1,284	0,909	0,828	0,251	0,177	0,163	5,642	4,985	4,980
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Euro II	1997	2001	167,307	140,752	146,283	1,060	0,817	0,789	0,109	0,087	0,100	6,009	5,199	5,076

Continued

Heavy Duty Vehicles	Diesel RT 12 - 14 t	Euro III	2002	2006	175,726	146,513	151,354	1,243	0,856	0,772	0,109	0,077	0,072	4,913	4,029	3,844
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Euro IV	2007	2009	165,171	137,073	141,023	0,089	0,064	0,056	0,021	0,014	0,012	2,935	2,499	2,421
Heavy Duty Vehicles	Diesel RT 14 - 20t	Conventional	0	1993	263,547	207,773	198,027	3,646	2,498	2,245	0,573	0,394	0,352	12,021	10,076	9,710
Heavy Duty Vehicles	Diesel RT 14 - 20t	Euro I	1994	1996	216,806	173,222	171,436	1,711	1,178	1,060	0,337	0,232	0,205	7,173	5,985	5,769
Heavy Duty Vehicles	Diesel RT 14 - 20t	Euro II	1997	2001	209,134	167,157	166,583	1,370	1,028	0,964	0,137	0,111	0,112	7,724	6,335	6,058
Heavy Duty Vehicles	Diesel RT 14 - 20t	Euro III	2002	2006	219,423	173,810	170,762	1,676	1,132	1,014	0,151	0,105	0,094	6,315	4,989	4,624
Heavy Duty Vehicles	Diesel RT 14 - 20t	Euro IV	2007	2009	204,908	162,692	159,703	0,123	0,084	0,073	0,030	0,020	0,017	3,734	3,017	2,858
Heavy Duty Vehicles	Diesel RT 14 - 20t	Euro V	2010	2014	208,878	165,319	161,803	0,124	0,085	0,074	0,030	0,020	0,017	2,240	1,786	1,681
Heavy Duty Vehicles	Diesel RT 20 - 26t	Conventional	0	1993	323,084	246,656	229,263	2,716	1,857	1,678	0,578	0,407	0,368	13,189	10,579	9,899
Heavy Duty Vehicles	Diesel RT 20 - 26t	Euro I	1994	1996	277,160	214,981	200,286	2,182	1,505	1,348	0,439	0,288	0,253	9,261	7,445	6,985
Heavy Duty Vehicles	Diesel RT 20 - 26t	Euro II	1997	2001	267,310	209,335	196,695	1,756	1,332	1,261	0,183	0,136	0,152	9,856	7,830	7,311
Heavy Duty Vehicles	Diesel RT 20 - 26t	Euro III	2002	2006	278,374	215,339	199,691	2,121	1,437	1,291	0,190	0,126	0,112	7,933	6,202	5,760
Heavy Duty Vehicles	Diesel RT 20 - 26t	Euro IV	2007	2009	259,989	200,877	186,331	0,151	0,104	0,090	0,036	0,023	0,020	4,769	3,800	3,546
Heavy Duty Vehicles	Diesel RT 20 - 26t	Euro V	2010	2014	264,916	203,965	188,898	0,153	0,105	0,090	0,037	0,024	0,020	2,840	2,250	2,096
Heavy Duty Vehicles	Diesel RT 26 - 28t	Conventional	0	1993	342,618	262,077	242,130	2,864	1,958	1,749	0,613	0,431	0,384	13,891	11,154	10,394
Heavy Duty Vehicles	Diesel RT 26 - 28t	Euro I	1994	1996	294,638	228,789	211,847	2,291	1,605	1,437	0,458	0,307	0,269	9,774	7,811	7,278
Heavy Duty Vehicles	Diesel RT 26 - 28t	Euro II	1997	2001	284,537	222,861	206,136	1,809	1,374	1,300	0,195	0,145	0,162	10,281	8,136	7,563
Heavy Duty Vehicles	Diesel RT 26 - 28t	Euro III	2002	2006	296,130	229,353	211,009	2,192	1,514	1,351	0,203	0,136	0,116	8,026	6,265	5,829
Heavy Duty Vehicles	Diesel RT 26 - 28t	Euro IV	2007	2009	276,478	213,564	196,337	0,159	0,108	0,092	0,037	0,024	0,020	4,920	3,903	3,635
Heavy Duty Vehicles	Diesel RT 26 - 28t	Euro V	2010	2014	281,780	216,892	199,043	0,161	0,110	0,092	0,038	0,024	0,020	2,905	2,290	2,133
Heavy Duty Vehicles	Diesel RT 28 - 32t	Conventional	0	1993	378,779	297,138	275,491	3,126	2,153	1,910	0,678	0,479	0,426	15,696	12,868	11,970
Heavy Duty Vehicles	Diesel RT 28 - 32t	Euro I	1994	1996	332,342	263,557	246,501	2,583	1,838	1,652	0,504	0,345	0,306	11,194	9,086	8,470
Heavy Duty Vehicles	Diesel RT 28 - 32t	Euro II	1997	2001	322,660	258,365	241,198	2,081	1,575	1,468	0,226	0,163	0,195	11,628	9,492	8,563
Heavy Duty Vehicles	Diesel RT 28 - 32t	Euro III	2002	2006	333,761	265,033	246,162	2,421	1,680	1,509	0,217	0,148	0,130	9,211	7,293	6,656
Heavy Duty Vehicles	Diesel RT 28 - 32t	Euro IV	2007	2009	312,241	246,686	227,949	0,174	0,120	0,102	0,040	0,026	0,022	5,677	4,590	4,173
Heavy Duty Vehicles	Diesel RT 28 - 32t	Euro V	2010	2014	318,221	250,590	231,247	0,177	0,121	0,103	0,041	0,027	0,022	3,374	2,698	2,413
Heavy Duty Vehicles	Diesel RT >32t	Conventional	0	1993	387,365	294,650	269,739	3,158	2,175	1,966	0,681	0,481	0,432	16,129	12,809	11,740
Heavy Duty Vehicles	Diesel RT >32t	Euro I	1994	1996	338,943	260,541	238,935	2,641	1,856	1,665	0,524	0,349	0,307	11,428	9,055	8,322
Heavy Duty Vehicles	Diesel RT >32t	Euro III	2002	2006	339,496	260,455	237,636	2,493	1,736	1,565	0,221	0,147	0,129	9,538	7,485	6,752
Heavy Duty Vehicles	Diesel RT >32t	Euro IV	2007	2009	316,183	242,176	220,892	0,174	0,119	0,104	0,041	0,026	0,022	5,853	4,616	4,240
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Conventional	0	1993	343,555	260,036	236,450	2,738	1,911	1,722	0,596	0,421	0,376	14,461	11,377	9,952
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Euro I	1994	1996	306,923	233,697	212,320	2,316	1,677	1,502	0,449	0,309	0,274	10,252	8,006	6,997
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Euro II	1997	2001	293,259	225,478	203,953	1,881	1,415	1,312	0,204	0,143	0,174	10,453	8,195	7,100
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Euro III	2002	2006	303,355	231,394	209,072	2,169	1,519	1,372	0,188	0,129	0,114	8,434	6,399	5,523
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Euro IV	2007	2009	283,113	215,309	194,236	0,149	0,102	0,088	0,035	0,022	0,019	5,190	3,961	3,537
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Euro V	2010	2014	288,186	218,561	196,902	0,151	0,103	0,089	0,035	0,023	0,019	3,078	2,321	2,064

Continued

Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Conventional	0	1993	398,891	296,003	264,722	3,217	2,206	1,987	0,697	0,485	0,431	16,667	12,937	11,208
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Euro I	1994	1996	350,514	262,234	234,473	2,730	1,918	1,717	0,539	0,357	0,312	11,743	9,110	7,904
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Euro II	1997	2001	341,156	257,431	229,531	2,199	1,662	1,554	0,243	0,166	0,202	12,255	9,433	8,176
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Euro III	2002	2006	351,246	262,639	233,347	2,553	1,777	1,602	0,225	0,149	0,130	9,759	7,458	6,473
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Euro IV	2007	2009	326,747	243,891	216,608	0,173	0,118	0,101	0,041	0,026	0,022	6,018	4,600	4,105
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Euro V	2010	2014	332,585	247,612	219,701	0,175	0,119	0,102	0,042	0,026	0,022	3,557	2,700	2,410
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Conventional	0	1993	443,142	330,536	294,460	3,472	2,403	2,169	0,760	0,534	0,475	18,739	14,561	12,573
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Euro I	1994	1996	389,973	292,874	260,505	2,973	2,170	1,968	0,589	0,398	0,350	13,110	10,164	8,785
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Euro II	1997	2001	382,402	288,742	255,439	2,441	1,852	1,732	0,273	0,189	0,227	13,610	10,454	9,009
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Euro III	2002	2006	391,940	293,248	258,907	2,782	1,950	1,761	0,242	0,162	0,141	10,808	8,275	7,184
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Euro IV	2007	2009	364,496	272,094	239,648	0,185	0,125	0,109	0,043	0,027	0,023	6,735	5,141	4,558
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Euro V	2010	2014	371,062	276,236	243,105	0,187	0,127	0,109	0,044	0,028	0,023	3,961	3,000	2,667
Heavy Duty Vehicles	Diesel TT/AT 50 - 60t	Euro II	1997	2001	462,505	347,232	302,541	2,921	2,080	2,298	0,333	0,231	0,275	16,388	12,481	10,660
Heavy Duty Vehicles	Diesel TT/AT 50 - 60t	Euro IV	2007	2009	440,676	327,160	283,955	0,211	0,144	0,124	0,049	0,031	0,026	8,166	6,177	5,397
Buses	Gasoline Urban Buses	Conventional	0	9999	225,000	150,000	165,000	70,000	55,000	55,000	0,400	0,400	0,400	4,500	7,500	7,500
Buses	Diesel Urban Buses <15t	Conventional	0	1993	254,519	199,726	188,313	4,690	3,142	2,705	0,859	0,554	0,466	9,228	7,495	7,107
Buses	Diesel Urban Buses <15t	Euro I	1994	1996	206,542	161,946	154,018	1,668	1,073	0,874	0,300	0,208	0,184	6,771	5,376	5,072
Buses	Diesel Urban Buses <15t	Euro II	1997	2001	197,589	158,105	149,177	1,514	0,934	0,721	0,136	0,100	0,092	7,260	5,708	5,355
Buses	Diesel Urban Buses <15t	Euro III	2002	2006	208,219	166,361	156,952	1,674	1,032	0,742	0,132	0,096	0,086	6,306	4,448	3,682
Buses	Diesel Urban Buses <15t	Euro IV	2007	2009	198,772	156,259	149,123	0,138	0,082	0,065	0,029	0,018	0,015	3,667	2,730	2,374
Buses	Diesel Urban Buses 15 - 18t	Conventional	0	1993	322,706	243,813	223,493	4,844	3,059	2,424	0,767	0,479	0,382	14,829	11,863	11,160
Buses	Diesel Urban Buses 15 - 18t	Euro I	1994	1996	274,847	211,253	194,777	2,323	1,475	1,080	0,416	0,279	0,215	9,029	7,194	6,521
Buses	Diesel Urban Buses 15 - 18t	Euro II	1997	2001	265,398	208,065	194,280	2,048	1,308	0,933	0,191	0,136	0,120	9,648	7,517	6,867
Buses	Diesel Urban Buses 15 - 18t	Euro III	2002	2006	279,078	216,481	199,731	2,267	1,401	1,009	0,180	0,122	0,103	8,172	5,883	5,016
Buses	Diesel Urban Buses 15 - 18t	Euro IV	2007	2009	263,088	203,469	188,046	0,185	0,108	0,083	0,038	0,023	0,018	4,807	3,706	3,107
Buses	Diesel Urban Buses >18t	Conventional	0	1993	402,598	306,217	279,065	6,091	3,927	3,119	0,946	0,604	0,482	19,133	15,142	13,936
Buses	Diesel Urban Buses >18t	Euro I	1994	1996	350,073	270,379	248,470	3,052	1,967	1,451	0,517	0,354	0,277	11,612	9,124	8,459
Buses	Diesel Urban Buses >18t	Euro II	1997	2001	344,223	267,704	244,604	2,788	1,661	1,163	0,258	0,178	0,152	12,066	9,475	8,348
Buses	Diesel Urban Buses >18t	Euro III	2002	2006	355,419	275,841	252,154	2,920	1,768	1,251	0,212	0,144	0,123	10,151	7,587	6,037
Buses	Diesel Urban Buses >18t	Euro IV	2007	2009	333,619	258,536	237,511	0,235	0,133	0,090	0,044	0,026	0,020	6,195	4,750	3,961
Buses	Gasoline Coaches	Conventional	0	9999	225,000	150,000	165,000	70,000	55,000	55,000	0,400	0,400	0,400	4,500	7,500	7,500
Buses	Diesel Coaches <15t	Conventional	0	1993	306,500	221,749	201,709	2,872	1,740	1,434	0,585	0,376	0,317	11,897	9,161	8,705
Buses	Diesel Coaches <15t	Euro I	1994	1996	282,096	204,733	185,736	2,328	1,452	1,199	0,463	0,286	0,231	9,107	6,966	6,519
Buses	Diesel Coaches <15t	Euro II	1997	2001	281,233	205,413	185,701	1,944	1,253	1,089	0,199	0,139	0,121	10,178	7,648	7,097
Buses	Diesel Coaches <15t	Euro III	2002	2006	301,264	220,508	201,327	2,395	1,501	1,252	0,220	0,144	0,119	8,745	6,216	5,621
Buses	Diesel Coaches <15t	Euro IV	2007	2009	285,248	207,955	189,950	0,186	0,116	0,095	0,044	0,027	0,022	5,217	3,799	3,465

Continued

Buses	Diesel Coaches 15 - 18t	Conventional	0	1993	306,500	221,749	201,709	2,872	1,740	1,434	0,585	0,376	0,317	11,897	9,161	8,705
Buses	Diesel Coaches 15 - 18t	Euro I	1994	1996	282,096	204,733	185,736	2,328	1,452	1,199	0,463	0,286	0,231	9,107	6,966	6,519
Buses	Diesel Coaches 15 - 18t	Euro II	1997	2001	281,233	205,413	185,701	1,944	1,253	1,089	0,199	0,139	0,121	10,178	7,648	7,097
Buses	Diesel Coaches 15 - 18t	Euro III	2002	2006	301,264	220,508	201,327	2,395	1,501	1,252	0,220	0,144	0,119	8,745	6,216	5,621
Buses	Diesel Coaches 15 - 18t	Euro IV	2007	2009	285,248	207,955	189,950	0,186	0,116	0,095	0,044	0,027	0,022	5,217	3,799	3,465
Buses	Diesel Coaches >18t	Conventional	0	1993	370,182	269,609	246,371	3,258	2,077	1,775	0,676	0,450	0,387	14,875	11,298	10,404
Buses	Diesel Coaches >18t	Euro I	1994	1996	330,019	240,992	219,214	2,651	1,729	1,463	0,514	0,334	0,282	11,189	8,363	7,688
Buses	Diesel Coaches >18t	Euro II	1997	2001	324,611	238,936	217,246	2,228	1,472	1,281	0,227	0,163	0,146	12,100	8,952	8,176
Buses	Diesel Coaches >18t	Euro III	2002	2006	336,072	239,073	214,011	2,661	1,682	1,382	0,238	0,155	0,129	9,785	7,006	6,166
Buses	Diesel Coaches >18t	Euro IV	2007	2009	317,902	225,401	202,042	0,199	0,124	0,103	0,047	0,029	0,024	5,905	4,299	3,767
Mopeds	<50 cm³	Conventional	0	1999	25,000	25,000	0,000	13,800	13,800	0,000	0,188	0,188	0,000	0,020	0,020	0,000
Mopeds	<50 cm³	Euro I	2000	2003	15,000	15,000	0,000	5,600	5,600	0,000	0,076	0,076	0,000	0,020	0,020	0,000
Mopeds	<50 cm³	Euro II	2004	9999	12,080	12,080	0,000	1,300	1,300	0,000	0,038	0,038	0,000	0,260	0,260	0,000
Motorcycles	2-stroke >50 cm³	Conventional	0	1999	27,115	28,317	39,640	15,605	19,285	28,470	0,200	0,200	0,200	0,029	0,030	0,035
Motorcycles	4-stroke <250 cm³	Conventional	0	1999	24,800	27,499	36,055	15,258	17,209	24,960	0,020	0,020	0,020	0,237	0,428	0,655
Motorcycles	4-stroke <250 cm³	Euro I	2000	2003	27,015	30,386	40,330	10,391	14,456	24,910	0,020	0,020	0,020	0,304	0,424	0,567
Motorcycles	4-stroke <250 cm³	Euro II	2004	2006	22,260	25,160	33,756	3,708	5,765	9,135	0,005	0,005	0,005	0,323	0,447	0,598
Motorcycles	4-stroke <250 cm³	Euro III	2007	9999	19,262	20,359	25,932	2,060	3,201	5,092	0,005	0,005	0,005	0,253	0,382	0,612
Motorcycles	4-stroke 250 - 750 cm³	Conventional	0	1999	26,648	23,766	26,620	20,461	19,486	22,990	0,020	0,020	0,020	0,196	0,300	0,548
Motorcycles	4-stroke 250 - 750 cm³	Euro I	2000	2003	37,374	35,472	41,400	10,599	9,003	10,460	0,020	0,020	0,020	0,258	0,400	0,610
Motorcycles	4-stroke 250 - 750 cm³	Euro II	2004	2006	34,197	33,450	41,276	2,230	2,436	6,092	0,005	0,005	0,005	0,257	0,390	0,577
Motorcycles	4-stroke 250 - 750 cm³	Euro III	2007	9999	30,983	30,719	38,129	1,228	1,345	3,357	0,005	0,005	0,005	0,076	0,132	0,265
Motorcycles	4-stroke >750 cm³	Conventional	0	1999	35,731	35,542	43,748	20,461	19,486	22,990	0,020	0,020	0,020	0,019	0,030	0,086
Motorcycles	4-stroke >750 cm³	Euro I	2000	2003	43,101	41,041	47,500	10,599	9,003	10,460	0,020	0,020	0,020	0,125	0,178	0,392
Motorcycles	4-stroke >750 cm³	Euro II	2004	2006	42,110	38,004	41,895	2,230	2,436	6,092	0,005	0,005	0,005	0,143	0,244	0,459
Motorcycles	4-stroke >750 cm³	Euro III	2007	9999	40,343	37,470	43,083	1,228	1,345	3,357	0,005	0,005	0,005	0,104	0,200	0,484

Sector	Subsector	Tech 2	FYear	LYear	CH4u	CH4r	CH4h	N2Ou	N2Or	N2Oh	NH3u	NH3r	NH3h	VOCu	VOCr
Passenger Cars	Gasoline <1,4 l	PRE ECE	0	1969	0,092	0,029	0,026	0,010	0,007	0,007	0,002	0,002	0,002	2,354	1,597
Passenger Cars	Gasoline <1,4 l	ECE 15/00-01	1970	1978	0,092	0,029	0,026	0,010	0,007	0,007	0,002	0,002	0,002	1,862	1,256
Passenger Cars	Gasoline <1,4 l	ECE 15/02	1979	1980	0,092	0,029	0,026	0,010	0,007	0,007	0,002	0,002	0,002	1,849	1,061
Passenger Cars	Gasoline <1,4 l	ECE 15/03	1981	1985	0,092	0,029	0,026	0,010	0,007	0,007	0,002	0,002	0,002	1,849	1,061
Passenger Cars	Gasoline <1,4 l	ECE 15/04	1986	1990	0,092	0,029	0,026	0,010	0,007	0,007	0,002	0,002	0,002	1,480	0,895
Passenger Cars	Gasoline <1,4 l	Euro I	1991	1996	0,026	0,016	0,014	0,024	0,009	0,005	0,070	0,132	0,074	0,177	0,121
Passenger Cars	Gasoline <1,4 l	Euro II	1997	2000	0,017	0,013	0,011	0,012	0,005	0,003	0,163	0,149	0,084	0,071	0,047

Continued															
Passenger Cars	Gasoline <1,4 l	Euro III	2001	2005	0,003	0,002	0,004	0,001	0,000	0,000	0,002	0,029	0,065	0,015	0,015
Passenger Cars	Gasoline <1,4 l	Euro IV	2006	2010	0,002	0,002	0,000	0,002	0,000	0,000	0,002	0,029	0,065	0,012	0,014
Passenger Cars	Gasoline 1,4 - 2,0 l	PRE ECE	0	1969	0,092	0,029	0,026	0,010	0,007	0,007	0,002	0,002	0,002	2,354	1,597
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/00-01	1970	1978	0,092	0,029	0,026	0,010	0,007	0,007	0,002	0,002	0,002	1,862	1,256
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/02	1979	1980	0,092	0,029	0,026	0,010	0,007	0,007	0,002	0,002	0,002	1,849	1,061
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/03	1981	1985	0,092	0,029	0,026	0,010	0,007	0,007	0,002	0,002	0,002	1,849	1,061
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/04	1986	1990	0,092	0,029	0,026	0,010	0,007	0,007	0,002	0,002	0,002	1,480	0,895
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro I	1991	1996	0,026	0,016	0,014	0,024	0,009	0,005	0,070	0,132	0,074	0,177	0,121
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro II	1997	2000	0,017	0,013	0,011	0,012	0,005	0,003	0,163	0,149	0,084	0,071	0,047
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro III	2001	2005	0,003	0,002	0,004	0,001	0,000	0,000	0,002	0,029	0,065	0,015	0,015
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro IV	2006	2010	0,002	0,002	0,000	0,002	0,000	0,000	0,002	0,029	0,065	0,012	0,014
Passenger Cars	Gasoline >2,0 l	PRE ECE	0	1969	0,092	0,029	0,026	0,010	0,007	0,007	0,002	0,002	0,002	2,354	1,597
Passenger Cars	Gasoline >2,0 l	ECE 15/00-01	1970	1978	0,092	0,029	0,026	0,010	0,007	0,007	0,002	0,002	0,002	1,862	1,256
Passenger Cars	Gasoline >2,0 l	ECE 15/02	1979	1980	0,092	0,029	0,026	0,010	0,007	0,007	0,002	0,002	0,002	1,849	1,061
Passenger Cars	Gasoline >2,0 l	ECE 15/03	1981	1985	0,092	0,029	0,026	0,010	0,007	0,007	0,002	0,002	0,002	1,849	1,061
Passenger Cars	Gasoline >2,0 l	ECE 15/04	1986	1990	0,092	0,029	0,026	0,010	0,007	0,007	0,002	0,002	0,002	1,480	0,895
Passenger Cars	Gasoline >2,0 l	Euro I	1991	1996	0,026	0,016	0,014	0,024	0,009	0,005	0,070	0,132	0,074	0,177	0,121
Passenger Cars	Gasoline >2,0 l	Euro II	1997	2000	0,017	0,013	0,011	0,012	0,005	0,003	0,163	0,149	0,084	0,071	0,047
Passenger Cars	Gasoline >2,0 l	Euro III	2001	2005	0,003	0,002	0,004	0,001	0,000	0,000	0,002	0,030	0,065	0,015	0,015
Passenger Cars	Gasoline >2,0 l	Euro IV	2006	2010	0,002	0,002	0,000	0,002	0,000	0,000	0,002	0,029	0,065	0,012	0,014
Passenger Cars	Diesel <2,0 l	Conventional	0	1990	0,028	0,012	0,008	0,000	0,000	0,000	0,001	0,001	0,001	0,145	0,086
Passenger Cars	Diesel <2,0 l	Euro I	1991	1996	0,011	0,009	0,003	0,002	0,004	0,004	0,001	0,001	0,001	0,053	0,031
Passenger Cars	Diesel <2,0 l	Euro II	1997	2000	0,007	0,003	0,002	0,004	0,006	0,006	0,001	0,001	0,001	0,034	0,021
Passenger Cars	Diesel <2,0 l	Euro III	2001	2005	0,003	0,000	0,000	0,009	0,004	0,004	0,001	0,001	0,001	0,018	0,011
Passenger Cars	Diesel <2,0 l	Euro IV	2006	2010	0,000	0,000	0,000	0,009	0,004	0,004	0,001	0,001	0,001	0,038	0,017
Passenger Cars	Diesel >2,0 l	Conventional	0	1990	0,028	0,012	0,008	0,000	0,000	0,000	0,001	0,001	0,001	0,145	0,086
Passenger Cars	Diesel >2,0 l	Euro I	1991	1996	0,011	0,009	0,003	0,002	0,004	0,004	0,001	0,001	0,001	0,080	0,046
Passenger Cars	Diesel >2,0 l	Euro II	1997	2000	0,007	0,003	0,002	0,004	0,006	0,006	0,001	0,001	0,001	0,098	0,058
Passenger Cars	Diesel >2,0 l	Euro III	2001	2005	0,003	0,000	0,000	0,009	0,004	0,004	0,001	0,001	0,001	0,038	0,017
Passenger Cars	Diesel >2,0 l	Euro IV	2006	2010	0,000	0,000	0,000	0,009	0,004	0,004	0,001	0,001	0,001	0,011	0,006
Passenger Cars	LPG cars	Conventional	0	1990	0,080	0,035	0,025	0,000	0,000	0,000	0,000	0,000	0,000	1,082	0,667
Passenger Cars	LPG cars	Euro I	1991	1996	0,080	0,035	0,025	0,021	0,013	0,008	0,000	0,000	0,000	0,239	0,071
Passenger Cars	LPG cars	Euro III	2001	2005	0,013	0,006	0,004	0,005	0,002	0,001	0,000	0,000	0,000	0,036	0,011
Light Duty Vehicles	Gasoline <3,5t	Conventional	0	1994	0,150	0,040	0,025	0,010	0,007	0,007	0,002	0,002	0,002	1,877	0,729
Light Duty Vehicles	Gasoline <3,5t	Euro I	1995	1998	0,026	0,016	0,014	0,034	0,020	0,010	0,070	0,132	0,074	0,220	0,109
Light Duty Vehicles	Gasoline <3,5t	Euro II	1999	2001	0,017	0,013	0,011	0,023	0,013	0,008	0,163	0,149	0,084	0,053	0,026

Continued																
Light Duty Vehicles	Gasoline <3,5t	Euro III	2002	2006	0,003	0,002	0,004	0,006	0,001	0,001	0,002	0,029	0,065	0,031	0,015
Light Duty Vehicles	Gasoline <3,5t	Euro IV	2007	2011	0,002	0,002	0,000	0,001	0,000	0,000	0,002	0,029	0,065	0,013	0,007
Light Duty Vehicles	Diesel <3,5t	Conventional	0	1994	0,028	0,012	0,008	0,000	0,000	0,000	0,001	0,001	0,001	0,131	0,106
Light Duty Vehicles	Diesel <3,5t	Euro I	1995	1998	0,011	0,009	0,003	0,002	0,004	0,004	0,001	0,001	0,001	0,131	0,106
Light Duty Vehicles	Diesel <3,5t	Euro II	1999	2001	0,007	0,003	0,002	0,004	0,006	0,006	0,001	0,001	0,001	0,131	0,106
Light Duty Vehicles	Diesel <3,5t	Euro III	2002	2006	0,003	0,000	0,000	0,009	0,004	0,004	0,001	0,001	0,001	0,081	0,065
Light Duty Vehicles	Diesel <3,5t	Euro IV	2007	2011	0,000	0,000	0,000	0,009	0,004	0,004	0,001	0,001	0,001	0,030	0,024
Light Duty Vehicles	LPG <3,5t	Conventional	0	1994	0,120	0,053	0,038	0,000	0,000	0,000	0,000	0,000	0,000	1,623	1,000
Light Duty Vehicles	LPG <3,5t	Euro II	1999	2001	0,029	0,013	0,009	0,020	0,005	0,003	0,000	0,000	0,000	0,075	0,022
Light Duty Vehicles	LPG <3,5t	Euro III	2002	2006	0,019	0,008	0,006	0,008	0,003	0,002	0,000	0,000	0,000	0,054	0,016
Light Duty Vehicles	LPG <3,5t	Euro IV	2007	2011	0,006	0,003	0,002	0,008	0,003	0,002	0,000	0,000	0,000	0,011	0,003
Heavy Duty Vehicles	Gasoline >3,5t	Conventional	0	9999	0,140	0,110	0,070	0,006	0,006	0,006	0,002	0,002	0,002	7,000	5,500
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Conventional	0	1993	0,085	0,023	0,020	0,030	0,030	0,030	0,003	0,003	0,003	1,432	0,865
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Euro I	1994	1996	0,085	0,023	0,020	0,030	0,030	0,030	0,003	0,003	0,003	0,285	0,185
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Euro II	1997	2001	0,054	0,020	0,019	0,030	0,030	0,030	0,003	0,003	0,003	0,184	0,118
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Euro III	2002	2006	0,048	0,021	0,018	0,030	0,030	0,030	0,003	0,003	0,003	0,166	0,105
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Euro IV	2007	2009	0,003	0,002	0,001	0,030	0,030	0,030	0,003	0,003	0,003	0,009	0,005
Heavy Duty Vehicles	Diesel RT 3,5 - 7,5t	Euro V	2010	2014	0,003	0,002	0,001	0,030	0,030	0,030	0,003	0,003	0,003	0,009	0,005
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Conventional	0	1993	0,085	0,023	0,020	0,030	0,030	0,030	0,003	0,003	0,003	1,054	0,638
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Euro I	1994	1996	0,085	0,023	0,020	0,030	0,030	0,030	0,003	0,003	0,003	0,440	0,286
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Euro II	1997	2001	0,054	0,020	0,019	0,030	0,030	0,030	0,003	0,003	0,003	0,284	0,182
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Euro III	2002	2006	0,048	0,021	0,018	0,030	0,030	0,030	0,003	0,003	0,003	0,257	0,162
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Euro IV	2007	2009	0,003	0,002	0,001	0,030	0,030	0,030	0,003	0,003	0,003	0,013	0,008
Heavy Duty Vehicles	Diesel RT 7,5 - 12t	Euro V	2010	2014	0,003	0,002	0,001	0,030	0,030	0,030	0,003	0,003	0,003	0,014	0,008
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Conventional	0	1993	0,085	0,023	0,020	0,030	0,030	0,030	0,003	0,003	0,003	1,110	0,702
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Euro I	1994	1996	0,085	0,023	0,020	0,030	0,030	0,030	0,003	0,003	0,003	0,473	0,318
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Euro II	1997	2001	0,054	0,020	0,019	0,030	0,030	0,030	0,003	0,003	0,003	0,302	0,200
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Euro III	2002	2006	0,048	0,021	0,018	0,030	0,030	0,030	0,003	0,003	0,003	0,265	0,175
Heavy Duty Vehicles	Diesel RT 12 - 14 t	Euro IV	2007	2009	0,003	0,002	0,001	0,030	0,030	0,030	0,003	0,003	0,003	0,013	0,009
Heavy Duty Vehicles	Diesel RT 14 - 20t	Conventional	0	1993	0,175	0,080	0,070	0,030	0,030	0,030	0,003	0,003	0,003	1,636	1,050
Heavy Duty Vehicles	Diesel RT 14 - 20t	Euro I	1994	1996	0,175	0,080	0,070	0,030	0,030	0,030	0,003	0,003	0,003	0,674	0,446
Heavy Duty Vehicles	Diesel RT 14 - 20t	Euro II	1997	2001	0,112	0,070	0,065	0,030	0,030	0,030	0,003	0,003	0,003	0,435	0,282
Heavy Duty Vehicles	Diesel RT 14 - 20t	Euro III	2002	2006	0,098	0,074	0,064	0,030	0,030	0,030	0,003	0,003	0,003	0,386	0,251
Heavy Duty Vehicles	Diesel RT 14 - 20t	Euro IV	2007	2009	0,005	0,006	0,004	0,030	0,030	0,030	0,003	0,003	0,003	0,020	0,013
Heavy Duty Vehicles	Diesel RT 14 - 20t	Euro V	2010	2014	0,005	0,006	0,004	0,030	0,030	0,030	0,003	0,003	0,003	0,020	0,013
Heavy Duty Vehicles	Diesel RT 20 - 26t	Conventional	0	1993	0,175	0,080	0,070	0,030	0,030	0,030	0,003	0,003	0,003	0,920	0,566

Continued

Heavy Duty Vehicles	Diesel RT 20 - 26t	Euro I	1994	1996	0,175	0,080	0,070	0,030	0,030	0,030	0,003	0,003	0,003	0,819	0,527
Heavy Duty Vehicles	Diesel RT 20 - 26t	Euro II	1997	2001	0,112	0,070	0,065	0,030	0,030	0,030	0,003	0,003	0,003	0,522	0,335
Heavy Duty Vehicles	Diesel RT 20 - 26t	Euro III	2002	2006	0,098	0,074	0,064	0,030	0,030	0,030	0,003	0,003	0,003	0,463	0,293
Heavy Duty Vehicles	Diesel RT 20 - 26t	Euro IV	2007	2009	0,005	0,006	0,004	0,030	0,030	0,030	0,003	0,003	0,003	0,024	0,015
Heavy Duty Vehicles	Diesel RT 20 - 26t	Euro V	2010	2014	0,005	0,006	0,004	0,030	0,030	0,030	0,003	0,003	0,003	0,024	0,015
Heavy Duty Vehicles	Diesel RT 26 - 28t	Conventional	0	1993	0,175	0,080	0,070	0,030	0,030	0,030	0,003	0,003	0,003	0,966	0,601
Heavy Duty Vehicles	Diesel RT 26 - 28t	Euro I	1994	1996	0,175	0,080	0,070	0,030	0,030	0,030	0,003	0,003	0,003	0,842	0,548
Heavy Duty Vehicles	Diesel RT 26 - 28t	Euro II	1997	2001	0,112	0,070	0,065	0,030	0,030	0,030	0,003	0,003	0,003	0,544	0,351
Heavy Duty Vehicles	Diesel RT 26 - 28t	Euro III	2002	2006	0,098	0,074	0,064	0,030	0,030	0,030	0,003	0,003	0,003	0,488	0,313
Heavy Duty Vehicles	Diesel RT 26 - 28t	Euro IV	2007	2009	0,005	0,006	0,004	0,030	0,030	0,030	0,003	0,003	0,003	0,025	0,015
Heavy Duty Vehicles	Diesel RT 26 - 28t	Euro V	2010	2014	0,005	0,006	0,004	0,030	0,030	0,030	0,003	0,003	0,003	0,026	0,016
Heavy Duty Vehicles	Diesel RT 28 - 32t	Conventional	0	1993	0,175	0,080	0,070	0,030	0,030	0,030	0,003	0,003	0,003	0,997	0,612
Heavy Duty Vehicles	Diesel RT 28 - 32t	Euro I	1994	1996	0,175	0,080	0,070	0,030	0,030	0,030	0,003	0,003	0,003	0,889	0,580
Heavy Duty Vehicles	Diesel RT 28 - 32t	Euro II	1997	2001	0,112	0,070	0,065	0,030	0,030	0,030	0,003	0,003	0,003	0,571	0,368
Heavy Duty Vehicles	Diesel RT 28 - 32t	Euro III	2002	2006	0,098	0,074	0,064	0,030	0,030	0,030	0,003	0,003	0,003	0,507	0,325
Heavy Duty Vehicles	Diesel RT 28 - 32t	Euro IV	2007	2009	0,005	0,006	0,004	0,030	0,030	0,030	0,003	0,003	0,003	0,026	0,016
Heavy Duty Vehicles	Diesel RT 28 - 32t	Euro V	2010	2014	0,005	0,006	0,004	0,030	0,030	0,030	0,003	0,003	0,003	0,026	0,016
Heavy Duty Vehicles	Diesel RT >32t	Conventional	0	1993	0,175	0,080	0,070	0,030	0,030	0,030	0,003	0,003	0,003	1,001	0,610
Heavy Duty Vehicles	Diesel RT >32t	Euro I	1994	1996	0,175	0,080	0,070	0,030	0,030	0,030	0,003	0,003	0,003	0,917	0,588
Heavy Duty Vehicles	Diesel RT >32t	Euro III	2002	2006	0,098	0,074	0,064	0,030	0,030	0,030	0,003	0,003	0,003	0,512	0,323
Heavy Duty Vehicles	Diesel RT >32t	Euro IV	2007	2009	0,005	0,006	0,004	0,030	0,030	0,030	0,003	0,003	0,003	0,026	0,016
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Conventional	0	1993	0,175	0,080	0,070	0,030	0,030	0,030	0,003	0,003	0,003	0,831	0,528
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Euro I	1994	1996	0,175	0,080	0,070	0,030	0,030	0,030	0,003	0,003	0,003	0,769	0,506
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Euro II	1997	2001	0,112	0,070	0,065	0,030	0,030	0,030	0,003	0,003	0,003	0,489	0,320
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Euro III	2002	2006	0,098	0,074	0,064	0,030	0,030	0,030	0,003	0,003	0,003	0,427	0,279
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Euro IV	2007	2009	0,005	0,006	0,004	0,030	0,030	0,030	0,003	0,003	0,003	0,022	0,014
Heavy Duty Vehicles	Diesel TT/AT 28 - 34t	Euro V	2010	2014	0,005	0,006	0,004	0,030	0,030	0,030	0,003	0,003	0,003	0,022	0,014
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Conventional	0	1993	0,175	0,080	0,070	0,030	0,030	0,030	0,003	0,003	0,003	0,988	0,608
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Euro I	1994	1996	0,175	0,080	0,070	0,030	0,030	0,030	0,003	0,003	0,003	0,914	0,586
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Euro II	1997	2001	0,112	0,070	0,065	0,030	0,030	0,030	0,003	0,003	0,003	0,580	0,371
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Euro III	2002	2006	0,098	0,074	0,064	0,030	0,030	0,030	0,003	0,003	0,003	0,507	0,322
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Euro IV	2007	2009	0,005	0,006	0,004	0,030	0,030	0,030	0,003	0,003	0,003	0,026	0,016
Heavy Duty Vehicles	Diesel TT/AT 34 - 40t	Euro V	2010	2014	0,005	0,006	0,004	0,030	0,030	0,030	0,003	0,003	0,003	0,026	0,016
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Conventional	0	1993	0,175	0,080	0,070	0,030	0,030	0,030	0,003	0,003	0,003	1,015	0,628
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Euro I	1994	1996	0,175	0,080	0,070	0,030	0,030	0,030	0,003	0,003	0,003	0,955	0,616
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Euro II	1997	2001	0,112	0,070	0,065	0,030	0,030	0,030	0,003	0,003	0,003	0,605	0,389

Continued

Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Euro III	2002	2006	0,098	0,074	0,064	0,030	0,030	0,030	0,003	0,003	0,003	0,525	0,336
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Euro IV	2007	2009	0,005	0,006	0,004	0,030	0,030	0,030	0,003	0,003	0,003	0,026	0,016
Heavy Duty Vehicles	Diesel TT/AT 40 - 50t	Euro V	2010	2014	0,005	0,006	0,004	0,030	0,030	0,030	0,003	0,003	0,003	0,027	0,017
Heavy Duty Vehicles	Diesel TT/AT 50 - 60t	Euro II	1997	2001	0,112	0,070	0,065	0,030	0,030	0,030	0,003	0,003	0,003	0,685	0,444
Heavy Duty Vehicles	Diesel TT/AT 50 - 60t	Euro IV	2007	2009	0,005	0,006	0,004	0,030	0,030	0,030	0,003	0,003	0,003	0,030	0,018
Buses	Gasoline Urban Buses	Conventional	0	9999	0,140	0,110	0,070	0,006	0,006	0,006	0,002	0,002	0,002	7,000	5,500
Buses	Diesel Urban Buses <15t	Conventional	0	1993	0,175	0,080	0,070	0,030	0,030	0,030	0,003	0,003	0,003	2,990	1,962
Buses	Diesel Urban Buses <15t	Euro I	1994	1996	0,175	0,080	0,070	0,030	0,030	0,030	0,003	0,003	0,003	0,577	0,396
Buses	Diesel Urban Buses <15t	Euro II	1997	2001	0,114	0,052	0,046	0,030	0,030	0,030	0,003	0,003	0,003	0,375	0,255
Buses	Diesel Urban Buses <15t	Euro III	2002	2006	0,103	0,047	0,041	0,030	0,030	0,030	0,003	0,003	0,003	0,334	0,228
Buses	Diesel Urban Buses <15t	Euro IV	2007	2009	0,005	0,002	0,002	0,030	0,030	0,030	0,003	0,003	0,003	0,017	0,011
Buses	Diesel Urban Buses 15 - 18t	Conventional	0	1993	0,175	0,080	0,070	0,030	0,030	0,030	0,003	0,003	0,003	1,830	1,116
Buses	Diesel Urban Buses 15 - 18t	Euro I	1994	1996	0,175	0,080	0,070	0,030	0,030	0,030	0,003	0,003	0,003	0,754	0,488
Buses	Diesel Urban Buses 15 - 18t	Euro II	1997	2001	0,114	0,052	0,046	0,030	0,030	0,030	0,003	0,003	0,003	0,491	0,318
Buses	Diesel Urban Buses 15 - 18t	Euro III	2002	2006	0,103	0,047	0,041	0,030	0,030	0,030	0,003	0,003	0,003	0,437	0,283
Buses	Diesel Urban Buses 15 - 18t	Euro IV	2007	2009	0,005	0,002	0,002	0,030	0,030	0,030	0,003	0,003	0,003	0,023	0,014
Buses	Diesel Urban Buses >18t	Conventional	0	1993	0,175	0,080	0,070	0,030	0,030	0,030	0,003	0,003	0,003	1,907	1,155
Buses	Diesel Urban Buses >18t	Euro I	1994	1996	0,175	0,080	0,070	0,030	0,030	0,030	0,003	0,003	0,003	0,821	0,537
Buses	Diesel Urban Buses >18t	Euro II	1997	2001	0,114	0,052	0,046	0,030	0,030	0,030	0,003	0,003	0,003	0,532	0,347
Buses	Diesel Urban Buses >18t	Euro III	2002	2006	0,103	0,047	0,041	0,030	0,030	0,030	0,003	0,003	0,003	0,468	0,304
Buses	Diesel Urban Buses >18t	Euro IV	2007	2009	0,005	0,002	0,002	0,030	0,030	0,030	0,003	0,003	0,003	0,024	0,015
Buses	Gasoline Coaches	Conventional	0	9999	0,140	0,110	0,070	0,006	0,006	0,006	0,002	0,002	0,002	7,000	5,500
Buses	Diesel Coaches <15t	Conventional	0	1993	0,175	0,080	0,070	0,030	0,030	0,030	0,003	0,003	0,003	1,008	0,577
Buses	Diesel Coaches <15t	Euro I	1994	1996	0,175	0,080	0,070	0,030	0,030	0,030	0,003	0,003	0,003	0,936	0,563
Buses	Diesel Coaches <15t	Euro II	1997	2001	0,114	0,052	0,046	0,030	0,030	0,030	0,003	0,003	0,003	0,623	0,380
Buses	Diesel Coaches <15t	Euro III	2002	2006	0,103	0,047	0,041	0,030	0,030	0,030	0,003	0,003	0,003	0,575	0,354
Buses	Diesel Coaches <15t	Euro IV	2007	2009	0,005	0,002	0,002	0,030	0,030	0,030	0,003	0,003	0,003	0,030	0,018
Buses	Diesel Coaches 15 - 18t	Conventional	0	1993	0,175	0,080	0,070	0,030	0,030	0,030	0,003	0,003	0,003	1,008	0,577
Buses	Diesel Coaches 15 - 18t	Euro I	1994	1996	0,175	0,080	0,070	0,030	0,030	0,030	0,003	0,003	0,003	0,936	0,563
Buses	Diesel Coaches 15 - 18t	Euro II	1997	2001	0,114	0,052	0,046	0,030	0,030	0,030	0,003	0,003	0,003	0,623	0,380
Buses	Diesel Coaches 15 - 18t	Euro III	2002	2006	0,103	0,047	0,041	0,030	0,030	0,030	0,003	0,003	0,003	0,575	0,354
Buses	Diesel Coaches 15 - 18t	Euro IV	2007	2009	0,005	0,002	0,002	0,030	0,030	0,030	0,003	0,003	0,003	0,030	0,018
Buses	Diesel Coaches >18t	Conventional	0	1993	0,175	0,080	0,070	0,030	0,030	0,030	0,003	0,003	0,003	1,104	0,668
Buses	Diesel Coaches >18t	Euro I	1994	1996	0,175	0,080	0,070	0,030	0,030	0,030	0,003	0,003	0,003	1,010	0,638
Buses	Diesel Coaches >18t	Euro II	1997	2001	0,114	0,052	0,046	0,030	0,030	0,030	0,003	0,003	0,003	0,660	0,409
Buses	Diesel Coaches >18t	Euro III	2002	2006	0,103	0,047	0,041	0,030	0,030	0,030	0,003	0,003	0,003	0,603	0,374

Continued															
Buses	Diesel Coaches >18t	Euro IV	2007	2009	0,005	0,002	0,002	0,030	0,030	0,030	0,003	0,003	0,003	0,031	0,019
Mopeds	<50 cm³	Conventional	0	1999	0,219	0,219	0,000	0,001	0,001	0,001	0,001	0,001	0,001	13,910	13,910
Mopeds	<50 cm³	Euro I	2000	2003	0,044	0,044	0,000	0,001	0,001	0,001	0,001	0,001	0,001	2,730	2,730
Mopeds	<50 cm³	Euro II	2004	9999	0,024	0,024	0,000	0,001	0,001	0,001	0,001	0,001	0,001	1,560	1,560
Motorcycles	2-stroke >50 cm³	Conventional	0	1999	0,150	0,150	0,150	0,002	0,002	0,002	0,002	0,002	0,002	8,393	7,078
Motorcycles	4-stroke <250 cm³	Conventional	0	1999	0,200	0,200	0,200	0,002	0,002	0,002	0,002	0,002	0,002	0,128	0,104
Motorcycles	4-stroke <250 cm³	Euro I	2000	2003	0,142	0,144	0,132	0,002	0,002	0,002	0,002	0,002	0,002	1,242	0,866
Motorcycles	4-stroke <250 cm³	Euro II	2004	2006	0,136	0,092	0,092	0,002	0,002	0,002	0,002	0,002	0,002	1,042	0,843
Motorcycles	4-stroke <250 cm³	Euro III	2007	9999	0,082	0,032	0,028	0,002	0,002	0,002	0,002	0,002	0,002	0,456	0,441
Motorcycles	4-stroke 250 - 750 cm³	Conventional	0	1999	0,200	0,200	0,200	0,002	0,002	0,002	0,002	0,002	0,002	0,545	0,487
Motorcycles	4-stroke 250 - 750 cm³	Euro I	2000	2003	0,148	0,174	0,156	0,002	0,002	0,002	0,002	0,002	0,002	2,390	1,522
Motorcycles	4-stroke 250 - 750 cm³	Euro II	2004	2006	0,156	0,120	0,122	0,002	0,002	0,002	0,002	0,002	0,002	1,326	0,925
Motorcycles	4-stroke 250 - 750 cm³	Euro III	2007	9999	0,094	0,042	0,036	0,002	0,002	0,002	0,002	0,002	0,002	0,598	0,499
Motorcycles	4-stroke >750 cm³	Conventional	0	1999	0,200	0,200	0,200	0,002	0,002	0,002	0,002	0,002	0,002	0,392	0,337
Motorcycles	4-stroke >750 cm³	Euro I	2000	2003	0,092	0,092	0,154	0,002	0,002	0,002	0,002	0,002	0,002	2,495	1,643
Motorcycles	4-stroke >750 cm³	Euro II	2004	2006	0,084	0,062	0,102	0,002	0,002	0,002	0,002	0,002	0,002	1,088	0,674
Motorcycles	4-stroke >750 cm³	Euro III	2007	9999	0,050	0,022	0,030	0,002	0,002	0,002	0,002	0,002	0,002	0,384	0,309

Annex 2B-5: Reduction factors

Sector	Subsector	Tech 2	FYear	LYear	FCuR	FCrR	FChR	COuR	COrR	COhR	PMuR	PMrR	PMhR	NOxuR	NOxrR	NOxhR	VOCuR	VOCrR	VOChR
Passenger Cars	Gasoline <1,4 l	PRE ECE	0	1969	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Passenger Cars	Gasoline <1,4 l	ECE 15/00-01	1970	1978	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Passenger Cars	Gasoline <1,4 l	ECE 15/02	1979	1980	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Passenger Cars	Gasoline <1,4 l	ECE 15/03	1981	1985	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Passenger Cars	Gasoline <1,4 l	ECE 15/04	1986	1990	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Passenger Cars	Gasoline <1,4 l	Euro I	1991	1996	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Passenger Cars	Gasoline <1,4 l	Euro II	1997	2000	1,93	5,83	4,43	62,65	58,10	57,55	0,00	0,00	0,00	43,59	45,20	60,45	60,19	61,27	62,09
Passenger Cars	Gasoline <1,4 l	Euro III	2001	2005	-2,72	-0,72	1,59	70,59	49,62	34,95	60,25	54,57	37,37	72,16	78,49	88,69	91,74	87,53	77,02
Passenger Cars	Gasoline <1,4 l	Euro IV	2006	2010	-5,57	-5,34	-4,84	88,95	79,10	70,06	60,25	54,57	37,37	80,12	89,24	95,86	93,34	88,71	84,51
Passenger Cars	Gasoline 1,4 - 2,0 l	PRE ECE	0	1969	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/00-01	1970	1978	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/02	1979	1980	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/03	1981	1985	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/04	1986	1990	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro I	1991	1996	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro II	1997	2000	2,08	1,72	5,30	62,65	58,10	57,55	0,00	0,00	0,00	43,59	45,20	60,45	60,19	61,27	62,09
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro III	2001	2005	-1,28	-2,83	-3,05	70,59	49,62	34,95	60,25	54,57	37,37	72,16	78,49	88,69	91,74	87,53	77,02
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro IV	2006	2010	-5,15	-8,80	-7,33	88,95	79,10	70,06	60,25	54,57	37,37	80,12	89,24	95,86	93,34	88,71	84,51
Passenger Cars	Gasoline >2,0 l	PRE ECE	0	1969	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Passenger Cars	Gasoline >2,0 l	ECE 15/00-01	1970	1978	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Passenger Cars	Gasoline >2,0 l	ECE 15/02	1979	1980	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Passenger Cars	Gasoline >2,0 l	ECE 15/03	1981	1985	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Passenger Cars	Gasoline >2,0 l	ECE 15/04	1986	1990	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Passenger Cars	Gasoline >2,0 l	Euro I	1991	1996	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Passenger Cars	Gasoline >2,0 l	Euro II	1997	2000	-2,98	-5,37	-2,63	62,65	58,10	57,55	0,00	0,00	0,00	43,59	45,20	60,45	60,19	61,27	62,09
Passenger Cars	Gasoline >2,0 l	Euro III	2001	2005	5,12	7,23	12,60	70,59	49,62	34,95	60,25	54,57	37,37	72,16	78,49	88,69	91,74	87,53	77,02
Passenger Cars	Gasoline >2,0 l	Euro IV	2006	2010	-15,39	-9,65	-1,29	88,95	79,10	70,06	60,25	54,57	37,37	80,12	89,24	95,86	93,34	88,71	84,51
Passenger Cars	Diesel <2,0 l	Conventional	0	1990	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Passenger Cars	Diesel <2,0 l	Euro I	1991	1996	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Passenger Cars	Diesel <2,0 l	Euro II	1997	2000	-5,45	-3,06	-0,81	18,08	48,77	83,05	17,92	36,92	53,22	-7,94	1,18	-0,20	34,81	33,43	41,61
Passenger Cars	Diesel <2,0 l	Euro III	2001	2005	-2,27	-1,45	5,79	76,38	81,12	94,30	48,53	51,90	58,32	-18,71	-18,46	-12,98	65,94	63,35	66,25
Passenger Cars	Diesel <2,0 l	Euro IV	2006	2010	-2,27	-1,45	5,79	80,09	84,22	89,72	49,02	60,57	75,83	10,60	24,53	13,19	27,61	44,26	51,85
Passenger Cars	Diesel >2,0 l	Conventional	0	1990	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Passenger Cars	Diesel >2,0 l	Euro I	1991	1996	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Continued

Passenger Cars	Diesel >2,0 l	Euro II	1997	2000	0,00	0,00	0,00	18,08	48,77	83,05	17,92	36,92	53,22	-7,94	1,18	-0,20	-22,14	-25,38	-11,51
Passenger Cars	Diesel >2,0 l	Euro III	2001	2005	0,00	0,00	0,00	76,38	81,12	94,30	48,53	51,90	58,32	-18,71	-18,46	-12,98	52,23	62,67	63,93
Passenger Cars	Diesel >2,0 l	Euro IV	2006	2010	0,00	0,00	0,00	80,09	84,22	89,72	49,02	60,57	75,83	10,60	24,53	13,19	86,39	86,10	83,20
Passenger Cars	LPG cars	Conventional	0	1990	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Passenger Cars	LPG cars	Euro I	1991	1996	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Passenger Cars	LPG cars	Euro II	1997	2000	0,00	0,00	0,00	32,00	32,00	32,00	0,00	0,00	0,00	64,00	64,00	64,00	79,00	79,00	79,00
Passenger Cars	LPG cars	Euro III	2001	2005	0,00	0,00	0,00	44,00	44,00	44,00	0,00	0,00	0,00	76,00	76,00	76,00	85,00	85,00	85,00
Passenger Cars	LPG cars	Euro IV	2006	2010	0,00	0,00	0,00	66,00	66,00	66,00	0,00	0,00	0,00	87,00	87,00	87,00	97,00	97,00	97,00
Passenger Cars	Electric cars	Conventional	0	9999	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Light Duty Vehicles	Gasoline <3,5t	Conventional	0	1994	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Light Duty Vehicles	Gasoline <3,5t	Euro I	1995	1998	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Light Duty Vehicles	Gasoline <3,5t	Euro II	1999	2001	0,00	0,00	0,00	39,00	39,00	39,00	0,00	0,00	0,00	66,00	66,00	66,00	76,00	76,00	76,00
Light Duty Vehicles	Gasoline <3,5t	Euro III	2002	2006	0,00	0,00	0,00	48,00	48,00	48,00	60,25	54,57	37,37	79,00	79,00	79,00	86,00	86,00	86,00
Light Duty Vehicles	Gasoline <3,5t	Euro IV	2007	2011	0,00	0,00	0,00	72,00	72,00	72,00	60,25	54,57	37,37	90,00	90,00	90,00	94,00	94,00	94,00
Light Duty Vehicles	Diesel <3,5t	Conventional	0	1994	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Light Duty Vehicles	Diesel <3,5t	Euro I	1995	1998	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Light Duty Vehicles	Diesel <3,5t	Euro II	1999	2001	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Light Duty Vehicles	Diesel <3,5t	Euro III	2002	2006	0,00	0,00	0,00	18,00	18,00	18,00	33,00	33,00	33,00	35,00	35,00	35,00	38,00	38,00	38,00
Light Duty Vehicles	Diesel <3,5t	Euro IV	2007	2011	0,00	0,00	0,00	35,00	35,00	35,00	65,00	65,00	65,00	72,00	72,00	72,00	77,00	77,00	77,00
Light Duty Vehicles	LPG <3,5t	Conventional	0	1994	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Light Duty Vehicles	LPG <3,5t	Euro II	1999	2001	0,00	0,00	0,00	32,00	32,00	32,00	0,00	0,00	0,00	64,00	64,00	64,00	79,00	79,00	79,00
Light Duty Vehicles	LPG <3,5t	Euro III	2002	2006	0,00	0,00	0,00	44,00	44,00	44,00	0,00	0,00	0,00	76,00	76,00	76,00	85,00	85,00	85,00
Light Duty Vehicles	LPG <3,5t	Euro IV	2007	2011	0,00	0,00	0,00	66,00	66,00	66,00	0,00	0,00	0,00	87,00	87,00	87,00	97,00	97,00	97,00
Light Duty Vehicles	Electric <3,5t	Conventional	0	9999	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Heavy Duty Veh.	Gasoline >3,5t	Conventional	0	9999	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Heavy Duty Veh.	Diesel RT 3,5 - 7,5t	Conventional	0	1993	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Heavy Duty Veh.	Diesel RT 3,5 - 7,5t	Euro I	1994	1996	19,41	13,86	11,62	66,97	65,69	60,81	61,51	61,35	61,09	30,34	27,31	27,37	80,08	78,62	76,18
Heavy Duty Veh.	Diesel RT 3,5 - 7,5t	Euro II	1997	2001	23,96	17,09	14,31	72,63	70,07	67,15	83,57	80,45	77,17	25,72	25,03	27,10	87,19	86,41	85,11
Heavy Duty Veh.	Diesel RT 3,5 - 7,5t	Euro III	2002	2006	18,81	12,58	11,10	67,25	69,42	70,43	82,21	83,12	84,01	41,88	44,80	47,19	88,42	87,82	87,33
Heavy Duty Veh.	Diesel RT 3,5 - 7,5t	Euro IV	2007	2009	23,88	17,99	16,51	97,42	97,51	97,57	96,62	96,96	97,24	64,74	64,88	65,56	99,40	99,41	99,42
Heavy Duty Veh.	Diesel RT 3,5 - 7,5t	Euro V	2010	2014	22,65	16,97	15,69	97,40	97,51	97,58	96,59	96,94	97,22	79,18	79,63	80,02	99,39	99,41	99,42
Heavy Duty Veh.	Diesel RT 7,5 - 12t	Conventional	0	1993	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Heavy Duty Veh.	Diesel RT 7,5 - 12t	Euro I	1994	1996	14,48	11,71	8,70	53,11	52,21	52,16	40,93	41,10	40,30	40,70	40,06	40,97	58,27	55,23	52,06
Heavy Duty Veh.	Diesel RT 7,5 - 12t	Euro II	1997	2001	18,36	14,62	11,03	61,36	57,79	55,70	74,55	70,47	63,66	37,20	37,70	39,86	73,01	71,48	69,76
Heavy Duty Veh.	Diesel RT 7,5 - 12t	Euro III	2002	2006	13,71	10,58	7,50	53,80	55,89	56,85	73,09	73,84	74,02	50,22	52,54	55,81	75,61	74,61	73,20
Heavy Duty Veh.	Diesel RT 7,5 - 12t	Euro IV	2007	2009	18,76	16,26	13,66	96,53	96,60	96,76	94,95	95,23	95,52	69,76	70,40	71,49	98,75	98,76	98,73
Heavy Duty Veh.	Diesel RT 7,5 - 12t	Euro V	2010	2014	17,14	14,93	12,65	96,48	96,57	96,72	94,86	95,15	95,45	82,13	82,51	83,61	98,72	98,74	98,70

Continued

Heavy Duty Veh.	Diesel RT 12 - 14 t	Conventional	0	1993	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Heavy Duty Veh.	Diesel RT 12 - 14 t	Euro I	1994	1996	14,00	11,81	9,90	51,98	51,86	51,84	40,50	40,59	40,00	40,22	40,02	41,03	57,38	54,76	53,17
Heavy Duty Veh.	Diesel RT 12 - 14 t	Euro II	1997	2001	17,58	14,74	12,75	60,35	56,72	54,16	74,17	70,73	63,07	36,33	37,45	39,89	72,77	71,56	70,80
Heavy Duty Veh.	Diesel RT 12 - 14 t	Euro III	2002	2006	13,44	11,25	9,72	53,50	54,67	55,12	74,18	74,13	73,49	47,95	51,53	54,48	76,11	75,05	74,06
Heavy Duty Veh.	Diesel RT 12 - 14 t	Euro IV	2007	2009	18,64	16,97	15,88	96,66	96,63	96,74	94,95	95,22	95,47	68,91	69,93	71,33	98,79	98,78	98,76
Heavy Duty Veh.	Diesel RT 12 - 14 t	Euro V	2010	2014	17,12	15,74	14,94	96,62	96,60	96,71	94,87	95,16	95,41	81,37	82,27	83,21	98,76	98,76	98,73
Heavy Duty Veh.	Diesel RT 14 - 20t	Conventional	0	1993	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Heavy Duty Veh.	Diesel RT 14 - 20t	Euro I	1994	1996	17,74	16,63	13,43	53,07	52,85	52,78	41,21	41,16	41,68	40,33	40,60	40,59	58,81	57,49	56,82
Heavy Duty Veh.	Diesel RT 14 - 20t	Euro II	1997	2001	20,65	19,55	15,88	62,41	58,84	57,06	76,03	71,76	68,05	35,74	37,13	37,61	73,41	73,11	72,71
Heavy Duty Veh.	Diesel RT 14 - 20t	Euro III	2002	2006	16,74	16,35	13,77	54,04	54,70	54,84	73,64	73,46	73,44	47,46	50,49	52,38	76,41	76,07	75,61
Heavy Duty Veh.	Diesel RT 14 - 20t	Euro IV	2007	2009	22,25	21,70	19,35	96,63	96,62	96,74	94,79	95,05	95,27	68,94	70,06	70,56	98,79	98,81	98,79
Heavy Duty Veh.	Diesel RT 14 - 20t	Euro V	2010	2014	20,74	20,43	18,29	96,59	96,59	96,70	94,72	94,99	95,22	81,36	82,28	82,69	98,76	98,78	98,77
Heavy Duty Veh.	Diesel RT 20 - 26t	Conventional	0	1993	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Heavy Duty Veh.	Diesel RT 20 - 26t	Euro I	1994	1996	14,21	12,84	12,64	19,63	18,94	19,66	24,10	29,41	31,30	29,79	29,62	29,43	11,04	7,01	3,05
Heavy Duty Veh.	Diesel RT 20 - 26t	Euro II	1997	2001	17,26	15,13	14,21	35,33	28,28	24,87	68,32	66,55	58,73	25,27	25,98	26,14	43,30	40,88	39,78
Heavy Duty Veh.	Diesel RT 20 - 26t	Euro III	2002	2006	13,84	12,70	12,90	21,91	22,62	23,06	67,20	69,00	69,67	39,86	41,37	41,81	49,68	48,23	45,89
Heavy Duty Veh.	Diesel RT 20 - 26t	Euro IV	2007	2009	19,53	18,56	18,73	94,44	94,41	94,66	93,69	94,28	94,61	63,84	64,08	64,18	97,42	97,43	97,34
Heavy Duty Veh.	Diesel RT 20 - 26t	Euro V	2010	2014	18,00	17,31	17,61	94,37	94,36	94,61	93,59	94,21	94,55	78,46	78,73	78,82	97,37	97,38	97,29
Heavy Duty Veh.	Diesel RT 26 - 28t	Conventional	0	1993	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Heavy Duty Veh.	Diesel RT 26 - 28t	Euro I	1994	1996	14,00	12,70	12,51	20,01	18,01	17,86	25,27	28,77	29,97	29,64	29,98	29,98	12,80	8,80	3,69
Heavy Duty Veh.	Diesel RT 26 - 28t	Euro II	1997	2001	16,95	14,96	14,87	36,85	29,81	25,67	68,28	66,29	57,85	25,99	27,06	27,24	43,65	41,57	40,08
Heavy Duty Veh.	Diesel RT 26 - 28t	Euro III	2002	2006	13,57	12,49	12,85	23,47	22,67	22,77	66,93	68,50	69,78	42,22	43,83	43,92	49,46	47,97	46,83
Heavy Duty Veh.	Diesel RT 26 - 28t	Euro IV	2007	2009	19,30	18,51	18,91	94,45	94,46	94,77	93,92	94,40	94,74	64,58	65,01	65,03	97,41	97,42	97,34
Heavy Duty Veh.	Diesel RT 26 - 28t	Euro V	2010	2014	17,76	17,24	17,79	94,38	94,41	94,73	93,83	94,33	94,68	79,09	79,47	79,48	97,35	97,37	97,29
Heavy Duty Veh.	Diesel RT 28 - 32t	Conventional	0	1993	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Heavy Duty Veh.	Diesel RT 28 - 32t	Euro I	1994	1996	12,26	11,30	10,52	17,38	14,65	13,49	25,71	28,05	28,20	28,68	29,39	29,24	10,80	5,19	2,39
Heavy Duty Veh.	Diesel RT 28 - 32t	Euro II	1997	2001	14,82	13,05	12,45	33,44	26,86	23,15	66,69	65,89	54,27	25,92	26,23	28,46	42,77	39,78	39,27
Heavy Duty Veh.	Diesel RT 28 - 32t	Euro III	2002	2006	11,88	10,80	10,65	22,56	21,95	20,96	68,08	69,19	69,50	41,32	43,32	44,39	49,15	46,82	45,76
Heavy Duty Veh.	Diesel RT 28 - 32t	Euro IV	2007	2009	17,57	16,98	17,26	94,42	94,43	94,66	94,07	94,53	94,85	63,83	64,33	65,14	97,41	97,39	97,33
Heavy Duty Veh.	Diesel RT 28 - 32t	Euro V	2010	2014	15,99	15,67	16,06	94,34	94,36	94,59	93,97	94,44	94,77	78,50	79,03	79,84	97,35	97,34	97,27
Heavy Duty Veh.	Diesel RT >32t	Euro I	1994	1996	12,50	11,58	11,42	16,36	14,69	15,31	23,16	27,51	29,07	29,15	29,31	29,12	8,38	3,49	0,77
Heavy Duty Veh.	Diesel RT >32t	Euro III	2002	2006	12,36	11,61	11,90	21,04	20,21	20,42	67,54	69,42	70,25	40,86	41,56	42,49	48,85	46,96	45,25
Heavy Duty Veh.	Diesel RT >32t	Euro IV	2007	2009	18,38	17,81	18,11	94,49	94,55	94,72	93,96	94,54	94,85	63,71	63,97	63,88	97,41	97,39	97,33
Heavy Duty Veh.	Diesel RT >32t	Euro V	2010	2014	16,89	16,56	16,96	94,41	94,49	94,68	93,86	94,46	94,79	78,48	78,77	78,75	97,35	97,33	97,28
Heavy Duty Veh.	Diesel TT/AT 28 - 34t	Conventional	0	1993	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Heavy Duty Veh.	Diesel TT/AT 28 - 34t	Euro I	1994	1996	10,66	10,13	10,20	15,43	12,25	12,77	24,63	26,46	27,12	29,11	29,63	29,69	7,38	4,00	3,37
Heavy Duty Veh.	Diesel TT/AT 28 - 34t	Euro II	1997	2001	14,64	13,29	13,74	31,30	25,94	23,81	65,67	65,99	53,62	27,71	27,97	28,65	41,09	39,33	40,65

Continued

Heavy Duty Veh.	Diesel TT/AT 28 - 34t	Euro III	2002	2006	11,70	11,01	11,58	20,78	20,50	20,31	68,41	69,33	69,54	41,68	43,76	44,51	48,57	47,10	46,10
Heavy Duty Veh.	Diesel TT/AT 28 - 34t	Euro IV	2007	2009	17,59	17,20	17,85	94,57	94,65	94,91	94,14	94,65	94,97	64,11	65,18	64,46	97,40	97,39	97,34
Heavy Duty Veh.	Diesel TT/AT 28 - 34t	Euro V	2010	2014	16,12	15,95	16,73	94,50	94,59	94,86	94,05	94,58	94,90	78,71	79,60	79,26	97,35	97,34	97,29
Heavy Duty Veh.	Diesel TT/AT 34 - 40t	Conventional	0	1993	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Heavy Duty Veh.	Diesel TT/AT 34 - 40t	Euro I	1994	1996	12,13	11,41	11,43	15,15	13,05	13,59	22,77	26,35	27,63	29,55	29,58	29,47	7,47	3,64	2,14
Heavy Duty Veh.	Diesel TT/AT 34 - 40t	Euro II	1997	2001	14,47	13,03	13,29	31,64	24,64	21,80	65,15	65,77	53,15	26,47	27,08	27,05	41,31	38,92	40,06
Heavy Duty Veh.	Diesel TT/AT 34 - 40t	Euro III	2002	2006	11,94	11,27	11,85	20,63	19,44	19,37	67,76	69,22	69,88	41,45	42,35	42,24	48,65	47,10	45,84
Heavy Duty Veh.	Diesel TT/AT 34 - 40t	Euro IV	2007	2009	18,09	17,61	18,18	94,63	94,66	94,93	94,11	94,66	94,93	63,89	64,44	63,38	97,40	97,39	97,33
Heavy Duty Veh.	Diesel TT/AT 34 - 40t	Euro V	2010	2014	16,62	16,35	17,01	94,55	94,60	94,89	94,01	94,58	94,86	78,66	79,13	78,50	97,35	97,34	97,27
Heavy Duty Veh.	Diesel TT/AT 40 - 50t	Conventional	0	1993	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Heavy Duty Veh.	Diesel TT/AT 40 - 50t	Euro I	1994	1996	12,00	11,39	11,53	14,38	9,70	9,28	22,52	25,41	26,29	30,04	30,19	30,13	5,93	1,77	1,82
Heavy Duty Veh.	Diesel TT/AT 40 - 50t	Euro II	1997	2001	13,71	12,64	13,25	29,69	22,96	20,14	64,07	64,68	52,14	27,37	28,20	28,34	40,39	37,95	40,18
Heavy Duty Veh.	Diesel TT/AT 40 - 50t	Euro III	2002	2006	11,55	11,28	12,07	19,87	18,88	18,81	68,17	69,70	70,31	42,32	43,17	42,86	48,25	46,50	47,44
Heavy Duty Veh.	Diesel TT/AT 40 - 50t	Euro IV	2007	2009	17,75	17,68	18,61	94,68	94,79	94,99	94,32	94,90	95,15	64,06	64,69	63,75	97,40	97,39	97,36
Heavy Duty Veh.	Diesel TT/AT 40 - 50t	Euro V	2010	2014	16,27	16,43	17,44	94,61	94,70	94,98	94,22	94,82	95,08	78,86	79,40	78,79	97,34	97,34	97,30
Heavy Duty Veh.	Diesel TT/AT 50 - 60t	Euro II	1997	2001	14,04	13,10	13,89	28,00	26,76	9,91	63,10	63,63	50,92	28,81	29,51	29,11	39,38	37,01	39,90
Heavy Duty Veh.	Diesel TT/AT 50 - 60t	Euro IV	2007	2009	18,10	18,12	19,18	94,79	94,92	95,16	94,58	95,14	95,36	64,53	65,11	64,11	97,39	97,39	97,37
Heavy Duty Veh.	Diesel TT/AT >60t	Euro V	2010	2014	16,40	16,64	17,80	94,72	94,86	95,10	94,49	95,06	95,28	79,29	79,80	79,09	97,34	97,34	97,32
Buses	Gasoline Urban Buses	Conventional	0	9999	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Buses	Diesel Urban Buses <15t	Conventional	0	1993	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Buses	Diesel Urban Buses <15t	Euro I	1994	1996	18,85	18,92	18,21	64,43	65,86	67,68	65,05	62,49	60,57	26,62	28,27	28,63	80,71	79,83	79,24
Buses	Diesel Urban Buses <15t	Euro II	1997	2001	22,37	20,84	20,78	67,71	70,27	73,36	84,13	81,90	80,25	21,33	23,84	24,64	87,45	87,01	86,66
Buses	Diesel Urban Buses <15t	Euro III	2002	2006	18,19	16,71	16,65	64,31	67,16	72,55	84,65	82,77	81,54	31,66	40,65	48,19	88,82	88,36	88,06
Buses	Diesel Urban Buses <15t	Euro IV	2007	2009	21,90	21,76	20,81	97,06	97,41	97,61	96,60	96,75	96,78	60,26	63,58	66,60	99,42	99,42	99,42
Buses	Diesel Urban Buses 15 - 18t	Conventional	0	1993	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Buses	Diesel Urban Buses 15 - 18t	Euro I	1994	1996	14,83	13,35	12,85	52,04	51,79	55,42	45,74	41,81	43,69	39,11	39,36	41,56	58,81	56,29	54,39
Buses	Diesel Urban Buses 15 - 18t	Euro II	1997	2001	17,76	14,66	13,07	57,73	57,23	61,50	75,04	71,66	68,52	34,94	36,64	38,47	73,19	71,52	69,69
Buses	Diesel Urban Buses 15 - 18t	Euro III	2002	2006	13,52	11,21	10,63	53,21	54,20	58,38	76,57	74,49	72,92	44,89	50,41	55,05	76,10	74,64	73,35
Buses	Diesel Urban Buses 15 - 18t	Euro IV	2007	2009	18,47	16,55	15,86	96,18	96,48	96,59	95,01	95,23	95,20	67,58	68,76	72,16	98,77	98,75	98,71
Buses	Diesel Urban Buses >18t	Conventional	0	1993	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Buses	Diesel Urban Buses >18t	Euro I	1994	1996	13,05	11,70	10,96	49,89	49,90	53,47	45,37	41,48	42,64	39,31	39,74	39,30	56,95	53,47	50,97
Buses	Diesel Urban Buses >18t	Euro II	1997	2001	14,50	12,58	12,35	54,22	57,70	62,71	72,77	70,48	68,51	36,94	37,43	40,10	72,09	69,98	67,95
Buses	Diesel Urban Buses >18t	Euro III	2002	2006	11,72	9,92	9,64	52,06	54,97	59,90	77,63	76,08	74,56	46,95	49,89	56,68	75,47	73,72	72,30
Buses	Diesel Urban Buses >18t	Euro IV	2007	2009	17,13	15,57	14,89	96,15	96,61	97,12	95,36	95,74	95,80	67,62	68,63	71,57	98,74	98,72	98,68
Buses	Gasoline Coaches	Conventional	0	9999	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Continued

Buses	Diesel Coaches <15t	Conventional	0	1993	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Buses	Diesel Coaches <15t	Euro I	1994	1996	7,96	7,67	7,92	18,93	16,53	16,34	20,89	23,78	27,11	23,46	23,96	25,12	7,21	2,52	-4,41
Buses	Diesel Coaches <15t	Euro II	1997	2001	8,24	7,37	7,94	32,32	27,97	24,04	65,98	63,06	61,68	14,45	16,52	18,47	38,19	34,08	31,34
Buses	Diesel Coaches <15t	Euro III	2002	2006	1,71	0,56	0,19	16,59	13,73	12,65	62,34	61,58	62,41	26,50	32,15	35,43	42,96	38,70	31,67
Buses	Diesel Coaches <15t	Euro IV	2007	2009	6,93	6,22	5,83	93,52	93,34	93,37	92,49	92,91	92,91	56,15	58,53	60,19	97,02	96,87	96,57
Buses	Diesel Coaches 15 - 18t	Conventional	0	1993	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Buses	Diesel Coaches 15 - 18t	Euro I	1994	1996	7,96	7,67	7,92	18,93	16,53	16,34	20,89	23,78	27,11	23,46	23,96	25,12	7,21	2,52	-4,41
Buses	Diesel Coaches 15 - 18t	Euro II	1997	2001	8,24	7,37	7,94	32,32	27,97	24,04	65,98	63,06	61,68	14,45	16,52	18,47	38,19	34,08	31,34
Buses	Diesel Coaches 15 - 18t	Euro III	2002	2006	1,71	0,56	0,19	16,59	13,73	12,65	62,34	61,58	62,41	26,50	32,15	35,43	42,96	38,70	31,67
Buses	Diesel Coaches 15 - 18t	Euro IV	2007	2009	6,93	6,22	5,83	93,52	93,34	93,37	92,49	92,91	92,91	56,15	58,53	60,19	97,02	96,87	96,57
Buses	Diesel Coaches >18t	Conventional	0	1993	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Buses	Diesel Coaches >18t	Euro I	1994	1996	10,85	10,61	11,02	18,66	16,77	17,56	23,95	25,83	27,25	24,78	25,97	26,10	8,54	4,54	2,08
Buses	Diesel Coaches >18t	Euro II	1997	2001	12,31	11,38	11,82	31,63	29,13	27,82	66,43	63,73	62,36	18,65	20,76	21,41	40,27	38,73	37,32
Buses	Diesel Coaches >18t	Euro III	2002	2006	9,21	11,33	13,13	18,34	19,05	22,13	64,85	65,53	66,70	34,22	37,99	40,74	45,39	43,98	42,31
Buses	Diesel Coaches >18t	Euro IV	2007	2009	14,12	16,40	17,99	93,89	94,02	94,22	93,08	93,60	93,92	60,31	61,95	63,79	97,17	97,16	97,11
Mopeds	<50 cm³	Conventional	0	1999	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Mopeds	<50 cm³	Euro I	2000	2003	40,00	40,00	0,00	59,42	59,42	0,00	59,84	59,84	0,00	0,00	0,00	0,00	80,37	80,37	0,00
Mopeds	<50 cm³	Euro II	2004	9999	51,68	51,68	0,00	90,58	90,58	0,00	80,00	80,00	0,00	-1.200,00	-1.200,00	0,00	88,79	88,79	0,00
Motorcycles	2-stroke >50 cm³	Conventional	0	1999	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Motorcycles	4-stroke <250 cm³	Conventional	0	1999	8,20	9,50	10,60	0,00	0,00	0,00	0,00	0,00	0,00	22,10	-0,90	-15,50	89,70	88,00	85,90
Motorcycles	4-stroke <250 cm³	Euro I	2000	2003	0,00	0,00	0,00	31,90	16,00	0,20	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Motorcycles	4-stroke <250 cm³	Euro II	2004	2006	17,60	17,20	16,30	75,70	66,50	63,40	75,00	75,00	75,00	-6,10	-5,40	-5,50	16,10	2,60	1,10
Motorcycles	4-stroke <250 cm³	Euro III	2007	9999	28,70	33,00	35,70	86,50	81,40	79,60	75,00	75,00	75,00	16,90	9,90	-7,90	63,30	49,10	47,60
Motorcycles	4-stroke 250 - 750 cm³	Conventional	0	1999	28,70	33,00	35,70	0,00	0,00	0,00	0,00	0,00	0,00	24,10	24,90	10,10	77,20	68,00	66,50
Motorcycles	4-stroke 250 - 750 cm³	Euro I	2000	2003	0,00	0,00	0,00	48,20	53,80	54,50	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Motorcycles	4-stroke 250 - 750 cm³	Euro II	2004	2006	8,50	5,70	0,30	89,10	87,50	73,50	75,00	75,00	75,00	0,20	2,50	5,40	44,50	39,20	23,30
Motorcycles	4-stroke 250 - 750 cm³	Euro III	2007	9999	17,10	13,40	7,90	94,00	93,10	85,40	75,00	75,00	75,00	70,40	67,00	56,50	75,00	67,20	43,00
Motorcycles	4-stroke >750 cm³	Conventional	0	1999	17,10	13,40	7,90	0,00	0,00	0,00	0,00	0,00	0,00	85,00	83,20	78,10	84,30	79,50	64,20
Motorcycles	4-stroke >750 cm³	Euro I	2000	2003	0,00	0,00	0,00	48,20	53,80	54,50	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Motorcycles	4-stroke >750 cm³	Euro II	2004	2006	2,30	7,40	11,80	89,10	87,50	73,50	75,00	75,00	75,00	-14,20	-37,30	-17,00	56,40	59,00	57,80
Motorcycles	4-stroke >750 cm³	Euro III	2007	9999	6,40	8,70	9,30	94,00	93,10	85,40	75,00	75,00	75,00	16,90	-12,40	-23,50	84,60	81,20	73,20

Annex 2B-6: Fuel consumption factors (MJ/km) and emission factors (g/km)

Sector	ForecastYear	FCu (MJ)	FCr (MJ)	FCh (MJ)	CO_2u	CO_2r	CO_2h	CH_4u	CH_4r	CH_4h	N_2Ou	N_2Or	N_2Oh	SO_2u	SO_2r	SO_2h	NO_xu	NO_xr	NO_xh
Passenger Cars	1985	3,393	2,112	2,438	248	154	178	0,149	0,027	0,024	0,009	0,006	0,006	0,079	0,048	0,058	1,898	2,194	2,706
Passenger Cars	1986	3,340	2,099	2,419	244	153	177	0,148	0,027	0,024	0,009	0,006	0,006	0,053	0,032	0,038	1,867	2,183	2,747
Passenger Cars	1987	3,317	2,087	2,393	242	153	175	0,148	0,027	0,024	0,009	0,006	0,006	0,052	0,032	0,038	1,865	2,192	2,797
Passenger Cars	1988	3,241	2,078	2,373	237	152	173	0,147	0,027	0,024	0,009	0,006	0,006	0,051	0,031	0,038	1,846	2,203	2,840
Passenger Cars	1989	3,203	2,070	2,356	234	151	172	0,145	0,027	0,024	0,009	0,006	0,006	0,037	0,023	0,028	1,835	2,205	2,862
Passenger Cars	1990	3,184	2,063	2,341	233	151	171	0,145	0,027	0,024	0,009	0,006	0,006	0,037	0,023	0,028	1,836	2,212	2,882
Passenger Cars	1991	3,196	2,058	2,326	234	150	170	0,142	0,027	0,023	0,009	0,006	0,006	0,037	0,023	0,027	1,787	2,126	2,777
Passenger Cars	1992	3,153	2,054	2,307	230	150	169	0,133	0,026	0,023	0,010	0,006	0,006	0,025	0,016	0,018	1,678	1,967	2,575
Passenger Cars	1993	3,155	2,047	2,283	231	150	167	0,126	0,025	0,022	0,011	0,006	0,005	0,013	0,008	0,010	1,596	1,819	2,387
Passenger Cars	1994	3,113	2,045	2,269	228	149	166	0,113	0,024	0,021	0,012	0,007	0,005	0,013	0,009	0,010	1,469	1,630	2,157
Passenger Cars	1995	3,110	2,046	2,259	227	150	165	0,103	0,022	0,020	0,012	0,007	0,005	0,013	0,009	0,010	1,364	1,454	1,940
Passenger Cars	1996	3,135	2,049	2,251	229	150	165	0,094	0,021	0,019	0,013	0,007	0,005	0,013	0,009	0,010	1,280	1,300	1,751
Passenger Cars	1997	3,084	2,050	2,238	225	150	164	0,084	0,020	0,017	0,014	0,007	0,005	0,013	0,008	0,010	1,175	1,151	1,562
Passenger Cars	1998	3,079	2,050	2,221	225	150	162	0,076	0,019	0,016	0,013	0,007	0,005	0,013	0,009	0,010	1,076	1,007	1,371
Passenger Cars	1999	3,058	2,050	2,209	224	150	161	0,069	0,018	0,015	0,013	0,006	0,004	0,010	0,007	0,008	0,988	0,883	1,202
Passenger Cars	2000	3,040	2,050	2,201	222	150	161	0,063	0,017	0,014	0,013	0,006	0,004	0,007	0,005	0,005	0,927	0,795	1,079
Passenger Cars	2001	3,066	2,053	2,199	224	150	161	0,059	0,015	0,013	0,013	0,006	0,004	0,007	0,005	0,005	0,885	0,733	0,990
Passenger Cars	2002	3,039	2,058	2,200	222	150	161	0,053	0,014	0,012	0,012	0,006	0,004	0,007	0,005	0,005	0,831	0,670	0,899
Passenger Cars	2003	3,044	2,061	2,200	223	151	161	0,047	0,012	0,011	0,012	0,005	0,003	0,007	0,005	0,005	0,781	0,610	0,811
Passenger Cars	2004	2,993	2,063	2,199	219	151	161	0,041	0,011	0,010	0,011	0,005	0,003	0,007	0,005	0,005	0,725	0,552	0,726
Passenger Cars	2005	3,019	2,064	2,198	221	151	161	0,037	0,009	0,009	0,011	0,005	0,003	0,001	0,001	0,001	0,676	0,496	0,644
Passenger Cars	2006	2,998	2,067	2,198	219	151	161	0,031	0,008	0,007	0,010	0,004	0,003	0,001	0,001	0,001	0,619	0,441	0,567
Passenger Cars	2007	2,975	2,073	2,201	217	152	161	0,026	0,007	0,006	0,010	0,004	0,003	0,001	0,001	0,001	0,573	0,398	0,509
Passenger Cars	2008	2,977	2,071	2,196	218	152	161	0,022	0,006	0,005	0,009	0,003	0,003	0,001	0,001	0,001	0,539	0,364	0,465
Passenger Cars	2009	2,955	2,065	2,190	216	151	160	0,020	0,005	0,004	0,009	0,003	0,003	0,001	0,001	0,001	0,515	0,342	0,437
Light Duty Vehicles	1985	4,031	2,783	2,979	297	205	220	0,052	0,017	0,011	0,002	0,001	0,001	0,758	0,546	0,597	2,086	1,241	1,281
Light Duty Vehicles	1986	4,010	2,785	2,985	296	206	220	0,050	0,017	0,011	0,002	0,001	0,001	0,460	0,332	0,363	2,067	1,217	1,254
Light Duty Vehicles	1987	4,022	2,785	2,985	297	206	220	0,050	0,017	0,011	0,002	0,001	0,001	0,461	0,332	0,363	2,073	1,218	1,255
Light Duty Vehicles	1988	3,967	2,785	2,985	293	206	220	0,050	0,017	0,011	0,002	0,001	0,001	0,455	0,332	0,363	2,039	1,216	1,253
Light Duty Vehicles	1989	3,944	2,787	2,989	291	206	221	0,049	0,016	0,011	0,002	0,001	0,001	0,305	0,224	0,244	2,021	1,200	1,235
Light Duty Vehicles	1990	3,939	2,787	2,990	291	206	221	0,048	0,016	0,011	0,002	0,001	0,001	0,305	0,224	0,245	2,016	1,196	1,230
Light Duty Vehicles	1991	3,977	2,787	2,989	293	206	221	0,049	0,016	0,011	0,002	0,001	0,001	0,307	0,223	0,244	2,041	1,203	1,238
Light Duty Vehicles	1992	3,966	2,784	2,982	293	206	220	0,051	0,017	0,011	0,002	0,001	0,001	0,197	0,144	0,157	2,040	1,229	1,267
Light Duty Vehicles	1993	4,006	2,784	2,979	296	205	220	0,051	0,017	0,011	0,002	0,001	0,001	0,077	0,056	0,061	2,065	1,239	1,279

Continued

Light Duty Vehicles	1994	3,981	2,783	2,979	294	205	220	0,051	0,017	0,011	0,002	0,001	0,001	0,077	0,056	0,061	2,049	1,233	1,272
Light Duty Vehicles	1995	3,976	2,768	2,962	293	204	219	0,049	0,016	0,010	0,002	0,001	0,001	0,077	0,055	0,061	1,993	1,202	1,241
Light Duty Vehicles	1996	3,978	2,737	2,931	294	202	216	0,044	0,015	0,009	0,003	0,002	0,002	0,077	0,055	0,060	1,900	1,150	1,189
Light Duty Vehicles	1997	3,894	2,707	2,899	287	200	214	0,039	0,014	0,009	0,003	0,003	0,002	0,076	0,055	0,060	1,763	1,107	1,147
Light Duty Vehicles	1998	3,873	2,682	2,870	286	198	212	0,036	0,014	0,008	0,004	0,003	0,003	0,075	0,054	0,059	1,669	1,073	1,114
Light Duty Vehicles	1999	3,834	2,659	2,845	283	196	210	0,032	0,012	0,007	0,005	0,004	0,003	0,042	0,030	0,032	1,575	1,040	1,082
Light Duty Vehicles	2000	3,803	2,640	2,823	281	195	208	0,028	0,011	0,006	0,006	0,005	0,004	0,009	0,006	0,007	1,499	1,018	1,061
Light Duty Vehicles	2001	3,820	2,623	2,804	282	194	207	0,025	0,010	0,006	0,006	0,005	0,004	0,009	0,006	0,007	1,453	0,997	1,041
Light Duty Vehicles	2002	3,778	2,609	2,789	279	193	206	0,022	0,009	0,005	0,007	0,005	0,005	0,009	0,006	0,007	1,357	0,955	0,998
Light Duty Vehicles	2003	3,767	2,594	2,777	278	192	205	0,019	0,007	0,004	0,008	0,005	0,005	0,009	0,006	0,006	1,264	0,896	0,938
Light Duty Vehicles	2004	3,699	2,581	2,766	273	191	204	0,016	0,006	0,003	0,009	0,005	0,004	0,009	0,006	0,006	1,149	0,837	0,876
Light Duty Vehicles	2005	3,723	2,571	2,757	275	190	204	0,013	0,004	0,003	0,010	0,005	0,004	0,002	0,001	0,001	1,073	0,779	0,817
Light Duty Vehicles	2006	3,693	2,561	2,749	273	189	203	0,011	0,003	0,002	0,011	0,005	0,004	0,002	0,001	0,001	0,996	0,732	0,768
Light Duty Vehicles	2007	3,648	2,547	2,744	269	188	203	0,009	0,003	0,002	0,011	0,004	0,004	0,002	0,001	0,001	0,918	0,680	0,713
Light Duty Vehicles	2008	3,664	2,543	2,741	271	188	202	0,008	0,002	0,001	0,011	0,004	0,004	0,002	0,001	0,001	0,833	0,614	0,644
Light Duty Vehicles	2009	3,658	2,541	2,739	270	187	202	0,007	0,002	0,001	0,012	0,004	0,004	0,002	0,001	0,001	0,782	0,577	0,606
Heavy Duty Vehicles	1985	13,634	10,397	9,631	1009	769	713	0,153	0,066	0,058	0,030	0,030	0,030	3,181	2,427	2,247	13,431	10,825	9,874
Heavy Duty Vehicles	1986	13,736	10,467	9,685	1016	775	717	0,154	0,067	0,059	0,030	0,030	0,030	1,924	1,467	1,356	13,531	10,890	9,921
Heavy Duty Vehicles	1987	13,819	10,523	9,729	1023	779	720	0,155	0,067	0,059	0,030	0,030	0,030	1,936	1,475	1,363	13,610	10,943	9,958
Heavy Duty Vehicles	1988	13,987	10,639	9,818	1035	787	726	0,156	0,068	0,060	0,030	0,030	0,030	1,960	1,491	1,375	13,779	11,058	10,038
Heavy Duty Vehicles	1989	14,045	10,679	9,848	1039	790	729	0,157	0,069	0,060	0,030	0,030	0,030	1,312	0,998	0,920	13,837	11,096	10,065
Heavy Duty Vehicles	1990	14,344	10,882	10,005	1061	805	740	0,159	0,070	0,061	0,030	0,030	0,030	1,340	1,017	0,935	14,122	11,288	10,197
Heavy Duty Vehicles	1991	14,327	10,871	9,996	1060	804	740	0,159	0,070	0,061	0,030	0,030	0,030	1,339	1,016	0,934	14,114	11,284	10,193
Heavy Duty Vehicles	1992	14,488	10,980	10,081	1072	813	746	0,160	0,071	0,062	0,030	0,030	0,030	0,880	0,667	0,612	14,264	11,385	10,266
Heavy Duty Vehicles	1993	14,732	11,145	10,206	1090	825	755	0,162	0,072	0,063	0,030	0,030	0,030	0,344	0,261	0,238	14,463	11,513	10,344
Heavy Duty Vehicles	1994	14,697	11,120	10,174	1088	823	753	0,163	0,072	0,063	0,030	0,030	0,030	0,344	0,260	0,238	14,231	11,315	10,152
Heavy Duty Vehicles	1995	14,348	10,880	9,965	1062	805	737	0,162	0,072	0,063	0,030	0,030	0,030	0,335	0,254	0,233	13,495	10,741	9,653
Heavy Duty Vehicles	1996	14,310	10,850	9,915	1059	803	734	0,163	0,073	0,064	0,030	0,030	0,030	0,335	0,254	0,232	13,020	10,335	9,260
Heavy Duty Vehicles	1997	14,147	10,740	9,804	1047	795	725	0,157	0,072	0,064	0,030	0,030	0,030	0,331	0,251	0,229	12,584	9,967	8,911
Heavy Duty Vehicles	1998	13,896	10,576	9,654	1028	783	714	0,147	0,071	0,063	0,030	0,030	0,030	0,325	0,247	0,226	12,200	9,650	8,623
Heavy Duty Vehicles	1999	13,741	10,476	9,556	1017	775	707	0,139	0,070	0,063	0,030	0,030	0,030	0,177	0,135	0,123	11,930	9,417	8,398
Heavy Duty Vehicles	2000	13,777	10,509	9,567	1019	778	708	0,132	0,069	0,062	0,030	0,030	0,030	0,032	0,025	0,022	11,851	9,330	8,298
Heavy Duty Vehicles	2001	13,743	10,500	9,555	1017	777	707	0,124	0,068	0,062	0,030	0,030	0,030	0,032	0,025	0,022	11,571	9,101	8,093
Heavy Duty Vehicles	2002	13,921	10,615	9,630	1030	786	713	0,119	0,068	0,061	0,030	0,030	0,030	0,033	0,025	0,023	11,328	8,880	7,870
Heavy Duty Vehicles	2003	13,997	10,661	9,656	1036	789	715	0,113	0,068	0,061	0,030	0,030	0,030	0,033	0,025	0,023	10,954	8,567	7,585
Heavy Duty Vehicles	2004	14,023	10,673	9,661	1038	790	715	0,109	0,068	0,061	0,030	0,030	0,030	0,033	0,025	0,023	10,603	8,280	7,331
Heavy Duty Vehicles	2005	14,262	10,833	9,778	1055	802	724	0,106	0,069	0,061	0,030	0,030	0,030	0,007	0,005	0,005	10,387	8,085	7,143

Continued																			
Heavy Duty Vehicles	2006	14,296	10,850	9,789	1058	803	724	0,101	0,068	0,060	0,030	0,030	0,030	0,007	0,005	0,005	10,023	7,791	6,887
Heavy Duty Vehicles	2007	14,234	10,793	9,729	1053	799	720	0,087	0,060	0,052	0,030	0,030	0,030	0,007	0,005	0,005	9,295	7,219	6,389
Heavy Duty Vehicles	2008	13,948	10,554	9,492	1032	781	702	0,068	0,047	0,041	0,029	0,029	0,029	0,007	0,005	0,004	8,204	6,360	5,635
Heavy Duty Vehicles	2009	14,105	10,657	9,565	1042	787	707	0,054	0,039	0,033	0,030	0,030	0,030	0,007	0,005	0,004	7,569	5,860	5,201
Buses	1985	13,264	9,858	8,936	981	729	661	0,174	0,081	0,070	0,029	0,029	0,029	3,057	2,258	2,006	13,431	10,515	9,565
Buses	1986	13,269	9,864	8,940	982	730	661	0,174	0,081	0,070	0,030	0,029	0,029	1,837	1,358	1,208	13,439	10,517	9,567
Buses	1987	13,271	9,868	8,944	982	730	662	0,174	0,081	0,070	0,030	0,029	0,029	1,838	1,359	1,209	13,449	10,527	9,578
Buses	1988	13,273	9,875	8,951	982	731	662	0,174	0,081	0,070	0,030	0,029	0,029	1,839	1,360	1,211	13,466	10,544	9,595
Buses	1989	13,276	9,879	8,954	982	731	662	0,174	0,081	0,070	0,030	0,029	0,029	1,227	0,908	0,809	13,472	10,545	9,596
Buses	1990	13,273	9,868	8,943	982	730	661	0,174	0,081	0,070	0,030	0,029	0,029	1,226	0,907	0,807	13,445	10,516	9,567
Buses	1991	13,271	9,865	8,941	982	730	661	0,174	0,081	0,070	0,030	0,029	0,029	1,226	0,906	0,806	13,440	10,513	9,563
Buses	1992	13,265	9,856	8,933	981	729	661	0,174	0,081	0,070	0,029	0,029	0,029	0,795	0,588	0,522	13,424	10,503	9,554
Buses	1993	13,261	9,847	8,925	981	728	660	0,174	0,081	0,070	0,029	0,029	0,029	0,306	0,226	0,201	13,404	10,486	9,536
Buses	1994	13,126	9,751	8,853	971	721	655	0,174	0,081	0,070	0,029	0,029	0,029	0,302	0,223	0,198	13,029	10,223	9,321
Buses	1995	12,931	9,598	8,738	957	710	646	0,174	0,081	0,070	0,029	0,029	0,028	0,296	0,218	0,194	12,431	9,774	8,956
Buses	1996	12,777	9,483	8,650	945	701	640	0,174	0,081	0,070	0,029	0,029	0,028	0,292	0,215	0,192	11,939	9,404	8,658
Buses	1997	12,600	9,381	8,576	932	694	634	0,171	0,080	0,069	0,029	0,029	0,028	0,288	0,213	0,191	11,571	9,132	8,436
Buses	1998	12,327	9,238	8,488	912	683	628	0,163	0,077	0,067	0,029	0,029	0,028	0,282	0,210	0,189	11,183	8,856	8,239
Buses	1999	12,079	9,113	8,414	894	674	622	0,156	0,074	0,064	0,029	0,029	0,029	0,152	0,114	0,104	10,801	8,585	8,046
Buses	2000	11,977	9,065	8,377	886	671	619	0,150	0,071	0,062	0,029	0,029	0,029	0,028	0,021	0,020	10,591	8,421	7,908
Buses	2001	11,964	9,064	8,366	885	670	619	0,146	0,069	0,061	0,029	0,029	0,029	0,028	0,021	0,020	10,484	8,328	7,815
Buses	2002	11,964	9,076	8,369	885	671	619	0,141	0,067	0,059	0,029	0,029	0,029	0,028	0,021	0,020	10,229	8,110	7,618
Buses	2003	11,970	9,098	8,386	886	673	620	0,135	0,064	0,057	0,029	0,029	0,029	0,028	0,021	0,020	9,956	7,855	7,377
Buses	2004	12,009	9,128	8,404	888	675	622	0,131	0,062	0,055	0,029	0,029	0,029	0,028	0,021	0,020	9,765	7,662	7,179
Buses	2005	11,991	9,131	8,409	887	675	622	0,127	0,060	0,053	0,029	0,029	0,029	0,006	0,004	0,004	9,563	7,464	6,975
Buses	2006	12,002	9,147	8,422	888	677	623	0,123	0,058	0,052	0,030	0,029	0,029	0,006	0,004	0,004	9,385	7,282	6,787
Buses	2007	12,013	9,157	8,428	889	677	623	0,115	0,055	0,049	0,030	0,029	0,029	0,006	0,004	0,004	9,085	7,030	6,546
Buses	2008	11,954	9,117	8,399	884	674	621	0,102	0,049	0,044	0,030	0,029	0,029	0,006	0,004	0,004	8,554	6,633	6,196
Buses	2009	11,919	9,091	8,379	881	672	619	0,086	0,042	0,039	0,030	0,029	0,029	0,006	0,004	0,004	7,998	6,219	5,827
Mopeds	1985	1,095	1,095		80	80		0,219	0,219		0,001	0,001		0,003	0,003		0,020	0,020	
Mopeds	1986	1,095	1,095		80	80		0,219	0,219		0,001	0,001		0,003	0,003		0,020	0,020	
Mopeds	1987	1,095	1,095		80	80		0,219	0,219		0,001	0,001		0,003	0,003		0,020	0,020	
Mopeds	1988	1,095	1,095		80	80		0,219	0,219		0,001	0,001		0,003	0,003		0,020	0,020	
Mopeds	1989	1,095	1,095		80	80		0,219	0,219		0,001	0,001		0,003	0,003		0,020	0,020	
Mopeds	1990	1,095	1,095		80	80		0,219	0,219		0,001	0,001		0,003	0,003		0,020	0,020	
Mopeds	1991	1,095	1,095		80	80		0,219	0,219		0,001	0,001		0,003	0,003		0,020	0,020	
Mopeds	1992	1,095	1,095		80	80		0,219	0,219		0,001	0,001		0,003	0,003		0,020	0,020	

Continued

Mopeds	1993	1,095	1,095		80	80		0,219	0,219		0,001	0,001		0,003	0,003		0,020	0,020	
Mopeds	1994	1,095	1,095		80	80		0,219	0,219		0,001	0,001		0,003	0,003		0,020	0,020	
Mopeds	1995	1,095	1,095		80	80		0,219	0,219		0,001	0,001		0,003	0,003		0,020	0,020	
Mopeds	1996	1,095	1,095		80	80		0,219	0,219		0,001	0,001		0,003	0,003		0,020	0,020	
Mopeds	1997	1,095	1,095		80	80		0,219	0,219		0,001	0,001		0,003	0,003		0,020	0,020	
Mopeds	1998	1,095	1,095		80	80		0,219	0,219		0,001	0,001		0,003	0,003		0,020	0,020	
Mopeds	1999	1,095	1,095		80	80		0,219	0,219		0,001	0,001		0,003	0,003		0,020	0,020	
Mopeds	2000	1,050	1,050		77	77		0,201	0,201		0,001	0,001		0,002	0,002		0,020	0,020	
Mopeds	2001	1,019	1,019		74	74		0,188	0,188		0,001	0,001		0,002	0,002		0,020	0,020	
Mopeds	2002	0,985	0,985		72	72		0,175	0,175		0,001	0,001		0,002	0,002		0,020	0,020	
Mopeds	2003	0,969	0,969		71	71		0,169	0,169		0,001	0,001		0,002	0,002		0,020	0,020	
Mopeds	2004	0,940	0,940		69	69		0,159	0,159		0,001	0,001		0,002	0,002		0,035	0,035	
Mopeds	2005	0,910	0,910		66	66		0,149	0,149		0,001	0,001		0,000	0,000		0,051	0,051	
Mopeds	2006	0,876	0,876		64	64		0,138	0,138		0,001	0,001		0,000	0,000		0,067	0,067	
Mopeds	2007	0,848	0,848		62	62		0,128	0,128		0,001	0,001		0,000	0,000		0,083	0,083	
Mopeds	2008	0,827	0,827		60	60		0,121	0,121		0,001	0,001		0,000	0,000		0,094	0,094	
Mopeds	2009	0,806	0,806		59	59		0,115	0,115		0,001	0,001		0,000	0,000		0,105	0,105	
Motorcycles	1985	1,241	1,208	1,481	91	88	108	0,193	0,193	0,193	0,002	0,002	0,002	0,003	0,003	0,003	0,140	0,224	0,391
Motorcycles	1986	1,241	1,208	1,481	91	88	108	0,193	0,193	0,193	0,002	0,002	0,002	0,003	0,003	0,003	0,140	0,224	0,391
Motorcycles	1987	1,241	1,208	1,481	91	88	108	0,193	0,193	0,193	0,002	0,002	0,002	0,003	0,003	0,003	0,140	0,224	0,391
Motorcycles	1988	1,241	1,208	1,481	91	88	108	0,193	0,193	0,193	0,002	0,002	0,002	0,003	0,003	0,003	0,140	0,224	0,391
Motorcycles	1989	1,241	1,208	1,481	91	88	108	0,193	0,193	0,193	0,002	0,002	0,002	0,003	0,003	0,003	0,140	0,224	0,391
Motorcycles	1990	1,241	1,208	1,481	91	88	108	0,193	0,193	0,193	0,002	0,002	0,002	0,003	0,003	0,003	0,140	0,224	0,391
Motorcycles	1991	1,241	1,208	1,481	91	88	108	0,193	0,193	0,193	0,002	0,002	0,002	0,003	0,003	0,003	0,140	0,224	0,391
Motorcycles	1992	1,241	1,208	1,481	91	88	108	0,193	0,193	0,193	0,002	0,002	0,002	0,003	0,003	0,003	0,140	0,224	0,391
Motorcycles	1993	1,241	1,208	1,481	91	88	108	0,193	0,193	0,193	0,002	0,002	0,002	0,003	0,003	0,003	0,140	0,224	0,391
Motorcycles	1994	1,241	1,208	1,481	91	88	108	0,193	0,193	0,193	0,002	0,002	0,002	0,003	0,003	0,003	0,140	0,224	0,391
Motorcycles	1995	1,241	1,208	1,481	91	88	108	0,193	0,193	0,193	0,002	0,002	0,002	0,003	0,003	0,003	0,140	0,224	0,391
Motorcycles	1996	1,241	1,208	1,481	91	88	108	0,193	0,193	0,193	0,002	0,002	0,002	0,003	0,003	0,003	0,140	0,224	0,391
Motorcycles	1997	1,241	1,208	1,481	91	88	108	0,193	0,193	0,193	0,002	0,002	0,002	0,003	0,003	0,003	0,140	0,224	0,391
Motorcycles	1998	1,241	1,208	1,481	91	88	108	0,193	0,193	0,193	0,002	0,002	0,002	0,003	0,003	0,003	0,140	0,224	0,391
Motorcycles	1999	1,241	1,208	1,481	91	88	108	0,193	0,193	0,193	0,002	0,002	0,002	0,003	0,003	0,003	0,140	0,224	0,391
Motorcycles	2000	1,256	1,224	1,499	92	89	109	0,190	0,190	0,190	0,002	0,002	0,002	0,003	0,003	0,003	0,143	0,228	0,395
Motorcycles	2001	1,266	1,233	1,509	92	90	110	0,188	0,189	0,189	0,002	0,002	0,002	0,003	0,003	0,003	0,146	0,231	0,400
Motorcycles	2002	1,276	1,243	1,519	93	91	111	0,187	0,188	0,188	0,002	0,002	0,002	0,003	0,003	0,003	0,148	0,235	0,404
Motorcycles	2003	1,285	1,251	1,528	94	91	112	0,185	0,187	0,187	0,002	0,002	0,002	0,003	0,003	0,003	0,151	0,238	0,409
Motorcycles	2004	1,290	1,257	1,534	94	92	112	0,184	0,184	0,185	0,002	0,002	0,002	0,003	0,003	0,004	0,154	0,243	0,413

Motorcycles	2005	1,299	1,265	1,545	95	92	113	0,181	0,180	0,181	0,002	0,002	0,002	0,001	0,001	0,001	0,158	0,248	0,419
Motorcycles	2006	1,306	1,273	1,554	95	93	113	0,179	0,175	0,177	0,002	0,002	0,002	0,001	0,001	0,001	0,162	0,254	0,426
Motorcycles	2007	1,310	1,277	1,559	95	93	113	0,172	0,166	0,168	0,002	0,002	0,002	0,001	0,001	0,001	0,158	0,249	0,421
Motorcycles	2008	1,311	1,278	1,560	95	93	114	0,169	0,161	0,163	0,002	0,002	0,002	0,001	0,001	0,001	0,157	0,247	0,420
Motorcycles	2009	1,312	1,279	1,560	95	93	114	0,167	0,159	0,160	0,002	0,002	0,002	0,001	0,001	0,001	0,156	0,246	0,420

Sector	ForecastYear	NMVOCu (exh)	NMVOCr (exh)	NMVOCh (exh)	NMVOCu (tot)	NMVOCr (tot)	NMVOCh (tot)	COu	COr	COh	NH_3u	NH_3r	NH_3h	TSPu	TSPr	TSPh
Passenger Cars	1985	3,272	1,058	0,933	5,400	1,437	0,988	39,845	10,662	11,775	0,002	0,002	0,002	0,092	0,049	0,051
Passenger Cars	1986	3,171	1,024	0,902	5,304	1,402	0,956	37,281	9,808	10,609	0,002	0,002	0,002	0,092	0,048	0,051
Passenger Cars	1987	3,144	0,994	0,869	5,265	1,368	0,922	35,687	9,007	9,533	0,002	0,002	0,002	0,089	0,046	0,049
Passenger Cars	1988	2,908	0,967	0,839	5,113	1,355	0,894	31,789	8,379	8,629	0,002	0,002	0,002	0,083	0,044	0,047
Passenger Cars	1989	2,783	0,940	0,809	5,015	1,331	0,865	29,625	7,840	7,854	0,002	0,002	0,002	0,081	0,043	0,046
Passenger Cars	1990	2,720	0,920	0,787	4,948	1,310	0,842	28,383	7,452	7,324	0,002	0,002	0,002	0,078	0,042	0,045
Passenger Cars	1991	2,728	0,873	0,744	4,826	1,238	0,795	28,260	6,968	6,776	0,004	0,007	0,005	0,076	0,039	0,043
Passenger Cars	1992	2,535	0,801	0,681	4,496	1,142	0,729	25,718	6,357	6,186	0,008	0,017	0,010	0,066	0,035	0,038
Passenger Cars	1993	2,490	0,728	0,614	4,222	1,028	0,655	24,623	5,638	5,477	0,011	0,027	0,016	0,062	0,032	0,035
Passenger Cars	1994	2,256	0,641	0,539	3,822	0,911	0,576	21,742	4,948	4,787	0,016	0,039	0,022	0,055	0,028	0,032
Passenger Cars	1995	2,153	0,565	0,476	3,508	0,798	0,508	20,505	4,449	4,364	0,021	0,051	0,029	0,050	0,025	0,029
Passenger Cars	1996	2,134	0,498	0,420	3,267	0,692	0,446	20,113	4,013	4,000	0,025	0,061	0,035	0,046	0,022	0,026
Passenger Cars	1997	1,858	0,432	0,364	2,859	0,603	0,387	17,215	3,564	3,615	0,032	0,072	0,041	0,038	0,019	0,023
Passenger Cars	1998	1,699	0,367	0,310	2,507	0,505	0,328	15,747	3,108	3,207	0,041	0,083	0,047	0,033	0,017	0,020
Passenger Cars	1999	1,477	0,311	0,262	2,167	0,428	0,278	13,568	2,709	2,853	0,049	0,091	0,051	0,030	0,015	0,018
Passenger Cars	2000	1,347	0,271	0,228	1,802	0,348	0,239	12,361	2,431	2,612	0,055	0,097	0,054	0,027	0,014	0,017
Passenger Cars	2001	1,303	0,241	0,203	1,691	0,306	0,212	12,113	2,237	2,454	0,055	0,096	0,056	0,027	0,013	0,016
Passenger Cars	2002	1,142	0,211	0,179	1,479	0,267	0,186	10,704	2,046	2,304	0,052	0,091	0,056	0,024	0,012	0,015
Passenger Cars	2003	1,050	0,181	0,154	1,325	0,226	0,161	10,023	1,839	2,122	0,049	0,086	0,055	0,024	0,012	0,015
Passenger Cars	2004	0,872	0,152	0,131	1,096	0,189	0,136	8,396	1,633	1,935	0,046	0,080	0,055	0,022	0,012	0,015
Passenger Cars	2005	0,830	0,124	0,108	1,017	0,155	0,112	8,333	1,424	1,735	0,040	0,073	0,054	0,023	0,011	0,016
Passenger Cars	2006	0,699	0,100	0,088	0,852	0,125	0,092	7,134	1,217	1,522	0,036	0,066	0,052	0,022	0,011	0,015
Passenger Cars	2007	0,576	0,079	0,070	0,688	0,097	0,073	5,867	0,994	1,269	0,030	0,057	0,048	0,023	0,012	0,015
Passenger Cars	2008	0,523	0,064	0,058	0,610	0,079	0,060	5,383	0,846	1,102	0,026	0,051	0,046	0,024	0,012	0,015
Passenger Cars	2009	0,463	0,055	0,050	0,538	0,067	0,052	4,774	0,739	0,979	0,023	0,046	0,044	0,025	0,012	0,015
Light Duty Vehicles	1985	0,805	0,198	0,151	1,148	0,254	0,162	7,613	1,882	2,184	0,001	0,001	0,001	0,480	0,258	0,273
Light Duty Vehicles	1986	0,759	0,192	0,148	1,085	0,245	0,158	7,146	1,830	2,117	0,001	0,001	0,001	0,475	0,260	0,276
Light Duty Vehicles	1987	0,769	0,192	0,148	1,094	0,245	0,158	7,243	1,832	2,119	0,001	0,001	0,001	0,482	0,260	0,276
Light Duty Vehicles	1988	0,719	0,191	0,147	1,056	0,246	0,158	6,786	1,827	2,114	0,001	0,001	0,001	0,445	0,260	0,276
Light Duty Vehicles	1989	0,681	0,187	0,145	1,010	0,240	0,155	6,423	1,792	2,068	0,001	0,001	0,001	0,435	0,262	0,278

Continued

Light Duty Vehicles	1990	0,673	0,186	0,144	0,998	0,238	0,155	6,341	1,784	2,057	0,001	0,001	0,001	0,433	0,263	0,278
Light Duty Vehicles	1991	0,712	0,188	0,145	1,039	0,240	0,156	6,702	1,799	2,077	0,001	0,001	0,001	0,455	0,262	0,277
Light Duty Vehicles	1992	0,729	0,195	0,149	1,086	0,252	0,160	6,911	1,855	2,150	0,001	0,001	0,001	0,436	0,259	0,274
Light Duty Vehicles	1993	0,775	0,197	0,151	1,127	0,253	0,161	7,346	1,878	2,179	0,001	0,001	0,001	0,457	0,258	0,273
Light Duty Vehicles	1994	0,749	0,196	0,150	1,113	0,253	0,161	7,125	1,870	2,156	0,001	0,001	0,001	0,444	0,258	0,274
Light Duty Vehicles	1995	0,729	0,187	0,145	1,063	0,240	0,155	6,882	1,752	2,017	0,002	0,002	0,002	0,429	0,244	0,260
Light Duty Vehicles	1996	0,701	0,172	0,136	0,975	0,215	0,144	6,524	1,541	1,777	0,002	0,005	0,003	0,408	0,217	0,234
Light Duty Vehicles	1997	0,612	0,159	0,129	0,851	0,197	0,136	5,639	1,349	1,564	0,003	0,007	0,004	0,336	0,190	0,207
Light Duty Vehicles	1998	0,581	0,149	0,123	0,777	0,180	0,129	5,369	1,199	1,399	0,004	0,009	0,006	0,295	0,165	0,184
Light Duty Vehicles	1999	0,527	0,139	0,118	0,692	0,165	0,122	4,827	1,056	1,243	0,006	0,011	0,007	0,254	0,144	0,162
Light Duty Vehicles	2000	0,488	0,133	0,113	0,599	0,150	0,117	4,509	0,955	1,135	0,007	0,013	0,008	0,219	0,125	0,144
Light Duty Vehicles	2001	0,480	0,126	0,109	0,571	0,140	0,112	4,405	0,861	1,033	0,008	0,015	0,009	0,205	0,110	0,129
Light Duty Vehicles	2002	0,428	0,118	0,103	0,506	0,130	0,106	3,981	0,780	0,944	0,009	0,015	0,009	0,173	0,096	0,115
Light Duty Vehicles	2003	0,390	0,108	0,096	0,452	0,118	0,098	3,626	0,692	0,844	0,008	0,013	0,009	0,156	0,084	0,102
Light Duty Vehicles	2004	0,323	0,098	0,088	0,372	0,106	0,090	3,015	0,605	0,745	0,007	0,012	0,009	0,128	0,073	0,091
Light Duty Vehicles	2005	0,304	0,089	0,081	0,344	0,095	0,082	2,850	0,527	0,654	0,006	0,010	0,009	0,120	0,063	0,081
Light Duty Vehicles	2006	0,267	0,082	0,075	0,298	0,087	0,076	2,461	0,464	0,581	0,005	0,009	0,008	0,106	0,056	0,073
Light Duty Vehicles	2007	0,233	0,075	0,069	0,257	0,079	0,070	2,040	0,420	0,527	0,004	0,008	0,007	0,096	0,052	0,068
Light Duty Vehicles	2008	0,215	0,067	0,062	0,235	0,070	0,062	1,923	0,384	0,485	0,004	0,007	0,007	0,090	0,046	0,061
Light Duty Vehicles	2009	0,200	0,062	0,058	0,217	0,065	0,058	1,824	0,365	0,461	0,004	0,007	0,007	0,084	0,043	0,057
Heavy Duty Vehicles	1985	0,954	0,626	0,494	0,954	0,626	0,494	3,309	2,325	2,128	0,003	0,003	0,003	0,592	0,416	0,373
Heavy Duty Vehicles	1986	0,946	0,620	0,490	0,946	0,620	0,490	3,278	2,299	2,101	0,003	0,003	0,003	0,595	0,418	0,374
Heavy Duty Vehicles	1987	0,943	0,618	0,489	0,943	0,618	0,489	3,275	2,296	2,098	0,003	0,003	0,003	0,598	0,420	0,376
Heavy Duty Vehicles	1988	0,935	0,613	0,485	0,935	0,613	0,485	3,271	2,290	2,090	0,003	0,003	0,003	0,603	0,423	0,379
Heavy Duty Vehicles	1989	0,931	0,610	0,484	0,931	0,610	0,484	3,254	2,276	2,076	0,003	0,003	0,003	0,604	0,424	0,380
Heavy Duty Vehicles	1990	0,918	0,602	0,477	0,918	0,602	0,477	3,253	2,272	2,070	0,003	0,003	0,003	0,613	0,430	0,385
Heavy Duty Vehicles	1991	0,920	0,604	0,479	0,920	0,604	0,479	3,259	2,277	2,075	0,003	0,003	0,003	0,613	0,430	0,385
Heavy Duty Vehicles	1992	0,913	0,599	0,475	0,913	0,599	0,475	3,275	2,287	2,084	0,003	0,003	0,003	0,618	0,433	0,387
Heavy Duty Vehicles	1993	0,901	0,591	0,470	0,901	0,591	0,470	3,279	2,289	2,085	0,003	0,003	0,003	0,624	0,437	0,391
Heavy Duty Vehicles	1994	0,882	0,581	0,463	0,882	0,581	0,463	3,198	2,232	2,029	0,003	0,003	0,003	0,615	0,430	0,384
Heavy Duty Vehicles	1995	0,856	0,568	0,453	0,856	0,568	0,453	3,079	2,155	1,958	0,003	0,003	0,003	0,590	0,410	0,365
Heavy Duty Vehicles	1996	0,815	0,543	0,435	0,815	0,543	0,435	2,962	2,080	1,888	0,003	0,003	0,003	0,566	0,391	0,349
Heavy Duty Vehicles	1997	0,761	0,509	0,406	0,761	0,509	0,406	2,816	1,994	1,814	0,003	0,003	0,003	0,519	0,358	0,324
Heavy Duty Vehicles	1998	0,697	0,465	0,370	0,697	0,465	0,370	2,663	1,907	1,744	0,003	0,003	0,003	0,457	0,316	0,295
Heavy Duty Vehicles	1999	0,642	0,428	0,338	0,642	0,428	0,338	2,535	1,834	1,685	0,003	0,003	0,003	0,405	0,280	0,270
Heavy Duty Vehicles	2000	0,599	0,398	0,313	0,599	0,398	0,313	2,454	1,793	1,655	0,003	0,003	0,003	0,367	0,254	0,253
Heavy Duty Vehicles	2001	0,559	0,370	0,289	0,559	0,370	0,289	2,393	1,760	1,630	0,003	0,003	0,003	0,326	0,227	0,231

Continued

Heavy Duty Vehicles	2002	0,528	0,347	0,271	0,528	0,347	0,271	2,407	1,764	1,631	0,003	0,003	0,003	0,304	0,210	0,215
Heavy Duty Vehicles	2003	0,498	0,324	0,254	0,498	0,324	0,254	2,406	1,750	1,613	0,003	0,003	0,003	0,283	0,195	0,196
Heavy Duty Vehicles	2004	0,475	0,306	0,241	0,475	0,306	0,241	2,407	1,738	1,596	0,003	0,003	0,003	0,267	0,183	0,181
Heavy Duty Vehicles	2005	0,455	0,290	0,229	0,455	0,290	0,229	2,436	1,746	1,599	0,003	0,003	0,003	0,254	0,173	0,168
Heavy Duty Vehicles	2006	0,432	0,273	0,216	0,432	0,273	0,216	2,410	1,717	1,568	0,003	0,003	0,003	0,239	0,163	0,154
Heavy Duty Vehicles	2007	0,375	0,237	0,187	0,375	0,237	0,187	2,148	1,527	1,394	0,003	0,003	0,003	0,209	0,142	0,133
Heavy Duty Vehicles	2008	0,291	0,183	0,145	0,291	0,183	0,145	1,702	1,208	1,102	0,003	0,003	0,003	0,167	0,113	0,105
Heavy Duty Vehicles	2009	0,237	0,149	0,117	0,237	0,149	0,117	1,432	1,017	0,928	0,003	0,003	0,003	0,140	0,095	0,087
Buses	1985	1,742	1,101	0,777	1,742	1,101	0,777	5,846	4,395	4,713	0,003	0,003	0,003	0,736	0,454	0,360
Buses	1986	1,733	1,090	0,766	1,733	1,090	0,766	5,756	4,284	4,537	0,003	0,003	0,003	0,736	0,454	0,359
Buses	1987	1,735	1,092	0,768	1,735	1,092	0,768	5,743	4,269	4,520	0,003	0,003	0,003	0,737	0,455	0,360
Buses	1988	1,737	1,092	0,770	1,737	1,092	0,770	5,711	4,232	4,471	0,003	0,003	0,003	0,738	0,455	0,360
Buses	1989	1,732	1,086	0,763	1,732	1,086	0,763	5,653	4,161	4,356	0,003	0,003	0,003	0,738	0,455	0,360
Buses	1990	1,725	1,080	0,756	1,725	1,080	0,756	5,679	4,189	4,385	0,003	0,003	0,003	0,736	0,454	0,359
Buses	1991	1,727	1,083	0,759	1,727	1,083	0,759	5,710	4,226	4,441	0,003	0,003	0,003	0,735	0,454	0,359
Buses	1992	1,736	1,094	0,770	1,736	1,094	0,770	5,819	4,359	4,648	0,003	0,003	0,003	0,735	0,453	0,359
Buses	1993	1,737	1,097	0,772	1,737	1,097	0,772	5,888	4,439	4,763	0,003	0,003	0,003	0,733	0,453	0,359
Buses	1994	1,671	1,080	0,774	1,671	1,080	0,774	5,978	4,659	5,183	0,003	0,003	0,003	0,706	0,439	0,350
Buses	1995	1,549	1,023	0,738	1,549	1,023	0,738	6,012	4,815	5,421	0,003	0,003	0,003	0,663	0,416	0,336
Buses	1996	1,431	0,960	0,697	1,431	0,960	0,697	5,894	4,760	5,326	0,003	0,003	0,003	0,626	0,397	0,323
Buses	1997	1,322	0,901	0,663	1,322	0,901	0,663	5,620	4,566	5,132	0,003	0,003	0,003	0,586	0,375	0,307
Buses	1998	1,200	0,837	0,628	1,200	0,837	0,628	5,322	4,379	4,979	0,003	0,003	0,003	0,528	0,344	0,288
Buses	1999	1,076	0,768	0,588	1,076	0,768	0,588	4,971	4,130	4,739	0,003	0,003	0,003	0,472	0,314	0,268
Buses	2000	0,986	0,720	0,561	0,986	0,720	0,561	4,770	4,003	4,635	0,003	0,003	0,003	0,431	0,290	0,252
Buses	2001	0,930	0,690	0,543	0,930	0,690	0,543	4,653	3,925	4,566	0,003	0,003	0,003	0,403	0,274	0,240
Buses	2002	0,854	0,648	0,519	0,854	0,648	0,519	4,496	3,812	4,455	0,003	0,003	0,003	0,367	0,254	0,226
Buses	2003	0,776	0,596	0,485	0,776	0,596	0,485	4,214	3,544	4,125	0,003	0,003	0,003	0,337	0,236	0,212
Buses	2004	0,725	0,560	0,458	0,725	0,560	0,458	4,050	3,367	3,868	0,003	0,003	0,003	0,315	0,222	0,200
Buses	2005	0,672	0,522	0,431	0,672	0,522	0,431	3,848	3,165	3,603	0,003	0,003	0,003	0,294	0,208	0,188
Buses	2006	0,628	0,490	0,408	0,628	0,490	0,408	3,686	3,000	3,380	0,003	0,003	0,003	0,275	0,195	0,177
Buses	2007	0,576	0,452	0,378	0,576	0,452	0,378	3,445	2,788	3,122	0,003	0,003	0,003	0,252	0,180	0,165
Buses	2008	0,512	0,408	0,345	0,512	0,408	0,345	3,129	2,560	2,895	0,003	0,003	0,003	0,223	0,161	0,149
Buses	2009	0,439	0,356	0,305	0,439	0,356	0,305	2,759	2,282	2,604	0,003	0,003	0,003	0,192	0,140	0,131
Mopeds	1985	13,691	13,691		14,110	13,838		13,800	13,800		0,001	0,001		0,188	0,188	
Mopeds	1986	13,691	13,691		14,118	13,841		13,800	13,800		0,001	0,001		0,188	0,188	
Mopeds	1987	13,691	13,691		14,114	13,840		13,800	13,800		0,001	0,001		0,188	0,188	
Mopeds	1988	13,691	13,691		14,143	13,850		13,800	13,800		0,001	0,001		0,188	0,188	

Continued																
Mopeds	1989	13,691	13,691		14,161	13,856		13,800	13,800		0,001	0,001		0,188	0,188	
Mopeds	1990	13,691	13,691		14,151	13,853		13,800	13,800		0,001	0,001		0,188	0,188	
Mopeds	1991	13,691	13,691		14,131	13,846		13,800	13,800		0,001	0,001		0,188	0,188	
Mopeds	1992	13,691	13,691		14,135	13,847		13,800	13,800		0,001	0,001		0,188	0,188	
Mopeds	1993	13,691	13,691		14,106	13,837		13,800	13,800		0,001	0,001		0,188	0,188	
Mopeds	1994	13,691	13,691		14,124	13,843		13,800	13,800		0,001	0,001		0,188	0,188	
Mopeds	1995	13,691	13,691		14,125	13,844		13,800	13,800		0,001	0,001		0,188	0,188	
Mopeds	1996	13,691	13,691		14,108	13,838		13,800	13,800		0,001	0,001		0,188	0,188	
Mopeds	1997	13,691	13,691		14,131	13,846		13,800	13,800		0,001	0,001		0,188	0,188	
Mopeds	1998	13,691	13,691		14,111	13,839		13,800	13,800		0,001	0,001		0,188	0,188	
Mopeds	1999	13,691	13,691		14,157	13,855		13,800	13,800		0,001	0,001		0,188	0,188	
Mopeds	2000	12,563	12,563		12,947	12,699		12,960	12,960		0,001	0,001		0,176	0,176	
Mopeds	2001	11,773	11,773		12,189	11,920		12,371	12,371		0,001	0,001		0,168	0,168	
Mopeds	2002	10,937	10,937		11,364	11,087		11,748	11,748		0,001	0,001		0,160	0,160	
Mopeds	2003	10,520	10,520		10,942	10,669		11,437	11,437		0,001	0,001		0,156	0,156	
Mopeds	2004	9,924	9,924		10,346	10,072		10,776	10,776		0,001	0,001		0,148	0,148	
Mopeds	2005	9,299	9,299		9,757	9,460		10,085	10,085		0,001	0,001		0,140	0,140	
Mopeds	2006	8,636	8,636		9,108	8,802		9,353	9,353		0,001	0,001		0,131	0,131	
Mopeds	2007	8,023	8,023		8,481	8,185		8,669	8,669		0,001	0,001		0,123	0,123	
Mopeds	2008	7,588	7,588		8,032	7,744		8,189	8,189		0,001	0,001		0,118	0,118	
Mopeds	2009	7,169	7,169		7,620	7,328		7,727	7,727		0,001	0,001		0,112	0,112	
Motorcycles	1985	1,426	1,186	1,588	2,214	1,409	1,625	18,848	19,069	24,147	0,002	0,002	0,002	0,047	0,047	0,047
Motorcycles	1986	1,426	1,186	1,588	2,223	1,410	1,625	18,848	19,069	24,147	0,002	0,002	0,002	0,047	0,047	0,047
Motorcycles	1987	1,426	1,186	1,588	2,219	1,409	1,625	18,848	19,069	24,147	0,002	0,002	0,002	0,047	0,047	0,047
Motorcycles	1988	1,426	1,186	1,588	2,255	1,418	1,626	18,848	19,069	24,147	0,002	0,002	0,002	0,047	0,047	0,047
Motorcycles	1989	1,426	1,186	1,588	2,276	1,423	1,627	18,848	19,069	24,147	0,002	0,002	0,002	0,047	0,047	0,047
Motorcycles	1990	1,426	1,186	1,588	2,271	1,421	1,626	18,848	19,069	24,147	0,002	0,002	0,002	0,047	0,047	0,047
Motorcycles	1991	1,426	1,186	1,588	2,257	1,416	1,625	18,848	19,069	24,147	0,002	0,002	0,002	0,047	0,047	0,047
Motorcycles	1992	1,426	1,186	1,588	2,267	1,418	1,626	18,848	19,069	24,147	0,002	0,002	0,002	0,047	0,047	0,047
Motorcycles	1993	1,426	1,186	1,588	2,230	1,407	1,624	18,848	19,069	24,147	0,002	0,002	0,002	0,047	0,047	0,047
Motorcycles	1994	1,426	1,186	1,588	2,261	1,415	1,625	18,848	19,069	24,147	0,002	0,002	0,002	0,047	0,047	0,047
Motorcycles	1995	1,426	1,186	1,588	2,260	1,414	1,624	18,848	19,069	24,147	0,002	0,002	0,002	0,047	0,047	0,047
Motorcycles	1996	1,426	1,186	1,588	2,241	1,408	1,623	18,848	19,069	24,147	0,002	0,002	0,002	0,047	0,047	0,047
Motorcycles	1997	1,426	1,186	1,588	2,288	1,420	1,625	18,848	19,069	24,147	0,002	0,002	0,002	0,047	0,047	0,047
Motorcycles	1998	1,426	1,186	1,588	2,266	1,413	1,624	18,848	19,069	24,147	0,002	0,002	0,002	0,047	0,047	0,047
Motorcycles	1999	1,426	1,186	1,588	2,307	1,424	1,625	18,848	19,069	24,147	0,002	0,002	0,002	0,047	0,047	0,047
Motorcycles	2000	1,503	1,232	1,624	2,206	1,421	1,654	18,476	18,693	23,725	0,002	0,002	0,002	0,047	0,047	0,047

Continued																
Motorcycles	2001	1,511	1,228	1,600	2,211	1,415	1,629	18,260	18,455	23,434	0,002	0,002	0,002	0,046	0,046	0,046
Motorcycles	2002	1,519	1,223	1,575	2,245	1,415	1,604	18,047	18,219	23,145	0,002	0,002	0,002	0,045	0,045	0,045
Motorcycles	2003	1,524	1,216	1,548	2,252	1,409	1,578	17,851	18,002	22,877	0,002	0,002	0,002	0,044	0,044	0,044
Motorcycles	2004	1,498	1,193	1,513	2,247	1,391	1,543	17,330	17,497	22,330	0,002	0,002	0,002	0,043	0,043	0,043
Motorcycles	2005	1,485	1,178	1,484	2,297	1,392	1,517	16,604	16,797	21,579	0,002	0,002	0,002	0,041	0,041	0,041
Motorcycles	2006	1,475	1,165	1,458	2,324	1,389	1,492	15,823	16,046	20,773	0,002	0,002	0,002	0,040	0,040	0,040
Motorcycles	2007	1,424	1,132	1,420	2,270	1,354	1,453	14,954	15,190	19,752	0,002	0,002	0,002	0,038	0,038	0,038
Motorcycles	2008	1,380	1,099	1,379	2,226	1,320	1,412	14,464	14,697	19,156	0,002	0,002	0,002	0,037	0,037	0,037
Motorcycles	2009	1,337	1,065	1,334	2,214	1,293	1,368	14,245	14,467	18,862	0,002	0,002	0,002	0,035	0,035	0,035

Annex 2B-7: Fuel use (GJ) and emissions (tons) per vehicle category and as totals

Sector	Year	FC (PJ)	SO_2	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3	TSP
Passenger Cars	1985	65,0	1508	53603	69206	1754	530786	4751	171	47	1607
Passenger Cars	1986	65,7	1023	54585	69215	1778	503246	4802	174	48	1628
Passenger Cars	1987	65,9	1022	55484	68908	1801	478767	4816	176	48	1591
Passenger Cars	1988	66,7	1038	57155	68897	1829	442145	4875	181	49	1538
Passenger Cars	1989	66,1	757	57141	67362	1812	410530	4830	180	49	1493
Passenger Cars	1990	70,1	807	61178	70678	1929	417142	5124	191	52	1546
Passenger Cars	1991	74,6	845	62884	72550	2003	432366	5449	209	165	1565
Passenger Cars	1992	77,9	602	61679	70903	1986	414613	5696	231	398	1465
Passenger Cars	1993	79,9	336	59268	67558	1939	398524	5841	248	618	1389
Passenger Cars	1994	82,8	351	56047	63335	1846	366009	6052	272	930	1297
Passenger Cars	1995	83,5	351	51255	57878	1707	343722	6105	288	1221	1173
Passenger Cars	1996	84,3	353	46997	53196	1585	331558	6164	302	1479	1071
Passenger Cars	1997	86,5	358	43630	47964	1485	296261	6320	314	1844	943
Passenger Cars	1998	88,2	367	39680	42451	1388	273409	6446	312	2225	835
Passenger Cars	1999	88,7	295	35727	36805	1277	238592	6482	306	2509	758
Passenger Cars	2000	88,2	202	32541	30399	1180	215971	6446	299	2686	693
Passenger Cars	2001	87,6	201	30071	27775	1085	206059	6408	286	2661	660
Passenger Cars	2002	89,0	204	28252	24615	991	186833	6506	276	2602	617
Passenger Cars	2003	91,1	209	26582	22297	909	177375	6667	267	2520	623
Passenger Cars	2004	92,3	212	24708	18839	814	154178	6755	258	2425	609
Passenger Cars	2005	91,8	42	22264	16826	710	146534	6718	239	2209	608
Passenger Cars	2006	92,9	43	20280	14179	615	127412	6793	226	2041	600
Passenger Cars	2007	99,7	46	19871	12214	542	112559	7291	230	1909	657
Passenger Cars	2008	100,2	46	18485	10691	465	101896	7330	222	1727	645
Passenger Cars	2009	97,7	45	17122	9149	399	88173	7146	211	1552	596
Light Duty Vehicles	1985	11,7	2259	5572	2036	103	14397	864	5	4	1221
Light Duty Vehicles	1986	13,5	1582	6330	2226	115	15730	994	5	5	1408
Light Duty Vehicles	1987	14,1	1659	6645	2344	121	16625	1043	5	5	1485
Light Duty Vehicles	1988	14,5	1707	6805	2361	125	16412	1072	6	5	1475
Light Duty Vehicles	1989	15,0	1190	6983	2356	127	16299	1110	6	5	1520
Light Duty Vehicles	1990	16,1	1273	7434	2485	135	17209	1185	6	6	1620
Light Duty Vehicles	1991	16,6	1313	7730	2639	140	18442	1226	6	6	1709
Light Duty Vehicles	1992	16,5	839	7779	2741	143	18920	1218	7	6	1657
Light Duty Vehicles	1993	17,0	334	8035	2881	148	20220	1251	7	6	1729

Continued											
Light Duty Vehicles	1994	18,1	358	8569	3059	158	21197	1339	7	7	1830
Light Duty Vehicles	1995	18,2	360	8409	2936	152	20406	1345	9	12	1764
Light Duty Vehicles	1996	18,5	369	8226	2741	142	19330	1369	13	21	1663
Light Duty Vehicles	1997	18,8	374	8004	2492	133	17236	1386	17	31	1453
Light Duty Vehicles	1998	19,3	382	7941	2356	127	16611	1423	21	43	1318
Light Duty Vehicles	1999	19,8	218	7867	2192	117	15349	1458	26	55	1180
Light Duty Vehicles	2000	20,1	47	7812	1978	108	14581	1487	31	68	1053
Light Duty Vehicles	2001	20,7	48	7844	1932	99	14331	1528	36	79	984
Light Duty Vehicles	2002	21,2	49	7679	1791	89	13353	1567	40	84	873
Light Duty Vehicles	2003	22,9	53	7787	1742	82	13091	1691	46	82	844
Light Duty Vehicles	2004	24,6	57	7798	1602	73	11969	1814	52	80	775
Light Duty Vehicles	2005	26,1	12	7724	1561	62	11742	1929	57	75	745
Light Duty Vehicles	2006	28,1	13	7826	1491	54	11042	2078	63	72	716
Light Duty Vehicles	2007	27,5	13	7125	1289	44	9218	2028	62	58	636
Light Duty Vehicles	2008	26,6	12	6235	1124	36	8332	1964	61	53	553
Light Duty Vehicles	2009	24,0	11	5307	941	29	7144	1774	56	47	459
Heavy Duty Vehicles	1985	27,6	6447	28197	1675	213	6312	2044	76	8	1123
Heavy Duty Vehicles	1986	31,0	4345	31644	1852	239	6962	2296	84	8	1259
Heavy Duty Vehicles	1987	30,5	4272	31092	1803	235	6799	2257	83	8	1236
Heavy Duty Vehicles	1988	30,1	4216	30661	1746	232	6618	2226	81	8	1215
Heavy Duty Vehicles	1989	31,3	2928	31935	1804	241	6826	2319	84	8	1265
Heavy Duty Vehicles	1990	32,5	3036	33038	1808	249	6932	2403	85	9	1305
Heavy Duty Vehicles	1991	33,1	3095	33706	1851	254	7089	2450	87	9	1331
Heavy Duty Vehicles	1992	32,5	1976	33074	1786	250	6926	2407	85	8	1303
Heavy Duty Vehicles	1993	31,7	741	32133	1694	243	6660	2347	81	8	1264
Heavy Duty Vehicles	1994	33,9	793	33846	1782	262	6957	2509	87	9	1333
Heavy Duty Vehicles	1995	34,1	797	33034	1787	268	6896	2523	90	9	1308
Heavy Duty Vehicles	1996	35,0	818	32691	1757	278	6838	2586	92	9	1286
Heavy Duty Vehicles	1997	35,5	831	32385	1687	280	6720	2628	95	10	1214
Heavy Duty Vehicles	1998	36,0	842	32287	1587	278	6604	2663	98	10	1112
Heavy Duty Vehicles	1999	37,2	479	32931	1523	283	6627	2754	102	10	1040
Heavy Duty Vehicles	2000	36,1	85	31586	1370	266	6263	2673	99	10	922
Heavy Duty Vehicles	2001	36,6	86	31271	1291	262	6232	2709	101	10	840
Heavy Duty Vehicles	2002	36,5	86	30123	1197	254	6170	2703	99	10	770
Heavy Duty Vehicles	2003	38,5	90	30478	1178	263	6425	2845	104	10	746
Heavy Duty Vehicles	2004	39,6	93	30339	1150	267	6575	2933	107	11	712
Heavy Duty Vehicles	2005	40,0	19	29462	1087	264	6577	2959	107	11	667

Continued											
Heavy Duty Vehicles	2006	42,0	20	29754	1076	270	6779	3105	112	11	653
Heavy Duty Vehicles	2007	43,8	21	28945	978	248	6331	3240	118	12	598
Heavy Duty Vehicles	2008	41,1	19	24479	725	186	4805	3039	111	11	451
Heavy Duty Vehicles	2009	35,6	17	19404	507	130	3476	2633	96	10	324
Buses	1985	6,1	1405	6351	736	67	2756	453	16	2	310
Buses	1986	6,6	910	6850	788	72	2908	488	17	2	334
Buses	1987	6,5	892	6718	773	70	2842	479	17	2	328
Buses	1988	6,5	895	6740	775	70	2826	480	17	2	329
Buses	1989	6,6	610	6889	788	72	2847	490	17	2	336
Buses	1990	7,1	649	7321	835	76	3050	522	18	2	357
Buses	1991	7,1	649	7318	836	76	3073	522	18	2	357
Buses	1992	6,7	402	6979	803	73	3011	498	17	2	340
Buses	1993	6,8	156	7042	813	74	3091	503	18	2	343
Buses	1994	7,3	166	7391	851	79	3452	536	19	2	357
Buses	1995	7,6	172	7469	840	83	3733	559	20	2	355
Buses	1996	7,9	180	7647	830	88	3915	587	21	2	357
Buses	1997	7,9	179	7451	776	87	3763	582	21	2	338
Buses	1998	7,7	175	7187	710	83	3577	569	21	2	306
Buses	1999	7,5	94	6889	638	79	3328	554	21	2	274
Buses	2000	7,2	17	6551	574	73	3117	534	20	2	244
Buses	2001	7,0	16	6305	531	69	2969	519	20	2	213
Buses	2002	7,0	16	6108	490	66	2862	516	20	2	195
Buses	2003	7,3	17	6217	471	67	2797	541	21	2	182
Buses	2004	7,4	17	6165	447	66	2706	551	21	2	173
Buses	2005	7,4	3	5961	412	63	2529	545	21	2	156
Buses	2006	7,4	3	5832	387	61	2406	546	21	2	147
Buses	2007	7,5	4	5761	363	58	2289	558	22	2	138
Buses	2008	7,3	3	5242	315	50	2021	536	21	2	118
Buses	2009	6,9	3	4659	259	41	1704	507	20	2	97
Mopeds	1985	0,4	1	7	4936	77	4865	28	0	0	66
Mopeds	1986	0,3	1	6	4431	69	4365	25	0	0	59
Mopeds	1987	0,3	1	6	4100	64	4040	23	0	0	55
Mopeds	1988	0,3	1	6	3860	60	3798	22	0	0	52
Mopeds	1989	0,3	1	5	3665	57	3603	21	0	0	49
Mopeds	1990	0,3	1	5	3727	58	3665	21	0	0	50
Mopeds	1991	0,3	1	5	3825	60	3766	22	0	0	51
Mopeds	1992	0,3	1	5	3849	60	3789	22	0	0	52

Continued											
Mopeds	1993	0,3	1	5	3811	60	3757	22	0	0	51
Mopeds	1994	0,3	1	5	3751	59	3694	21	0	0	50
Mopeds	1995	0,3	1	6	3997	62	3936	23	0	0	54
Mopeds	1996	0,3	1	6	4252	67	4191	24	0	0	57
Mopeds	1997	0,4	1	7	4619	72	4548	26	0	0	62
Mopeds	1998	0,4	1	7	4978	78	4906	28	0	0	67
Mopeds	1999	0,4	1	6	4525	71	4449	26	0	0	61
Mopeds	2000	0,3	1	6	3992	62	4027	24	0	0	55
Mopeds	2001	0,3	1	5	3099	48	3173	19	0	0	43
Mopeds	2002	0,3	1	5	3049	47	3183	19	0	0	43
Mopeds	2003	0,3	1	5	2916	45	3079	19	0	0	42
Mopeds	2004	0,3	1	9	2732	42	2876	18	0	0	39
Mopeds	2005	0,2	0	13	2546	39	2664	18	0	0	37
Mopeds	2006	0,2	0	18	2385	37	2482	17	0	0	35
Mopeds	2007	0,2	0	23	2266	35	2349	17	0	0	33
Mopeds	2008	0,2	0	25	2121	33	2194	16	0	0	31
Mopeds	2009	0,2	0	27	1944	30	2002	15	0	0	29
Motorcycles	1985	0,3	1	57	508	53	5441	26	1	1	13
Motorcycles	1986	0,3	1	57	509	53	5443	26	1	1	13
Motorcycles	1987	0,3	1	55	495	52	5305	25	1	1	13
Motorcycles	1988	0,3	1	56	507	53	5374	25	1	1	13
Motorcycles	1989	0,3	1	55	502	52	5296	25	1	1	13
Motorcycles	1990	0,4	1	60	538	56	5684	27	1	1	14
Motorcycles	1991	0,4	1	61	552	57	5859	27	1	1	14
Motorcycles	1992	0,4	1	66	591	61	6263	29	1	1	15
Motorcycles	1993	0,4	1	70	618	65	6635	31	1	1	16
Motorcycles	1994	0,5	1	74	662	69	7041	33	1	1	17
Motorcycles	1995	0,5	1	76	681	71	7250	34	1	1	17
Motorcycles	1996	0,5	1	77	685	72	7341	34	1	1	18
Motorcycles	1997	0,5	1	81	726	75	7676	36	1	1	18
Motorcycles	1998	0,5	1	84	746	78	7943	37	1	1	19
Motorcycles	1999	0,5	1	85	769	79	8093	38	1	1	19
Motorcycles	2000	0,5	1	89	771	80	8157	39	1	1	20
Motorcycles	2001	0,6	1	93	785	81	8222	41	1	1	20
Motorcycles	2002	0,6	1	97	808	83	8321	42	1	1	20
Motorcycles	2003	0,6	1	99	815	83	8316	43	1	1	20
Motorcycles	2004	0,6	1	102	820	83	8200	43	1	1	19

Continued											
Motorcycles	2005	0,6	0	108	858	85	8147	45	1	1	19
Motorcycles	2006	0,7	0	118	917	88	8291	48	1	1	20
Motorcycles	2007	0,7	0	125	962	91	8450	52	1	1	20
Motorcycles	2008	0,7	0	125	948	89	8247	53	1	1	20
Motorcycles	2009	0,7	0	118	887	84	7700	50	1	1	18
Total	1985	111,2	11621	93787	79097	2267	564556	8166	268	61	4341
Total	1986	117,5	7862	99472	79021	2327	538653	8631	281	63	4701
Total	1987	117,7	7847	100001	78423	2343	514377	8643	281	64	4708
Total	1988	118,4	7857	101422	78147	2368	477172	8700	284	65	4623
Total	1989	119,7	5488	103009	76478	2361	445400	8795	287	65	4676
Total	1990	126,3	5767	109035	80071	2503	453681	9282	302	69	4891
Total	1991	132,0	5903	111706	82252	2590	470593	9697	321	183	5026
Total	1992	134,4	3820	109581	80674	2574	453523	9870	341	415	4831
Total	1993	136,1	1569	106554	77375	2528	438888	9995	355	635	4791
Total	1994	142,9	1669	105932	73439	2472	408350	10491	386	948	4883
Total	1995	144,2	1682	100249	68119	2344	385944	10588	408	1245	4670
Total	1996	146,6	1721	95644	63461	2231	373173	10766	429	1512	4452
Total	1997	149,5	1744	91557	58265	2132	336203	10978	448	1887	4027
Total	1998	152,0	1768	87186	52828	2032	313050	11167	453	2281	3656
Total	1999	154,0	1088	83506	46451	1905	276439	11312	457	2578	3331
Total	2000	152,5	352	78585	39084	1770	252115	11203	451	2767	2986
Total	2001	152,8	353	75589	35413	1645	240986	11223	443	2753	2760
Total	2002	154,5	357	72264	31951	1531	220720	11352	437	2699	2520
Total	2003	160,6	371	71168	29419	1449	211083	11806	440	2616	2457
Total	2004	164,8	381	69121	25590	1345	186503	12115	440	2518	2328
Total	2005	166,1	77	65533	23290	1224	178194	12214	425	2298	2233
Total	2006	171,3	79	63829	20433	1125	158413	12587	424	2127	2170
Total	2007	179,5	83	61849	18073	1018	141197	13187	433	1982	2083
Total	2008	176,0	81	54591	15924	859	127495	12938	417	1794	1818
Total	2009	165,1	76	46637	13685	712	110199	12125	384	1612	1523

Annex 2B-8: COPERT IV:DEA statistics fuel use ratios and mileage adjustment factors

Sales			1985	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Fuel ratio	Gasoline	DEA:COPERT IV	1,04	0,98	1,03	1,08	1,11	1,13	1,11	1,09	1,10	1,11	1,09	1,11	1,11	1,14	1,14	1,13	1,12	1,13	1,15	1,15	1,16
	Diesel	DEA:COPERT IV	1,07	1,17	1,20	1,16	1,15	1,23	1,22	1,23	1,24	1,24	1,23	1,18	1,16	1,15	1,19	1,21	1,20	1,20	1,23	1,18	1,12
Consumption																							
Fuel ratio	Gasoline	DEA:COPERT IV	1,08	1,08	1,07	1,08	1,09	1,10	1,10	1,10	1,11	1,12	1,14	1,17	1,16	1,17	1,17	1,16	1,14	1,14	1,15	1,15	1,18
	Diesel	DEA:COPERT IV	1,00	1,07	1,14	1,11	1,10	1,13	1,11	1,12	1,13	1,12	1,12	1,10	1,08	1,06	1,07	1,08	1,08	1,09	1,10	1,06	1,02

Annex 2B-9: Basis fuel consumption and emission factors, deterioration factors, transient factors and specific operational data for non road working machinery and equipment, and recreational craft

Basis factors for diesel fuelled non road machinery.

Engine size [P=kW]	Emission Level	NO_x	VOC	CO	N_2O [g pr kWh]	NH_3	TSP	Fuel
P<19	<1981	12.0	5.0	7	0.035	0.002	2.8	300
P<19	1981-1990	11.5	3.8	6	0.035	0.002	2.3	285
P<19	1991-Stage I	11.2	2.5	5	0.035	0.002	1.6	270
P<19	Stage I	11.2	2.5	5	0.035	0.002	1.6	270
P<19	Stage II	11.2	2.5	5	0.035	0.002	1.6	270
P<19	Stage IIIA	11.2	2.5	5	0.035	0.002	1.6	270
P<19	Stage IIIB	11.2	2.5	5	0.035	0.002	1.6	270
P<19	Stage IV	11.2	2.5	5	0.035	0.002	1.6	270
19<=P<37	<1981	18.0	2.5	6.5	0.035	0.002	2	300
19<=P<37	1981-1990	18.0	2.2	5.5	0.035	0.002	1.4	281
19<=P<37	1991-Stage I	9.8	1.8	4.5	0.035	0.002	1.4	262
19<=P<37	Stage I	9.8	1.8	4.5	0.035	0.002	1.4	262
19<=P<37	Stage II	6.5	0.6	2.2	0.035	0.002	0.4	262
19<=P<37	Stage IIIA	6.2	0.6	2.2	0.035	0.002	0.4	262
19<=P<37	Stage IIIB	6.2	0.6	2.2	0.035	0.002	0.4	262
19<=P<37	Stage IV	6.2	0.6	2.2	0.035	0.002	0.4	262
37<=P<56	<1981	7.7	2.4	6	0.035	0.002	1.8	290
37<=P<56	1981-1990	8.6	2.0	5.3	0.035	0.002	1.2	275
37<=P<56	1991-Stage I	11.5	1.5	4.5	0.035	0.002	0.8	260
37<=P<56	Stage I	7.7	0.6	2.2	0.035	0.002	0.4	260
37<=P<56	Stage II	5.5	0.4	2.2	0.035	0.002	0.2	260
37<=P<56	Stage IIIA	3.9	0.4	2.2	0.035	0.002	0.2	260
37<=P<56	Stage IIIB	3.9	0.4	2.2	0.035	0.002	0.0225	260
37<=P<56	Stage IV	3.9	0.4	2.2	0.035	0.002	0.0225	260
56<=P<75	<1981	7.7	2.0	5	0.035	0.002	1.4	290
56<=P<75	1981-1990	8.6	1.6	4.3	0.035	0.002	1	275
56<=P<75	1991-Stage I	11.5	1.2	3.5	0.035	0.002	0.4	260
56<=P<75	Stage I	7.7	0.4	1.5	0.035	0.002	0.2	260
56<=P<75	Stage II	5.5	0.3	1.5	0.035	0.002	0.2	260
56<=P<75	Stage IIIA	4.0	0.3	1.5	0.035	0.002	0.2	260
56<=P<75	Stage IIIB	3.0	0.2	1.5	0.035	0.002	0.0225	260
56<=P<75	Stage IV	0.4	0.2	1.5	0.035	0.002	0.0225	260
75<=P<130	<1981	10.5	2.0	5	0.035	0.002	1.4	280
75<=P<130	1981-1990	11.8	1.6	4.3	0.035	0.002	1	268
75<=P<130	1991-Stage I	13.3	1.2	3.5	0.035	0.002	0.4	255
75<=P<130	Stage I	8.1	0.4	1.5	0.035	0.002	0.2	255
75<=P<130	Stage II	5.2	0.3	1.5	0.035	0.002	0.2	255
75<=P<130	Stage IIIA	3.4	0.3	1.5	0.035	0.002	0.2	255
75<=P<130	Stage IIIB	3.0	0.2	1.5	0.035	0.002	0.0225	255
75<=P<130	Stage IV	0.4	0.2	1.5	0.035	0.002	0.0225	255
130<=P<560	<1981	17.8	1.5	2.5	0.035	0.002	0.9	270
130<=P<560	1981-1990	12.4	1.0	2.5	0.035	0.002	0.8	260
130<=P<560	1991-Stage I	11.2	0.5	2.5	0.035	0.002	0.4	250
130<=P<560	Stage I	7.6	0.3	1.5	0.035	0.002	0.2	250
130<=P<560	Stage II	5.2	0.3	1.5	0.035	0.002	0.1	250
130<=P<560	Stage IIIA	3.4	0.3	1.5	0.035	0.002	0.1	250
130<=P<560	Stage IIIB	3.0	0.2	1.5	0.035	0.002	0.0225	250
130<=P<560	Stage IV	0.4	0.2	1.5	0.035	0.002	0.0225	250

Basis factors for 4-stroke gasoline non road machinery.

Engine	Size code	Size classe [S=ccm]	Emission Level	NO_x	VOC	CO	N_2O [g pr kWh]	NH_3	TSP	Fuel
4-stroke	SH2	20<=S<50	<1981	2.4	33	198	0.002	0.03	0.08	496
4-stroke	SH2	20<=S<50	1981-1990	3.5	27.5	165	0.002	0.03	0.08	474
4-stroke	SH2	20<=S<50	1991-Stage I	4.7	22	132	0.002	0.03	0.08	451
4-stroke	SH2	20<=S<50	Stage I	4.7	22	132	0.002	0.03	0.08	406
4-stroke	SH2	20<=S<50	Stage II	4.7	22	132	0.002	0.03	0.08	406
4-stroke	SH3	S>=50	<1981	2.4	33	198	0.002	0.03	0.08	496
4-stroke	SH3	S>=50	1981-1990	3.5	27.5	165	0.002	0.03	0.08	474
4-stroke	SH3	S>=50	1991-Stage I	4.7	22	132	0.002	0.03	0.08	451
4-stroke	SH3	S>=50	Stage I	4.7	22	132	0.002	0.03	0.08	406
4-stroke	SH3	S>=50	Stage II	4.7	22	132	0.002	0.03	0.08	406
4-stroke	SN1	S<66	<1981	1.2	26.9	822	0.002	0.03	0.08	603
4-stroke	SN1	S<66	1981-1990	1.8	22.5	685	0.002	0.03	0.08	603
4-stroke	SN1	S<66	1991-Stage I	2.4	18	548	0.002	0.03	0.08	603
4-stroke	SN1	S<66	Stage I	4.3	16.1	411	0.002	0.03	0.08	475
4-stroke	SN1	S<66	Stage II	4.3	16.1	411	0.002	0.03	0.08	475
4-stroke	SN2	66<=S<100	<1981	2.3	10.5	822	0.002	0.03	0.08	627
4-stroke	SN2	66<=S<100	1981-1990	3.5	8.7	685	0.002	0.03	0.08	599
4-stroke	SN2	66<=S<100	1991-Stage I	4.7	7	548	0.002	0.03	0.08	570
4-stroke	SN2	66<=S<100	Stage I	4.7	7	467	0.002	0.03	0.08	450
4-stroke	SN2	66<=S<100	Stage II	4.7	7	467	0.002	0.03	0.08	450
4-stroke	SN3	100<=S<225	<1981	2.6	19.1	525	0.002	0.03	0.08	601
4-stroke	SN3	100<=S<225	1981-1990	3.8	15.9	438	0.002	0.03	0.08	573
4-stroke	SN3	100<=S<225	1991-Stage I	5.1	12.7	350	0.002	0.03	0.08	546
4-stroke	SN3	100<=S<225	Stage I	5.1	11.6	350	0.002	0.03	0.08	546
4-stroke	SN3	100<=S<225	Stage II	5.1	9.4	350	0.002	0.03	0.08	546
4-stroke	SN4	S>=225	<1981	1.3	11.1	657	0.002	0.03	0.08	539
4-stroke	SN4	S>=225	1981-1990	2	9.3	548	0.002	0.03	0.08	514
4-stroke	SN4	S>=225	1991-Stage I	2.6	7.4	438	0.002	0.03	0.08	490
4-stroke	SN4	S>=225	Stage I	2.6	7.4	438	0.002	0.03	0.08	490
4-stroke	SN4	S>=225	Stage II	2.6	7.4	438	0.002	0.03	0.08	490

Basis factors for 2-stroke gasoline non road machinery.

Engine	Size code	Size classe [ccm]	Emission Level	NO_x	VOC	CO	N_2O [g pr kWh]	NH_3	TSP	Fuel
2-stroke	SH2	20<=S<50	<1981	1	305	695	0.002	0.01	7	882
2-stroke	SH2	20<=S<50	1981-1990	1	300	579	0.002	0.01	5.3	809
2-stroke	SH2	20<=S<50	1991-Stage I	1.1	203	463	0.002	0.01	3.5	735
2-stroke	SH2	20<=S<50	Stage I	1.5	188	379	0.002	0.01	3.5	720
2-stroke	SH2	20<=S<50	Stage II	1.5	44	379	0.002	0.01	3.5	500
2-stroke	SH3	S>=50	<1981	1.1	189	510	0.002	0.01	3.6	665
2-stroke	SH3	S>=50	1981-1990	1.1	158	425	0.002	0.01	2.7	609
2-stroke	SH3	S>=50	1991-Stage I	1.2	126	340	0.002	0.01	1.8	554
2-stroke	SH3	S>=50	Stage I	2	126	340	0.002	0.01	1.8	529
2-stroke	SH3	S>=50	Stage II	1.2	64	340	0.002	0.01	1.8	500
2-stroke	SN1	S<66	<1981	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN1	S<66	1981-1990	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN1	S<66	1991-Stage I	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN1	S<66	Stage I	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN1	S<66	Stage II	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN2	66<=S<100	<1981	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN2	66<=S<100	1981-1990	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN2	66<=S<100	1991-Stage I	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN2	66<=S<100	Stage I	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN2	66<=S<100	Stage II	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN3	100<=S<225	<1981	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN3	100<=S<225	1981-1990	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN3	100<=S<225	1991-Stage I	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN3	100<=S<225	Stage I	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN3	100<=S<225	Stage II	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN4	S>=225	<1981	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN4	S>=225	1981-1990	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN4	S>=225	1991-Stage I	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN4	S>=225	Stage I	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN4	S>=225	Stage II	0.5	155	418	0.002	0.01	2.6	652

Fuel consumption and emission factors LPG fork lifts.

NO_x [g pr kWh]	VOC [g pr kWh]	CO [g pr kWh]	NH_3 [g pr kWh]	N_2O [g pr kWh]	TSP [g pr kWh]	FC [g pr kWh]
19	2.2	1.5	0.003	0.05	0.07	311

Fuel consumption and emission factors for All Terrain Vehicles (ATV's).

ATV type	NO_x [g pr GJ]	VOC [g pr GJ]	CO [g pr GJ]	NH_3 [g pr GJ]	N_2O [g pr GJ]	TSP [g pr GJ]	Fuel [kg pr hour]
Professional	108	1077	16306	2	2	32	1.125
Private	128	1527	22043	2	2	39	0.75

Fuel consumption and emission factors for recreational craft.

Fuel type	Vessel type	Engine	Engine type	Direktiv	Engine size	CO	VOC	N_2O	NH_3	NO_x	TSP	Fuel
					[kW]							[g pr kWh]
Gasoline	Other boats (< 20 ft)	Out board	2-stroke	2003/44	8	202.5	45.9	0.01	0.002	2	10	791
Gasoline	Other boats (< 20 ft)	Out board	2-stroke	Konv.	8	427	257.0	0.01	0.002	2	10	791
Gasoline	Other boats (< 20 ft)	Out board	4-stroke	2003/44	8	202.5	24.0	0.03	0.002	7	0.08	426
Gasoline	Other boats (< 20 ft)	Out board	4-stroke	Konv.	8	520	24.0	0.03	0.002	7	0.08	426
Gasoline	Yawls and cabin boats	Out board	2-stroke	2003/44	20	162	36.5	0.01	0.002	3	10	791
Gasoline	Yawls and cabin boats	Out board	2-stroke	Konv.	20	374	172.0	0.01	0.002	3	10	791
Gasoline	Yawls and cabin boats	Out board	4-stroke	2003/44	20	162	14.0	0.03	0.002	10	0.08	426
Gasoline	Yawls and cabin boats	Out board	4-stroke	Konv.	20	390	14.0	0.03	0.002	10	0.08	426
Gasoline	Sailing boats (< 26 ft)	Out board	2-stroke	2003/44	10	189	43.0	0.01	0.002	2	10	791
Gasoline	Sailing boats (< 26 ft)	Out board	2-stroke	Konv.	10	427	257.0	0.01	0.002	2	10	791
Gasoline	Sailing boats (< 26 ft)	Out board	4-stroke	2003/44	10	189	24.0	0.03	0.002	7	0.08	426
Gasoline	Sailing boats (< 26 ft)	Out board	4-stroke	Konv.	10	520	24.0	0.03	0.002	7	0.08	426
Gasoline	Speed boats	In board	4-stroke	2003/44	90	141	10.0	0.03	0.002	12	0.08	426
Gasoline	Speed boats	In board	4-stroke	Konv.	90	346	10.0	0.03	0.002	12	0.08	426
Gasoline	Speed boats	Out board	2-stroke	2003/44	50	145.8	31.8	0.01	0.002	3	10	791
Gasoline	Speed boats	Out board	2-stroke	Konv.	50	374	172.0	0.01	0.002	3	10	791
Gasoline	Speed boats	Out board	4-stroke	2003/44	50	145.8	14.0	0.03	0.002	10	0.08	426
Gasoline	Speed boats	Out board	4-stroke	Konv.	50	390	14.0	0.03	0.002	10	0.08	426
Gasoline	Water scooters	Built in	2-stroke	2003/44	45	147	32.2	0.01	0.002	3	10	791
Gasoline	Water scooters	Built in	2-stroke	Konv.	45	374	172.0	0.01	0.002	3	10	791
Gasoline	Water scooters	Built in	4-stroke	2003/44	45	147	14.0	0.03	0.002	10	0.08	426
Gasoline	Water scooters	Built in	4-stroke	Konv.	45	390	14.0	0.03	0.002	10	0.08	426
Diesel	Motor boats (27-34 ft)	In board		2003/44	150	5	1.7	0.035	0.002	8.6	1	275
Diesel	Motor boats (27-34 ft)	In board		Konv.	150	5.3	2.0	0.035	0.002	8.6	1.2	275
Diesel	Motor boats (> 34 ft)	In board		2003/44	250	5	1.6	0.035	0.002	8.6	1	275
Diesel	Motor boats (> 34 ft)	In board		Konv.	250	5.3	2.0	0.035	0.002	8.6	1.2	275
Diesel	Motor boats (< 27 ft)	In board		2003/44	40	5	1.8	0.035	0.002	9.8	1	281
Diesel	Motor boats (< 27 ft)	In board		Konv.	40	5.5	2.2	0.035	0.002	18	1.4	281
Diesel	Motor sailors	In board		2003/44	30	5	1.9	0.035	0.002	9.8	1	281
Diesel	Motor sailors	In board		Konv.	30	5.5	2.2	0.035	0.002	18	1.4	281
Diesel	Sailing boats (> 26 ft)	In board		2003/44	30	5	1.9	0.035	0.002	9.8	1	281
Diesel	Sailing boats (> 26 ft)	In board		Konv.	30	5.5	2.2	0.035	0.002	18	1.4	281

CH_4 shares of VOC for diesel, gasoline and LPG.

Fuel type	CH_4 share of VOC
Diesel	0.016
Gasoline 4-stroke	0.1
Gasoline 2-stroke	0.009
LPG	0.05

Deterioration factors for diesel machinery.

Emission Level	NO_x	VOC	CO	TSP
<1981	0.024	0.047	0.185	0.473
1981-1990	0.024	0.047	0.185	0.473
1991-Stage I	0.024	0.047	0.185	0.473
Stage I	0.024	0.036	0.101	0.473
Stage II	0.009	0.034	0.101	0.473
Stage IIIA	0.008	0.027	0.151	0.473
Stage IIIB	0.008	0.027	0.151	0.473
Stage IV	0.008	0.027	0.151	0.473

Deterioration factors for gasoline 2-stroke machinery.

Engine	Size code	Size classe	Emission Level	NO_x	VOC	CO	TSP
2-stroke	SH2	20<=S<50	<1981	0	0.2	0.2	0
2-stroke	SH2	20<=S<50	1981-1990	0	0.2	0.2	0
2-stroke	SH2	20<=S<50	1991-Stage I	0	0.2	0.2	0
2-stroke	SH2	20<=S<50	Stage I	0	0.29	0.24	0
2-stroke	SH2	20<=S<50	Stage II	0	0.29	0.24	0
2-stroke	SH3	S>=50	<1981	-0.031	0.2	0.2	0
2-stroke	SH3	S>=50	1981-1990	-0.031	0.2	0.2	0
2-stroke	SH3	S>=50	1991-Stage I	-0.031	0.2	0.2	0
2-stroke	SH3	S>=50	Stage I	0	0.266	0.231	0
2-stroke	SH3	S>=50	Stage II	0	0.266	0.231	0
2-stroke	SN1	S<66	<1981	-0.6	0.201	0.9	1.1
2-stroke	SN1	S<66	1981-1990	-0.6	0.201	0.9	1.1
2-stroke	SN1	S<66	1991-Stage I	-0.6	0.201	0.9	1.1
2-stroke	SN1	S<66	Stage I	-0.33	0.266	1.109	5.103
2-stroke	SN1	S<66	Stage II	-0.33	0	1.109	5.103
2-stroke	SN2	66<=S<100	<1981	-0.6	0.201	0.9	1.1
2-stroke	SN2	66<=S<100	1981-1990	-0.6	0.201	0.9	1.1
2-stroke	SN2	66<=S<100	1991-Stage I	-0.6	0.201	0.9	1.1
2-stroke	SN2	66<=S<100	Stage I	-0.33	0.266	1.109	5.103
2-stroke	SN2	66<=S<100	Stage II	-0.33	0	1.109	5.103
2-stroke	SN3	100<=S<225	<1981	-0.6	0.201	0.9	1.1
2-stroke	SN3	100<=S<225	1981-1990	-0.6	0.201	0.9	1.1
2-stroke	SN3	100<=S<225	1991-Stage I	-0.6	0.201	0.9	1.1
2-stroke	SN3	100<=S<225	Stage I	-0.33	0.266	1.109	5.103
2-stroke	SN3	100<=S<225	Stage II	-0.33	0	1.109	5.103
2-stroke	SN4	S>=225	<1981	-0.6	0.201	0.9	1.1
2-stroke	SN4	S>=225	1981-1990	-0.6	0.201	0.9	1.1
2-stroke	SN4	S>=225	1991-Stage I	-0.6	0.201	0.9	1.1
2-stroke	SN4	S>=225	Stage I	-0.274	0	0.887	1.935
2-stroke	SN4	S>=225	Stage II	-0.274	0	0.887	1.935

Deterioration factors for gasoline 4-stroke machinery.

Engine	Size code	Size classe	Emission Level	NO_x	VOC	CO	TSP
4-stroke	SN1	S<66	<1981	-0.6	1.1	0.9	1.1
4-stroke	SN1	S<66	1981-1990	-0.6	1.1	0.9	1.1
4-stroke	SN1	S<66	1991-Stage I	-0.6	1.1	0.9	1.1
4-stroke	SN1	S<66	Stage I	-0.3	1.753	1.051	1.753
4-stroke	SN1	S<66	Stage II	-0.3	1.753	1.051	1.753
4-stroke	SN2	66<=S<100	<1981	-0.6	1.1	0.9	1.1
4-stroke	SN2	66<=S<100	1981-1990	-0.6	1.1	0.9	1.1
4-stroke	SN2	66<=S<100	1991-Stage I	-0.6	1.1	0.9	1.1
4-stroke	SN2	66<=S<100	Stage I	-0.3	1.753	1.051	1.753
4-stroke	SN2	66<=S<100	Stage II	-0.3	1.753	1.051	1.753
4-stroke	SN3	100<=S<225	<1981	-0.6	1.1	0.9	1.1
4-stroke	SN3	100<=S<225	1981-1990	-0.6	1.1	0.9	1.1
4-stroke	SN3	100<=S<225	1991-Stage I	-0.6	1.1	0.9	1.1
4-stroke	SN3	100<=S<225	Stage I	-0.3	1.753	1.051	1.753
4-stroke	SN3	100<=S<225	Stage II	-0.3	1.753	1.051	1.753
4-stroke	SN4	S>=225	<1981	-0.6	1.1	0.9	1.1
4-stroke	SN4	S>=225	1981-1990	-0.6	1.1	0.9	1.1
4-stroke	SN4	S>=225	1991-Stage I	-0.6	1.1	0.9	1.1
4-stroke	SN4	S>=225	Stage I	-0.599	1.095	1.307	1.095
4-stroke	SN4	S>=225	Stage II	-0.599	1.095	1.307	1.095
4-stroke	SH2	20<=S<50	<1981	0	0	0	0
4-stroke	SH2	20<=S<50	1981-1990	0	0	0	0
4-stroke	SH2	20<=S<50	1991-Stage I	0	0	0	0
4-stroke	SH2	20<=S<50	Stage I	0	0	0	0
4-stroke	SH2	20<=S<50	Stage II	0	0	0	0
4-stroke	SH3	S>=50	<1981	0	0	0	0
4-stroke	SH3	S>=50	1981-1990	0	0	0	0
4-stroke	SH3	S>=50	1991-Stage I	0	0	0	0
4-stroke	SH3	S>=50	Stage I	0	0	0	0
4-stroke	SH3	S>=50	Stage II	0	0	0	0

Transient factors for diesel machinery.

Emission Level	Load	NO_x	VOC	CO	TSP	Fuel
<1981	High	0.95	1.05	1.53	1.23	1.01
1981-1990	High	0.95	1.05	1.53	1.23	1.01
1991-Stage I	High	0.95	1.05	1.53	1.23	1.01
Stage I	High	0.95	1.05	1.53	1.23	1.01
Stage II	High	0.95	1.05	1.53	1.23	1.01
Stage IIIA	High	0.95	1.05	1.53	1.23	1.01
Stage IIIB	High	1	1	1	1	1
Stage IV	High	1	1	1	1	1
<1981	Low	1.1	2.29	2.57	1.97	1.18
1981-1990	Low	1.1	2.29	2.57	1.97	1.18
1991-Stage I	Low	1.1	2.29	2.57	1.97	1.18
Stage I	Low	1.1	2.29	2.57	1.97	1.18
Stage II	Low	1.1	2.29	2.57	1.97	1.18
Stage IIIA	Low	1.1	2.29	2.57	1.97	1.18
Stage IIIB	Low	1	1	1	1	1
Stage IV	Low	1	1	1	1	1

Annual working hours, load factors and lifetimes for agricultural tractors.

Tractor type	Annual working hours	Load factor	Lifetime (yrs)
Diesel	500 (0-7 years) 500-100 (7-16 years) 100 (>16 years)	0.5	30
Gasoline (certified)	100	0.4	37
Gasoline (non certified)	50	0.4	37

Annual working hours, load factors and lifetimes for harvesters.

Annual working hours	Load factor	Lifetime (yrs)
250-100 (linear decrease 0-24 years)	0.8	25

Annual working hours, load factors and lifetime for machine pool machinery.

Tractor type	Hours pr yr	Load factor	Lifetime (yrs)
Tractors	750	0.5	7
Harvesters	100	0.8	11
Self-propelled vehicles	500	0.75	6

Operational data for other machinery types in agriculture.

Machinery type	Fuel type	Load factor	Lifetime (yrs)	Hours	Size (kW)
ATV private	Gasoline	-	6	250	-
ATV professional	Gasoline	-	8	400	-
Bedding machines	Gasoline	0.3	10	50	3
Fodder trucks	Gasoline	0.4	10	200	8
Other (gasoline)	Gasoline	0.4	10	50	5
Scrapers	Gasoline	0.3	10	50	3
Self-propelled vehicles	Diesel	0.75	15	150	60
Sweepers	Gasoline	0.3	10	50	3

Annual working hours, load factors and lifetimes for forestry machinery.

Machinery type	Hours	Load factors	Lifetime
Chippers	1200	0.5	6
Tractors (other)	100 (1990) 400 (2004)	0.5	15
Tractors (silvicultural)	800	0.5	6
Harvesters	1200	0.5	8
Forwarders	1200	0.5	8
Chain saws (forestry)	800	0.4	3

Annual working hours, load factors and lifetime for fork lifts.

Hours pr yr	Load factor	Lifetime (yrs)
1200 (>=50 kW and <=10 years old) 650 (>=50 kW and >10 years old) 650 (<50 kW)	0.27	20

Operational data for construction machinery.

Machinery type	Load factor	Lifetime	Hours	Size
Track type dozers	0.5	10	1100	140
Track type loaders	0.5	10	1100	100 (1990) 150 (2004)
Wheel loaders (0-5 tons)	0.5	10	1200	20
Wheel loaders (> 5,1 tons)	0.5	10	1200	120
Wheel type excavators	0.6	10	1200	100
Track type excavators (0-5 tons)	0.6	10	1100	20
Track type excavators (>5,1 tons)	0.6	10	1100	120
Excavators/Loaders	0.45	10	700	50
Dump trucks	0.4	10	900 (1990) 1200 (2004)	60 (1990) 180 (2004)
Mini loaders	0.5	14	700	30
Telescopic loaders	0.5	14	1000	35

Stock and operational data for other machinery types in industry.

Sector	Fuel type	Machinery type	Size (kW)	No	Load Factor	Hours
Construction machinery	Diesel	Tampers/Land rollers	30	2800	0.45	600
Construction machinery	Diesel	Generators (diesel)	45	5000	0.5	200
Construction machinery	Diesel	Kompressors (diesel)	45	5000	0.5	500
Construction machinery	Diesel	Pumps (diesel)	75	1000	0.5	5
Construction machinery	Diesel	Asphalt pavers	80	300	0.35	700
Construction machinery	Diesel	Motor graders	100	100	0.4	700
Construction machinery	Diesel	Refuse compressors	160	100	0.25	1300
Construction machinery	Gasoline	Generators (gasoline)	2.5	11000	0.4	80
Construction machinery	Gasoline	Pumps (gasoline)	4	10000	0.4	300
Construction machinery	Gasoline	Kompressors (gasoline)	4	500	0.35	15
Industry	Diesel	Refrigerating units (distribution)	8	3000	0.5	1250
Industry	Diesel	Refrigerating units (long distance)	15	3500	0.5	200
Industry	Diesel	Tractors (transport, industry)	50	3000	0.4	500
Airport GSE and other	Diesel	Airport GSE and other (light duty)	100	500	0.5	400
Airport GSE and other	Diesel	Airport GSE and other (medium duty)	125	350	0.5	300
Airport GSE and other	Diesel	Airport GSE and other (Heavy duty)	175	650	0.5	200
Building and construction	Diesel	Vibratory plates	6	3500	0.6	300
Building and construction	Diesel	Aereal lifts (diesel)	30	150	0.4	400
Building and construction	Diesel	Sweepers (diesel)	30	200	0.4	300
Building and construction	Diesel	High pressure cleaners (diesel)	30	50	0.8	500
Building and construction	Gasoline	Rammers	2.5	3000	0.4	80
Building and construction	Gasoline	Drills	3	100	0.4	10
Building and construction	Gasoline	Vibratory plates (gasoline)	4	2500	0.5	200
Building and construction	Gasoline	Cutters	4	800	0.5	50
Building and construction	Gasoline	Other (gasoline)	5	1000	0.5	40
Building and construction	Gasoline	High pressure cleaners (gasoline)	5	500	0.6	200
Building and construction	Gasoline	Sweepers (gasoline)	10	500	0.4	150
Building and construction	Gasoline	Slicers	10	100	0.7	150
Building and construction	Gasoline	Aereal lifts (gasoline)	20	50	0.4	400

Operational data for the most important types of household and gardening machinery.

Machinery type	Engine	Size (kW)	Hours	Load factor	Lifetime (yrs)
Chain saws (private)	2-stroke	2	5	0.3	10
Chain saws (professional)	2-stroke	3	270	0.4	3
Cultivators (private-large)	4-stroke	3.7	5	0.6	5
Cultivators (private-small)	4-stroke	1	5	0.6	15
Cultivators (professional)	4-stroke	7	360	0.6	8
Hedge cutters (private)	2-stroke	0.9	10	0.5	10
Hedge cutters (professional)	2-stroke	2	300	0.5	4
Lawn movers (private)	4-stroke	2.5 (2000) 3.5 (2004)	25	0.4	8
Lawn movers (professional)	4-stroke	2.5 (2000) 3.5 (2004)	250	0.4	4
Riders (private)	4-stroke	11	50	0.5	12
Riders (professional)	4-stroke	13	330	0.5	5
Shrub clearers (private)	2-stroke	1	15	0.6	10
Shrub clearers (professional)	2-stroke	2	300	0.6	4
Trimmers (private)	2-stroke	0.9	20	0.5	10
Trimmers (professional)	2-stroke	0.9	200	0.5	4

Stock and operational data for other machines in household and gardening.

Machinery type	Engine	No.	Size (kW)	Hours	Load factor	Lifetime (yrs)
Chippers	2-stroke	200	10	100	0.7	10
Garden shredders	2-stroke	500	3	20	0.7	10
Other (gasoline)	2-stroke	200	2	20	0.5	10
Suction machines	2-stroke	300	4	80	0.5	10
Wood cutters	4-stroke	100	4	15	0.5	10

Operational data for recreational craft.

Fuel type	Vessel type	Engine type	Stroke	Hours	Lifetime	Load factor
Gasoline	Other boats (<20 ft)	Out board engine	2-stroke	30	10	0.5
Gasoline	Other boats (<20 ft)	Out board engine	4-stroke	30	10	0.5
Gasoline	Yawls and cabin boats	Out board engine	2-stroke	50	10	0.5
Gasoline	Yawls and cabin boats	Out board engine	4-stroke	50	10	0.5
Gasoline	Sailing boats (<26ft)	Out board engine	2-stroke	5	10	0.5
Gasoline	Sailing boats (<26ft)	Out board engine	4-stroke	5	10	0.5
Gasoline	Speed boats	In board engine	4-stroke	75	10	0.5
Gasoline	Speed boats	Out board engine	2-stroke	50	10	0.5
Gasoline	Speed boats	Out board engine	4-stroke	50	10	0.5
Gasoline	Water scooters	Built in	2-stroke	10	10	0.5
Gasoline	Water scooters	Built in	4-stroke	10	10	0.5
Diesel	Motor boats (27-34 ft)	In board engine		150	15	0.5
Diesel	Motor boats (>34 ft)	In board engine		100	15	0.5
Diesel	Motor boats (<27 ft)	In board engine		75	15	0.5
Diesel	Motor sailors	In board engine		75	15	0.5
Diesel	Sailing boats (<26ft)	In board engine		25	15	0.5

Annex 2B-10: Stock data for non-road working machinery and equipment

Stock data for diesel tractors 1985-2009.

Size (kW)	Emission Level	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
37	<1981	3882	3792	3542	3543	3403	3234	3106	2922	2861	2610	2605	2273	2193	1918	1796
37	1981-1990	635	731	760	835	855	879	889	883	915	887	945	883	918	869	888
37	1991-Stage I							25	107	153	201	278	354	445	496	554
37	Stage I															
37	Stage II															
37	Stage IIIA															
45	<1981	25988	25387	23709	23718	22781	21650	20796	19563	19154	17475	17441	15219	14684	12840	12025
45	1981-1990	5740	6808	7263	8075	8476	8770	8867	8805	9128	8848	9419	8807	9151	8668	8856
45	1991-Stage I							203	202	209	203	216	202	210	199	203
49	1991-Stage I								154	281	485	602	618	702	749	765
52	1991-Stage I															247
52	Stage I															
52	Stage II															
52	Stage IIIA															
56	1991-Stage I								201	338	428	747	943	1181	1280	1307
60	<1981	54651	53387	49857	49877	47907	45529	43732	41140	40278	36747	36676	32004	30879	27001	25287
60	1981-1990	11751	14613	15795	17797	19395	20542	20770	20624	21380	20725	22063	20628	21434	20304	20744
60	1991-Stage I							863	857	888	861	917	857	891	844	862
63	1991-Stage I								468	855	1325	2014	2384	2837	3011	3076
67	1991-Stage I															671
67	Stage I															
67	Stage II															
67	Stage IIIA															
71	1991-Stage I								411	715	1179	1949	2507	3344	3594	3672
78	<1981	14558	14221	13281	13286	12761	12128	11649	10959	10729	9789	9770	8525	8226	7192	6736
78	1981-1990	4592	6152	7196	8559	10026	11323	11448	11368	11785	11424	12162	11371	11815	11192	11434
78	1991-Stage I							1233	1503	1713	1945	2429	2561	2946	2994	3287
78	Stage I															
78	Stage II															
78	Stage IIIA															
86	1991-Stage I								108	193	333	589	880	1364	1532	1718
86	Stage I															
86	Stage II															

Continued																
86	Stage IIIA															
93	1991-Stage I															149
93	Stage I															
93	Stage II															
93	Stage IIIA															
97	1991-Stage I								71	175	443	962	1556	2327	2638	2695
101	<1981	4659	4551	4250	4252	4084	3881	3728	3507	3433	3132	3126	2728	2632	2302	2156
101	1981-1990	1158	1434	1618	1921	2156	2377	2403	2387	2474	2398	2553	2387	2480	2350	2400
101	1991-Stage I							266	264	274	266	283	264	275	260	696
101	Stage I															
101	Stage II															
101	Stage IIIA															
112	1991-Stage I								63	114	166	252	422	690	790	978
112	Stage I															
112	Stage II															
112	Stage IIIA															
127	1991-Stage I								12	36	81	193	279	408	457	590
127	Stage I															
127	Stage II															
127	Stage IIIA															
131	<1981	798	780	728	728	700	665	639	601	588	537	536	467	451	394	369
131	1981-1990	288	421	500	651	753	887	897	890	923	895	952	890	925	876	895
131	1991-Stage I							97	97	100	97	103	97	100	95	97
157	1981-1990		2	3	6	11	15	15	15	16	15	16	15	16	15	15
157	1991-Stage I							9	23	39	102	232	357	545	648	784
157	Stage I															
157	Stage II															
157	Stage IIIA															
186	1991-Stage I															23
186	Stage I															
186	Stage II															
186	Stage IIIA															

Size (kW)	Emission Level	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
37	<1981	1601	1449	1298	1148	993	833	664	504	342	176
37	1981-1990	871	876	882	892	900	906	903	914	930	959
37	1991-Stage I	568	572	576	582	587	592	590	597	607	626
37	Stage I		33	56	83	84	84	84	85	86	89
37	Stage II					23	53	162	324	330	340
37	Stage IIIA									109	205
45	<1981	10715	9700	8690	7685	6646	5577	4447	3376	2290	1180
45	1981-1990	8681	8731	8800	8894	8974	9037	9006	9116	9274	9563
45	1991-Stage I	199	200	202	204	206	207	207	209	213	219
49	1991-Stage I	750	754	760	768	775	780	778	787	801	826
52	1991-Stage I	358	360	363	367	370	373	372	376	383	395
52	Stage I		132	242	377	381	383	382	387	393	406
52	Stage II					68	147	241	347	353	364
52	Stage IIIA									86	133
56	1991-Stage I	1281	1289	1299	1313	1325	1334	1329	1346	1369	1412
60	<1981	22533	20397	18273	16162	13976	11729	9351	7099	4815	2482
60	1981-1990	20333	20451	20612	20834	21019	21167	21096	21353	21723	22401
60	1991-Stage I	845	850	856	866	873	879	876	887	903	931
63	1991-Stage I	3015	3033	3057	3090	3117	3139	3128	3167	3221	3322
67	1991-Stage I	1343	1351	1361	1376	1388	1398	1393	1410	1435	1479
67	Stage I		533	835	1113	1123	1131	1127	1141	1161	1197
67	Stage II					375	729	1144	1524	1550	1599
67	Stage IIIA									303	472
71	1991-Stage I	3600	3620	3649	3688	3721	3747	3735	3780	3846	3966
78	<1981	6002	5433	4868	4305	3723	3124	2491	1891	1283	661
78	1981-1990	11208	11273	11361	11484	11586	11668	11628	11770	11974	12348
78	1991-Stage I	3436	3727	3756	3797	3830	3857	3844	3891	3959	4082
78	Stage I			325	329	332	334	333	337	343	354
78	Stage II				227	310	400	463	469	477	492
78	Stage IIIA								63	121	147
86	1991-Stage I	1876	2023	2039	2061	2079	2094	2087	2112	2149	2216
86	Stage I			134	136	137	138	137	139	142	146
86	Stage II				91	343	530	760	769	783	807
86	Stage IIIA								226	434	529
93	1991-Stage I	245	325	327	331	334	336	335	339	345	356
93	Stage I			114	115	116	117	116	118	120	123

Continued											
93	Stage II				107	186	313	512	518	527	544
93	Stage IIIA								264	470	574
97	1991-Stage I	2642	2657	2678	2707	2731	2750	2741	2774	2822	2911
101	<1981	1921	1739	1558	1378	1191	1000	797	605	410	212
101	1981-1990	2353	2367	2385	2411	2432	2449	2441	2471	2514	2592
101	1991-Stage I	1116	1567	1579	1596	1611	1622	1616	1636	1664	1716
101	Stage I			232	234	236	238	237	240	244	252
101	Stage II				136	357	635	776	785	799	824
101	Stage IIIA								188	336	410
112	1991-Stage I	1265	1626	1639	1656	1671	1683	1677	1698	1727	1781
112	Stage I			465	470	474	478	476	482	490	505
112	Stage II				337	732	1170	1763	1785	1815	1872
112	Stage IIIA								378	663	823
127	1991-Stage I	707	847	854	863	871	877	874	884	900	928
127	Stage I			152	154	155	156	156	158	161	166
127	Stage II				78	268	453	591	599	609	628
127	Stage IIIA								292	675	880
131	<1981	329	298	267	236	204	171	137	104	70	36
131	1981-1990	878	883	890	899	907	914	911	922	938	967
131	1991-Stage I	95	96	96	97	98	99	99	100	102	105
157	1981-1990	15	15	15	15	16	16	16	16	16	17
157	1991-Stage I	900	905	912	922	930	937	934	945	961	991
157	Stage I		89	89	90	91	92	91	92	94	97
157	Stage II			149	415	695	1089	1085	1098	1117	1152
157	Stage IIIA							623	1453	2140	2586
186	1991-Stage I	53	54	54	55	55	56	55	56	57	59
186	Stage I		47	48	48	49	49	49	49	50	52
186	Stage II			68	207	320	481	480	486	494	509
186	Stage IIIA							272	685	1103	1427

Stock data for gasoline tractors 1985-2005.

Size (kW)	Emission Level	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Certified	<1981	13176	12541	11906	11270	10635	10000	9053	8148	7285	6465	5687	4951	4258	3607	2998
Non certified	<1981	26352	25082	23811	22541	21270	20000	19042	18041	16998	15913	14785	13616	12403	11149	9852

Size (kW)	Emission Level	2000	2001	2002	2003	2004	2005
Certified	<1981	2432	1908	1427	987	591	236
Non certified	<1981	8512	7131	5707	4240	2732	1180

Stock data for harvesters 1985-2009.

Size Group	Emission Level	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
0<S<=50	<1981	26601	24394	22599	22144	19842	18915	17241	15607	14575	12673	10700	9491	6966	5446	3589
0<S<=50	1981-1990	519	534	550	582	566	591	594	601	635	636	633	683	641	686	672
50<S<=60	<1981	2703	2648	2634	2785	2711	2828	2847	2876	3040	3044	3029	3271	3068	2930	2235
50<S<=60	1981-1990	853	1102	1164	1275	1258	1333	1341	1355	1432	1434	1427	1541	1446	1548	1516
50<S<=60	1991-Stage I							8	8	8	8	8	9	9	9	9
60<S<=70	<1981	1786	1750	1741	1841	1792	1869	1881	1901	2009	2012	2002	2162	2028	2171	2127
60<S<=70	1981-1990	1138	1679	1943	2237	2213	2348	2363	2388	2524	2527	2515	2716	2547	2727	2671
60<S<=70	1991-Stage I							8	16	18	21	22	24	23	24	24
70<S<=80	<1981	929	910	905	958	932	972	979	989	1045	1046	1041	1125	1055	1129	1106
70<S<=80	1981-1990	383	699	1026	1165	1318	1493	1502	1518	1604	1606	1598	1726	1619	1733	1698
70<S<=80	1991-Stage I							72	77	83	86	87	96	91	98	96
70<S<=80	Stage I															1
80<S<=90	<1981	323	317	315	333	324	338	340	344	363	364	362	391	367	393	385
80<S<=90	1981-1990	383	562	645	967	1107	1466	1475	1491	1575	1577	1570	1695	1590	1702	1667
80<S<=90	1991-Stage I							61	158	181	200	200	217	207	222	217
80<S<=90	Stage I															1
90<S<=100	1981-1990	89	175	235	387	515	670	674	681	720	721	717	775	726	778	762
90<S<=100	1991-Stage I							180	257	320	329	351	382	367	393	385
90<S<=100	Stage I															1
100<S<=120	1981-1990		54	106	219	334	589	592	599	633	634	630	681	639	684	670
100<S<=120	1991-Stage I							129	253	316	375	440	567	586	673	660
100<S<=120	Stage I															2
120<S<=140	1981-1990				4	69	183	184	186	197	197	196	212	199	213	208
120<S<=140	1991-Stage I							70	148	189	215	319	484	626	804	860
120<S<=140	Stage I															21
120<S<=140	Stage II															
120<S<=140	Stage IIIA															
140<S<=160	1991-Stage I								8	36	69	112	271	354	554	632
140<S<=160	Stage II															
140<S<=160	Stage IIIA															

Continued													
160<S<=180	1991-Stage I								26	69	200	374	440
160<S<=180	Stage II												
160<S<=180	Stage IIIA												
180<S<=200	1991-Stage I									20	67	117	193
180<S<=200	Stage II												
180<S<=200	Stage IIIA												
200<S<=220	1991-Stage I											45	92
200<S<=220	Stage II												
200<S<=220	Stage IIIA												
220<S<=240	1991-Stage I												3
220<S<=240	Stage II												
220<S<=240	Stage IIIA												
240<S<=260	1991-Stage I												3
240<S<=260	Stage II												
240<S<=260	Stage IIIA												
260<S<=280	1991-Stage I												14
260<S<=280	Stage II												
260<S<=280	Stage IIIA												
280<S<=300	1991-Stage I												
280<S<=300	Stage II												
280<S<=300	Stage IIIA												
300<S<=320	Stage II												
300<S<=320	Stage IIIA												

Continued

Size Group	Emission Level	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
0<S<=50	<1981	2873	1854	1272	750	267					
0<S<=50	1981-1990	715	758	776	812	877	908	774	625	445	264
50<S<=60	<1981	1999	1570	1257	892	389					
50<S<=60	1981-1990	1612	1711	1751	1831	1979	2048	1844	1635	1326	1020
50<S<=60	1991-Stage I	10	10	10	11	12	12	12	12	12	12
60<S<=70	<1981	2073	1648	1337	976	480					
60<S<=70	1981-1990	2841	3014	3085	3226	3486	3608	3323	3043	2642	2253
60<S<=70	1991-Stage I	25	27	27	29	31	32	32	32	32	33
70<S<=80	<1981	1176	1248	1102	731	215					
70<S<=80	1981-1990	1806	1916	1961	2051	2216	2293	2151	2030	1926	1836
70<S<=80	1991-Stage I	102	109	111	116	126	130	130	129	130	133
70<S<=80	Stage I	1	1	1	1	1	1	1	1	1	1
80<S<=90	<1981	409	434	444	465	215					
80<S<=90	1981-1990	1773	1881	1926	2014	2176	2252	2110	1989	1885	1794
80<S<=90	1991-Stage I	231	245	251	263	284	294	292	290	293	299
80<S<=90	Stage I	1	1	1	1	1	1	1	1	1	1
90<S<=100	1981-1990	810	860	880	920	994	1029	1024	1017	980	951
90<S<=100	1991-Stage I	410	435	445	465	503	520	518	514	520	530
90<S<=100	Stage I	1	1	1	1	1	1	1	1	1	1
100<S<=120	1981-1990	712	756	773	809	874	904	900	894	903	921
100<S<=120	1991-Stage I	702	744	762	797	861	891	887	881	890	907
100<S<=120	Stage I	2	2	2	3	3	3	3	3	3	3
120<S<=140	1981-1990	222	235	241	252	272	282	280	278	281	287
120<S<=140	1991-Stage I	918	977	1000	1046	1130	1170	1164	1156	1168	1191
120<S<=140	Stage I	26	31	32	33	36	37	37	37	37	38
120<S<=140	Stage II					3	4	4	4	4	4
120<S<=140	Stage IIIA							1	1	1	4
140<S<=160	1991-Stage I	715	795	814	851	920	952	947	940	950	969
140<S<=160	Stage II			23	40	53	62	61	61	61	63
140<S<=160	Stage IIIA							5	8	12	16
160<S<=180	1991-Stage I	533	602	616	644	696	720	717	712	720	734
160<S<=180	Stage II			45	80	101	116	115	114	116	118
160<S<=180	Stage IIIA							9	14	20	24
180<S<=200	1991-Stage I	249	300	307	321	347	359	358	355	359	366
180<S<=200	Stage II			68	103	127	142	142	141	142	145
180<S<=200	Stage IIIA							9	14	20	24
200<S<=220	1991-Stage I	142	187	192	200	217	224	223	221	224	228
200<S<=220	Stage II			45	80	101	116	115	114	116	118
200<S<=220	Stage IIIA							9	14	20	24
220<S<=240	1991-Stage I	48	151	154	161	174	180	180	178	180	184
220<S<=240	Stage II			80	129	180	238	237	235	238	242
220<S<=240	Stage IIIA							61	122	194	251
240<S<=260	1991-Stage I	71	142	145	152	164	169	169	167	169	173
240<S<=260	Stage II			80	143	220	319	318	315	319	325
240<S<=260	Stage IIIA							113	231	369	477
260<S<=280	1991-Stage I	61	131	134	140	151	156	156	154	156	159
260<S<=280	Stage II			80	143	220	319	318	315	319	325
260<S<=280	Stage IIIA							113	231	369	477
280<S<=300	1991-Stage I		33	34	36	38	40	40	39	40	40
280<S<=300	Stage II			80	143	220	319	318	315	319	325
280<S<=300	Stage IIIA							113	231	369	477
300<S<=320	Stage II				29	65	113	112	111	113	115
300<S<=320	Stage IIIA							56	115	184	239

Stock data for fork lifts 1985-2009.

FuelCode	Size (kW)	Emission Level	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
205B	35	<1981	387	361	336	311	285	260	234	209	183	158	133	107	84	58	30
205B	35	1981-1990	120	162	202	239	270	297	297	297	297	297	297	297	297	297	297
205B	35	1991-Stage I							26	49	65	93	131	168	218	247	275
205B	35	Stage II															
205B	35	Stage IIIA															
205B	45	<1981	1612	1506	1400	1294	1188	1082	976	870	764	658	552	446	349	243	126
205B	45	1981-1990	499	674	839	994	1122	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233
205B	45	1991-Stage I							108	203	270	386	544	699	905	1063	1063
205B	45	Stage I															151
205B	45	Stage II															
205B	45	Stage IIIA															
205B	50	<1981	2173	2031	1888	1745	1602	1459	1316	1174	1031	888	745	602	471	328	170
205B	50	1981-1990	673	909	1131	1340	1512	1662	1662	1662	1662	1662	1662	1662	1662	1662	1662
205B	50	1991-Stage I							145	273	363	519	732	940	1217	1469	1469
205B	50	Stage I															240
205B	50	Stage II															
205B	50	Stage IIIA															
205B	75	<1981	497	465	432	399	367	334	301	269	236	203	170	138	108	75	39
205B	75	1981-1990	154	208	259	307	347	382	382	382	382	382	382	382	382	382	382
205B	75	1991-Stage I							33	63	84	120	169	217	281	354	354
205B	75	Stage I															70
205B	75	Stage II															
205B	75	Stage IIIA															
205B	120	<1981	111	103	96	89	81	74	67	60	52	45	38	31	24	17	9
205B	120	1981-1990	34	46	57	68	77	85	85	85	85	85	85	85	85	85	85
205B	120	1991-Stage I							7	14	19	27	38	49	63	97	97
205B	120	Stage I															32
205B	120	Stage II															
205B	120	Stage IIIA															
3030	33		5420	5427	5390	5323	5265	5215	5156	5068	4947	4863	4835	4792	4732	4765	4712
3030	40		4917	4923	4889	4828	4775	4730	4676	4596	4486	4410	4384	4344	4289	4295	4223
3030	50		2149	2151	2137	2110	2087	2067	2044	2008	1960	1926	1915	1897	1874	1926	1941
3030	78		97	97	96	95	94	93	92	91	89	88	88	87	86	90	92
3030	120															1	2

Continued

FuelCode	Size (kW)	Emission Level	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
205B	35	<1981										
205B	35	1981-1990	297	277	249	232	198	177	135	95	58	27
205B	35	1991-Stage I	304	304	304	304	304	304	304	304	304	304
205B	35	Stage II		23	53	75	89	117	152	152	152	152
205B	35	Stage IIIA								41	76	92
205B	45	<1981										
205B	45	1981-1990	1233	1151	1036	964	820	734	559	394	239	111
205B	45	1991-Stage I	1063	1063	1063	1063	1063	1063	1063	1063	1063	1063
205B	45	Stage I	303	422	524	664	664	664	664	664	664	664
205B	45	Stage II					104	232	452	612	612	612
205B	45	Stage IIIA									126	181
205B	50	<1981										
205B	50	1981-1990	1662	1551	1396	1299	1105	989	753	531	322	150
205B	50	1991-Stage I	1469	1469	1469	1469	1469	1469	1469	1469	1469	1469
205B	50	Stage I	461	682	897	1135	1135	1135	1135	1135	1135	1135
205B	50	Stage II					187	447	818	1134	1134	1134
205B	50	Stage IIIA									181	275
205B	75	<1981										
205B	75	1981-1990	382	357	321	299	255	228	174	123	75	35
205B	75	1991-Stage I	354	354	354	354	354	354	354	354	354	354
205B	75	Stage I	162	234	311	311	311	311	311	311	311	311
205B	75	Stage II				58	129	208	326	326	326	326
205B	75	Stage IIIA								142	213	252
205B	120	<1981										
205B	120	1981-1990	85	80	72	67	57	51	39	28	17	8
205B	120	1991-Stage I	97	97	97	97	97	97	97	97	97	97
205B	120	Stage I	71	89	118	118	118	118	118	118	118	118
205B	120	Stage II				16	38	58	112	112	112	112
205B	120	Stage IIIA								58	70	76
3030	33		4718	4677	4655	4595	4494	4345	4220	4154	4043	3941
3030	40		4218	4214	4244	4224	4166	4116	4048	4005	3951	3878
3030	50		1897	1938	2003	2020	2018	2029	2061	2136	2198	2192
3030	78		88	95	98	99	104	104	114	123	147	149
3030	120		2	2	3	3	3	3	3	3	3	3

Stock data for construction machinery 1985-2009.

EquipmentName (Eng)	Emission Level	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Track type dozers	<1981	125	100	75	50	25										
Track type dozers	1981-1990	125	150	175	200	225	250	221	193	166	139	114	89	66	43	21
Track type dozers	1991-Stage I							25	48	71	93	114	134	153	172	189
Track type dozers	Stage II															
Track type dozers	Stage IIIA															
Track type loaders	<1981	50	40	30	20	10										
Track type loaders	1981-1990	50	60	70	80	90	100	89	79	68	58	48	38	28	19	9
Track type loaders	1991-Stage I							10	20	29	39	48	57	66	75	83
Track type loaders	Stage II															
Track type loaders	Stage IIIA															
Wheel loaders (0-5 tons)	1981-1990							186	331	434	496	517	496	434	331	186
Wheel loaders (0-5 tons)	1991-Stage I							21	83	186	331	517	744	1013	1323	1674
Wheel loaders (0-5 tons)	Stage II															
Wheel loaders (0-5 tons)	Stage IIIA															
Wheel loaders (> 5,1 tons)	<1981	1250	1000	750	500	250										
Wheel loaders (> 5,1 tons)	1981-1990	1250	1500	1750	2000	2250	2500	2228	1960	1698	1441	1188	941	698	460	228
Wheel loaders (> 5,1 tons)	1991-Stage I							248	490	728	960	1188	1411	1629	1841	1822
Wheel loaders (> 5,1 tons)	Stage I															228
Wheel loaders (> 5,1 tons)	Stage II															
Wheel loaders (> 5,1 tons)	Stage IIIA															
Wheel type excavators	<1981	500	400	300	200	100										
Wheel type excavators	1981-1990	500	600	700	800	900	1000	862	732	611	498	394	298	211	132	62
Wheel type excavators	1991-Stage I							96	183	262	332	394	447	491	528	493
Wheel type excavators	Stage I															62
Wheel type excavators	Stage II															
Wheel type excavators	Stage IIIA															
Track type excavators (0-5 tons)	1981-1990							459	816	1071	1224	1275	1224	1071	816	459
Track type excavators (0-5 tons)	1991-Stage I							51	204	459	816	1275	1837	2500	3265	4132
Track type excavators (0-5 tons)	Stage II															
Track type excavators (0-5 tons)	Stage IIIA															
Track type excavators (>5,1 tons)	<1981	1000	800	600	400	200										
Track type excavators (>5,1 tons)	1981-1990	1000	1200	1400	1600	1800	2000	1798	1596	1394	1194	993	794	594	396	198
Track type excavators (>5,1 tons)	1991-Stage I							200	399	598	796	993	1190	1387	1583	1581
Track type excavators (>5,1 tons)	Stage I															198
Track type excavators (>5,1 tons)	Stage II															

Continued																
Track type excavators (>5,1 tons)	Stage IIIA															
Excavators/Loaders	<1981	2100	1680	1260	840	420										
Excavators/Loaders	1981-1990	2100	2520	2940	3360	3780	4200	3807	3408	3003	2592	2175	1752	1323	888	447
Excavators/Loaders	1991-Stage I							423	852	1287	1728	2175	2628	3087	3552	3575
Excavators/Loaders	Stage I															447
Excavators/Loaders	Stage II															
Excavators/Loaders	Stage IIIA															
Dump trucks	<1981	250	200	150	100	50										
Dump trucks	1981-1990	250	300	350	400	450	500	489	469	441	404	358	304	241	169	89
Dump trucks	1991-Stage I							54	117	189	269	358	455	561	676	711
Dump trucks	Stage I															89
Dump trucks	Stage II															
Dump trucks	Stage IIIA															
Mini loaders	<1981	1800	1600	1400	1200	1000	800	635	447	235						
Mini loaders	1981-1990	1000	1200	1400	1600	1800	2000	2118	2237	2355	2473	2332	2168	1980	1768	1532
Mini loaders	1991-Stage I							212	447	706	989	1296	1626	1980	2357	2758
Mini loaders	Stage II															
Mini loaders	Stage IIIA															
Telescopic loaders	1981-1990											149	265	348	398	414
Telescopic loaders	1991-Stage I											83	199	348	530	746
Telescopic loaders	Stage II															
Telescopic loaders	Stage IIIA															

Continued											
EquipmentName (Eng)	Emission Level	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Track type dozers	<1981										
Track type dozers	1981-1990										
Track type dozers	1991-Stage I	206	201	177	154	132	128	125	116	95	59
Track type dozers	Stage II			20	38	56	86	100	116	126	119
Track type dozers	Stage IIIA							25	58	95	119
Track type loaders	<1981										
Track type loaders	1981-1990										
Track type loaders	1991-Stage I	91	91	81	71	62	61	71	68	55	38
Track type loaders	Stage II			9	18	26	40	56	68	73	76
Track type loaders	Stage IIIA							14	34	55	76

Continued											
Wheel loaders (0-5 tons)	1981-1990										
Wheel loaders (0-5 tons)	1991-Stage I	2067	2046	1984	1881	1736	1444	1269	1045	726	353
Wheel loaders (0-5 tons)	Stage II		227	496	806	1158	1444	1903	2090	2177	2117
Wheel loaders (0-5 tons)	Stage IIIA								348	726	1058
Wheel loaders (> 5,1 tons)	<1981										
Wheel loaders (> 5,1 tons)	1981-1990										
Wheel loaders (> 5,1 tons)	1991-Stage I	1802	1559	1322	1089	861	677	485	273		
Wheel loaders (> 5,1 tons)	Stage I	450	668	881	871	861	902	969	1092	1174	854
Wheel loaders (> 5,1 tons)	Stage II				218	431	677	969	1092	1174	1138
Wheel loaders (> 5,1 tons)	Stage IIIA								273	587	854
Wheel type excavators	<1981										
Wheel type excavators	1981-1990										
Wheel type excavators	1991-Stage I	459	372	293	223	162	118	74	38		
Wheel type excavators	Stage I	115	160	196	179	162	157	148	152	146	103
Wheel type excavators	Stage II				45	81	118	148	152	146	138
Wheel type excavators	Stage IIIA								38	73	103
Track type excavators (0-5 tons)	1981-1990										
Track type excavators (0-5 tons)	1991-Stage I	5101	5050	4897	4642	4285	3889	3599	3027	2073	995
Track type excavators (0-5 tons)	Stage II		561	1224	1990	2857	3889	5399	6054	6220	5968
Track type excavators (0-5 tons)	Stage IIIA								1009	2073	2984
Track type excavators (>5,1 tons)	<1981										
Track type excavators (>5,1 tons)	1981-1990										
Track type excavators (>5,1 tons)	1991-Stage I	1579	1380	1181	983	785	683	536	313		
Track type excavators (>5,1 tons)	Stage I	395	591	787	786	785	910	1073	1251	1338	980
Track type excavators (>5,1 tons)	Stage II				197	393	683	1073	1251	1338	1307
Track type excavators (>5,1 tons)	Stage IIIA								313	669	980
Excavators/Loaders	<1981										
Excavators/Loaders	1981-1990										
Excavators/Loaders	1991-Stage I	3599	3170	2735	2295	1848	1370	938	481		
Excavators/Loaders	Stage I	900	1359	1824	2295	2310	2283	2344	2403	2314	1688
Excavators/Loaders	Stage II					462	913	1406	1922	1851	1688
Excavators/Loaders	Stage IIIA									463	844
Dump trucks	<1981										
Dump trucks	1981-1990										
Dump trucks	1991-Stage I	745	682	611	530	442	385	301	176		
Dump trucks	Stage I	186	292	407	530	552	642	752	880	943	739

Continued

Dump trucks	Stage II					110	257	451	704	754	739
Dump trucks	Stage IIIA									189	369
Mini loaders	<1981										
Mini loaders	1981-1990	1273	990	684	354						
Mini loaders	1991-Stage I	3183	3301	3419	3537	3656	2756	2294	1077	715	498
Mini loaders	Stage II		330	684	1061	1462	1531	1720	923	715	597
Mini loaders	Stage IIIA								154	238	299
Telescopic loaders	1981-1990	398	348	265	149						
Telescopic loaders	1991-Stage I	994	1160	1326	1491	1657	1740	1837	1846	1687	1343
Telescopic loaders	Stage II		116	265	447	663	966	1378	1582	1687	1612
Telescopic loaders	Stage IIIA								264	562	806

Stock data for machine pools 1985-2009.

EquipmentName (Eng)	Emission Level	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Tractors (machine pools)	<1981	1236	627													
Tractors (machine pools)	1981-1990	3091	3763	4575	4515	4370	4100	3643	2808	2368	1786	1214	604			
Tractors (machine pools)	1991-Stage I							607	1123	1776	2382	3035	3624	4324	4210	4336
Tractors (machine pools)	Stage I															
Tractors (machine pools)	Stage II															
Tractors (machine pools)	Stage IIIA															
Harvesters (machine pools)	<1981	969	776	661	472	287	139									
Harvesters (machine pools)	1981-1990	807	932	1157	1257	1294	1385	1385	1197	927	794	712	512	421	282	162
Harvesters (machine pools)	1991-Stage I							139	266	348	454	593	615	737	751	729
Harvesters (machine pools)	Stage II															
Harvesters (machine pools)	Stage IIIA															
Self-propelled vehicles (machine pools)	1981-1990									72	61	38				
Self-propelled vehicles (machine pools)	1991-Stage I									72	122	190	263	278	277	295
Self-propelled vehicles (machine pools)	Stage II															
Self-propelled vehicles (machine pools)	Stage IIIA															

EquipmentName (Eng)	Emission Level	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Tractors (machine pools)	<1981										
Tractors (machine pools)	1981-1990										
Tractors (machine pools)	1991-Stage I	3956	4069	3323	2566	2066	1421	927	487		
Tractors (machine pools)	Stage I			554	513	517	474	464	487	487	
Tractors (machine pools)	Stage II				513	1033	1421	1855	1946	1946	1946
Tractors (machine pools)	Stage IIIA								487	973	1460
Harvesters (machine pools)	<1981										
Harvesters (machine pools)	1981-1990	78									
Harvesters (machine pools)	1991-Stage I	778	779	651	531	472	300	257	211	169	127
Harvesters (machine pools)	Stage II			65	118	177	171	172	169	169	169
Harvesters (machine pools)	Stage IIIA							43	85	127	169
Self-propelled vehicles (machine pools)	1981-1990										
Self-propelled vehicles (machine pools)	1991-Stage I	289	314	237	203	153	99	49			
Self-propelled vehicles (machine pools)	Stage II			47	102	153	199	194	189	142	94
Self-propelled vehicles (machine pools)	Stage IIIA							49	94	142	189

Stock data for household and gardening 1985-2009.

SNAP	EquipmentName (Eng)	Emission Level	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
0809	Lawn movers (private)	<1981	253125	168750	84375												
0809	Lawn movers (private)	1981-1990	421875	506250	590625	675000	675000	675000	590625	506250	421875	337500	253125	168750	84375		
0809	Lawn movers (private)	1991-Stage I							84375	168750	253125	337500	421875	506250	590625	675000	675000
0809	Lawn movers (private)	Stage I															
0809	Lawn movers (private)	Stage II															
0809	Cultivators (private-large)	<1981	73333	66000	58667	51333	44000	36667	29333	22000	14667	7333					
0809	Cultivators (private-large)	1981-1990	36667	44000	51333	58667	66000	73333	73333	73333	73333	73333	73333	66000	58667	51333	44000
0809	Cultivators (private-large)	1991-Stage I							7333	14667	22000	29333	36667	44000	51333	58667	66000
0809	Cultivators (private-large)	Stage II															
0809	Cultivators (private-small)	1981-1990	10000	10000	10000	10000	10000	10000	8000	6000	4000	2000					
0809	Cultivators (private-small)	1991-Stage I							2000	4000	6000	8000	10000	10000	10000	10000	10000
0809	Cultivators (private-small)	Stage II															
0809	Chain saws (private)	<1981	125000	100000	75000	50000	25000										
0809	Chain saws (private)	1981-1990	125000	150000	175000	200000	225000	250000	227250	204000	180250	156000	131250	106000	80250	54000	27250
0809	Chain saws (private)	1991-Stage I							25250	51000	77250	104000	131250	159000	187250	216000	245250
0809	Chain saws (private)	Stage I															
0809	Chain saws (private)	Stage II															
0809	Riders (private)	<1981	40950	35100	29250	23400	17550	11700	5880								
0809	Riders (private)	1981-1990	29250	35100	40950	46800	52650	58500	58796	59388	54248	49167	44056	38828	33392	27660	21544
0809	Riders (private)	1991-Stage I							5880	11878	18083	24583	31469	38828	46748	55320	64631
0809	Riders (private)	Stage I															
0809	Riders (private)	Stage II															
0809	Shrub clearers (private)	<1981	24000	19200	14400	9600	4800										
0809	Shrub clearers (private)	1981-1990	24000	28800	33600	38400	43200	48000	47520	46080	43680	40320	36000	30720	24480	17280	9120
0809	Shrub clearers (private)	1991-Stage I							5280	11520	18720	26880	36000	46080	57120	69120	82080
0809	Shrub clearers (private)	Stage I															
0809	Shrub clearers (private)	Stage II															
0809	Hedge cutters (private)	<1981	6850	5480	4110	2740	1370										
0809	Hedge cutters (private)	1981-1990	6850	8220	9590	10960	12330	13700	15237	16128	16373	15972	14925	13232	10893	7908	4277
0809	Hedge cutters (private)	1991-Stage I							1693	4032	7017	10648	14925	19848	25417	31632	38493
0809	Hedge cutters (private)	Stage I															
0809	Hedge cutters (private)	Stage II															
0809	Trimmers (private)	<1981	25500	20400	15300	10200	5100										
0809	Trimmers (private)	1981-1990	25500	30600	35700	40800	45900	51000	48086	44686	40800	36429	31571	26229	20400	14086	7286
0809	Trimmers (private)	1991-Stage I							5343	11171	17486	24286	31571	39343	47600	56343	65571

Continued																	
0809	Trimmers (private)	Stage I															
0809	Trimmers (private)	Stage II															
0811	Lawn movers (professional)	1981-1990	25000	25000	25000	25000	25000	25000	18750	12500	6250						
0811	Lawn movers (professional)	1991-Stage I							6250	12500	18750	25000	25000	25000	25000	25000	25000
0811	Lawn movers (professional)	Stage I															
0811	Lawn movers (professional)	Stage II															
0811	Cultivators (professional)	<1981	3750	2500	1250												
0811	Cultivators (professional)	1981-1990	6250	7500	8750	10000	10000	10000	8750	7500	6250	5000	3750	2500	1250		
0811	Cultivators (professional)	1991-Stage I							1250	2500	3750	5000	6250	7500	8750	10000	10000
0811	Cultivators (professional)	Stage I															
0811	Cultivators (professional)	Stage II															
0811	Chain saws (professional)	1981-1990	10000	10000	10000	10000	10000	10000	7333	4000							
0811	Chain saws (professional)	1991-Stage I							3667	8000	13000	14000	15000	16000	17000	18000	19000
0811	Chain saws (professional)	Stage I															
0811	Chain saws (professional)	Stage II															
0811	Riders (professional)	1981-1990	4800	4800	4800	4800	4800	4800	3878	2966	2035	1056					
0811	Riders (professional)	1991-Stage I							970	1978	3053	4224	5520	5760	6000	6240	6480
0811	Riders (professional)	Stage I															
0811	Riders (professional)	Stage II															
0811	Shrub clearers (professional)	1981-1990	2000	2000	2000	2000	2000	2000	1650	1200	650						
0811	Shrub clearers (professional)	1991-Stage I							550	1200	1950	2800	3000	3200	3400	3600	3800
0811	Shrub clearers (professional)	Stage I															
0811	Shrub clearers (professional)	Stage II															
0811	Hedge cutters (professional)	1981-1990	1300	1300	1300	1300	1300	1300	1178	920	528						
0811	Hedge cutters (professional)	1991-Stage I							393	920	1583	2380	2650	2920	3190	3460	3730
0811	Hedge cutters (professional)	Stage I															
0811	Hedge cutters (professional)	Stage II															
0811	Trimmers (professional)	1981-1990	9000	9000	9000	9000	9000	9000	7071	4929	2571						
0811	Trimmers (professional)	1991-Stage I							2357	4929	7714	10714	11143	11571	12000	12429	12857
0811	Trimmers (professional)	Stage I															
0811	Trimmers (professional)	Stage II															

Continued

SNAP	EquipmentName (Eng)	Emission Level	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
0809	Lawn movers (private)	<1981										
0809	Lawn movers (private)	1981-1990										
0809	Lawn movers (private)	1991-Stage I	675000	675000	675000	675000	675000	595000	513750	428125	342500	256875
0809	Lawn movers (private)	Stage I						85000	171250	256875	256875	256875
0809	Lawn movers (private)	Stage II									85625	171250
0809	Cultivators (private-large)	<1981										
0809	Cultivators (private-large)	1981-1990	36667	29333	22000	14667	7333					
0809	Cultivators (private-large)	1991-Stage I	73333	80667	88000	95333	102667	102667	95333	88000	80667	73333
0809	Cultivators (private-large)	Stage II						7333	14667	22000	29333	36667
0809	Cultivators (private-small)	1981-1990										
0809	Cultivators (private-small)	1991-Stage I	10000	10000	10000	10000	10000	8000	6000	4000	2000	
0809	Cultivators (private-small)	Stage II						2000	4000	6000	8000	10000
0809	Chain saws (private)	<1981										
0809	Chain saws (private)	1981-1990										
0809	Chain saws (private)	1991-Stage I	275000	280750	286500	292250	298000	268200	238400	208600	178800	149000
0809	Chain saws (private)	Stage I						29800	59600	89400	89400	89400
0809	Chain saws (private)	Stage II									29800	59600
0809	Riders (private)	<1981										
0809	Riders (private)	1981-1990	14954	7910								
0809	Riders (private)	1991-Stage I	74771	87015	101775	109920	119360	117741	114313	107663	99047	86666
0809	Riders (private)	Stage I						10704	22863	23925	24762	24762
0809	Riders (private)	Stage II								11963	24762	37143
0809	Shrub clearers (private)	<1981										
0809	Shrub clearers (private)	1981-1990										
0809	Shrub clearers (private)	1991-Stage I	96000	107000	118000	129000	140000	126000	112000	98000	84000	70000
0809	Shrub clearers (private)	Stage I						14000	28000	42000	42000	42000
0809	Shrub clearers (private)	Stage II									14000	28000
0809	Hedge cutters (private)	<1981										
0809	Hedge cutters (private)	1981-1990										
0809	Hedge cutters (private)	1991-Stage I	46000	52900	59800	66700	73600	66240	58880	51520	44160	36800
0809	Hedge cutters (private)	Stage I						7360	14720	22080	22080	22080
0809	Hedge cutters (private)	Stage II									7360	14720
0809	Trimmers (private)	<1981										
0809	Trimmers (private)	1981-1990										
0809	Trimmers (private)	1991-Stage I	75286	77714	80143	82571	85000	76500	68000	59500	51000	42500

Continued												
0809	Trimmers (private)	Stage I						8500	17000	25500	25500	25500
0809	Trimmers (private)	Stage II									8500	17000
0811	Lawn movers (professional)	1981-1990										
0811	Lawn movers (professional)	1991-Stage I	25000	25000	25000	25000	25000	18750	12500	6250		
0811	Lawn movers (professional)	Stage I						6250	12500	18750	18750	12500
0811	Lawn movers (professional)	Stage II									6250	12500
0811	Cultivators (professional)	<1981										
0811	Cultivators (professional)	1981-1990										
0811	Cultivators (professional)	1991-Stage I	10000	10000	10000	10000	10000	8750	7500	6250	5000	3750
0811	Cultivators (professional)	Stage I						1250	2500	3750	3750	3750
0811	Cultivators (professional)	Stage II									1250	2500
0811	Chain saws (professional)	1981-1990										
0811	Chain saws (professional)	1991-Stage I	20000	27500	35000	42500	50000	33333	16667			
0811	Chain saws (professional)	Stage I						16667	33333	50000	50000	33333
0811	Chain saws (professional)	Stage II										16667
0811	Riders (professional)	1981-1990										
0811	Riders (professional)	1991-Stage I	6720	7802	9726	12492	16100	15728	13398	9444	4800	
0811	Riders (professional)	Stage I						3932	8932	9444	9600	9600
0811	Riders (professional)	Stage II								4722	9600	14400
0811	Shrub clearers (professional)	1981-1990										
0811	Shrub clearers (professional)	1991-Stage I	4000	5500	7000	8500	10000	7500	5000	2500		
0811	Shrub clearers (professional)	Stage I						2500	5000	7500	7500	5000
0811	Shrub clearers (professional)	Stage II									2500	5000
0811	Hedge cutters (professional)	1981-1990										
0811	Hedge cutters (professional)	1991-Stage I	4000	4600	5200	5800	6400	4800	3200	1600		
0811	Hedge cutters (professional)	Stage I						1600	3200	4800	4800	3200
0811	Hedge cutters (professional)	Stage II									1600	3200
0811	Trimmers (professional)	1981-1990										
0811	Trimmers (professional)	1991-Stage I	13286	13714	14143	14571	15000	11250	7500	3750		
0811	Trimmers (professional)	Stage I						3750	7500	11250	11250	7500
0811	Trimmers (professional)	Stage II									3750	7500

Stock data for small boats and pleasure crafts 1985-2009.

Brændstof	Motortakt	Boat type	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Diesel		Motor boats (27-34 ft)	1550	1550	1719	1889	2058	2228	2397	2567	2736	2906	3075	3244	3414	3583	3753
Diesel		Motor boats (> 34 ft)	450	450	503	556	608	661	714	767	819	872	925	978	1031	1083	1136
Diesel		Motor boats <(27 ft)	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
Diesel		Motor sailors	3500	3500	3583	3667	3750	3833	3917	4000	4083	4167	4250	4333	4417	4500	4583
Diesel		Sailing boats (> 26 ft)	7500	7500	7917	8333	8750	9167	9583	10000	10417	10833	11250	11667	12083	12500	12917
Benzin	2-takt	Other boats (< 20 ft)	4000	4000	4056	4111	4167	4222	4278	4333	4389	4444	4500	4556	4565	4527	4439
Benzin	2-takt	Yawls and cabin boats	4000	4000	4056	4111	4167	4222	4278	4333	4389	4444	4500	4556	4565	4527	4439
Benzin	2-takt	Sailing boats (< 26 ft)	19000	19000	18778	18556	18333	18111	17889	17667	17444	17222	17000	16778	16390	15843	15144
Benzin	2-takt	Speed boats	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	2970	2910	2820
Benzin	2-takt	Water scooters	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	990	970	940
Benzin	4-takt	Other boats (< 20 ft)													46	140	283
Benzin	4-takt	Yawls and cabin boats													46	140	283
Benzin	4-takt	Sailing boats (< 26 ft)													166	490	967
Benzin	4-takt	Speed boats	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
Benzin	4-takt	Speed boats													30	90	180
Benzin	4-takt	Water scooters													10	30	60

Continued

Brændstof	Motortakt	Boat type	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Diesel		Motor boats (27-34 ft)	3922	4092	4261	4431	4600	4600	4600	4600	4600	4600
Diesel		Motor boats (> 34 ft)	1189	1242	1294	1347	1400	1400	1400	1400	1400	1400
Diesel		Motor boats <(27 ft)	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
Diesel		Motor sailors	4667	4750	4833	4917	5000	5000	5000	5000	5000	5000
Diesel		Sailing boats (> 26 ft)	13333	13750	14167	14583	15000	15000	15000	15000	15000	15000
Benzin	2-takt	Other boats (< 20 ft)	4300	4108	3862	3560	3200	2750	2250	1800	1400	1050
Benzin	2-takt	Yawls and cabin boats	4300	4108	3862	3560	3200	2750	2250	1800	1400	1050
Benzin	2-takt	Sailing boats (< 26 ft)	14300	13317	12201	10960	9600	8250	6750	5400	4200	3150
Benzin	2-takt	Speed boats	2700	2550	2370	2160	1920	1650	1350	1080	840	630
Benzin	2-takt	Water scooters	900	850	790	720	640	550	450	360	280	210
Benzin	4-takt	Other boats (< 20 ft)	478	725	1027	1384	1800	2250	2750	3200	3600	3950
Benzin	4-takt	Yawls and cabin boats	478	725	1027	1384	1800	2250	2750	3200	3600	3950
Benzin	4-takt	Sailing boats (< 26 ft)	1589	2350	3243	4262	5400	6750	8250	9600	10800	11850
Benzin	4-takt	Speed boats	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
Benzin	4-takt	Speed boats	300	450	630	840	1080	1350	1650	1920	2160	2370
Benzin	4-takt	Water scooters	100	150	210	280	360	450	550	640	720	790

Engine sizes (kW) for recreational craft 1985-2009.

Motor type	Boat type	1985	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004-2009
2-takt	Other boats (< 20 ft)	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
2-takt	Yawls and cabin boats	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
2-takt	Sailing boats (< 26 ft)	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
2-takt	Speed boats	25	31	32	33	35	36	38	39	40	42	43	44	46	47	49	50
2-takt	Water scooters	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45
4-takt	Other boats (< 20 ft)									8	8	8	8	8	8	8	8
4-takt	Yawls and cabin boats									20	20	20	20	20	20	20	20
4-takt	Sailing boats (< 26 ft)									10	10	10	10	10	10	10	10
4-takt	Speed boats (in board eng.)	45	55	58	60	63	65	68	70	73	75	78	80	83	85	88	90
4-takt	Speed boats (out board eng.)									40	42	43	44	46	47	49	50
4-takt	Water scooters									45	45	45	45	45	45	45	45
Diesel	Motor boats (27-34 ft)	70	88	92	97	101	106	110	114	119	123	128	132	137	141	146	150
Diesel	Motor boats (> 34 ft)	120	149	156	163	171	178	185	192	199	207	214	221	228	236	243	250
Diesel	Motor boats <(27 ft)	20	24	26	27	28	29	30	31	32	33	34	36	37	38	39	40
Diesel	Motor sailors	20	22	23	23	24	24	25	26	26	27	27	28	28	29	29	30
Diesel	Sailing boats (> 26 ft)	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30

Annex 3B-11: Traffic data and different technical and operational data for Danish domestic ferries

Annual traffic data for ferries (no. of round trips) for Danish domestic ferries.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Korsør-Nyborg, DSB	9305	9167	9237	8959	8813	8789	8746	3258	0	0
Korsør-Nyborg, Vognmandsruten	7512	7363	7468	7496	7502	7828	7917	8302	3576	0
Halsskov-Knudshoved	10601	10582	11701	11767	12420	12970	13539	13612	5732	0
Kalundborg-Juelsminde	0	1326	1733	1542	1541	1508	856	0	0	0
Kalundborg-Århus	1907	2400	3162	2921	2913	3540	4962	4888	4483	1454
Sjællands Odde-Ebeltoft	3908	3978	4008	3988	4325	4569	5712	8153	7851	7720
Sjællands Odde-Århus	0	0	0	0	0	0	0	0	0	2339
Hundested-Grenaa	1026	1025	1032	1030	718	602	67	0	0	0
København-Rønne	558	545	484	412	427	426	437	465	458	506
Køge-Rønne	0	0	0	0	0	0	0	0	0	0
Kalundborg-Samsø	873	873	860	881	826	811	813	823	824	850
Tårs-Spodsbjerg	7656	8835	9488	9535	9402	9562	9000	9129	7052	6442
Hanstholm-Torshavn	0	14	15	0	0	0	0	0	0	48
Esbjerg-Torshavn	9	9	9	15	14	13	0	0	0	0
Local ferries	176891	179850	181834	178419	202445	209129	182750	197489	200027	202054

Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Korsør-Nyborg, DSB	0	0	0	0	0	0	0	0	0	0
Korsør-Nyborg, Vognmandsruten	0	0	0	0	0	0	0	0	0	0
Halsskov-Knudshoved	0	0	0	0	0	0	0	0	0	0
Kalundborg-Juelsminde	0	0	0	0	0	0	0	0	0	0
Kalundborg-Århus	1870	1804	2037	1800	1750	1725	1724	1695	1694	1668
Sjællands Odde-Ebeltoft	4775	4226	3597	3191	2906	2889	2690	2670	2577	2454
Sjællands Odde-Århus	1799	1817	1825	2359	2863	2795	2853	2810	2814	2810
Hundested-Grenaa	0	0	0	0	0	0	0	0	0	0
København-Rønne	491	430	413	397	293	0	0	0	0	0
Køge-Rønne	0	0	0	0	154	488	436	399	428	407
Kalundborg-Samsø	828	817	833	831	841	867	862	887	921	969
Tårs-Spodsbjerg	6477	6498	6468	6516	6497	6494	6460	6493	6504	6474
Hanstholm-Torshavn	67	94	85	50	59	51	51	48	52	27
Esbjerg-Torshavn	0	0	0	0	0	0	0	0	0	35
Local ferries	201833	200130	208396	208501	206297	205564	203413	205260	210089	209082

Ferry data: Service, name, engine year, main engine MCR (kW), engine type, specific fuel consumption (sfc), aux. engine (kW).

Ferry service	Ferry name	Engine year	Main engine MCR (kW)	Engine type	Sfc (g/kWh)	Fuel type	Aux engine (kW)
Esbjerg-Torshavn	Gamle Norrøna	1973	11768	Medium speed (4-stroke)	239	Diesel	2354
Esbjerg-Torshavn	Nye Norrøna	2003	21600	Medium speed (4-stroke)	190	Fuel	4320
Halsskov-Knudshoved	ARVEPRINS KNUD	1963	8238	Slow speed (2-stroke)	220	Fuel	1666
Halsskov-Knudshoved	DRONNING MARGRETHE II	1973	8826	Medium speed (4-stroke)	230	Diesel	1692
Halsskov-Knudshoved	HEIMDAL	1983	8309	Medium speed (4-stroke)	220	Diesel	740
Halsskov-Knudshoved	KNUDSHOVED	1961	6400	Slow speed (2-stroke)	220	Fuel	1840
Halsskov-Knudshoved	KONG FREDERIK IX	1954	6767	Slow speed (2-stroke)	225	Fuel	1426
Halsskov-Knudshoved	KRAKA	1982	8309	Medium speed (4-stroke)	220	Diesel	740
Halsskov-Knudshoved	LODBROG	1982	8309	Medium speed (4-stroke)	220	Diesel	740
Halsskov-Knudshoved	PRINSESSE ANNE-MARIE	1960	8238	Slow speed (2-stroke)	220	Fuel	1360
Halsskov-Knudshoved	PRINSESSE ELISABETH	1964	8238	Slow speed (2-stroke)	220	Fuel	1360
Halsskov-Knudshoved	ROMSØ	1973	8826	Medium speed (4-stroke)	230	Diesel	1728
Halsskov-Knudshoved	SPROGØ	1962	6400	Slow speed (2-stroke)	220	Fuel	1840
Hanstholm-Torshavn	Gamle Norrøna	1973	11768	Medium speed (4-stroke)	239	Diesel	2354
Hanstholm-Torshavn	Nye Norrøna	2003	21600	Medium speed (4-stroke)	190	Fuel	4320
Hundested-Grenaa	DJURSLAND	1974	9856	Medium speed (4-stroke)	230	Diesel	900
Hundested-Grenaa	KATTEGAT	1995	23200	High speed (4-stroke)	205	Diesel	1223
Hundested-Grenaa	KONG FREDERIK IX	1954	6767	Slow speed (2-stroke)	235	Fuel	1375
Hundested-Grenaa	PRINSESSE ANNE-MARIE	1960	8238	Slow speed (2-stroke)	220	Fuel	1360
Kalundborg-Juelsminde	Mercandia I	1989	2950	High speed (4-stroke)	220	Diesel	0
Kalundborg-Juelsminde	Mercandia II	1989	2950	High speed (4-stroke)	220	Diesel	0
Kalundborg-Juelsminde	Mercandia III	1989	2950	High speed (4-stroke)	220	Diesel	0
Kalundborg-Juelsminde	Mercandia IV	1989	2950	High speed (4-stroke)	220	Diesel	0
Kalundborg-Samsø	HOLGER DANSKE	1976	2354	High speed (4-stroke)	225	Diesel	600
Kalundborg-Samsø	KALUNDBORG	1952	3825	Slow speed (2-stroke)	235	Fuel	570
Kalundborg-Samsø	KYHOLM	1998	2940	High speed (4-stroke)	195	Diesel	864
Kalundborg-Samsø	VESBORG	1995	1770	High speed (4-stroke)	200	Diesel	494
Kalundborg-Århus	ASK	1984	8826	Medium speed (4-stroke)	215	Diesel	2220
Kalundborg-Århus	ASK	1984	8826	Medium speed (4-stroke)	215	Diesel	3000
Kalundborg-Århus	ASK	1984	9840	Medium speed (4-stroke)	215	Diesel	3000
Kalundborg-Århus	CAT-LINK I	1995	17280	High speed (4-stroke)	205	Diesel	1160
Kalundborg-Århus	CAT-LINK II	1995	17280	High speed (4-stroke)	205	Diesel	1160
Kalundborg-Århus	CAT-LINK III	1995	22000	High speed (4-stroke)	205	Diesel	800
Kalundborg-Århus	CAT-LINK IV	1998	28320	High speed (4-stroke)	205	Diesel	920
Kalundborg-Århus	CAT-LINK V	1998	28320	High speed (4-stroke)	205	Diesel	920

Continued							
Kalundborg-Århus	KATTEGAT SYD	1979	7650	Medium speed (4-stroke)	225	Diesel	1366
Kalundborg-Århus	KNUDSHOVED	1961	6400	Slow speed (2-stroke)	220	Fuel	1840
Kalundborg-Århus	KONG FREDERIK IX	1954	6767	Slow speed (2-stroke)	225	Fuel	1426
Kalundborg-Århus	KRAKA	1982	8309	Medium speed (4-stroke)	220	Diesel	740
Kalundborg-Århus	MAREN MOLS	1996	11700	Slow speed (2-stroke)	180	Diesel	2530
Kalundborg-Århus	METTE MOLS	1996	11700	Slow speed (2-stroke)	180	Diesel	2530
Kalundborg-Århus	NIELS KLIM	1986	12474	Slow speed (2-stroke)	215	Fuel	4440
Kalundborg-Århus	PEDER PAARS	1985	12474	Slow speed (2-stroke)	215	Fuel	4440
Kalundborg-Århus	PRINSESSE ELISABETH	1964	8238	Slow speed (2-stroke)	220	Fuel	1360
Kalundborg-Århus	ROSTOCK LINK	1975	8385	Medium speed (4-stroke)	230	Diesel	2500
Kalundborg-Århus	SØLØVEN/SØBJØRNEN	1992	4000	High speed (4-stroke)	210	Diesel	272
Kalundborg-Århus	URD	1981	8826	Medium speed (4-stroke)	215	Diesel	2220
Kalundborg-Århus	URD	1981	8826	Medium speed (4-stroke)	215	Diesel	3000
Kalundborg-Århus	URD	1981	9840	Medium speed (4-stroke)	215	Diesel	3000
Korsør-Nyborg, DSB	ASA-THOR	1965	6472	Slow speed (2-stroke)	220	Fuel	1305
Korsør-Nyborg, DSB	DRONNING INGRID	1980	18720	Medium speed (4-stroke)	220	Diesel	2932
Korsør-Nyborg, DSB	DRONNING MARGRETHE II	1973	8826	Medium speed (4-stroke)	230	Diesel	1692
Korsør-Nyborg, DSB	KONG FREDERIK IX	1954	6767	Slow speed (2-stroke)	225	Fuel	1426
Korsør-Nyborg, DSB	KRONPRINS FREDERIK	1981	18720	Medium speed (4-stroke)	220	Diesel	2932
Korsør-Nyborg, DSB	PRINS JOACHIM	1980	18720	Medium speed (4-stroke)	220	Diesel	2932
Korsør-Nyborg, DSB	SPROGØ/KNUDSHOVED	1962	6400	Slow speed (2-stroke)	220	Fuel	1840
Korsør-Nyborg, Vognmandsruten	Superflex Alfa	1989	2950	High speed (4-stroke)	220	Diesel	0
Korsør-Nyborg, Vognmandsruten	Superflex Bravo	1989	2950	High speed (4-stroke)	220	Diesel	0
Korsør-Nyborg, Vognmandsruten	Superflex Charlie	1988	2950	High speed (4-stroke)	220	Diesel	0
København-Rønne	JENS KOFOED	1979	12950	Medium speed (4-stroke)	233	Fuel	2889
København-Rønne	JENS KOFOED	2009	12950	Medium speed (4-stroke)	190	Fuel	2889
København-Rønne	POVL ANKER	1979	12950	Medium speed (4-stroke)	233	Fuel	2889
København-Rønne	POVL ANKER	2009	12950	Medium speed (4-stroke)	190	Fuel	2889
Køge-Rønne	DUEODDE	2005	8640	Medium speed (4-stroke)	190	Fuel	1545
Køge-Rønne	HAMMERODDE	2005	8640	Medium speed (4-stroke)	190	Fuel	1545
Køge-Rønne	JENS KOFOED	1979	12950	Medium speed (4-stroke)	233	Fuel	2889
Køge-Rønne	POVL ANKER	1979	12950	Medium speed (4-stroke)	233	Fuel	2889
Køge-Rønne	POVL ANKER	2009	12950	Medium speed (4-stroke)	190	Fuel	2889
Sjællands Odde-Ebeltoft	MAI MOLS	1996	24800	Gas turbine	240	Diesel	752
Sjællands Odde-Ebeltoft	MAREN MOLS	1975	12062	Medium speed (4-stroke)	230	Fuel	1986
Sjællands Odde-Ebeltoft	MAREN MOLS 2	1996	11700	Slow speed (2-stroke)	180	Diesel	2530

Continued							
Sjællands Odde-Ebeltoft	METTE MOLS	1975	12062	Medium speed (4-stroke)	230	Fuel	1986
Sjællands Odde-Ebeltoft	METTE MOLS 2	1996	11700	Slow speed (2-stroke)	180	Diesel	2530
Sjællands Odde-Ebeltoft	MIE MOLS	1971	5884	Medium speed (4-stroke)	230	Diesel	
Sjællands Odde-Ebeltoft	MIE MOLS 2	1996	24800	Gas turbine	240	Diesel	752
Sjællands Odde-Århus	MADS MOLS	1998	28320	High speed (4-stroke)	205	Diesel	920
Sjællands Odde-Århus	MAI MOLS	1996	24800	Gas turbine	240	Diesel	752
Sjællands Odde-Århus	MAX MOLS	1998	28320	High speed (4-stroke)	205	Diesel	920
Sjællands Odde-Århus	MIE MOLS	1996	24800	Gas turbine	240	Diesel	752
Tårs-Spodsbjerg	FRIGG SYDFYEN	1984	1300	Medium speed (4-stroke)	220	Diesel	780
Tårs-Spodsbjerg	ODIN SYDFYEN	1982	1180	Medium speed (4-stroke)	220	Diesel	780
Tårs-Spodsbjerg	SPODSBJERG	1972	1530	Medium speed (4-stroke)	225	Diesel	300
Tårs-Spodsbjerg	SPODSBJERG	2006	1545	Medium speed (4-stroke)	190	Diesel	300
Tårs-Spodsbjerg	THOR SYDFYEN	1978	1176	Medium speed (4-stroke)	225	Diesel	300
Tårs-Spodsbjerg	THOR SYDFYEN	2008	1176	Medium speed (4-stroke)	190	Diesel	300
Sjællands Odde-Århus	MIE MOLS	1996	24800	Gas turbine	240	Diesel	752
Tårs-Spodsbjerg	FRIGG SYDFYEN	1984	1300	Medium speed (4-stroke)	220	Diesel	780
Tårs-Spodsbjerg	ODIN SYDFYEN	1982	1180	Medium speed (4-stroke)	220	Diesel	780
Tårs-Spodsbjerg	SPODSBJERG	1972	1530	Medium speed (4-stroke)	225	Diesel	300
Tårs-Spodsbjerg	SPODSBJERG	2006	1545	Medium speed (4-stroke)	190	Diesel	300
Tårs-Spodsbjerg	THOR SYDFYEN	1978	1176	Medium speed (4-stroke)	225	Diesel	300
Tårs-Spodsbjerg	THOR SYDFYEN	2008	1176	Medium speed (4-stroke)	190	Diesel	300

Ferry data: Sailing time (single trip).

Ferry service	Ferry name	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Esbjerg-Torshavn	Gamle Norrøna	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860							
Esbjerg-Torshavn	Nye Norrøna														1860	1860	1860	1860	1860	1860	1860
Halsskov-Knudshoved	ARVEPRINS KNUD	60	60	60	60	60	60	60	60	60											
Halsskov-Knudshoved	DRONNING MARGRETHE II	60	60	60	60	60	60	60	60	60											
Halsskov-Knudshoved	HEIMDAL	60	60	60	60	60	60	60	60	60											
Halsskov-Knudshoved	KNUDSHOVED	60	60	60	60	60	60	60	60	60											
Halsskov-Knudshoved	KONG FREDERIK IX	60	60	60	60	60	60	60	60	60											
Halsskov-Knudshoved	KRAKA	60	60	60	60	60	60	60	60	60											
Halsskov-Knudshoved	LODBROG	60	60	60	60	60	60	60	60	60											
Halsskov-Knudshoved	PRINSESSE ANNE-MARIE	60	60	60	60	60	60	60	60	60											
Halsskov-Knudshoved	PRINSESSE ELISABETH	60	60	60	60	60	60	60	60	60											
Halsskov-Knudshoved	ROMSØ	60	60	60	60	60	60	60	60	60											
Halsskov-Knudshoved	SPROGØ	60	60	60	60	60	60	60	60	60											
Hanstholm-Torshavn	Gamle Norrøna	1740	1740	1740	1740	1740	1740	1740	1740	1740	1740	1740	1740	1740							
Hanstholm-Torshavn	Nye Norrøna														1740	1740	1740	1740	1740	1740	1740
Hundested-Grenaa	DJURSLAND	160	160	160	160	160															
Hundested-Grenaa	KATTEGAT						90	90													
Hundested-Grenaa	KONG FREDERIK IX					170															
Hundested-Grenaa	PRINSESSE ANNE-MARIE					165															
Kalundborg-Juelsminde	Mercandia I	160	160	160	160	160	160	160													
Kalundborg-Juelsminde	Mercandia II	160	160	160	160	160	160	160													
Kalundborg-Juelsminde	Mercandia III	160	160	160	160	160	160	160													
Kalundborg-Juelsminde	Mercandia IV	160	160	160	160	160	160	160													
Kalundborg-Samsø	HOLGER DANSKE			120	120	120	120	120	120	120											
Kalundborg-Samsø	KALUNDBORG	120	120	120																	
Kalundborg-Samsø	KYHOLM									110	110	110	110	110	110	110	110	110	110	110	110
Kalundborg-Samsø	VESBORG									120											
Kalundborg-Århus	ASK		195	195	195	195	195	195	195	195	195										
Kalundborg-Århus	CAT-LINK I						80	85	90	95											
Kalundborg-Århus	CAT-LINK II						80	85	90	95											
Kalundborg-Århus	CAT-LINK III							85	90	95											
Kalundborg-Århus	CAT-LINK IV									80	80										
Kalundborg-Århus	CAT-LINK V									80	80										
Kalundborg-Århus	KATTEGAT SYD										195										
Kalundborg-Århus	KNUDSHOVED		190																		
Kalundborg-Århus	KONG FREDERIK IX		190	190	190	190	190	190													

Continued

Kalundborg-Århus	KRAKA									195											
Kalundborg-Århus	MAREN MOLS											160	160	155	155	155	155	165	165	165	165
Kalundborg-Århus	METTE MOLS											160	160	155	155	155	155	165	165	165	165
Kalundborg-Århus	NIELS KLIM	185	185																		
Kalundborg-Århus	PEDER PAARS	185	185																		
Kalundborg-Århus	PRINSESSE ELISABETH		185																		
Kalundborg-Århus	ROSTOCK LINK										195										
Kalundborg-Århus	SØLØVEN/SØBJØRNEN		90	90	90	90	90	90													
Kalundborg-Århus	URD		195	195	195	195	195	195	195	195	195										
Korsør-Nyborg, DSB	ASA-THOR	65	65	65	65	65	65	65	65												
Korsør-Nyborg, DSB	DRONNING INGRID	65	65	65	65	65	65	65	65												
Korsør-Nyborg, DSB	DRONNING MARGRETHE II	65	65	65	65	65	65	65	65												
Korsør-Nyborg, DSB	KONG FREDERIK IX	75	75	75	75	75	75	75	75												
Korsør-Nyborg, DSB	KRONPRINS FREDERIK	65	65	65	65	65	65	65	65												
Korsør-Nyborg, DSB	PRINS JOACHIM	65	65	65	65	65	65	65	65												
Korsør-Nyborg, DSB	SPROGØ/KNUDSHOVED	75	75	75	75	75	75	75	75												
Korsør-Nyborg, Vognmandsruten	Superflex Alfa	70	70	70	70	70	70	70	70	70											
Korsør-Nyborg, Vognmandsruten	Superflex Bravo	70	70	70	70	70	70	70	70	70											
Korsør-Nyborg, Vognmandsruten	Superflex Charlie	70	70	70	70	70	70	70	70	70											
København-Rønne	JENS KOFOED	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420
København-Rønne	POVL ANKER	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420
Køge-Rønne	DUEODDE																375	375	375	375	375
Køge-Rønne	HAMMERODDE																375	375	375	375	375
Køge-Rønne	JENS KOFOED															375	375				
Køge-Rønne	POVL ANKER															375	375	375	375	375	375
Sjællands Odde-Ebeltoft	MAI MOLS							45	45	45	45	45	45	45	45	45	45	50	50	50	50
Sjællands Odde-Ebeltoft	MAREN MOLS	100	100	100	100	100	100	100													
Sjællands Odde-Ebeltoft	MAREN MOLS 2							100	100	100	95										
Sjællands Odde-Ebeltoft	METTE MOLS	100	100	100	100	100	100	100													
Sjællands Odde-Ebeltoft	METTE MOLS 2							100	100	100	95										
Sjællands Odde-Ebeltoft	MIE MOLS	105	105	105	105	105	105	105													
Sjællands Odde-Ebeltoft	MIE MOLS 2							45	45	45	45	45	45	45	45	45	45	50	50	50	50
Sjællands Odde-Århus	MADS MOLS										60	65	65	65	65	65	65	70	70	70	70
Sjællands Odde-Århus	MAI MOLS													65	65	65	65	68	68	68	68
Sjællands Odde-Århus	MAX MOLS										60	65	65	65	65	65	65	70	70	70	70
Sjællands Odde-Århus	MIE MOLS													65	65	65	65	68	68	68	68
Tårs-Spodsbjerg	FRIGG SYDFYEN	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45

Continued																					
Tårs-Spodsbjerg	ODIN SYDFYEN	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45
Tårs-Spodsbjerg	SPODSBJERG	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45
Tårs-Spodsbjerg	THOR SYDFYEN	45	45	45	45	45	17	45	45	45	45	45	45	45	45	45	45	45	45	45	45

Ferry data: Load factor (% MCR).

Ferry service	Ferry name	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Esbjerg-Torshavn	Gamle Norrøna	90	90	90	90	90	90	90	90	90	90	90	90	90							
Esbjerg-Torshavn	Nye Norrøna														90	90	90	90	90	90	90
Halsskov-Knudshoved	ARVEPRINS KNUD	85	85	85	85	85	85	85	85	85											
Halsskov-Knudshoved	DRONNING MARGRETHE II	85	85	85	85	85	85	85	85	85											
Halsskov-Knudshoved	HEIMDAL	85	85	85	85	85	85	85	85	85											
Halsskov-Knudshoved	KNUDSHOVED	85	85	85	85	85	85	85	85	85											
Halsskov-Knudshoved	KONG FREDERIK IX	85	85	85	85	85	85	85	85	85											
Halsskov-Knudshoved	KRAKA	85	85	85	85	85	85	85	85	85											
Halsskov-Knudshoved	LODBROG	85	85	85	85	85	85	85	85	85											
Halsskov-Knudshoved	PRINSESSE ANNE-MARIE	85	85	85	85	85	85	85	85	85											
Halsskov-Knudshoved	PRINSESSE ELISABETH	85	85	85	85	85	85	85	85	85											
Halsskov-Knudshoved	ROMSØ	85	85	85	85	85	85	85	85	85											
Halsskov-Knudshoved	SPROGØ	85	85	85	85	85	85	85	85	85											
Hanstholm-Torshavn	Gamle Norrøna	90	90	90	90	90	90	90	90	90	90	90	90	90							
Hanstholm-Torshavn	Nye Norrøna														90	90	90	90	90	90	90
Hundested-Grenaa	DJURSLAND	80	80	80	80	80															
Hundested-Grenaa	KATTEGAT						85	85													
Hundested-Grenaa	KONG FREDERIK IX					65															
Hundested-Grenaa	PRINSESSE ANNE-MARIE					85															
Kalundborg-Juelsminde	Mercandia I	75	75	75	75	75	75	75													
Kalundborg-Juelsminde	Mercandia II	70	70	70	70	70	70	70													
Kalundborg-Juelsminde	Mercandia III	70	70	70	70	70	70	70													
Kalundborg-Juelsminde	Mercandia IV	70	70	70	70	70	70	70													
Kalundborg-Samsø	HOLGER DANSKE			85	85	85	85	85	85	85											
Kalundborg-Samsø	KALUNDBORG	80	80	80																	
Kalundborg-Samsø	KYHOLM									85	85	85	85	85	85	85	85	85	85	85	85
Kalundborg-Samsø	VESBORG									95											

Continued

Kalundborg-Århus	ASK		85	85	85	80	80	80	80	80	80										
Kalundborg-Århus	CAT-LINK I						95	90	90	85											
Kalundborg-Århus	CAT-LINK II						95	90	90	85											
Kalundborg-Århus	CAT-LINK III							95	95	90											
Kalundborg-Århus	CAT-LINK IV									95	95										
Kalundborg-Århus	CAT-LINK V									95	95										
Kalundborg-Århus	KATTEGAT SYD										85										
Kalundborg-Århus	KNUDSHOVED		85																		
Kalundborg-Århus	KONG FREDERIK IX		85	85	85	85	85	85													
Kalundborg-Århus	KRAKA									85											
Kalundborg-Århus	MAREN MOLS											85	85	85	85	85	85	82	80	80	80
Kalundborg-Århus	METTE MOLS											85	85	85	85	85	85	82	80	80	80
Kalundborg-Århus	NIELS KLIM	85	85																		
Kalundborg-Århus	PEDER PAARS	85	85																		
Kalundborg-Århus	PRINSESSE ELISABETH		80																		
Kalundborg-Århus	ROSTOCK LINK										80										
Kalundborg-Århus	SØLØVEN/SØBJØRNEN		90	90	90	90	90	90													
Kalundborg-Århus	URD		85	85	85	85	85	85	85	80	80										
Korsør-Nyborg, DSB	ASA-THOR	85	85	85	85	85	85	85	85												
Korsør-Nyborg, DSB	DRONNING INGRID	60	60	60	60	60	60	60	60												
Korsør-Nyborg, DSB	DRONNING MARGRETHE II	85	85	85	85	85	85	85	85												
Korsør-Nyborg, DSB	KONG FREDERIK IX	70	70	70	70	70	70	70	70												
Korsør-Nyborg, DSB	KRONPRINS FREDERIK	60	60	60	60	60	60	60	60												
Korsør-Nyborg, DSB	PRINS JOACHIM	60	60	60	60	60	60	60	60												
Korsør-Nyborg, DSB	SPROGØ/KNUDSHOVED	70	70	70	70	70	70	70	70												
Korsør-Nyborg, Vognmandsruten	Superflex Alfa	70	70	70	70	70	70	70	70	70											
Korsør-Nyborg, Vognmandsruten	Superflex Bravo	70	70	70	70	70	70	70	70	70											
Korsør-Nyborg, Vognmandsruten	Superflex Charlie	70	70	70	70	70	70	70	70	70											
København-Rønne	JENS KOFOED	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31
København-Rønne	POVL ANKER	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31
Køge-Rønne	DUEODDE																69	65	65	65	65
Køge-Rønne	HAMMERODDE																69	65	66	66	66
Køge-Rønne	JENS KOFOED															31	31				
Køge-Rønne	POVL ANKER															31	31	45	49	49	49

Continued

Sjællands Odde-Ebeltoft	MAI MOLS							80	80	80	80	80	80	80	80	80	80	79	78	78	78
Sjællands Odde-Ebeltoft	MAREN MOLS	75	75	75	75	75	75	75													
Sjællands Odde-Ebeltoft	MAREN MOLS 2							80	80	80	85										
Sjællands Odde-Ebeltoft	METTE MOLS	75	75	75	75	75	75	75													
Sjællands Odde-Ebeltoft	METTE MOLS 2							80	80	80	85										
Sjællands Odde-Ebeltoft	MIE MOLS	85	85	85	85	85	85	85													
Sjællands Odde-Ebeltoft	MIE MOLS 2							80	80	80	80	80	80	80	80	80	80	79	78	78	78
Sjællands Odde-Århus	MADS MOLS										90	85	85	85	85	85	85	67	67	67	67
Sjællands Odde-Århus	MAI MOLS													75	75	75	75	69	69	69	69
Sjællands Odde-Århus	MAX MOLS										90	85	85	85	85	85	85	67	67	67	67
Sjællands Odde-Århus	MIE MOLS													75	75	75	75	69	69	69	69
Tårs-Spodsbjerg	FRIGG SYDFYEN	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
Tårs-Spodsbjerg	ODIN SYDFYEN	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
Tårs-Spodsbjerg	SPODSBJERG	75	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
Tårs-Spodsbjerg	THOR SYDFYEN	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80

Ferry data: Round trip shares (%).

Ferry service	Ferry name	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Esbjerg-Torshavn	Gamle Norrøna	100	100	100	100	100	100	100	100	100	100	100	100	100							
Esbjerg-Torshavn	Nye Norrøna														100	100	100	100	100	100	100
Halsskov-Knudshoved	ARVEPRINS KNUD	21	20	20	20	21	19	19	18	20											
Halsskov-Knudshoved	DRONNING MARGRETHE II	2	0	0	0	0	0	0	0	0											
Halsskov-Knudshoved	HEIMDAL	23	24	22	24	23	21	21	19	22											
Halsskov-Knudshoved	KNUDSHOVED	0	0	0	0	0	0	2	5	0											
Halsskov-Knudshoved	KONG FREDERIK IX	0	0	0	0	0	0	0	0	0											
Halsskov-Knudshoved	KRAKA	24	25	23	23	21	20	20	20	21											
Halsskov-Knudshoved	LODBROG	0	0	0	0	0	0	0	7	14											
Halsskov-Knudshoved	PRINSESSE ANNE-MARIE	0	0	0	0	0	6	2	0	0											
Halsskov-Knudshoved	PRINSESSE ELISABETH	0	0	0	3	0	0	0	0	0											
Halsskov-Knudshoved	ROMSØ	21	22	21	16	20	19	21	21	23											
Halsskov-Knudshoved	SPROGØ	9	9	15	14	15	15	14	11	1											
Hanstholm-Torshavn	Gamle Norrøna	100	100	100	100	100	100	100	100	100	100	100	100	100							
Hanstholm-Torshavn	Nye Norrøna														100	100	100	100	100	100	100
Hundested-Grenaa	DJURSLAND	100	100	100	100	50															
Hundested-Grenaa	KATTEGAT						100	100													

Continued																					
Hundested-Grenaa	KONG FREDERIK IX					5															
Hundested-Grenaa	PRINSESSE ANNE-MARIE					45															
Kalundborg-Juelsminde	Mercandia I	25	25	25	25	25	25	25													
Kalundborg-Juelsminde	Mercandia II	25	25	25	25	25	25	25													
Kalundborg-Juelsminde	Mercandia III	25	25	25	25	25	25	25													
Kalundborg-Juelsminde	Mercandia IV	25	25	25	25	25	25	25													
Kalundborg-Samsø	HOLGER DANSKE			95	100	100	100	100	100	92											
Kalundborg-Samsø	KALUNDBORG	100	100	5																	
Kalundborg-Samsø	KYHOLM									6	100	100	100	100	100	100	100	100	100	100	100
Kalundborg-Samsø	VESBORG									2											
Kalundborg-Århus	ASK		16	32	26	33	27	18	11	12	2										
Kalundborg-Århus	CAT-LINK I						17	25	28	11											
Kalundborg-Århus	CAT-LINK II						1	23	28	8											
Kalundborg-Århus	CAT-LINK III							8	24	19											
Kalundborg-Århus	CAT-LINK IV									23	26										
Kalundborg-Århus	CAT-LINK V									15	26										
Kalundborg-Århus	KATTEGAT SYD										2										
Kalundborg-Århus	KNUDSHOVED		4																		
Kalundborg-Århus	KONG FREDERIK IX		4	0	7	0	0	2													
Kalundborg-Århus	KRAKA									2											
Kalundborg-Århus	MAREN MOLS											50	50	50	50	50	50	50	50	50	50
Kalundborg-Århus	METTE MOLS											50	50	50	50	50	50	50	50	50	50
Kalundborg-Århus	NIELS KLIM	50	20																		
Kalundborg-Århus	PEDER PAARS	50	16																		
Kalundborg-Århus	PRINSESSE ELISABETH		4																		
Kalundborg-Århus	ROSTOCK LINK										22										
Kalundborg-Århus	SØLØVEN/SØBJØRNEN		21	36	34	34	28	5													
Kalundborg-Århus	URD		16	32	33	33	27	18	11	9	22										
Korsør-Nyborg, DSB	ASA-THOR	13	13	13	11	9	9	9	6												
Korsør-Nyborg, DSB	DRONNING INGRID	26	28	26	28	28	29	28	31												
Korsør-Nyborg, DSB	DRONNING MARGRETHE II	3	0	3	1	3	1	2	0												
Korsør-Nyborg, DSB	KONG FREDERIK IX	0	0	0	0	3	4	1	0												
Korsør-Nyborg, DSB	KRONPRINS FREDERIK	27	28	27	29	28	29	29	32												
Korsør-Nyborg, DSB	PRINS JOACHIM	25	27	25	27	27	27	27	28												
Korsør-Nyborg, DSB	SPROGØ/KNUDSHOVED	6	4	5	4	1	1	4	3												
Korsør-Nyborg, Vognmandsruten	Superflex Alfa	33	33	33	33	33	33	33	33	33											
Korsør-Nyborg, Vognmandsruten	Superflex Bravo	33	33	33	33	33	33	33	33	33											

Continued																					
Korsør-Nyborg, Vognmandsruten	Superflex Charlie	34	34	34	34	34	34	34	34	34											
København-Rønne	JENS KOFOED	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
København-Rønne	POVL ANKER	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Køge-Rønne	DUEODDE																25	49	47	47	47
Køge-Rønne	HAMMERODDE																35	49	53	53	53
Køge-Rønne	JENS KOFOED															50	20				
Køge-Rønne	POVL ANKER															50	20	3	1	1	1
Sjællands Odde-Ebeltoft	MAI MOLS							21	35	35	35	50	50	50	50	50	50	50	50	50	50
Sjællands Odde-Ebeltoft	MAREN MOLS	40	40	40	40	40	40	15													
Sjællands Odde-Ebeltoft	MAREN MOLS 2							18	15	15	15										
Sjællands Odde-Ebeltoft	METTE MOLS	40	40	40	40	40	40	17													
Sjællands Odde-Ebeltoft	METTE MOLS 2							15	15	15	15										
Sjællands Odde-Ebeltoft	MIE MOLS	20	20	20	20	20	20	5													
Sjællands Odde-Ebeltoft	MIE MOLS 2							9	35	35	35	50	50	50	50	50	50	50	50	50	50
Sjællands Odde-Århus	MADS MOLS										50	95	90	95	60	60	35	30	31	31	31
Sjællands Odde-Århus	MAI MOLS													1	10	15	15	20	19	19	19
Sjællands Odde-Århus	MAX MOLS										50	5	10	3	20	10	35	30	31	31	31
Sjællands Odde-Århus	MIE MOLS													1	10	15	15	20	19	19	19
Tårs-Spodsbjerg	FRIGG SYDFYEN	41	40	39	38	36	36	36	32	33	45	45	45	45	45	45	45	45	45	45	45
Tårs-Spodsbjerg	ODIN SYDFYEN	41	40	39	38	36	36	36	32	33	45	45	45	45	45	45	45	45	45	45	45
Tårs-Spodsbjerg	SPODSBJERG	4	2	8	8	9	8	8	19	20	10	10	10	10	10	10	10	10	10	10	10
Tårs-Spodsbjerg	THOR SYDFYEN	14	18	14	16	19	20	20	17	14	0	0	0	0	0	0	0	0	0	0	0

Annex 2B-12 Fuel consumption and emission factors, engine specific (NO_x, CO, VOC (NMVOC and CH_4)), and fuel type specific (S-%, SO_2, PM) for ship engines

Specific fuel consumption and NO_x emission factors (g pr kWh) per engine year for diesel ship engines.

Year	High speed 4-stroke sfc (g pr kWh)	Medium speed 4-stroke sfc (g pr kWh)	Slow speed 2-stroke sfc (g pr kWh)	High speed 4-stroke NO_X (g pr kWh)	Medium speed 4-stroke NO_X (g pr kWh)	Slow speed 2-stroke NO_X (g pr kWh)
1949	265.5	255.5	235.5	7.3	8.0	14.5
1950	265.0	255.0	235.0	7.3	8.0	14.5
1951	264.5	254.5	234.5	7.3	8.0	14.5
1952	264.0	254.0	234.0	7.3	8.0	14.5
1953	263.5	253.5	233.5	7.3	8.0	14.5
1954	263.0	253.0	233.0	7.3	8.0	14.5
1955	262.4	252.4	232.4	7.3	8.0	14.5
1956	261.9	251.9	231.9	7.4	8.1	14.6
1957	261.3	251.3	231.3	7.5	8.2	14.7
1958	260.7	250.7	230.7	7.6	8.3	14.8
1959	260.1	250.1	230.1	7.7	8.4	14.9
1960	259.5	249.5	229.5	7.8	8.5	15.0
1961	258.9	248.9	228.9	7.9	8.6	15.1
1962	258.2	248.2	228.2	8.0	8.7	15.1
1963	257.6	247.6	227.6	8.1	8.8	15.2
1964	256.9	246.9	226.9	8.2	8.9	15.3
1965	256.1	246.1	226.1	8.3	9.0	15.4
1966	255.4	245.4	225.4	8.3	9.1	15.5
1967	254.6	244.6	224.6	8.4	9.2	15.6
1968	253.8	243.8	223.8	8.5	9.3	15.7
1969	253.0	243.0	223.0	8.6	9.4	15.8
1970	252.1	242.1	222.1	8.7	9.5	15.9
1971	251.2	241.2	221.2	8.8	9.6	16.0
1972	250.3	240.3	220.3	8.9	9.7	16.1
1973	249.3	239.3	219.3	9.0	9.8	16.2
1974	248.3	238.3	218.3	9.1	9.9	16.3
1975	247.3	237.3	217.3	9.2	10.0	16.4
1976	246.2	236.2	216.2	9.3	10.1	16.4
1977	245.0	235.0	215.0	9.3	10.2	16.5

Continued						
1978	243.8	233.8	213.8	9.4	10.3	16.6
1979	242.6	232.6	212.6	9.5	10.4	16.7
1980	241.3	231.3	211.3	9.6	10.5	16.8
1981	239.9	229.9	209.9	9.7	10.6	16.9
1982	238.5	228.5	208.5	9.8	10.7	17.0
1983	237.0	227.0	207.0	9.9	10.8	17.4
1984	235.5	225.5	205.5	10.0	10.9	17.8
1985	233.9	223.9	203.9	10.1	11.0	18.2
1986	232.2	222.2	202.2	10.2	11.1	18.6
1987	230.5	220.5	200.5	10.3	11.3	19.0
1988	228.6	218.6	198.6	10.5	11.4	19.3
1989	226.7	216.7	196.7	10.6	11.6	19.5
1990	224.8	214.8	194.8	10.7	11.7	19.8
1991	222.7	212.7	192.7	10.9	11.9	20.0
1992	220.5	210.5	190.5	11.0	12.0	19.8
1993	218.3	208.3	188.3	11.1	12.1	19.6
1994	216.0	206.0	186.0	11.3	12.3	19.4
1995	213.6	203.6	183.6	11.4	12.4	19.3
1996	211.0	201.0	181.0	11.5	12.6	19.1
1997	208.4	198.4	178.4	11.7	12.7	18.9
1998	205.7	195.7	175.7	11.8	12.9	18.7
1999	202.9	192.9	172.9	11.9	13.0	18.5
2000	199.9	189.9	169.9	11.0	12.0	16.0

CO, VOC, NMVOC and CH_4 emission factors (g/kg fuel) for ship engines

	High speed 4-stroke CO	Medium speed 4-stroke CO	Slow speed 2-stroke CO	High speed 4-stroke VOC	Medium speed 4-stroke VOC	Slow speed 2-stroke VOC
1949	6.03	6.26	6.79	1.88	1.96	2.12
1950	6.04	6.27	6.81	1.89	1.96	2.13
1951	6.05	6.29	6.82	1.89	1.96	2.13
1952	6.06	6.30	6.84	1.89	1.97	2.14
1953	6.07	6.31	6.85	1.90	1.97	2.14
1954	6.08	6.33	6.87	1.90	1.98	2.15
1955	6.10	6.34	6.88	1.91	1.98	2.15
1956	6.11	6.35	6.90	1.91	1.99	2.16
1957	6.12	6.37	6.92	1.91	1.99	2.16
1958	6.14	6.38	6.93	1.92	1.99	2.17
1959	6.15	6.40	6.95	1.92	2.00	2.17
1960	6.17	6.41	6.97	1.93	2.00	2.18
1961	6.18	6.43	6.99	1.93	2.01	2.18
1962	6.20	6.45	7.01	1.94	2.01	2.19
1963	6.21	6.46	7.03	1.94	2.02	2.20
1964	6.23	6.48	7.05	1.95	2.03	2.20
1965	6.25	6.50	7.08	1.95	2.03	2.21
1966	6.26	6.52	7.10	1.96	2.04	2.22
1967	6.28	6.54	7.12	1.96	2.04	2.23
1968	6.30	6.56	7.15	1.97	2.05	2.23
1969	6.32	6.58	7.17	1.98	2.06	2.24
1970	6.35	6.61	7.20	1.98	2.06	2.25
1971	6.37	6.63	7.23	1.99	2.07	2.26
1972	6.39	6.66	7.26	2.00	2.08	2.27
1973	6.42	6.69	7.29	2.01	2.09	2.28
1974	6.44	6.71	7.33	2.01	2.10	2.29
1975	6.47	6.74	7.36	2.02	2.11	2.30
1976	6.50	6.77	7.40	2.03	2.12	2.31
1977	6.53	6.81	7.44	2.04	2.13	2.33
1978	6.56	6.84	7.48	2.05	2.14	2.34
1979	6.60	6.88	7.53	2.06	2.15	2.35
1980	6.63	6.92	7.57	2.07	2.16	2.37
1981	6.67	6.96	7.62	2.08	2.17	2.38
1982	6.71	7.00	7.67	2.10	2.19	2.40

Continued						
1983	6.75	7.05	7.73	2.11	2.20	2.42
1984	6.79	7.10	7.79	2.12	2.22	2.43
1985	6.84	7.15	7.85	2.14	2.23	2.45
1986	6.89	7.20	7.91	2.15	2.25	2.47
1987	6.94	7.26	7.98	2.17	2.27	2.49
1988	7.00	7.32	8.05	2.19	2.29	2.52
1989	7.06	7.38	8.13	2.21	2.31	2.54
1990	7.12	7.45	8.22	2.22	2.33	2.57
1991	7.18	7.52	8.30	2.25	2.35	2.59
1992	7.25	7.60	8.40	2.27	2.37	2.62
1993	7.33	7.68	8.50	2.29	2.40	2.66
1994	7.41	7.77	8.60	2.31	2.43	2.69
1995	7.49	7.86	8.72	2.34	2.46	2.72
1996	7.58	7.96	8.84	2.37	2.49	2.76
1997	7.68	8.06	8.97	2.40	2.52	2.80
1998	7.78	8.18	9.11	2.43	2.56	2.85
1999	7.89	8.30	9.26	2.46	2.59	2.89
2000	8.00	8.43	9.42	2.50	2.63	2.94

	High speed 4-stroke NMVOC	Medium speed 4-stroke NMVOC	Slow speed 2-stroke NMVOC	High speed 4-stroke CH_4	Medium speed 4-stroke CH_4	Slow speed 2-stroke CH_4
1949	1.83	1.90	2.06	0.06	0.06	0.06
1950	1.83	1.90	2.06	0.06	0.06	0.06
1951	1.83	1.91	2.07	0.06	0.06	0.06
1952	1.84	1.91	2.07	0.06	0.06	0.06
1953	1.84	1.91	2.08	0.06	0.06	0.06
1954	1.84	1.92	2.08	0.06	0.06	0.06
1955	1.85	1.92	2.09	0.06	0.06	0.06
1956	1.85	1.93	2.09	0.06	0.06	0.06
1957	1.86	1.93	2.10	0.06	0.06	0.06
1958	1.86	1.93	2.10	0.06	0.06	0.07
1959	1.86	1.94	2.11	0.06	0.06	0.07
1960	1.87	1.94	2.11	0.06	0.06	0.07

Continued						
1961	1.87	1.95	2.12	0.06	0.06	0.07
1962	1.88	1.95	2.13	0.06	0.06	0.07
1963	1.88	1.96	2.13	0.06	0.06	0.07
1964	1.89	1.96	2.14	0.06	0.06	0.07
1965	1.89	1.97	2.14	0.06	0.06	0.07
1966	1.90	1.98	2.15	0.06	0.06	0.07
1967	1.90	1.98	2.16	0.06	0.06	0.07
1968	1.91	1.99	2.17	0.06	0.06	0.07
1969	1.92	2.00	2.17	0.06	0.06	0.07
1970	1.92	2.00	2.18	0.06	0.06	0.07
1971	1.93	2.01	2.19	0.06	0.06	0.07
1972	1.94	2.02	2.20	0.06	0.06	0.07
1973	1.95	2.03	2.21	0.06	0.06	0.07
1974	1.95	2.04	2.22	0.06	0.06	0.07
1975	1.96	2.04	2.23	0.06	0.06	0.07
1976	1.97	2.05	2.24	0.06	0.06	0.07
1977	1.98	2.06	2.26	0.06	0.06	0.07
1978	1.99	2.07	2.27	0.06	0.06	0.07
1979	2.00	2.09	2.28	0.06	0.06	0.07
1980	2.01	2.10	2.30	0.06	0.06	0.07
1981	2.02	2.11	2.31	0.06	0.07	0.07
1982	2.03	2.12	2.33	0.06	0.07	0.07
1983	2.05	2.14	2.34	0.06	0.07	0.07
1984	2.06	2.15	2.36	0.06	0.07	0.07
1985	2.07	2.17	2.38	0.06	0.07	0.07
1986	2.09	2.18	2.40	0.06	0.07	0.07
1987	2.10	2.20	2.42	0.07	0.07	0.07
1988	2.12	2.22	2.44	0.07	0.07	0.08
1989	2.14	2.24	2.47	0.07	0.07	0.08
1990	2.16	2.26	2.49	0.07	0.07	0.08
1991	2.18	2.28	2.52	0.07	0.07	0.08
1992	2.20	2.30	2.55	0.07	0.07	0.08
1993	2.22	2.33	2.58	0.07	0.07	0.08
1994	2.25	2.35	2.61	0.07	0.07	0.08
1995	2.27	2.38	2.64	0.07	0.07	0.08
1996	2.30	2.41	2.68	0.07	0.07	0.08
1997	2.33	2.44	2.72	0.07	0.08	0.08

Continued						
1998	2.36	2.48	2.76	0.07	0.08	0.09
1999	2.39	2.51	2.81	0.07	0.08	0.09
2000	2.43	2.55	2.85	0.08	0.08	0.09

S-%, SO_2 and PM emission factors (g/kg fuel and g/GJ) per fuel type for diesel ship engines

Fuel type	SNAPCode	Year	S %	SO_2 (g/kg)	TSP (g/kg)	PM_{10} (g/kg)	$PM_{2,5}$ (g/kg)	SO_2 (g/GJ)	TSP (g/GJ)	PM_{10} (g/GJ)	$PM_{2,5}$ (g/GJ)
Fuel	National sea	1990	2,64	52,8	6,1	6,0	6,0	1291,0	149,2	147,8	147,0
Fuel	National sea	1991	2,35	47,0	4,9	4,9	4,8	1149,1	120,2	119,0	118,4
Fuel	National sea	1992	1,80	36,0	3,3	3,2	3,2	880,2	79,8	79,0	78,6
Fuel	National sea	1993	2,39	47,8	5,1	5,0	5,0	1168,7	123,9	122,6	122,0
Fuel	National sea	1994	2,62	52,4	6,0	6,0	5,9	1281,2	147,0	145,6	144,8
Fuel	National sea	1995	2,95	59,0	7,7	7,6	7,6	1442,5	188,0	186,1	185,2
Fuel	National sea	1996	2,57	51,4	5,8	5,7	5,7	1256,7	141,7	140,2	139,5
Fuel	National sea	1997	2,74	54,8	6,6	6,5	6,5	1339,9	160,8	159,2	158,4
Fuel	National sea	1998	1,97	39,4	3,7	3,7	3,6	963,3	90,6	89,7	89,2
Fuel	National sea	1999	1,97	39,4	3,7	3,7	3,6	963,3	90,6	89,7	89,2
Fuel	National sea	2000	1,81	36,2	3,3	3,3	3,2	885,1	80,4	79,6	79,2
Fuel	National sea	2001	1,70	34,0	3,0	3,0	3,0	831,3	74,1	73,4	73,0
Fuel	National sea	2002	1,51	30,2	2,6	2,6	2,6	738,4	64,3	63,7	63,3
Fuel	National sea	2003	1,62	32,4	2,9	2,8	2,8	792,2	69,8	69,1	68,8
Fuel	National sea	2004	1,98	39,6	3,7	3,7	3,7	968,2	91,3	90,4	89,9
Fuel	National sea	2005	2,00	40,0	3,8	3,8	3,7	978,0	92,6	91,7	91,3
Fuel	National sea	2006	1,94	38,8	3,6	3,6	3,6	948,7	88,6	87,7	87,3
Fuel	National sea	2007	1,20	24,0	2,1	2,1	2,1	586,8	51,0	50,5	50,3
Fuel	National sea	2008	1,20	24,0	2,1	2,1	2,1	586,8	51,0	50,5	50,3
Fuel	National sea	2009	1,20	24,0	2,1	2,1	2,1	586,8	51,0	50,5	50,3
Fuel	International sea	1990	2,96	59,2	7,7	7,7	7,6	1447,4	189,4	187,5	186,6
Fuel	International sea	1991	2,89	57,8	7,4	7,3	7,2	1413,2	179,8	178,0	177,1
Fuel	International sea	1992	2,88	57,6	7,3	7,2	7,2	1408,3	178,5	176,7	175,8
Fuel	International sea	1993	3,20	64,0	9,3	9,2	9,1	1564,8	226,5	224,2	223,1
Fuel	International sea	1994	3,03	60,6	8,2	8,1	8,0	1481,7	199,6	197,6	196,6
Fuel	International sea	1995	3,30	66,0	10,0	9,9	9,8	1613,7	244,0	241,6	240,4
Fuel	International sea	1996	3,42	68,4	10,9	10,8	10,8	1672,4	266,9	264,2	262,9
Fuel	International sea	1997	3,45	69,0	11,2	11,0	11,0	1687,0	272,9	270,2	268,8
Fuel	International sea	1998	3,42	68,4	10,9	10,8	10,8	1672,4	266,9	264,2	262,9
Fuel	International sea	1999	3,45	69,0	11,2	11,0	11,0	1687,0	272,9	270,2	268,8

Continued

Fuel	International sea	2000	3,36	67,2	10,4	10,3	10,3	1643,0	255,2	252,6	251,4
Fuel	International sea	2001	3,42	68,4	10,9	10,8	10,8	1672,4	266,9	264,2	262,9
Fuel	International sea	2002	3,44	68,8	11,1	11,0	10,9	1682,2	270,9	268,2	266,8
Fuel	International sea	2003	3,11	62,2	8,7	8,6	8,5	1520,8	211,8	209,7	208,6
Fuel	International sea	2004	3,20	64,0	9,3	9,2	9,1	1564,8	226,5	224,2	223,1
Fuel	International sea	2005	3,50	70,0	11,6	11,5	11,4	1711,5	283,2	280,4	279,0
Fuel	International sea	2006	3,35	67,0	10,4	10,3	10,2	1638,1	253,3	250,8	249,5
Fuel	International sea	2007	1,50	30,0	2,6	2,6	2,6	733,5	63,8	63,2	62,9
Fuel	International sea	2008	1,50	30,0	2,6	2,6	2,6	733,5	63,8	63,2	62,9
Fuel	International sea	2009	1,50	30,0	2,6	2,6	2,6	733,5	63,8	63,2	62,9
Fuel	International sea	1990	0,20	4,0	1,0	1,0	1,0	93,7	23,2	23,0	22,9
Diesel	-	1991	0,20	4,0	1,0	1,0	1,0	93,7	23,2	23,0	22,9
Diesel	-	1992	0,20	4,0	1,0	1,0	1,0	93,7	23,2	23,0	22,9
Diesel	-	1993	0,20	4,0	1,0	1,0	1,0	93,7	23,2	23,0	22,9
Diesel	-	1994	0,20	4,0	1,0	1,0	1,0	93,7	23,2	23,0	22,9
Diesel	-	1995	0,20	4,0	1,0	1,0	1,0	93,7	23,2	23,0	22,9
Diesel	-	1996	0,20	4,0	1,0	1,0	1,0	93,7	23,2	23,0	22,9
Diesel	-	1997	0,20	4,0	1,0	1,0	1,0	93,7	23,2	23,0	22,9
Diesel	-	1998	0,20	4,0	1,0	1,0	1,0	93,7	23,2	23,0	22,9
Diesel	-	1999	0,20	4,0	1,0	1,0	1,0	93,7	23,2	23,0	22,9
Diesel	-	2000	0,20	4,0	1,0	1,0	1,0	93,7	23,2	23,0	22,9
Diesel	-	2001	0,20	4,0	1,0	1,0	1,0	93,7	23,2	23,0	22,9
Diesel	-	2002	0,20	4,0	1,0	1,0	1,0	93,7	23,2	23,0	22,9
Diesel	-	2003	0,20	4,0	1,0	1,0	1,0	93,7	23,2	23,0	22,9
Diesel	-	2004	0,20	4,0	1,0	1,0	1,0	93,7	23,2	23,0	22,9
Diesel	-	2005	0,20	4,0	1,0	1,0	1,0	93,7	23,2	23,0	22,9
Diesel	-	2006	0,20	4,0	1,0	1,0	1,0	93,7	23,2	23,0	22,9
Diesel	-	2007	0,20	4,0	1,0	1,0	1,0	93,7	23,2	23,0	22,9
Diesel	-	2008	0,10	2,0	0,9	0,9	0,9	46,8	21,5	21,3	21,2
Diesel	-	2009	0,10	2,0	0,9	0,9	0,9	46,8	21,5	21,3	21,2

Annex 2B-13: Fuel sales figures from DEA, and further processed fuel consumption data suited for the Danish inventory

Enhed: TJ	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Agriculture and forestry, DEA statistics															
- LPG	88	84	354	311	457	438	412	359	234	205	204	212	184	219	162
- gasoline	425	184	315	317	304	274	251	240	208	166	161	191	70	61	56
- gas/diesel oil	9 199	9 634	9 498	9 520	10 605	10 528	10 700	11 028	11 423	11 494	11 585	13 088	13 875	13 310	13 909
Gartneri, DEA statistics															
- LPG	8	5	47	47	53	50	47	39	26	23	23	22	20	24	17
- gasoline	10	3	6	6	11	10	10	12	23	18	18	19	7	6	6
- gas/diesel oil	1 705	1 270	1 405	1 383	1 231	1 409	1 687	1 887	1 205	963	1 138	487	356	341	347
Fishery, DEA statistics															
- LPG	-	-	34	29	50	42	34	30	12	18	16	36	5	1	16
- gasoline	-	1	2	2	9	9	10	8	7	7	8	7	6	6	60
- kerosene	7	2	9	5	12	26	9	5	4	3	4	3	3	2	0
- gas/diesel oil	9 152	10 248	8 390	9 499	10 038	10 422	10 809	10 868	8 843	8 796	8 277	8 750	8 748	9 186	9 282
- fuel oil	27	5	82	68	251	285	113	231	146	8	19	219	260	27	-
Manufacturing industry, DEA statistics															
- LPG	2 860	2 839	2 688	2 553	2 080	2 032	2 076	1 827	1 858	2 029	2 234	2 404	2 106	2 017	1 917
- gasoline	262	273	453	326	136	177	161	158	145	138	110	86	82	137	80
- gas/diesel oil	15 576	15 441	14 743	13 346	12 670	12 259	12 934	11 901	11 323	10 154	10 401	10 184	8 921	8 720	8 852
- fuel oil	29 465	29 451	21 518	19 056	16 741	15 989	17 133	16 694	14 600	15 438	14 000	12 632	11 009	10 943	8 704
Building and construction, DEA statistics															
- LPG	305	343	500	451	575	500	573	708	579	522	501	509	471	575	422
- gasoline	19	85	52	48	36	34	26	24	20	23	25	34	27	23	27
- gas/diesel oil	5 313	4 962	4 378	4 220	3 945	3 548	3 797	3 839	3 871	4 145	5 317	5 572	6 079	5 947	6 556
Housing, DEA statistics															
- gasoline	1 006	1 046	1 073	1 114	1 128	1 131	1 146	1 158	1 168	1 194	1 233	1 258	1 299	1 317	1 357
- gas/dieselolie	74 257	69 392	68 349	59 832	46 935	41 152	45 219	38 406	45 029	39 770	40 004	41 836	36 491	34 902	32 936
Etageboliger															
- gas/dieselolie	10 584	9 968	10 112	7 266	7 350	5 311	5 420	4 507	4 938	3 909	3 284	3 460	3 105	2 948	2 739
Road transport, DEA statistics															
- gasoline	66 037	68 670	70 502	73 151	74 152	74 326	75 290	76 084	76 697	78 425	80 998	82 656	85 341	86 520	89 129
- gas/diesel oil	45 609	49 738	49 626	49 686	51 854	54 746	58 427	57 511	56 796	58 755	58 561	59 851	60 528	61 072	63 619

Continued (1985-1999)															
- bioethanol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- biodiesel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Non-road, DEA statistics															
- LPG	2 955	2 929	3 089	2 911	2 590	2 520	2 535	2 224	2 118	2 257	2 461	2 638	2 310	2 260	2 097
- gasoline	1 722	1 590	1 898	1 810	1 616	1 626	1 595	1 592	1 563	1 540	1 547	1 589	1 485	1 545	1 526
- gas/diesel oil	31 793	31 307	30 025	28 469	28 451	27 744	29 118	28 655	27 822	26 755	28 441	29 331	29 231	28 319	29 665
Non-road, NERI model															
- LPG	1232	1233	1225	1209	1196	1185	1172	1151	1124	1105	1099	1088	1075	1086	1077
- gasoline	2998	2950	2903	2856	2813	2770	2702	2641	2587	2550	2521	2499	2479	2463	2456
- gas/diesel oil	26357	26895	26577	27075	26940	26800	26734	26046	26073	25235	25798	25139	25536	24844	24885
Recreational craft, NERI model															
- gasoline	270	270	279	289	299	309	319	329	339	348	358	368	377	385	391
- gas/diesel oil	219	219	247	277	309	343	378	415	454	495	537	581	628	676	726
Non-road, added 0202															
- gas/diesel oil	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-road, added 0203 and 0301															
- gas/diesel oil	5436	4412	3448	1395	1510	944	2384	2609	1748	1521	2642	4192	3695	3475	4780
- LPG	1724	1696	1864	1701	1393	1335	1363	1073	994	1152	1362	1549	1235	1175	1020
Non-road, added 0203															
- gas/diesel oil	1864	1537	1252	534	628	406	1014	1176	794	708	1182	1940	1799	1675	2297
- LPG	56	52	242	209	274	259	247	192	122	116	125	137	109	126	87
Non-road, added 0301															
- gas/diesel oil	3572	2875	2196	860	882	538	1370	1433	955	813	1460	2252	1896	1800	2483
- LPG	1668	1644	1622	1492	1119	1076	1116	881	872	1036	1237	1412	1126	1048	933
Non-road, added road transport															
- gasoline	-1276	-1360	-1005	-1046	-1197	-1145	-1107	-1049	-1023	-1010	-975	-909	-994	-918	-931
Fisheries, added national sea transport															
- fuel oil	27	5	82	68	251	285	113	231	146	8	19	219	260	27	0
Fisheries, consumed by recreational craft															
- gasoline	0	1	2	2	9	9	10	8	7	7	8	7	6	6	60
National sea transport, input NERI model															
- LPG	3	1	3	-	2	2	2	3	16	1	2	1	2	3	1
- kerosene	5	-	5	3	1	0	2	1	1	1	1	1	0	1	0
- gas/diesel oil	3 074	3 045	3 032	3 230	2 669	2 782	3 313	3 501	4 971	5 035	6 049	6 764	5 899	4 113	3 409

Continued (1985-1999)															
- fuel oil	2 541	3 424	3 922	2 795	4 228	3 845	4 429	3 646	2 797	2 160	1 592	1 379	1 210	1 367	1 435
Fisheries, input NERI model															
- LPG	-	-	34	29	50	42	34	30	12	18	16	36	5	1	16
- gasoline	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- kerosene	7	2	9	5	12	26	9	5	4	3	4	3	3	2	0
- gas/diesel oil	8 932	10 029	8 143	9 222	9 729	10 080	10 431	10 453	8 389	8 301	7 740	8 169	8 120	8 510	8 556
International sea transport, input NERI model															
- gas/diesel oil	7 171	7 867	8 547	9 743	10 514	11 633	12 590	16 881	19 114	24 123	26 743	27 231	25 325	31 243	26 085
- fuel oil	10 123	12 236	20 883	27 532	27 667	28 543	23 470	20 998	36 988	39 024	39 509	35 739	32 427	26 952	28 526
National sea transport, output NERI model															
- gas/diesel oil	5285	5285	5285	5285	5285	5285	6015	6920	6673	6618	7028	8465	8967	7333	6201
- fuel oil	4571	4571	4571	4571	4571	4571	3926	3202	3201	3362	3382	2826	2052	1590	1455
- kerosene	5	0	5	3	1	0	2	1	1	1	1	1	0	1	0
- LPG	3	1	3	0	2	2	2	3	16	1	2	1	2	3	1
Fisheries, output NERI model															
- gas/diesel oil	7064	8131	6233	7509	7455	7920	8170	7482	7075	7097	7134	6744	5328	5566	6375
- kerosene	7	2	9	5	12	26	9	5	4	3	4	3	3	2	0
- LPG	0	0	34	29	50	42	34	30	12	18	16	36	5	1	16
International sea transport, output NERI model															
- gas/diesel oil	6828	7524	8204	9400	10171	11289	12149	16433	18726	23742	26370	26955	25049	30967	25474
- fuel oil	9394	11507	20155	26804	26938	27815	22742	20269	36259	38296	38780	35010	31698	26223	27797
National sea transport, added 0301															
- fuel oil	-2 030	-1 147	- 649	-1 776	- 343	- 726	504	445	- 404	-1 201	-1 789	-1 447	- 842	- 223	- 20
Road transport, NERI excl. traded fuels															
- gasoline	64 492	67 041	69 220	71 819	72 664	72 882	73 874	74 714	75 342	77 074	79 674	81 385	83 976	85 223	87 867
- gas/diesel oil	45 609	49 738	49 626	49 686	51 854	54 746	58 427	57 511	56 796	58 755	58 561	59 851	60 528	61 072	63 619
- bioethanol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- biodiesel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Road transport, input NERI model incl. traded fuels															
- gasoline	62 077	62 442	62 716	63 442	62 546	66 279	70 589	74 320	76 459	79 209	80 101	80 958	83 089	84 832	84 506
- gas/diesel oil	49 016	54 939	54 827	54 887	57 055	59 947	61 296	59 950	59 522	63 561	64 013	65 590	66 374	67 206	69 501
- bioethanol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- biodiesel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Continued (2000-2009)										
Enhed: TJ	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Agriculture and forestry, DEA statistics										
- LPG	179	190	159	153	138	121	116	110	104	114
- gasoline	38	39	28	42	51	52	20	21	20	31
- gas/diesel oil	13 689	13 437	13 706	13 463	12 934	12 464	13 047	12 481	13 698	14 389
Gartneri, DEA statistics										
- LPG	19	20	17	16	14	12	12	11	10	11
- gasoline	4	4	3	5	6	6	2	2	2	3
- gas/diesel oil	698	581	529	556	488	407	391	418	444	466
Fishery, DEA statistics										
- LPG	13	19	21	20	18	20	20	18	12	12
- gasoline	67	3	3	0	0	0	1	1	1	1
- kerosene	25	1	1	1	1	1	0	0	0	-
- gas/diesel oil	9 347	8 908	8 888	8 428	7 337	7 340	7 362	6 854	6 258	6 075
- fuel oil	-	-	4	84	35	126	86	13	14	17
Manufacturing industry, DEA statistics										
- LPG	1 819	1 526	1 405	1 472	1 488	1 478	1 482	1 216	1 178	1 029
- gasoline	97	69	42	26	30	21	32	16	15	97
- gas/diesel oil	8 635	10 099	9 155	9 964	10 515	10 022	9 132	8 170	7 448	6 665
- fuel oil	8 221	7 395	7 818	6 916	6 940	6 055	8 527	6 422	5 177	4 067
Building and construction, DEA statistics										
- LPG	165	179	236	226	228	224	248	222	172	85
- gasoline	33	24	26	27	27	27	27	28	26	20
- gas/diesel oil	5 950	6 356	6 226	6 226	6 227	6 338	6 187	6 410	6 339	5 429
Housing, DEA statistics										
- gasoline	1 355	1 317	1 313	1 303	1 288	1 250	1 216	1 193	1 135	1 092
- gas/dieselolie	27 929	28 996	26 967	24 932	22 863	21 712	19 572	18 012	16 585	15 762
Etageboliger										
- gas/dieselolie	2 346	2 511	2 031	2 095	2 427	2 151	1 625	1 411	1 610	1 658
Road transport, DEA statistics										
- gasoline	88 975	86 474	86 247	85 611	84 629	82 118	79 822	78 325	74 545	71 689
- gas/diesel oil	64 282	66 254	66 814	70 875	75 422	79 476	86 223	93 111	93 447	88 069
- bioethanol	-	-	-	-	-	-	151	252	210	204
- biodiesel	-	-	-	-	-	-	-	-	10	139
Non-road, DEA statistics										

Continued (2000-2009)										
- LPG	2 018	1 736	1 581	1 641	1 640	1 612	1 610	1 337	1 292	1 155
- gasoline	1 525	1 453	1 412	1 404	1 402	1 356	1 296	1 259	1 199	1 242
- gas/diesel oil	28 972	30 473	29 616	30 209	30 164	29 232	28 757	27 479	27 928	26 948
Non-road, NERI model										
- LPG	1071	1073	1084	1079	1065	1049	1038	1040	986	817
- gasoline	2458	2622	2833	3090	3391	3604	3807	3923	3975	3942
- gas/diesel oil	24630	24923	25117	25334	25704	26393	27762	29522	30515	27089
Recreational craft, NERI model										
- gasoline	396	400	403	404	404	393	382	371	361	353
- gas/diesel oil	777	831	886	944	1002	1002	1002	1002	1002	1002
Non-road, added 0202										
- gas/diesel oil	0	0	0	0	0	0	0	-2043	-2587	-141
Non-road, added 0203 and 0301										
- gas/diesel oil	4342	5550	4500	4875	4460	2838	995	0	0	0
- LPG	947	662	497	563	575	562	572	298	306	338
Non-road, added 0203										
- gas/diesel oil	2156	2553	2163	2262	1985	1250	465	0	0	0
- LPG	93	80	55	58	53	46	46	27	27	37
Non-road, added 0301										
- gas/diesel oil	2186	2997	2337	2612	2476	1589	530	0	0	0
- LPG	854	582	442	505	522	516	526	271	279	301
Non-road, added road transport										
- gasoline	-932	-1169	-1421	-1686	-1990	-2248	-2511	-2663	-2776	-2700
Fisheries, added national sea transport										
- fuel oil	0	0	4	84	35	126	86	13	14	17
Fisheries, consumed by recreational craft										
- gasoline	67	3	3	0	0	0	1	1	1	1
National sea transport, input NERI model										
- LPG	0	-	-	0	0	0	0	0	-	-
- kerosene	1	1	1	1	1	1	0	-	-	-
- gas/diesel oil	5 348	5 608	5 855	6 009	5 259	6 646	5 986	5 233	6 954	6 489
- fuel oil	1 509	1 513	2 068	1 907	1 704	1 506	1 367	1 110	1 174	1 634
Fisheries, input NERI model										
- LPG	13	19	21	20	18	20	20	18	12	12
- gasoline	-	-	-	-	-	-	-	-	-	-

Continued (2000-2009)										
- kerosene	25	1	1	1	1	1	0	0	0	-
Continued										
- gas/diesel oil	8 570	8 077	8 001	7 484	6 335	6 338	6 360	5 852	5 256	5 073
International sea transport, input NERI model										
- gas/diesel oil	20 892	19 022	19 505	18 549	14 357	11 630	10 829	9 124	11 218	10 433
- fuel oil	33 165	25 924	17 547	20 462	17 298	20 591	31 565	35 243	27 164	11 091
National sea transport, output NERI model										
- gas/diesel oil	5258	5233	5061	4475	4591	4559	4427	4435	4393	4315
- fuel oil	1444	1400	1387	1862	1853	1859	2026	2005	2142	2289
- kerosene	1	1	1	1	1	1	0	0	0	0
- LPG	0	0	0	0	0	0	0	0	0	0
Fisheries, output NERI model										
- gas/diesel oil	7422	9384	9664	9294	7286	8725	8166	6966	8106	7517
- kerosene	25	1	1	1	1	1	0	0	0	0
- LPG	13	19	21	20	18	20	20	18	12	12
International sea transport, output NERI model										
- gas/diesel oil	22129	18090	18636	18273	14074	11330	10583	8809	10928	10164
- fuel oil	32437	25195	16818	19247	16118	19411	30172	33848	25650	9416
National sea transport, added 0301										
- fuel oil	65	113	681	45	- 148	- 353	- 659	- 895	- 968	- 655
Road transport, NERI excl. traded fuels										
- gasoline	87 713	84 907	84 426	83 521	82 235	79 477	76 930	75 292	71 409	68 637
- gas/diesel oil	64 282	66 254	66 814	70 875	75 422	79 476	86 223	93 111	93 447	88 069
- bioethanol	-	-	-	-	-	-	151	252	210	204
- biodiesel	-	-	-	-	-	-	-	-	10	139
Road transport, input NERI model incl. traded fuels										
- gasoline	83 312	81 852	81 963	81 878	80 593	77 835	76 109	75 292	71 409	67 815
- gas/diesel oil	69 196	70 916	72 552	78 766	84 209	88 264	95 010	103 871	103 490	97 036
- bioethanol	-	-	-	-	-	-	151	252	210	204
- biodiesel	-	-	-	-	-	-	-	-	10	139

Annex 2B-14: Emission factors and total emissions in CollectER format

1990 emission factors for CO_2, CH_4, N_2O, SO_2, NO_x; NMVOC, NH_3 and TSP.

Year	SNAP ID	Category		Fuel type	SO_2 g pr GJ	NO_x g pr GJ	NMVOC g pr GJ	CH_4 g pr GJ	CO g pr GJ	CO_2 g pr GJ	N_2O g pr GJ	NH_3 g pr GJ	TSP g pr GJ
1990	070101	Passenger cars	Highway	Diesel	93,68	281,80	25,07	3,74	179,70	74,00	0,00	0,47	79,48
1990	070101	Passenger cars	Highway	Gasoline	2,28	1341,85	372,77	10,99	3471,98	73,00	2,75	0,85	12,32
1990	070101	Passenger cars	Highway	LPG	0,00	1151,70	187,09	10,06	3914,25	65,00	0,00	0,00	10,06
1990	070102	Passenger cars	Rural	Diesel	93,68	282,97	42,09	6,82	268,08	74,00	0,00	0,57	75,13
1990	070102	Passenger cars	Rural	Gasoline	2,28	1157,33	489,92	13,86	3975,56	73,00	3,09	0,95	14,22
1990	070102	Passenger cars	Rural	LPG	0,00	1248,46	305,18	16,91	1146,38	65,00	0,00	0,00	14,49
1990	070103	Passenger cars	Urban	Diesel	93,68	228,36	83,84	8,41	317,11	74,00	0,00	0,35	122,24
1990	070103	Passenger cars	Urban	Gasoline	2,28	616,49	943,13	49,98	9909,86	73,00	3,10	0,62	13,42
1990	070103	Passenger cars	Urban	LPG	0,00	620,57	439,16	23,63	1315,38	65,00	0,00	0,00	11,82
1990	070201	Light duty vehicles	Highway	Diesel	93,68	270,67	30,19	2,60	344,14	74,00	0,00	0,32	104,48
1990	070201	Light duty vehicles	Highway	Gasoline	2,28	1369,26	170,29	10,11	2987,40	73,00	2,63	0,81	16,17
1990	070201	Light duty vehicles	Highway	LPG	0,00	1151,70	187,09	10,06	3914,25	65,00	0,00	0,00	10,06
1990	070202	Light duty vehicles	Rural	Diesel	93,68	299,25	33,22	4,26	358,42	74,00	0,00	0,36	107,73
1990	070202	Light duty vehicles	Rural	Gasoline	2,28	1188,86	262,59	15,25	2316,18	73,00	2,48	0,76	15,25
1990	070202	Light duty vehicles	Rural	LPG	0,00	1248,46	305,18	16,91	1146,38	65,00	0,00	0,00	14,49
1990	070203	Light duty vehicles	Urban	Diesel	93,68	487,30	55,86	6,31	411,00	74,00	0,00	0,26	131,44
1990	070203	Light duty vehicles	Urban	Gasoline	2,28	626,69	712,66	40,57	7326,15	73,00	2,22	0,44	8,90
1990	070203	Light duty vehicles	Urban	LPG	0,00	620,31	439,26	23,62	1316,15	65,00	0,00	0,00	11,81
1990	070301	Heavy duty vehicles	Highway	Diesel	93,68	1022,46	48,05	6,21	189,51	74,00	3,02	0,30	38,50
1990	070301	Heavy duty vehicles	Highway	Gasoline	2,28	1037,78	474,61	9,69	7610,35	73,00	0,83	0,28	55,35
1990	070302	Heavy duty vehicles	Rural	Diesel	93,68	1041,19	59,99	6,66	202,57	74,00	2,79	0,28	40,44
1990	070302	Heavy duty vehicles	Rural	Gasoline	2,28	1141,55	820,40	16,74	8371,39	73,00	0,91	0,30	60,88
1990	070303	Heavy duty vehicles	Urban	Diesel	93,68	995,93	79,54	11,66	245,07	74,00	2,14	0,21	46,48
1990	070303	Heavy duty vehicles	Urban	Gasoline	2,28	456,62	696,09	14,21	7102,99	73,00	0,61	0,20	40,59
1990	070400	Mopeds	Urban	Gasoline	2,28	18,26	12503,20	200,00	12602,74	73,00	0,91	0,91	171,69
1990	070501	Motorcycles	Highway	Gasoline	2,28	264,11	1072,19	129,96	16302,60	73,00	1,35	1,35	31,73
1990	070502	Motorcycles	Rural	Gasoline	2,28	185,41	981,69	159,32	15782,07	73,00	1,66	1,66	38,90
1990	070503	Motorcycles	Urban	Gasoline	2,28	112,92	1149,21	155,11	15187,59	73,00	1,61	1,61	37,87
1990	080100	Military		AvGas	22,83	859,00	1242,60	21,90	6972,00	73,00	2,00	1,60	10,00
1990	080100	Military		Diesel	93,68	785,58	58,23	7,33	258,20	74,00	1,72	0,30	65,61
1990	080100	Military		Gasoline	2,28	932,90	1154,80	31,10	6608,56	73,00	2,99	0,78	14,43

Continued											
1990	080100	Military	Jet fuel	22,99	250,57	24,94	2,65	229,89	72,00	2,30	0,00	1,16
1990	080200	Railways	Diesel	93,68	1225,13	79,94	3,07	223,21	74,00	2,04	0,20	50,26
1990	080200	Railways	Kerosene	5,00	50,00	3,00	7,00	20,00	72,00	2,00	0,00	121,95
1990	080300	Inland waterways	Diesel	93,68	983,64	171,79	2,79	453,65	74,00	2,96	0,17	106,93
1990	080300	Inland waterways	Gasoline	2,28	291,33	3606,55	50,38	13853,27	73,00	0,78	0,08	182,44
1990	080402	National sea traffic	Diesel	93,68	1104,18	50,57	1,56	166,83	74,00	4,68	0,00	23,21
1990	080402	National sea traffic	Kerosene	2,30	50,00	3,00	7,00	20,00	72,00	0,00	0,00	5,00
1990	080402	National sea traffic	LPG	0,00	1249,00	384,94	20,26	443,00	65,00	0,00	0,00	0,20
1990	080402	National sea traffic	Residual oil	1290,95	1615,26	53,44	1,65	176,29	78,00	4,89	0,00	149,25
1990	080403	Fishing	Diesel	93,68	1052,12	49,13	1,52	162,08	74,00	4,68	0,00	23,21
1990	080403	Fishing	Kerosene	2,30	50,00	3,00	7,00	20,00	72,00	0,00	0,00	5,00
1990	080403	Fishing	LPG	0,00	1249,00	384,94	20,26	443,00	65,00	0,00	0,00	0,20
1990	080404	International sea traffic	Diesel	93,68	1208,60	49,46	1,53	163,17	74,00	4,68	0,00	23,21
1990	080404	International sea traffic	Residual oil	1447,43	1689,57	53,98	1,67	178,09	78,00	4,89	0,00	189,43
1990	080501	Air traffic, Dom. < 3000 ft.	AvGas	22,83	859,00	1242,60	21,90	6972,00	73,00	2,00	1,60	10,00
1990	080501	Air traffic, Dom. < 3000 ft.	Jet fuel	22,99	314,51	14,93	1,59	90,41	72,00	5,70	0,00	1,16
1990	080502	Air traffic, Int. < 3000 ft.	AvGas	22,83	859,00	1242,60	21,90	6972,00	73,00	2,00	1,60	10,00
1990	080502	Air traffic, Int. < 3000 ft.	Jet fuel	22,99	309,25	16,47	1,75	168,98	72,00	7,10	0,00	1,16
1990	080503	Air traffic, Dom. > 3000 ft.	Jet fuel	22,99	330,11	12,36	1,31	90,75	72,00	2,30	0,00	1,16
1990	080504	Air traffic, Int. > 3000 ft.	Jet fuel	22,99	244,20	6,48	0,69	54,10	72,00	2,30	0,00	1,16
1990	080600	Agriculture	Diesel	93,68	758,87	156,85	2,55	635,53	74,00	2,93	0,17	144,45
1990	080600	Agriculture	Gasoline	2,28	31,60	949,55	88,42	47524,17	73,00	1,28	0,09	6,56
1990	080700	Forestry	Diesel	93,68	857,48	156,47	2,54	645,65	74,00	2,97	0,17	149,05
1990	080700	Forestry	Gasoline	2,28	40,39	7206,91	60,42	18057,40	73,00	0,37	0,07	101,22
1990	080800	Industry	Diesel	93,68	933,58	178,23	2,90	655,80	74,00	2,94	0,17	154,50
1990	080800	Industry	Gasoline	2,28	136,27	1610,77	120,61	14797,46	73,00	1,33	0,09	12,40
1990	080800	Industry	LPG	0,00	1328,11	146,09	7,69	104,85	65,00	3,50	0,21	4,89
1990	080900	Household and gardening	Gasoline	2,28	63,98	3366,01	95,22	32901,19	73,00	1,15	0,08	20,75
1990	081100	Commercial and institutional	Gasoline	2,28	68,83	2280,66	97,87	29887,31	73,00	1,09	0,08	24,00
1990	080501	Air traffic, Dom. < 3000 ft.	AvGas	22,83	859,00	1242,60	21,90	6972,00	73,00	2,00	1,60	10,00
1990	080501	Air traffic, Dom. < 3000 ft.	Jet fuel	22,99	283,87	20,73	2,20	129,70	72,00	4,58	0,00	1,16
1990	080502	Air traffic, Int. < 3000 ft.	AvGas	22,83	859,00	1242,60	21,90	6972,00	73,00	2,00	1,60	10,00
1990	080502	Air traffic, Int. < 3000 ft.	Jet fuel	22,99	324,87	34,25	3,64	157,15	72,00	3,79	0,00	1,16
1990	080503	Air traffic, Dom. > 3000 ft.	Jet fuel	22,99	314,86	11,78	1,25	84,05	72,00	2,30	0,00	1,16
1990	080504	Air traffic, Int. > 3000 ft.	Jet fuel	22,99	290,20	10,08	1,07	37,65	72,00	2,30	0,00	1,16

2009 emission factors for CO_2, CH_4, N_2O, SO_2, NO_x; NMVOC, NH_3 and TSP.

Year	SNAP ID	Category		Fuel type	SO_2	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3	TSP
					g pr GJ	g pr GJ	g pr GJ	g pr GJ	g pr GJ	g pr GJ	g pr GJ	g pr GJ	g pr GJ
2009	070101	Passenger cars	Highway	Diesel	0,47	303,26	5,80	0,14	13,23	73,89	1,95	0,48	15,44
2009	070101	Passenger cars	Highway	Gasoline	0,45	142,30	32,30	2,97	685,83	72,78	0,72	30,88	0,90
2009	070101	Passenger cars	Highway	LPG	0,00	247,65	39,76	4,31	1443,35	65,00	0,76	0,00	10,05
2009	070102	Passenger cars	Rural	Diesel	0,47	259,62	8,38	0,28	25,61	73,89	2,08	0,51	12,65
2009	070102	Passenger cars	Rural	Gasoline	0,45	114,22	36,32	3,52	538,53	72,78	1,35	34,47	0,85
2009	070102	Passenger cars	Rural	LPG	0,00	270,21	59,92	7,23	562,88	65,00	1,58	0,00	14,45
2009	070103	Passenger cars	Urban	Diesel	0,47	258,88	23,86	0,76	65,93	73,89	4,55	0,38	19,84
2009	070103	Passenger cars	Urban	Gasoline	0,45	132,47	221,92	9,48	2378,17	72,78	2,43	11,46	0,92
2009	070103	Passenger cars	Urban	LPG	0,00	162,36	123,43	11,53	816,28	65,00	3,20	0,00	13,44
2009	070201	Light duty vehicles	Highway	Diesel	0,47	227,43	21,27	0,22	129,50	73,89	1,52	0,37	21,83
2009	070201	Light duty vehicles	Highway	Gasoline	0,45	160,23	18,87	2,74	543,60	72,78	1,49	22,77	1,39
2009	070201	Light duty vehicles	Highway	LPG	0,00	74,28	10,46	1,74	860,66	65,00	0,44	0,00	10,04
2009	070202	Light duty vehicles	Rural	Diesel	0,47	237,74	24,06	0,51	111,29	73,89	1,66	0,40	17,90
2009	070202	Light duty vehicles	Rural	Gasoline	0,45	140,14	27,94	2,92	411,60	72,78	2,28	21,84	1,24
2009	070202	Light duty vehicles	Rural	LPG	0,00	81,85	14,66	2,92	386,57	65,00	0,99	0,00	14,45
2009	070203	Light duty vehicles	Urban	Diesel	0,47	227,90	40,68	1,11	136,49	73,89	3,11	0,29	24,98
2009	070203	Light duty vehicles	Urban	Gasoline	0,45	119,52	148,31	7,07	2931,76	72,78	3,89	5,74	0,85
2009	070203	Light duty vehicles	Urban	LPG	0,00	54,81	36,84	4,79	428,25	65,00	2,29	0,00	13,82
2009	070301	Heavy duty vehicles	Highway	Diesel	0,47	552,97	12,59	3,55	89,59	73,89	3,13	0,31	9,16
2009	070301	Heavy duty vehicles	Highway	Gasoline	0,45	1037,78	474,61	9,69	7610,35	72,78	0,83	0,28	55,35
2009	070302	Heavy duty vehicles	Rural	Diesel	0,47	567,88	15,12	3,74	92,25	73,89	2,85	0,29	9,35
2009	070302	Heavy duty vehicles	Rural	Gasoline	0,45	1141,55	820,40	16,74	8371,39	72,78	0,91	0,30	60,88
2009	070303	Heavy duty vehicles	Urban	Diesel	0,47	572,06	19,24	4,70	106,84	73,89	2,21	0,22	10,85
2009	070303	Heavy duty vehicles	Urban	Gasoline	0,45	456,62	696,09	14,21	7102,99	72,78	0,61	0,20	40,59
2009	070400	Mopeds	Urban	Gasoline	0,45	129,62	8889,08	142,19	9581,58	72,78	1,24	1,24	139,02
2009	070501	Motorcycles	Highway	Gasoline	0,45	269,39	854,98	102,85	12090,75	72,78	1,28	1,28	22,72
2009	070502	Motorcycles	Rural	Gasoline	0,45	192,38	832,68	124,55	11313,83	72,78	1,56	1,56	27,72
2009	070503	Motorcycles	Urban	Gasoline	0,45	118,86	1019,07	127,53	10859,93	72,78	1,52	1,52	27,03
2009	080100	Military		AvGas	22,99	859,00	1242,60	21,90	6972,00	73,00	2,00	1,60	10,00
2009	080100	Military		Diesel	0,47	389,51	18,42	2,05	82,75	74,00	2,73	0,35	14,50
2009	080100	Military		Gasoline	0,46	129,33	175,09	7,54	1503,62	73,00	1,75	23,22	1,69
2009	080100	Military		Jet fuel	22,99	250,57	24,94	2,65	229,89	72,00	2,30	0,00	1,16
2009	080200	Railways		Diesel	0,47	836,81	55,89	2,15	144,66	74,00	2,04	0,20	27,13
2009	080300	Inland waterways		Diesel	46,84	842,80	162,30	2,64	445,05	74,00	2,97	0,17	99,56

Continued

2009	080300	Inland waterways	Gasoline	0,46	517,18	1365,08	61,52	13946,94	73,00	1,41	0,10	47,96
2009	080402	National sea traffic	Diesel	46,84	970,74	52,37	1,51	86,75	74,00	4,68	0,00	21,55
2009	080402	National sea traffic	Residual oil	586,80	1886,45	62,25	1,93	205,36	78,00	4,89	0,00	51,05
2009	080403	Fishing	Diesel	46,84	1367,70	57,22	1,77	188,76	74,00	4,68	0,00	21,55
2009	080403	Fishing	LPG	0,00	1249,00	384,94	20,26	443,00	65,00	0,00	0,00	0,20
2009	080404	International sea traffic	Diesel	46,84	1562,60	56,55	1,75	186,57	74,00	4,68	0,00	21,55
2009	080404	International sea traffic	Residual oil	733,50	2100,18	62,13	1,92	204,97	78,00	4,89	0,00	63,83
2009	080501	Air traffic, Dom. < 3000 ft.	AvGas	22,83	859,00	1242,60	21,90	6972,00	73,00	2,00	1,60	10,00
2009	080501	Air traffic, Dom. < 3000 ft.	Jet fuel	22,99	299,23	71,46	7,59	192,55	72,00	10,85	0,00	1,16
2009	080502	Air traffic, Int. < 3000 ft.	AvGas	22,83	859,00	1242,60	21,90	6972,00	73,00	2,00	1,60	10,00
2009	080502	Air traffic, Int. < 3000 ft.	Jet fuel	22,99	294,91	23,08	2,45	176,23	72,00	7,90	0,00	1,16
2009	080503	Air traffic, Dom. > 3000 ft.	Jet fuel	22,99	275,78	19,38	2,06	113,69	72,00	2,30	0,00	1,16
2009	080504	Air traffic, Int. > 3000 ft.	Jet fuel	22,99	238,94	7,14	0,76	54,53	72,00	2,30	0,00	1,16
2009	080600	Agriculture	Diesel	2,34	623,15	61,56	1,00	350,97	74,00	3,17	0,18	48,30
2009	080600	Agriculture	Gasoline	0,46	111,21	1198,25	160,47	21741,45	73,00	1,72	1,52	31,17
2009	080700	Forestry	Diesel	2,34	453,17	33,45	0,54	248,17	74,00	3,21	0,18	27,86
2009	080700	Forestry	Gasoline	0,46	76,20	6037,15	49,79	17249,02	73,00	0,44	0,09	79,13
2009	080800	Industry	Diesel	2,34	586,11	65,50	1,07	332,21	74,00	3,09	0,18	56,52
2009	080800	Industry	Gasoline	0,46	207,71	1551,34	108,68	13776,12	73,00	1,48	0,10	16,59
2009	080800	Industry	LPG	0,00	1328,11	146,09	7,69	104,85	65,00	3,50	0,21	4,89
2009	080900	Household and gardening	Gasoline	0,46	97,45	2401,47	76,04	29381,95	73,00	1,25	0,09	16,51
2009	081100	Commercial and institutional	Gasoline	0,46	92,03	2160,09	70,04	30239,09	73,00	1,11	0,09	27,90
2009	080501	Air traffic, Dom. < 3000 ft.	AvGas	22,83	859,00	1242,60	21,90	6972,00	73,00	2,00	1,60	10,00
2009	080501	Air traffic, Dom. < 3000 ft.	Jet fuel	22,99	285,51	108,59	11,53	263,98	72,00	6,46	0,00	1,16
2009	080502	Air traffic, Int. < 3000 ft.	AvGas	22,83	859,00	1242,60	21,90	6972,00	73,00	2,00	1,60	10,00
2009	080502	Air traffic, Int. < 3000 ft.	Jet fuel	22,99	337,22	72,55	7,70	272,32	72,00	3,87	0,00	1,16
2009	080503	Air traffic, Dom. > 3000 ft.	Jet fuel	22,99	280,51	18,06	1,92	61,14	72,00	2,30	0,00	1,16
2009	080504	Air traffic, Int. > 3000 ft.	Jet fuel	22,99	310,99	10,91	1,16	33,10	72,00	2,30	0,00	1,16

1990 emissions for CO_2, CH_4, N_2O, SO_2, NO_x; NMVOC, NH_3 and TSP.

Year	SNAP ID	Category		Fuel type	Fuel	SO_2	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3	TSP
					PJ	tonnes	tonnes	tonnes	tonnes	tonnes	ktonnes	tonnes	tonnes	tonnes
1990	070101	Passenger cars	Highway	Diesel	1,226	114,87	345,56	30,74	4,59	220,35	90,74	0,00	0,57	97,47
1990	070101	Passenger cars	Highway	Gasoline	10,527	24,04	14126,19	3924,34	115,65	36550,79	768,50	28,92	8,90	129,66
1990	070101	Passenger cars	Highway	LPG	0,011	0,00	12,22	1,99	0,11	41,54	0,69	0,00	0,00	0,11
1990	070102	Passenger cars	Rural	Diesel	2,564	240,15	725,44	107,91	17,48	687,24	189,71	0,00	1,46	192,60
1990	070102	Passenger cars	Rural	Gasoline	23,760	54,25	27498,37	11640,51	329,26	94459,77	1734,49	73,48	22,61	337,77
1990	070102	Passenger cars	Rural	LPG	0,022	0,00	28,06	6,86	0,38	25,76	1,46	0,00	0,00	0,33
1990	070103	Passenger cars	Urban	Diesel	3,295	308,69	752,51	276,29	27,73	1044,98	243,85	0,00	1,15	402,81
1990	070103	Passenger cars	Urban	Gasoline	28,666	65,45	17672,12	27035,58	1432,67	284073,19	2092,60	88,92	17,78	384,77
1990	070103	Passenger cars	Urban	LPG	0,029	0,00	17,94	12,70	0,68	38,03	1,88	0,00	0,00	0,34
1990	070201	Light duty vehicles	Highway	Diesel	1,840	172,39	498,11	55,56	4,78	633,30	136,18	0,00	0,60	192,27
1990	070201	Light duty vehicles	Highway	Gasoline	0,265	0,60	362,30	45,06	2,67	790,46	19,32	0,70	0,21	4,28
1990	070201	Light duty vehicles	Highway	LPG	0,008	0,00	8,68	1,41	0,08	29,51	0,49	0,00	0,00	0,08
1990	070202	Light duty vehicles	Rural	Diesel	5,886	551,40	1761,44	195,56	25,09	2109,75	435,58	0,00	2,09	634,13
1990	070202	Light duty vehicles	Rural	Gasoline	0,982	2,24	1167,44	257,85	14,98	2274,44	71,68	2,43	0,75	14,98
1990	070202	Light duty vehicles	Rural	LPG	0,022	0,00	27,45	6,71	0,37	25,20	1,43	0,00	0,00	0,32
1990	070203	Light duty vehicles	Urban	Diesel	5,804	543,73	2828,44	324,26	36,60	2385,57	429,52	0,00	1,51	762,91
1990	070203	Light duty vehicles	Urban	Gasoline	1,218	2,78	763,60	868,35	49,43	8926,67	88,95	2,71	0,54	10,84
1990	070203	Light duty vehicles	Urban	LPG	0,026	0,00	16,15	11,44	0,62	34,27	1,69	0,00	0,00	0,31
1990	070301	Heavy duty vehicles	Highway	Diesel	9,549	894,51	9763,34	458,80	59,29	1809,63	706,62	28,81	2,88	367,64
1990	070301	Heavy duty vehicles	Highway	Gasoline	0,047	0,11	48,50	22,18	0,45	355,68	3,41	0,04	0,01	2,59
1990	070302	Heavy duty vehicles	Rural	Diesel	16,737	1567,87	17426,38	1004,08	111,45	3390,48	1238,54	46,73	4,67	676,90
1990	070302	Heavy duty vehicles	Rural	Gasoline	0,082	0,19	93,21	66,99	1,37	683,54	5,96	0,07	0,02	4,97
1990	070303	Heavy duty vehicles	Urban	Diesel	13,045	1222,03	12992,09	1037,60	152,14	3197,03	965,34	27,85	2,79	606,28
1990	070303	Heavy duty vehicles	Urban	Gasoline	0,077	0,18	35,05	53,43	1,09	545,19	5,60	0,05	0,02	3,12
1990	070400	Mopeds	Urban	Gasoline	0,291	0,66	5,31	3636,22	58,16	3665,17	21,23	0,27	0,27	49,93
1990	070501	Motorcycles	Highway	Gasoline	0,056	0,13	14,88	60,41	7,32	918,58	4,11	0,08	0,08	1,79
1990	070502	Motorcycles	Rural	Gasoline	0,135	0,31	25,04	132,60	21,52	2131,72	9,86	0,22	0,22	5,25
1990	070503	Motorcycles	Urban	Gasoline	0,173	0,40	19,58	199,25	26,89	2633,25	12,66	0,28	0,28	6,57
1990	080100	Military		AvGas	0,005	0,11	4,22	6,11	0,11	34,26	0,36	0,01	0,01	0,05
1990	080100	Military		Diesel	0,146	13,69	114,82	8,51	1,07	37,74	10,82	0,25	0,04	9,59
1990	080100	Military		Gasoline	0,001	0,00	0,92	1,14	0,03	6,51	0,07	0,00	0,00	0,01
1990	080100	Military		Jet fuel	1,497	34,41	375,06	37,33	3,96	344,09	107,77	3,44		1,74
1990	080200	Railways		Diesel	4,010	375,64	4912,78	320,54	12,32	895,07	296,74	8,18	0,82	201,55
1990	080200	Railways		Gasoline	0,000	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Continued													
1990	080200	Railways	Kerosene	0,000	0,00	0,00	0,00	0,00	0,00	0,01	0,00		0,01
1990	080300	Inland waterways	Diesel	0,343	32,10	337,02	58,86	0,96	155,43	25,35	1,01	0,06	36,64
1990	080300	Inland waterways	Gasoline	0,309	0,71	90,06	1114,91	15,58	4282,54	22,57	0,24	0,02	56,40
1990	080402	National sea traffic	Diesel	5,285	495,12	5836,01	267,28	8,27	881,74	391,12	24,76		122,69
1990	080402	National sea traffic	Kerosene	0,000	0,00	0,02	0,00	0,00	0,01	0,03	0,00		0,00
1990	080402	National sea traffic	LPG	0,002		2,24	0,69	0,04	0,79	0,12	0,00		0,00
1990	080402	National sea traffic	Residual oil	4,571	5901,32	7383,82	244,28	7,56	805,87	356,56	22,35		682,25
1990	080403	Fishing	Diesel	7,920	741,91	8332,71	389,10	12,03	1283,63	586,07	37,10		183,85
1990	080403	Fishing	Gasoline	0,000	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
1990	080403	Fishing	Kerosene	0,026	0,06	1,29	0,08	0,18	0,52	1,86	0,00		0,13
1990	080403	Fishing	LPG	0,042		52,86	16,29	0,86	18,75	2,75	0,00		0,01
1990	080403	Fishing	Residual oil	0,000	0,00	0,00	0,00	0,00	0,00	0,00	0,00		0,00
1990	080404	International sea traffic	Diesel	11,289	1057,56	13644,52	558,38	17,27	1842,07	835,42	52,88		262,07
1990	080404	International sea traffic	Residual oil	27,815	40259,78	46994,61	1501,54	46,44	4953,54	2169,54	136,01		5268,82
1990	080501	Air traffic, Dom. < 3000 ft.	AvGas	0,105	2,40	90,15	130,41	2,30	731,69	7,66	0,21	0,17	1,05
1990	080501	Air traffic, Dom. < 3000 ft.	Jet fuel	0,422	9,71	132,78	6,30	0,67	38,17	30,40	2,40		0,49
1990	080502	Air traffic, Int. < 3000 ft.	AvGas	0,031	0,70	26,34	38,10	0,67	213,76	2,24	0,06	0,05	0,31
1990	080502	Air traffic, Int. < 3000 ft.	Jet fuel	0,132	3,04	40,93	2,18	0,23	22,36	9,53	0,94		0,15
1990	080503	Air traffic, Dom. > 3000 ft.	Jet fuel	1,026	23,59	338,70	12,68	1,35	93,11	73,87	2,36		1,19
1990	080504	Air traffic, Int. > 3000 ft.	Jet fuel	1,612	37,06	393,62	10,45	1,11	87,20	116,06	3,71		1,87
1990	080600	Agriculture	Diesel	16,496	1545,32	12518,46	2587,36	42,07	10483,86	1220,72	48,34	2,76	2382,90
1990	080600	Agriculture	Gasoline	0,709	1,62	22,40	673,10	62,68	33688,19	51,75	0,91	0,06	4,65
1990	080700	Forestry	Diesel	0,145	13,62	124,63	22,74	0,37	93,84	10,76	0,43	0,02	21,66
1990	080700	Forestry	Gasoline	0,341	0,78	13,79	2460,65	20,63	6165,33	24,92	0,13	0,03	34,56
1990	080800	Industry	Diesel	10,158	951,61	9483,66	1810,53	29,44	6661,90	751,72	29,87	1,71	1569,49
1990	080800	Industry	Gasoline	0,175	0,40	23,88	282,25	21,13	2592,92	12,79	0,23	0,02	2,17
1990	080800	Industry	LPG	1,185	0,00	1573,62	173,10	9,11	124,23	77,02	4,14	0,25	5,80
1990	080900	Household and gardening	Gasoline	0,535	1,22	34,24	1801,26	50,96	17606,46	39,06	0,62	0,04	11,10
1990	081100	Commercial and institutional	Gasoline	1,010	2,31	69,51	2303,07	98,83	30181,04	73,72	1,10	0,08	24,24
1990	080501	Air traffic, Dom. < 3000 ft.	AvGas	0,009	0,20	7,42	10,74	0,19	60,25	0,63	0,02	0,01	0,09
1990	080501	Air traffic, Dom. < 3000 ft.	Jet fuel	0,502	11,54	142,54	10,41	1,11	65,13	36,16	2,30		0,58
1990	080502	Air traffic, Int. < 3000 ft.	AvGas	0,006	0,13	4,82	6,97	0,12	39,13	0,41	0,01	0,01	0,06
1990	080502	Air traffic, Int. < 3000 ft.	Jet fuel	2,001	46,00	650,12	68,54	7,28	314,49	144,09	7,58		2,32
1990	080503	Air traffic, Dom. > 3000 ft.	Jet fuel	1,305	30,00	410,96	15,38	1,63	109,71	93,97	3,00		1,51
1990	080504	Air traffic, Int. > 3000 ft.	Jet fuel	20,330	467,36	5899,81	204,92	21,76	765,45	1463,78	46,74		23,58

2009 emissions for CO_2, CH_4, N_2O, SO_2, NO_x; NMVOC, NH_3 and TSP.

	SNAP ID	Category		Fuel type	Fuel PJ	SO_2 tonnes	NO_x tonnes	NMVOC tons	CH_4 tonnes	CO tons	CO_2 ktonnes	N_2O tonnes	NH_3 tonnes	TSP tonnes
2009	070101	Passenger cars	Highway	Diesel	6,306	2,95	1912,49	36,58	0,89	83,43	466,01	12,27	3,00	97,40
2009	070101	Passenger cars	Highway	Gasoline	11,464	5,21	1631,36	370,29	34,06	7862,70	834,34	8,22	354,07	10,36
2009	070101	Passenger cars	Highway	LPG	0,000	0,00	0,03	0,00	0,00	0,16	0,01	0,00	0,00	0,00
2009	070102	Passenger cars	Rural	Diesel	13,692	6,40	3554,78	114,81	3,84	350,59	1011,79	28,44	6,95	173,18
2009	070102	Passenger cars	Rural	Gasoline	25,166	11,43	2874,53	914,03	88,70	13552,89	1831,53	33,91	867,50	21,38
2009	070102	Passenger cars	Rural	LPG	0,000	0,00	0,06	0,01	0,00	0,12	0,01	0,00	0,00	0,00
2009	070103	Passenger cars	Urban	Diesel	13,537	6,33	3504,44	323,03	10,27	892,42	1000,30	61,58	5,13	268,63
2009	070103	Passenger cars	Urban	Gasoline	27,513	12,50	3644,75	6105,62	260,89	65430,50	2002,30	66,97	315,26	25,29
2009	070103	Passenger cars	Urban	LPG	0,000	0,00	0,04	0,03	0,00	0,19	0,01	0,00	0,00	0,00
2009	070201	Light duty vehicles	Highway	Diesel	3,177	1,49	722,43	67,56	0,71	411,35	234,73	4,83	1,17	69,33
2009	070201	Light duty vehicles	Highway	Gasoline	0,329	0,15	52,75	6,21	0,90	178,95	23,96	0,49	7,50	0,46
2009	070201	Light duty vehicles	Highway	LPG	0,000	0,00	0,02	0,00	0,00	0,20	0,02	0,00	0,00	0,00
2009	070202	Light duty vehicles	Rural	Diesel	9,269	4,33	2203,66	222,99	4,75	1031,53	684,94	15,41	3,72	165,96
2009	070202	Light duty vehicles	Rural	Gasoline	1,113	0,51	156,03	31,11	3,25	458,25	81,03	2,54	24,32	1,38
2009	070202	Light duty vehicles	Rural	LPG	0,001	0,00	0,05	0,01	0,00	0,24	0,04	0,00	0,00	0,01
2009	070203	Light duty vehicles	Urban	Diesel	8,840	4,13	2014,60	359,58	9,77	1206,54	653,22	27,49	2,53	220,87
2009	070203	Light duty vehicles	Urban	Gasoline	1,316	0,60	157,24	195,12	9,31	3857,12	95,75	5,12	7,55	1,12
2009	070203	Light duty vehicles	Urban	LPG	0,001	0,00	0,03	0,02	0,00	0,25	0,04	0,00	0,00	0,01
2009	070301	Heavy duty vehicles	Highway	Diesel	11,255	5,26	6223,44	141,71	39,93	1008,30	831,65	35,23	3,52	103,12
2009	070301	Heavy duty vehicles	Highway	Gasoline	0,034	0,02	35,12	16,06	0,33	257,53	2,46	0,03	0,01	1,87
2009	070302	Heavy duty vehicles	Rural	Diesel	18,173	8,50	10320,21	274,73	68,06	1676,57	1342,90	51,85	5,18	169,97
2009	070302	Heavy duty vehicles	Rural	Gasoline	0,057	0,03	65,54	47,10	0,96	480,63	4,18	0,05	0,02	3,50
2009	070303	Heavy duty vehicles	Urban	Diesel	12,926	6,04	7394,17	248,75	60,81	1380,94	955,12	28,52	2,85	140,22
2009	070303	Heavy duty vehicles	Urban	Gasoline	0,053	0,02	24,14	36,81	0,75	375,57	3,85	0,03	0,01	2,15
2009	070400	Mopeds	Urban	Gasoline	0,209	0,09	27,08	1857,34	29,71	2002,03	15,21	0,26	0,26	29,05
2009	070501	Motorcycles	Highway	Gasoline	0,117	0,05	31,59	100,25	12,06	1417,67	8,53	0,15	0,15	2,66
2009	070502	Motorcycles	Rural	Gasoline	0,258	0,12	49,56	214,53	32,09	2914,89	18,75	0,40	0,40	7,14
2009	070503	Motorcycles	Urban	Gasoline	0,310	0,14	36,85	315,95	39,54	3366,97	22,56	0,47	0,47	8,38
2009	080100	Military		AvGas	0,005	0,12	4,33	6,26	0,11	35,12	0,37	0,01	0,01	0,05
2009	080100	Military		Diesel	1,099	0,51	428,08	20,24	2,25	90,95	81,33	3,00	0,39	15,93
2009	080100	Military		Gasoline	0,009	0,00	1,14	1,55	0,07	13,29	0,65	0,02	0,21	0,01
2009	080100	Military		Jet fuel	1,079	24,79	270,25	26,90	2,86	247,94	77,65	2,48	0,00	1,25
2009	080200	Railways		Diesel	3,111	1,46	2603,18	173,87	6,68	450,01	230,20	6,35	0,62	84,40
2009	080200	Railways		Gasoline	0,000	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Continued

2009	080200	Railways	Kerosene	0,000	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
2009	080300	Inland waterways	Diesel	1,002	46,94	844,61	162,65	2,64	446,01	74,16	2,98	0,17	99,78
2009	080300	Inland waterways	Gasoline	0,353	0,16	182,53	481,79	21,71	4922,43	25,76	0,50	0,04	16,93
2009	080402	National sea traffic	Diesel	4,315	202,10	4188,54	225,97	6,53	374,33	319,30	20,21	0,00	92,97
2009	080402	National sea traffic	Kerosene	0,000									
2009	080402	National sea traffic	LPG	0,000									
2009	080402	National sea traffic	Residual oil	2,289	1343,34	4318,62	142,51	4,41	470,13	178,56	11,19		116,87
2009	080403	Fishing	Diesel	7,517	352,07	10280,54	430,08	13,30	1418,81	556,23	35,21	0,00	161,96
2009	080403	Fishing	Gasoline	0,000	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
2009	080403	Fishing	Kerosene	0,000									
2009	080403	Fishing	LPG	0,012	0,00	15,11	4,66	0,25	5,36	0,79	0,00	0,00	0,00
2009	080403	Fishing	Residual oil	0,000	0,00	0,00	0,00	0,00	0,00	0,00	0,00		0,00
2009	080404	International sea traffic	Diesel	10,164	476,06	15881,99	574,80	17,78	1896,25	752,12	47,61		219,00
2009	080404	International sea traffic	Residual oil	9,416	6906,88	19776,10	585,04	18,09	1930,03	734,48	46,05		601,09
2009	080501	Air traffic, Dom. < 3000 ft.	AvGas	0,073	1,66	62,54	90,47	1,59	507,62	5,31	0,15	0,12	0,73
2009	080501	Air traffic, Dom. < 3000 ft.	Jet fuel	0,229	5,27	68,56	16,37	1,74	44,12	16,50	2,49		0,27
2009	080502	Air traffic, Int. < 3000 ft.	AvGas	0,003	0,08	2,89	4,18	0,07	23,47	0,25	0,01	0,01	0,03
2009	080502	Air traffic, Int. < 3000 ft.	Jet fuel	0,261	6,00	77,00	6,03	0,64	46,01	18,80	2,06		0,30
2009	080503	Air traffic, Dom. > 3000 ft.	Jet fuel	0,586	13,47	161,53	11,35	1,21	66,59	42,17	1,35		0,68
2009	080504	Air traffic, Int. > 3000 ft.	Jet fuel	2,834	65,15	677,17	20,24	2,15	154,54	204,05	6,52		3,29
2009	080600	Agriculture	Diesel	16,646	38,98	10372,88	1024,68	16,66	5842,16	1231,79	52,73	3,01	803,91
2009	080600	Agriculture	Gasoline	0,501	0,23	55,71	600,30	80,39	10892,04	36,57	0,86	0,76	15,61
2009	080700	Forestry	Diesel	0,159	0,37	72,08	5,32	0,09	39,48	11,77	0,51	0,03	4,43
2009	080700	Forestry	Gasoline	0,073	0,03	5,55	439,44	3,62	1255,55	5,31	0,03	0,01	5,76
2009	080800	Industry	Diesel	10,284	24,09	6027,83	673,63	10,95	3416,61	761,05	31,82	1,82	581,23
2009	080800	Industry	Gasoline	0,118	0,05	24,44	182,51	12,79	1620,75	8,59	0,17	0,01	1,95
2009	080800	Industry	LPG	0,817	0,00	1085,11	119,36	6,28	85,67	53,11	2,86	0,17	4,00
2009	080900	Household and gardening	Gasoline	0,862	0,39	84,05	2071,21	65,58	25341,18	62,96	1,08	0,08	14,24
2009	081100	Commercial and institutional	Gasoline	2,389	1,09	219,82	5159,43	167,29	72226,83	174,36	2,65	0,21	66,64
2009	080501	Air traffic, Dom. < 3000 ft.	AvGas	0,001	0,01	0,50	0,72	0,01	4,07	0,04	0,00	0,00	0,01
2009	080501	Air traffic, Dom. < 3000 ft.	Jet fuel	0,286	6,59	81,79	31,11	3,30	75,62	20,63	1,85		0,33
2009	080502	Air traffic, Int. < 3000 ft.	AvGas	0,000	0,01	0,42	0,61	0,01	3,42	0,04	0,00	0,00	0,00
2009	080502	Air traffic, Int. < 3000 ft.	Jet fuel	2,517	57,87	848,84	182,61	19,39	685,49	181,24	9,73	0,00	2,92
2009	080503	Air traffic, Dom. > 3000 ft.	Jet fuel	0,984	22,63	276,13	17,78	1,89	60,19	70,88	2,26	0,00	1,14
2009	080504	Air traffic, Int. > 3000 ft.	Jet fuel	26,520	609,67	8247,70	289,26	30,72	877,84	1909,47	60,97	0,00	30,76

Non-exhaust emission factors, activity data and total non-exhaust emissions of TSP, PM_{10} and $PM_{2.5}$ in 2009.

Year	Source	Category	Mileage kmkveh	TSP mg pr km	PM_{10} mg pr km	$PM_{2.5}$ mg pr km	As µg pr km	Cd µg pr km	Cr µg pr km	Cu µg pr km	Hg µg pr km	Ni µg pr km	Pb µg pr km	Se µg pr km	Zn µg pr km
2009	Brake wear	1	40824463,63	7,5	7,4	2,9	0,1	0,1	0,8	789,2	0,0	0,8	104,1	0,2	151,4
2009	Brake wear	2	8142866,592	13,6	13,3	5,3	0,1	0,1	1,4	1427,8	0,0	1,4	188,3	0,3	274,0
2009	Brake wear	3	3236089,017	34,3	33,6	13,4	0,3	0,1	5,6	258,7	0,0	3,9	14,0	0,7	257,9
2009	Brake wear	4	674010,8652	47,1	46,1	18,4	0,5	0,1	3,0	644,5	0,0	7,5	34,4	0,9	439,4
2009	Brake wear	5	259079,8056	6,2	6,1	2,4	0,1	0,1	0,7	649,2	0,0	0,7	85,6	0,1	124,6
2009	Brake wear	6	513019,3691	4,2	4,1	1,6	0,0	0,0	0,4	441,0	0,0	0,4	58,1	0,1	84,6
2009	Road abrasion	1	40824463,63	15,0	7,5	4,1	0,0	0,0	0,3	0,1	0,0	0,2	0,7	0,0	1,1
2009	Road abrasion	2	8142866,592	15,0	7,5	4,1	0,0	0,0	0,3	0,1	0,0	0,2	0,7	0,0	1,1
2009	Road abrasion	3	3236089,017	75,1	37,6	20,3	0,0	0,0	1,5	0,8	0,0	1,2	3,5	0,0	5,7
2009	Road abrasion	4	674010,8652	76,0	38,0	20,5	0,0	0,0	1,5	0,8	0,0	1,2	3,6	0,0	5,7
2009	Road abrasion	5	259079,8056	6,0	3,0	1,6	0,0	0,0	0,1	0,1	0,0	0,1	0,3	0,0	0,5
2009	Road abrasion	6	513019,3691	6,0	3,0	1,6	0,0	0,0	0,1	0,1	0,0	0,1	0,3	0,0	0,5
2009	Tyre wear	1	40824463,63	10,8	6,5	4,6	0,0	0,0	0,0	0,2	0,0	0,3	0,9	0,2	118,5
2009	Tyre wear	2	8142866,592	17,2	10,3	7,2	0,0	0,0	0,1	0,3	0,0	0,4	1,4	0,3	187,7
2009	Tyre wear	3	3236089,017	65,6	39,3	27,5	0,1	0,2	0,2	1,0	0,0	1,7	5,3	1,3	716,9
2009	Tyre wear	4	674010,8652	60,8	36,5	25,5	0,0	0,2	0,2	0,9	0,0	1,6	4,9	1,2	664,8
2009	Tyre wear	5	259079,8056	14,2	8,5	6,0	0,0	0,0	0,1	0,2	0,0	0,4	1,1	0,3	154,9
2009	Tyre wear	6	513019,3691	17,8	10,7	7,5	0,0	0,0	0,1	0,3	0,0	0,5	1,4	0,4	194,1
2009	Total	1	40824464	33,3	21,4	11,5	0,1	0,1	1,1	789,5	0,0	1,3	105,6	0,4	271,1
2009	Total	2	8142867	45,8	31,1	16,6	0,1	0,2	1,8	1428,3	0,0	2,1	190,3	0,6	462,9
2009	Total	3	3236089	175,0	110,5	61,2	0,4	0,3	7,4	260,5	0,0	6,8	22,8	2,0	980,4
2009	Total	4	674011	183,9	120,6	64,4	0,5	0,3	4,7	646,2	0,0	10,2	42,8	2,2	1110,0
2009	Total	5	259080	26,3	17,6	10,0	0,1	0,1	0,8	649,5	0,0	1,1	87,0	0,4	280,0
2009	Total	6	513019	27,9	17,8	10,7	0,1	0,1	0,6	441,3	0,0	1,0	59,9	0,4	279,2

Year	Source	Category	TSP	PM_{10}	$PM_{2.5}$	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
			tonnes	tonnes	tonnes	kg	kg	kg	kg	kg	kg	kg	kg	kg
2009	Brake wear	1	307	300	120	3,066	3,008	32,257	32217,063		32,288	4247,846	6,133	6182,811
2009	Brake wear	2	111	108	43	1,107	1,086	11,641	11626,702		11,652	1532,990	2,213	2231,293
2009	Brake wear	3	111	109	43	1,111	0,341	18,216	837,319		12,662	45,207	2,221	834,547
2009	Brake wear	4	32	31	12	0,317	0,096	2,031	434,416		5,044	23,173	0,634	296,163
2009	Brake wear	5	2	2	1	0,016	0,016	0,168	168,201		0,169	22,177	0,032	32,280
2009	Brake wear	6	2	2	1	0,022	0,021	0,227	226,226		0,227	29,828	0,043	43,415
2009	Road abrasion	1	612	306	165	0,000	0,058	12,152	6,118	0,035	9,721	28,797	0,000	46,270
2009	Road abrasion	2	122	61	33	0,000	0,012	2,424	1,220	0,007	1,939	5,744	0,000	9,229
2009	Road abrasion	3	243	122	66	0,000	0,023	4,823	2,428	0,014	3,858	11,430	0,000	18,365
2009	Road abrasion	4	51	26	14	0,000	0,005	1,017	0,512	0,003	0,813	2,409	0,000	3,871
2009	Road abrasion	5	2	1	0	0,000	0,000	0,031	0,016	0,000	0,025	0,073	0,000	0,117
2009	Road abrasion	6	3	2	1	0,000	0,000	0,061	0,031	0,000	0,049	0,145	0,000	0,233
2009	Tyre wear	1	442	265	186	0,354	1,150	1,592	6,899		11,278	35,602	8,845	4836,610
2009	Tyre wear	2	140	84	59	0,112	0,363	0,503	2,181		3,565	11,253	2,796	1528,698
2009	Tyre wear	3	212	127	89	0,170	0,552	0,764	3,309		5,409	17,076	4,243	2319,820
2009	Tyre wear	4	41	25	17	0,033	0,107	0,148	0,639		1,045	3,299	0,820	448,105
2009	Tyre wear	5	4	2	2	0,003	0,010	0,013	0,057		0,094	0,295	0,073	40,138
2009	Tyre wear	6	9	5	4	0,007	0,024	0,033	0,142		0,232	0,733	0,182	99,584
2009	Total	1	1361	872	471	3,420	4,216	46,002	32230,079	0,035	53,287	4312,245	14,978	11065,692
2009	Total	2	373	253	135	1,218	1,461	14,568	11630,102	0,007	17,156	1549,987	5,009	3769,220
2009	Total	3	566	358	198	1,280	0,916	23,803	843,056	0,014	21,930	73,713	6,464	3172,732
2009	Total	4	124	81	43	0,350	0,207	3,195	435,567	0,003	6,902	28,881	1,454	748,139
2009	Total	5	7	5	3	0,019	0,025	0,212	168,274	0,000	0,287	22,546	0,105	72,535
2009	Total	6	14	9	5	0,029	0,045	0,320	226,399	0,000	0,508	30,706	0,225	143,232

Exhaust heavy metal emission factors for 1990 and 2009 in CollectER format.

Year	SNAP ID	Category		Fuel type	Arsenic	Cadmium	Chromium	Copper	Mercury	Nickel	Lead	Selenium	Zinc
					mg pr GJ	mg pr GJ	mg pr GJ	mg pr GJ	mg pr GJ	mg pr GJ	mg pr GJ	mg pr GJ	mg pr GJ
1990	070101	Passenger cars	Highway	Diesel	0,002	0,287	0,914	0,648	0,124	0,291	1,727	0,002	57,591
1990	070101	Passenger cars	Highway	Gasoline	0,007	0,266	0,379	1,016	0,199	0,314	1471,982	0,005	52,967
1990	070101	Passenger cars	Highway	LPG	0,000	0,295	0,266	1,034	0,000	0,295	0,886	0,000	59,059
1990	070102	Passenger cars	Rural	Diesel	0,002	0,349	1,068	0,759	0,124	0,352	2,096	0,002	69,910
1990	070102	Passenger cars	Rural	Gasoline	0,007	0,299	0,408	1,132	0,199	0,346	1472,080	0,005	59,541
1990	070102	Passenger cars	Rural	LPG	0,000	0,354	0,319	1,240	0,000	0,354	1,063	0,000	70,871
1990	070103	Passenger cars	Urban	Diesel	0,002	0,214	0,731	0,516	0,124	0,217	1,287	0,002	42,946
1990	070103	Passenger cars	Urban	Gasoline	0,007	0,196	0,316	0,774	0,199	0,244	1471,774	0,005	39,083
1990	070103	Passenger cars	Urban	LPG	0,000	0,217	0,195	0,758	0,000	0,217	0,650	0,000	43,335
1990	070201	Light duty vehicles	Highway	Diesel	0,002	0,190	0,672	0,474	0,124	0,194	1,147	0,002	38,267
1990	070201	Light duty vehicles	Highway	Gasoline	0,007	0,245	0,360	0,944	0,199	0,293	1471,920	0,005	48,812
1990	070201	Light duty vehicles	Highway	LPG	0,000	0,195	0,175	0,681	0,000	0,195	0,584	0,000	38,924
1990	070202	Light duty vehicles	Rural	Diesel	0,002	0,208	0,717	0,506	0,124	0,212	1,254	0,002	41,830
1990	070202	Light duty vehicles	Rural	Gasoline	0,007	0,231	0,348	0,896	0,199	0,279	1471,878	0,005	46,074
1990	070202	Light duty vehicles	Rural	LPG	0,000	0,234	0,210	0,817	0,000	0,234	0,701	0,000	46,709
1990	070203	Light duty vehicles	Urban	Diesel	0,002	0,153	0,579	0,407	0,124	0,157	0,924	0,002	30,817
1990	070203	Light duty vehicles	Urban	Gasoline	0,007	0,137	0,263	0,565	0,199	0,185	1471,595	0,005	27,191
1990	070203	Light duty vehicles	Urban	LPG	0,000	0,143	0,128	0,500	0,000	0,143	0,428	0,000	28,551
1990	070301	Heavy duty vehicles	Highway	Diesel	0,002	0,148	0,566	0,397	0,124	0,151	0,891	0,002	29,743
1990	070301	Heavy duty vehicles	Highway	Gasoline	0,007	0,207	0,326	0,812	0,199	0,255	1471,806	0,005	41,266
1990	070302	Heavy duty vehicles	Rural	Diesel	0,002	0,137	0,539	0,379	0,124	0,141	0,829	0,002	27,650
1990	070302	Heavy duty vehicles	Rural	Gasoline	0,007	0,221	0,338	0,859	0,199	0,269	1471,847	0,005	43,989
1990	070303	Heavy duty vehicles	Urban	Diesel	0,002	0,106	0,461	0,322	0,124	0,109	0,640	0,002	21,359
1990	070303	Heavy duty vehicles	Urban	Gasoline	0,007	0,146	0,271	0,597	0,199	0,194	1471,622	0,005	29,002
1990	070400	Mopeds	Urban	Gasoline	0,007	0,005	0,144	0,103	0,199	0,053	1471,199	0,005	0,753
1990	070501	Motorcycles	Highway	Gasoline	0,007	0,106	0,235	0,456	0,199	0,153	1471,501	0,005	20,940
1990	070502	Motorcycles	Rural	Gasoline	0,007	0,128	0,255	0,536	0,199	0,176	1471,570	0,005	25,500
1990	070503	Motorcycles	Urban	Gasoline	0,007	0,125	0,252	0,524	0,199	0,173	1471,560	0,005	24,847
1990	080100	Military		AvGas	0,007	0,253	0,367	0,972	0,198	0,301	12785,388	0,005	50,452
1990	080100	Military		Diesel	0,002	0,186	0,660	0,465	0,124	0,189	1,118	0,002	37,295
1990	080100	Military		Gasoline	0,007	0,253	0,367	0,972	0,198	0,301	0,773	0,005	50,452
1990	080100	Military		Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080200	Railways		Diesel	0,002	0,186	0,660	0,465	0,124	0,189	1,118	0,002	37,295
1990	080200	Railways		Kerosene	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000

Continued												
1990	080300	Inland waterways	Diesel	0,002	0,186	0,660	0,465	0,124	0,189	1,118	0,002	37,295
1990	080300	Inland waterways	Gasoline	0,007	0,253	0,367	0,972	0,198	0,301	0,773	0,005	50,452
1990	080402	National sea traffic	Diesel	1,171	0,234	0,937	1,171	1,170	1,639	2,340	4,684	11,710
1990	080402	National sea traffic	Kerosene	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080402	National sea traffic	LPG	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080402	National sea traffic	Residual oil	12,225	0,733	4,890	12,225	0,490	733,496	4,890	9,780	22,005
1990	080403	Fishing	Diesel	1,171	0,234	0,937	1,171	1,170	1,639	2,340	4,684	11,710
1990	080403	Fishing	Kerosene	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080403	Fishing	LPG	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080404	International sea traffic	Diesel	1,171	0,234	0,937	1,171	1,170	1,639	2,340	4,684	11,710
1990	080404	International sea traffic	Residual oil	12,225	0,733	4,890	12,225	0,490	733,496	4,890	9,780	22,005
1990	080501	Air traffic, Dom. < 3000 ft.	AvGas	0,007	0,253	0,367	0,972	0,198	0,301	13505,692	0,005	50,452
1990	080501	Air traffic, Dom. < 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080502	Air traffic, Int. < 3000 ft.	AvGas	0,007	0,253	0,367	0,972	0,198	0,301	13505,692	0,005	50,452
1990	080502	Air traffic, Int. < 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080503	Air traffic, Dom. > 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080504	Air traffic, Int. > 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080600	Agriculture	Diesel	0,002	0,186	0,660	0,465	0,124	0,189	1,118	0,002	37,295
1990	080600	Agriculture	Gasoline	0,007	0,253	0,367	0,972	0,198	0,301	0,773	0,005	50,452
1990	080700	Forestry	Diesel	0,002	0,186	0,660	0,465	0,124	0,189	1,118	0,002	37,295
1990	080700	Forestry	Gasoline	0,007	0,253	0,367	0,972	0,198	0,301	0,773	0,005	50,452
1990	080800	Industry	Diesel	0,002	0,186	0,660	0,465	0,124	0,189	1,118	0,002	37,295
1990	080800	Industry	Gasoline	0,007	0,253	0,367	0,972	0,198	0,301	0,773	0,005	50,452
1990	080800	Industry	LPG	0,000	0,131	0,118	0,457	0,000	0,131	0,392	0,000	26,126
1990	080900	Household and gardening	Gasoline	0,007	0,253	0,367	0,972	0,198	0,301	0,773	0,005	50,452
1990	081100	Commercial and institutional	Gasoline	0,007	0,253	0,367	0,972	0,198	0,301	0,773	0,005	50,452
1990	080501	Air traffic, Dom. < 3000 ft.	AvGas	0,007	0,253	0,367	0,972	0,198	0,301	13505,692	0,005	50,452
1990	080501	Air traffic, Dom. < 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080502	Air traffic, Int. < 3000 ft.	AvGas	0,007	0,253	0,367	0,972	0,198	0,301	13505,692	0,005	50,452
1990	080502	Air traffic, Int. < 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080503	Air traffic, Dom. > 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080504	Air traffic, Int. > 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000

Year	SNAP ID	Category		Fuel type	Arsenic	Cadmium	Chromium	Copper	Mercury	Nickel	Lead	Selenium	Zinc
					mg pr GJ	mg pr GJ	mg pr GJ	mg pr GJ	mg pr GJ	mg pr GJ	mg pr GJ	mg pr GJ	mg pr GJ
2009	070101	Passenger cars	Highway	Diesel	0,002	0,262	0,852	0,603	0,124	0,266	1,578	0,002	52,645
2009	070101	Passenger cars	Highway	Gasoline	0,007	0,287	0,398	1,091	0,198	0,335	0,875	0,005	57,253
2009	070101	Passenger cars	Highway	LPG	0,000	0,267	0,241	0,936	0,000	0,267	0,802	0,000	53,465
2009	070102	Passenger cars	Rural	Diesel	0,002	0,280	0,896	0,635	0,124	0,283	1,684	0,002	56,180
2009	070102	Passenger cars	Rural	Gasoline	0,007	0,303	0,412	1,147	0,198	0,351	0,922	0,005	60,419
2009	070102	Passenger cars	Rural	LPG	0,000	0,320	0,288	1,122	0,000	0,320	0,961	0,000	64,099
2009	070103	Passenger cars	Urban	Diesel	0,002	0,209	0,719	0,508	0,124	0,213	1,261	0,002	42,065
2009	070103	Passenger cars	Urban	Gasoline	0,007	0,206	0,325	0,808	0,198	0,254	0,632	0,005	41,050
2009	070103	Passenger cars	Urban	LPG	0,000	0,224	0,201	0,782	0,000	0,224	0,671	0,000	44,710
2009	070201	Light duty vehicles	Highway	Diesel	0,002	0,211	0,723	0,511	0,124	0,214	1,270	0,002	42,370
2009	070201	Light duty vehicles	Highway	Gasoline	0,007	0,221	0,339	0,861	0,198	0,269	0,678	0,005	44,114
2009	070201	Light duty vehicles	Highway	LPG	0,000	0,152	0,137	0,531	0,000	0,152	0,455	0,000	30,365
2009	070202	Light duty vehicles	Rural	Diesel	0,002	0,231	0,772	0,546	0,124	0,234	1,389	0,002	46,318
2009	070202	Light duty vehicles	Rural	Gasoline	0,007	0,209	0,328	0,819	0,198	0,257	0,641	0,005	41,686
2009	070202	Light duty vehicles	Rural	LPG	0,000	0,182	0,164	0,637	0,000	0,182	0,546	0,000	36,399
2009	070203	Light duty vehicles	Urban	Diesel	0,002	0,165	0,608	0,428	0,124	0,168	0,993	0,002	33,119
2009	070203	Light duty vehicles	Urban	Gasoline	0,007	0,122	0,249	0,514	0,198	0,170	0,380	0,005	24,287
2009	070203	Light duty vehicles	Urban	LPG	0,000	0,131	0,118	0,457	0,000	0,131	0,392	0,000	26,126
2009	070301	Heavy duty vehicles	Highway	Diesel	0,002	0,146	0,561	0,394	0,124	0,150	0,882	0,002	29,416
2009	070301	Heavy duty vehicles	Highway	Gasoline	0,007	0,247	0,362	0,951	0,198	0,295	0,755	0,005	49,253
2009	070302	Heavy duty vehicles	Rural	Diesel	0,002	0,134	0,532	0,373	0,124	0,138	0,811	0,002	27,052
2009	070302	Heavy duty vehicles	Rural	Gasoline	0,007	0,279	0,391	1,064	0,198	0,327	0,852	0,005	55,722
2009	070303	Heavy duty vehicles	Urban	Diesel	0,002	0,105	0,459	0,320	0,124	0,109	0,635	0,002	21,206
2009	070303	Heavy duty vehicles	Urban	Gasoline	0,007	0,190	0,311	0,753	0,198	0,238	0,585	0,005	37,931
2009	070400	Mopeds	Urban	Gasoline	0,007	0,005	0,143	0,102	0,198	0,052	0,027	0,005	0,751
2009	070501	Motorcycles	Highway	Gasoline	0,007	0,136	0,261	0,561	0,198	0,183	0,420	0,005	26,963
2009	070502	Motorcycles	Rural	Gasoline	0,007	0,164	0,287	0,662	0,198	0,212	0,507	0,005	32,730
2009	070503	Motorcycles	Urban	Gasoline	0,007	0,160	0,284	0,648	0,198	0,208	0,495	0,005	31,925
2009	080100	Military		AvGas	0,007	0,253	0,367	0,972	0,198	0,301	12785,390	0,005	50,452
2009	080100	Military		Diesel	0,002	0,186	0,660	0,465	0,124	0,189	1,118	0,002	37,295
2009	080100	Military		Gasoline	0,007	0,253	0,367	0,972	0,198	0,301	0,773	0,005	50,452
2009	080100	Military		Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080200	Railways		Diesel	0,002	0,186	0,660	0,465	0,124	0,189	1,118	0,002	37,295
2009	080300	Inland waterways		Diesel	0,002	0,186	0,660	0,465	0,124	0,189	1,118	0,002	37,295
2009	080300	Inland waterways		Gasoline	0,007	0,253	0,367	0,972	0,198	0,301	0,773	0,005	50,452

Continued												
2009	080402	National sea traffic	Diesel	1,170	0,230	0,940	1,170	1,170	1,640	2,340	4,680	11,710
2009	080402	National sea traffic	Residual oil	12,220	0,730	4,890	12,220	0,490	733,500	4,890	9,780	22,000
2009	080403	Fishing	Diesel	1,170	0,230	0,940	1,170	1,170	1,640	2,340	4,680	11,710
2009	080403	Fishing	LPG	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080404	International sea traffic	Diesel	1,170	0,230	0,940	1,170	1,170	1,640	2,340	4,680	11,710
2009	080404	International sea traffic	Residual oil	12,220	0,730	4,890	12,220	0,490	733,500	4,890	9,780	22,000
2009	080501	Air traffic, Dom. < 3000 ft.	AvGas	0,007	0,253	0,367	0,972	0,198	0,301	13505,692	0,005	50,452
2009	080501	Air traffic, Dom. < 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080502	Air traffic, Int. < 3000 ft.	AvGas	0,007	0,253	0,367	0,972	0,198	0,301	13505,692	0,005	50,452
2009	080502	Air traffic, Int. < 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080503	Air traffic, Dom. > 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080504	Air traffic, Int. > 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080600	Agriculture	Diesel	0,002	0,186	0,660	0,465	0,124	0,189	1,118	0,002	37,295
2009	080600	Agriculture	Gasoline	0,007	0,253	0,367	0,972	0,198	0,301	0,773	0,005	50,452
2009	080700	Forestry	Diesel	0,002	0,186	0,660	0,465	0,124	0,189	1,118	0,002	37,295
2009	080700	Forestry	Gasoline	0,007	0,253	0,367	0,972	0,198	0,301	0,773	0,005	50,452
2009	080800	Industry	Diesel	0,002	0,186	0,660	0,465	0,124	0,189	1,118	0,002	37,295
2009	080800	Industry	Gasoline	0,007	0,253	0,367	0,972	0,198	0,301	0,773	0,005	50,452
2009	080800	Industry	LPG	0,000	0,131	0,118	0,457	0,000	0,131	0,392	0,000	26,126
2009	080900	Household and gardening	Gasoline	0,007	0,253	0,367	0,972	0,198	0,301	0,773	0,005	50,452
2009	081100	Commercial and institutional	Gasoline	0,007	0,253	0,367	0,972	0,198	0,301	0,773	0,005	50,452
2009	080501	Air traffic, Dom. < 3000 ft.	AvGas	0,007	0,253	0,367	0,972	0,198	0,301	13505,692	0,005	50,452
2009	080501	Air traffic, Dom. < 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080502	Air traffic, Int. < 3000 ft.	AvGas	0,007	0,253	0,367	0,972	0,198	0,301	13505,692	0,005	50,452
2009	080502	Air traffic, Int. < 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080503	Air traffic, Dom. > 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080504	Air traffic, Int. > 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000

Heavy metal emissions for 1990 and 2009 in CollectER format.

Year	SNAP ID	Category		Fuel type	Arsenic	Cadmium	Chromium	Copper	Mercury	Nickel	Lead	Selenium	Zinc
					kg	kg	kg	kg	kg	kg	kg	kg	kg
1990	070101	Passenger cars	Highway	Diesel	0,003	0,352	1,120	0,795	0,152	0,356	2,117	0,003	70,620
1990	070101	Passenger cars	Highway	Gasoline	0,072	2,796	3,988	10,701	2,091	3,301	15496,108	0,048	557,602
1990	070101	Passenger cars	Highway	LPG	0,000	0,003	0,003	0,011	0,000	0,003	0,009	0,000	0,627
1990	070102	Passenger cars	Rural	Diesel	0,006	0,894	2,737	1,945	0,318	0,903	5,374	0,006	179,223
1990	070102	Passenger cars	Rural	Gasoline	0,163	7,092	9,703	26,885	4,719	8,232	34976,787	0,108	1414,691
1990	070102	Passenger cars	Rural	LPG	0,000	0,008	0,007	0,028	0,000	0,008	0,024	0,000	1,593
1990	070103	Passenger cars	Urban	Diesel	0,008	0,705	2,408	1,701	0,409	0,716	4,242	0,008	141,519
1990	070103	Passenger cars	Urban	Gasoline	0,196	5,625	9,067	22,173	5,694	6,999	42189,428	0,131	1120,333
1990	070103	Passenger cars	Urban	LPG	0,000	0,006	0,006	0,022	0,000	0,006	0,019	0,000	1,253
1990	070201	Light duty vehicles	Highway	Diesel	0,004	0,350	1,237	0,872	0,228	0,357	2,111	0,004	70,421
1990	070201	Light duty vehicles	Highway	Gasoline	0,002	0,065	0,095	0,250	0,053	0,077	389,467	0,001	12,916
1990	070201	Light duty vehicles	Highway	LPG	0,000	0,001	0,001	0,005	0,000	0,001	0,004	0,000	0,293
1990	070202	Light duty vehicles	Rural	Diesel	0,014	1,226	4,218	2,979	0,731	1,246	7,381	0,014	246,220
1990	070202	Light duty vehicles	Rural	Gasoline	0,007	0,227	0,342	0,880	0,195	0,274	1445,356	0,004	45,243
1990	070202	Light duty vehicles	Rural	LPG	0,000	0,005	0,005	0,018	0,000	0,005	0,015	0,000	1,027
1990	070203	Light duty vehicles	Urban	Diesel	0,014	0,889	3,361	2,363	0,720	0,909	5,361	0,014	178,871
1990	070203	Light duty vehicles	Urban	Gasoline	0,008	0,167	0,320	0,689	0,242	0,225	1793,089	0,006	33,131
1990	070203	Light duty vehicles	Urban	LPG	0,000	0,004	0,003	0,013	0,000	0,004	0,011	0,000	0,743
1990	070301	Heavy duty vehicles	Highway	Diesel	0,022	1,411	5,401	3,795	1,185	1,445	8,512	0,022	284,015
1990	070301	Heavy duty vehicles	Highway	Gasoline	0,000	0,010	0,015	0,038	0,009	0,012	68,787	0,000	1,929
1990	070302	Heavy duty vehicles	Rural	Diesel	0,039	2,298	9,028	6,336	2,077	2,357	13,867	0,039	462,772
1990	070302	Heavy duty vehicles	Rural	Gasoline	0,001	0,018	0,028	0,070	0,016	0,022	120,180	0,000	3,592
1990	070303	Heavy duty vehicles	Urban	Diesel	0,031	1,381	6,011	4,200	1,619	1,427	8,347	0,031	278,638
1990	070303	Heavy duty vehicles	Urban	Gasoline	0,001	0,011	0,021	0,046	0,015	0,015	112,955	0,000	2,226
1990	070400	Mopeds	Urban	Gasoline	0,002	0,001	0,042	0,030	0,058	0,015	427,859	0,001	0,219
1990	070501	Motorcycles	Highway	Gasoline	0,000	0,006	0,013	0,026	0,011	0,009	82,913	0,000	1,180
1990	070502	Motorcycles	Rural	Gasoline	0,001	0,017	0,034	0,072	0,027	0,024	198,768	0,001	3,444
1990	070503	Motorcycles	Urban	Gasoline	0,001	0,022	0,044	0,091	0,034	0,030	255,141	0,001	4,308
1990	080100	Military		AvGas	0,000	0,001	0,002	0,005	0,001	0,001	62,821	0,000	0,248
1990	080100	Military		Diesel	0,000	0,027	0,096	0,068	0,018	0,028	0,163	0,000	5,451
1990	080100	Military		Gasoline	0,000	0,000	0,000	0,001	0,000	0,000	0,001	0,000	0,050
1990	080100	Military		Jet fuel		0,000	0,000	0,000		0,000		0,000	0,000
1990	080200	Railways		Diesel	0,009	0,744	2,645	1,865	0,497	0,758	4,483	0,009	149,554
1990	080200	Railways		Gasoline		0,000	0,000	0,000		0,000	0,000	0,000	0,000

Continued

1990	080300	Inland waterways	Diesel	0,001	0,064	0,226	0,159	0,042	0,065	0,383	0,001	12,778
1990	080300	Inland waterways	Gasoline	0,002	0,078	0,113	0,301	0,061	0,093	0,239	0,001	15,597
1990	080402	National sea traffic	Diesel	6,189	1,238	4,951	6,189	6,184	8,665	12,368	24,756	61,890
1990	080402	National sea traffic	Residual oil	55,884	3,353	22,353	55,884	2,240	3353,024	22,354	44,707	100,591
1990	080403	Fishing	Diesel	9,274	1,855	7,419	9,274	9,266	12,983	18,533	37,096	92,739
1990	080403	Fishing	Gasoline		0,000	0,000	0,000		0,000	0,000	0,000	0,000
1990	080403	Fishing	Residual oil	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080404	International sea traffic	Diesel	13,220	2,644	10,576	13,220	13,209	18,507	26,417	52,878	132,196
1990	080404	International sea traffic	Residual oil	340,032	20,402	136,013	340,032	13,629	20401,916	136,013	272,026	612,057
1990	080501	Air traffic, Dom. < 3000 ft.	AvGas	0,001	0,027	0,039	0,102	0,021	0,032	1417,384	0,000	5,295
1990	080501	Air traffic, Dom. < 3000 ft.	Jet fuel		0,000	0,000	0,000		0,000		0,000	0,000
1990	080502	Air traffic, Int. < 3000 ft.	AvGas	0,000	0,008	0,011	0,030	0,006	0,009	414,079	0,000	1,547
1990	080502	Air traffic, Int. < 3000 ft.	Jet fuel		0,000	0,000	0,000		0,000		0,000	0,000
1990	080503	Air traffic, Dom. > 3000 ft.	Jet fuel		0,000	0,000	0,000		0,000		0,000	0,000
1990	080504	Air traffic, Int. > 3000 ft.	Jet fuel		0,000	0,000	0,000		0,000		0,000	0,000
1990	080600	Agriculture	Diesel	0,039	3,061	10,883	7,674	2,045	3,119	18,442	0,039	615,231
1990	080600	Agriculture	Gasoline	0,005	0,179	0,260	0,689	0,140	0,213	0,548	0,003	35,764
1990	080700	Forestry	Diesel	0,000	0,027	0,096	0,068	0,018	0,027	0,162	0,000	5,421
1990	080700	Forestry	Gasoline	0,002	0,086	0,125	0,332	0,068	0,103	0,264	0,002	17,226
1990	080800	Industry	Diesel	0,024	1,885	6,702	4,725	1,259	1,920	11,356	0,024	378,860
1990	080800	Industry	Gasoline	0,001	0,044	0,064	0,170	0,035	0,053	0,135	0,001	8,841
1990	080800	Industry	LPG	0,000	0,155	0,139	0,542	0,000	0,155	0,464	0,000	30,956
1990	080900	Household and gardening	Gasoline	0,004	0,135	0,196	0,520	0,106	0,161	0,414	0,002	26,999
1990	081100	Commercial and institutional	Gasoline	0,007	0,256	0,371	0,982	0,200	0,304	0,780	0,005	50,948
1990	080501	Air traffic, Dom. < 3000 ft.	AvGas	0,000	0,002	0,003	0,008	0,002	0,003	116,719	0,000	0,436
1990	080501	Air traffic, Dom. < 3000 ft.	Jet fuel		0,000	0,000	0,000		0,000		0,000	0,000
1990	080502	Air traffic, Int. < 3000 ft.	AvGas	0,000	0,001	0,002	0,005	0,001	0,002	75,798	0,000	0,283
1990	080502	Air traffic, Int. < 3000 ft.	Jet fuel		0,000	0,000	0,000		0,000		0,000	0,000
1990	080503	Air traffic, Dom. > 3000 ft.	Jet fuel		0,000	0,000	0,000		0,000		0,000	0,000
1990	080504	Air traffic, Int. > 3000 ft.	Jet fuel		0,000	0,000	0,000		0,000		0,000	0,000

Year	SNAP ID	Category		Fuel type	Arsenic	Cadmium	Chromium	Copper	Mercury	Nickel	Lead	Selenium	Zinc
					kg	kg	kg	kg	kg	kg	kg	kg	kg
2009	070101	Passenger cars	Highway	Diesel	0,015	1,654	5,370	3,805	0,782	1,676	9,954	0,015	332,003
2009	070101	Passenger cars	Highway	Gasoline	0,078	3,291	4,559	12,510	2,270	3,839	10,030	0,052	656,376
2009	070101	Passenger cars	Highway	LPG	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,006
2009	070102	Passenger cars	Rural	Diesel	0,032	3,833	12,265	8,696	1,697	3,881	23,064	0,032	769,243
2009	070102	Passenger cars	Rural	Gasoline	0,172	7,623	10,366	28,856	4,984	8,826	23,212	0,115	1520,518
2009	070102	Passenger cars	Rural	LPG	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,014
2009	070103	Passenger cars	Urban	Diesel	0,032	2,834	9,738	6,878	1,678	2,882	17,070	0,032	569,432
2009	070103	Passenger cars	Urban	Gasoline	0,188	5,669	8,935	22,221	5,448	6,984	17,383	0,125	1129,420
2009	070103	Passenger cars	Urban	LPG	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,010
2009	070201	Light duty vehicles	Highway	Diesel	0,007	0,670	2,297	1,623	0,394	0,681	4,035	0,007	134,591
2009	070201	Light duty vehicles	Highway	Gasoline	0,002	0,073	0,111	0,284	0,065	0,089	0,223	0,001	14,522
2009	070201	Light duty vehicles	Highway	LPG	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,007
2009	070202	Light duty vehicles	Rural	Diesel	0,022	2,138	7,160	5,064	1,149	2,170	12,871	0,022	429,331
2009	070202	Light duty vehicles	Rural	Gasoline	0,008	0,233	0,365	0,912	0,220	0,286	0,714	0,005	46,411
2009	070202	Light duty vehicles	Rural	LPG	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,023
2009	070203	Light duty vehicles	Urban	Diesel	0,021	1,456	5,370	3,780	1,096	1,487	8,775	0,021	292,773
2009	070203	Light duty vehicles	Urban	Gasoline	0,009	0,161	0,328	0,677	0,261	0,224	0,500	0,006	31,953
2009	070203	Light duty vehicles	Urban	LPG	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,015
2009	070301	Heavy duty vehicles	Highway	Diesel	0,026	1,645	6,316	4,437	1,395	1,684	9,922	0,026	331,068
2009	070301	Heavy duty vehicles	Highway	Gasoline	0,000	0,008	0,012	0,032	0,007	0,010	0,026	0,000	1,667
2009	070302	Heavy duty vehicles	Rural	Diesel	0,042	2,441	9,662	6,778	2,252	2,505	14,732	0,042	491,624
2009	070302	Heavy duty vehicles	Rural	Gasoline	0,000	0,016	0,022	0,061	0,011	0,019	0,049	0,000	3,199
2009	070303	Heavy duty vehicles	Urban	Diesel	0,030	1,358	5,927	4,141	1,602	1,404	8,211	0,030	274,093
2009	070303	Heavy duty vehicles	Urban	Gasoline	0,000	0,010	0,016	0,040	0,010	0,013	0,031	0,000	2,006
2009	070400	Mopeds	Urban	Gasoline	0,001	0,001	0,030	0,021	0,041	0,011	0,006	0,001	0,157
2009	070501	Motorcycles	Highway	Gasoline	0,001	0,016	0,031	0,066	0,023	0,022	0,049	0,001	3,161
2009	070502	Motorcycles	Rural	Gasoline	0,002	0,042	0,074	0,171	0,051	0,055	0,131	0,001	8,433
2009	070503	Motorcycles	Urban	Gasoline	0,002	0,050	0,088	0,201	0,061	0,065	0,153	0,001	9,898
2009	080100	Military		AvGas	0,000	0,001	0,002	0,005	0,001	0,002	64,411	0,000	0,254
2009	080100	Military		Diesel	0,003	0,204	0,725	0,511	0,136	0,208	1,229	0,003	40,989
2009	080100	Military		Gasoline	0,000	0,002	0,003	0,009	0,002	0,003	0,007	0,000	0,446
2009	080100	Military		Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080200	Railways		Diesel	0,007	0,577	2,052	1,447	0,386	0,588	3,478	0,007	116,019
2009	080200	Railways		Gasoline		0,000	0,000	0,000		0,000	0,000	0,000	0,000
2009	080300	Inland waterways		Diesel	0,002	0,186	0,661	0,466	0,124	0,189	1,120	0,002	37,375

Continued

2009	080300	Inland waterways	Gasoline	0,002	0,089	0,130	0,343	0,070	0,106	0,273	0,002	17,807
2009	080402	National sea traffic	Diesel	5,048	0,992	4,056	5,048	5,048	7,076	10,097	20,193	50,526
2009	080402	National sea traffic	Residual oil	27,975	1,671	11,195	27,975	1,122	1679,189	11,195	22,389	50,364
2009	080403	Fishing	Diesel	8,795	1,729	7,066	8,795	8,795	12,327	17,589	35,178	88,020
2009	080403	Fishing	Gasoline		0,000	0,000	0,000		0,000	0,000	0,000	0,000
2009	080403	Fishing	Residual oil	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080404	International sea traffic	Diesel	11,892	2,338	9,554	11,892	11,892	16,669	23,783	47,567	119,018
2009	080404	International sea traffic	Residual oil	115,068	6,874	46,046	115,068	4,614	6906,919	46,046	92,092	207,160
2009	080501	Air traffic, Dom. < 3000 ft.	AvGas	0,000	0,018	0,027	0,071	0,014	0,022	983,322	0,000	3,673
2009	080501	Air traffic, Dom. < 3000 ft.	Jet fuel		0,000	0,000	0,000		0,000	0,000	0,000	0,000
2009	080502	Air traffic, Int. < 3000 ft.	AvGas	0,000	0,001	0,001	0,003	0,001	0,001	45,460	0,000	0,170
2009	080502	Air traffic, Int. < 3000 ft.	Jet fuel		0,000	0,000	0,000		0,000	0,000	0,000	0,000
2009	080503	Air traffic, Dom. > 3000 ft.	Jet fuel		0,000	0,000	0,000		0,000	0,000	0,000	0,000
2009	080504	Air traffic, Int. > 3000 ft.	Jet fuel		0,000	0,000	0,000		0,000	0,000	0,000	0,000
2009	080600	Agriculture	Diesel	0,039	3,088	10,981	7,743	2,063	3,147	18,609	0,039	620,808
2009	080600	Agriculture	Gasoline	0,003	0,127	0,184	0,487	0,099	0,151	0,387	0,002	25,276
2009	080700	Forestry	Diesel	0,000	0,030	0,105	0,074	0,020	0,030	0,178	0,000	5,932
2009	080700	Forestry	Gasoline	0,000	0,018	0,027	0,071	0,014	0,022	0,056	0,000	3,672
2009	080800	Industry	Diesel	0,024	1,908	6,785	4,784	1,275	1,944	11,497	0,024	383,560
2009	080800	Industry	Gasoline	0,001	0,030	0,043	0,114	0,023	0,035	0,091	0,001	5,936
2009	080800	Industry	LPG	0,000	0,107	0,096	0,374	0,000	0,107	0,320	0,000	21,346
2009	080900	Household and gardening	Gasoline	0,006	0,218	0,317	0,838	0,171	0,259	0,667	0,004	43,514
2009	081100	Commercial and institutional	Gasoline	0,016	0,604	0,877	2,322	0,473	0,719	1,846	0,011	120,506
2009	080501	Air traffic, Dom. < 3000 ft.	AvGas	0,000	0,000	0,000	0,001	0,000	0,000	7,876	0,000	0,029
2009	080501	Air traffic, Dom. < 3000 ft.	Jet fuel		0,000	0,000	0,000		0,000		0,000	0,000
2009	080502	Air traffic, Int. < 3000 ft.	AvGas	0,000	0,000	0,000	0,000	0,000	0,000	6,621	0,000	0,025
2009	080502	Air traffic, Int. < 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080503	Air traffic, Dom. > 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080504	Air traffic, Int. > 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000

PAH emission factors for 1990 and 2009 in CollectER format.

Year	SNAP ID	Category		Fuel type	Dioxins/ µg pr GJ	Flouranthene mg pr GJ	Benzo(b) mg pr GJ	Benzo(k) mg pr GJ	Benzo(a) mg pr GJ	Benzo(g,h,i) mg pr GJ	indeno(1,2,3-c,d) mg pr GJ
1990	070101	Passenger cars	Highway	Diesel	0,001	12,250	0,748	0,678	0,818	1,589	0,771
1990	070101	Passenger cars	Highway	Gasoline	0,013	8,506	0,553	0,425	0,468	1,106	0,425
1990	070101	Passenger cars	Highway	LPG	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	070102	Passenger cars	Rural	Diesel	0,001	14,889	0,909	0,824	0,994	1,932	0,937
1990	070102	Passenger cars	Rural	Gasoline	0,015	9,539	0,620	0,477	0,524	1,240	0,477
1990	070102	Passenger cars	Rural	LPG	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	070103	Passenger cars	Urban	Diesel	0,001	9,303	0,568	0,515	0,621	1,207	0,586
1990	070103	Passenger cars	Urban	Gasoline	0,010	6,426	0,418	0,321	0,353	0,835	0,321
1990	070103	Passenger cars	Urban	LPG	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	070201	Light duty vehicles	Highway	Diesel	0,000	8,505	0,519	0,470	0,568	1,104	0,536
1990	070201	Light duty vehicles	Highway	Gasoline	0,013	8,086	0,526	0,404	0,445	1,051	0,404
1990	070201	Light duty vehicles	Highway	LPG	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	070202	Light duty vehicles	Rural	Diesel	0,001	9,306	0,568	0,515	0,622	1,207	0,586
1990	070202	Light duty vehicles	Rural	Gasoline	0,012	7,625	0,495	0,381	0,419	0,991	0,381
1990	070202	Light duty vehicles	Rural	LPG	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	070203	Light duty vehicles	Urban	Diesel	0,000	6,954	0,425	0,385	0,464	0,902	0,438
1990	070203	Light duty vehicles	Urban	Gasoline	0,007	4,558	0,296	0,228	0,251	0,592	0,228
1990	070203	Light duty vehicles	Urban	LPG	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	070301	Heavy duty vehicles	Highway	Diesel	0,001	2,086	0,526	0,780	0,097	0,078	0,136
1990	070301	Heavy duty vehicles	Highway	Gasoline	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	070302	Heavy duty vehicles	Rural	Diesel	0,001	2,208	0,557	0,825	0,103	0,082	0,144
1990	070302	Heavy duty vehicles	Rural	Gasoline	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	070303	Heavy duty vehicles	Urban	Diesel	0,001	1,788	0,451	0,668	0,083	0,067	0,117
1990	070303	Heavy duty vehicles	Urban	Gasoline	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	070400	Mopeds	Urban	Gasoline	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	070501	Motorcycles	Highway	Gasoline	0,020	12,673	0,824	0,634	0,697	1,647	0,634
1990	070502	Motorcycles	Rural	Gasoline	0,024	15,176	0,986	0,759	0,834	1,973	0,759
1990	070503	Motorcycles	Urban	Gasoline	0,024	15,300	0,994	0,765	0,841	1,989	0,765
1990	080100	Military		AvGas	0,005	4,329	0,209	0,071	0,114	0,689	0,245
1990	080100	Military		Diesel	0,001	4,391	0,571	0,568	0,290	0,550	0,290
1990	080100	Military		Gasoline	0,006	5,257	0,277	0,116	0,142	0,825	0,300
1990	080100	Military		Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080200	Railways		Diesel	0,001	1,366	0,348	0,389	0,057	0,049	0,089
1990	080200	Railways		Kerosene	0,000	0,000	0,000	0,000	0,000	0,000	0,000

Continued										
1990	080300	Inland waterways	Diesel	0,001	4,391	0,571	0,568	0,290	0,550	0,290
1990	080300	Inland waterways	Gasoline	0,005	4,329	0,209	0,071	0,114	0,689	0,245
1990	080402	National sea traffic	Diesel	0,012	7,420	0,640	0,300	0,150	1,430	1,180
1990	080402	National sea traffic	Kerosene	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080402	National sea traffic	LPG	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080402	National sea traffic	Residual oil	0,013	5,190	0,270	0,050	0,020	0,070	0,030
1990	080403	Fishing	Diesel	0,012	7,420	0,640	0,300	0,150	1,430	1,180
1990	080403	Fishing	Kerosene	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080403	Fishing	LPG	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080404	International sea traffic	Diesel	0,012	7,420	0,640	0,300	0,150	1,430	1,180
1990	080404	International sea traffic	Residual oil	0,013	4,120	0,200	0,090	0,070	0,260	0,200
1990	080501	Air traffic, Dom. < 3000 ft.	AvGas	0,005	4,329	0,209	0,071	0,114	0,689	0,245
1990	080501	Air traffic, Dom. < 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080502	Air traffic, Int. < 3000 ft.	AvGas	0,005	4,329	0,209	0,071	0,114	0,689	0,245
1990	080502	Air traffic, Int. < 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080503	Air traffic, Dom. > 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080504	Air traffic, Int. > 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080600	Agriculture	Diesel	0,001	4,391	0,571	0,568	0,290	0,550	0,290
1990	080600	Agriculture	Gasoline	0,005	4,329	0,209	0,071	0,114	0,689	0,245
1990	080700	Forestry	Diesel	0,001	4,391	0,571	0,568	0,290	0,550	0,290
1990	080700	Forestry	Gasoline	0,005	4,329	0,209	0,071	0,114	0,689	0,245
1990	080800	Industry	Diesel	0,001	4,391	0,571	0,568	0,290	0,550	0,290
1990	080800	Industry	Gasoline	0,005	4,329	0,209	0,071	0,114	0,689	0,245
1990	080800	Industry	LPG	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080900	Household and gardening	Gasoline	0,005	4,329	0,209	0,071	0,114	0,689	0,245
1990	081100	Commercial and institutional	Gasoline	0,005	4,329	0,209	0,071	0,114	0,689	0,245
1990	080501	Air traffic, Dom. < 3000 ft.	AvGas	0,005	4,329	0,209	0,071	0,114	0,689	0,245
1990	080501	Air traffic, Dom. < 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080502	Air traffic, Int. < 3000 ft.	AvGas	0,005	4,329	0,209	0,071	0,114	0,689	0,245
1990	080502	Air traffic, Int. < 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080503	Air traffic, Dom. > 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080504	Air traffic, Int. > 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000

Year	SNAP ID	Category		Fuel type	Dioxins/ microg pr GJ	Flouranthene mg pr GJ	Benzo(b) mg pr GJ	Benzo(k) mg pr GJ	Benzo(a) mg pr GJ	Benzo(g,h,i) mg pr GJ	indeno(1,2,3-c,d) mg pr GJ
2009	070101	Passenger cars	Highway	Diesel	0,000	12,815	0,782	0,709	0,856	1,663	0,807
2009	070101	Passenger cars	Highway	Gasoline	0,000	1,092	0,206	0,251	0,204	0,412	0,298
2009	070101	Passenger cars	Highway	LPG	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	070102	Passenger cars	Rural	Diesel	0,001	14,593	0,891	0,807	0,975	1,894	0,919
2009	070102	Passenger cars	Rural	Gasoline	0,000	1,208	0,230	0,279	0,227	0,459	0,333
2009	070102	Passenger cars	Rural	LPG	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	070103	Passenger cars	Urban	Diesel	0,001	9,684	0,591	0,536	0,647	1,257	0,610
2009	070103	Passenger cars	Urban	Gasoline	0,000	0,692	0,127	0,154	0,125	0,255	0,183
2009	070103	Passenger cars	Urban	LPG	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	070201	Light duty vehicles	Highway	Diesel	0,001	9,234	0,564	0,511	0,617	1,198	0,581
2009	070201	Light duty vehicles	Highway	Gasoline	0,001	1,041	0,159	0,185	0,155	0,319	0,217
2009	070201	Light duty vehicles	Highway	LPG	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	070202	Light duty vehicles	Rural	Diesel	0,001	10,103	0,617	0,559	0,675	1,311	0,636
2009	070202	Light duty vehicles	Rural	Gasoline	0,001	0,983	0,150	0,175	0,146	0,301	0,205
2009	070202	Light duty vehicles	Rural	LPG	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	070203	Light duty vehicles	Urban	Diesel	0,000	7,261	0,443	0,402	0,485	0,942	0,457
2009	070203	Light duty vehicles	Urban	Gasoline	0,000	0,568	0,087	0,101	0,084	0,174	0,118
2009	070203	Light duty vehicles	Urban	LPG	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	070301	Heavy duty vehicles	Highway	Diesel	0,001	2,030	0,512	0,759	0,095	0,076	0,133
2009	070301	Heavy duty vehicles	Highway	Gasoline	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	070302	Heavy duty vehicles	Rural	Diesel	0,001	2,066	0,521	0,772	0,096	0,077	0,135
2009	070302	Heavy duty vehicles	Rural	Gasoline	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	070303	Heavy duty vehicles	Urban	Diesel	0,001	1,676	0,423	0,626	0,078	0,063	0,110
2009	070303	Heavy duty vehicles	Urban	Gasoline	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	070400	Mopeds	Urban	Gasoline	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	070501	Motorcycles	Highway	Gasoline	0,020	12,799	0,832	0,640	0,704	1,664	0,640
2009	070502	Motorcycles	Rural	Gasoline	0,024	15,331	0,996	0,766	0,843	1,993	0,766
2009	070503	Motorcycles	Urban	Gasoline	0,024	15,500	1,007	0,775	0,852	2,015	0,775
2009	080100	Military		AvGas	0,005	4,329	0,209	0,071	0,114	0,689	0,245
2009	080100	Military		Diesel	0,001	4,350	0,510	0,496	0,256	0,464	0,264
2009	080100	Military		Gasoline	0,007	2,152	0,180	0,115	0,118	0,358	0,179
2009	080100	Military		Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080200	Railways		Diesel	0,001	1,411	0,360	0,402	0,059	0,051	0,092
2009	080300	Inland waterways		Diesel	0,001	4,350	0,510	0,496	0,256	0,464	0,264
2009	080300	Inland waterways		Gasoline	0,005	4,329	0,209	0,071	0,114	0,689	0,245

Continued										
2009	080402	National sea traffic	Diesel	0,012	7,420	0,640	0,300	0,150	1,430	1,180
2009	080402	National sea traffic	Residual oil	0,013	5,190	0,270	0,050	0,020	0,070	0,030
2009	080403	Fishing	Diesel	0,012	7,420	0,640	0,300	0,150	1,430	1,180
2009	080403	Fishing	LPG	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080404	International sea traffic	Diesel	0,012	7,420	0,640	0,300	0,150	1,430	1,180
2009	080404	International sea traffic	Residual oil	0,013	4,120	0,200	0,090	0,070	0,260	0,200
2009	080501	Air traffic, Dom. < 3000 ft.	AvGas	0,005	4,329	0,209	0,071	0,114	0,689	0,245
2009	080501	Air traffic, Dom. < 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080502	Air traffic, Int. < 3000 ft.	AvGas	0,005	4,329	0,209	0,071	0,114	0,689	0,245
2009	080502	Air traffic, Int. < 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080503	Air traffic, Dom. > 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080504	Air traffic, Int. > 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080600	Agriculture	Diesel	0,001	4,350	0,510	0,496	0,256	0,464	0,264
2009	080600	Agriculture	Gasoline	0,005	4,329	0,209	0,071	0,114	0,689	0,245
2009	080700	Forestry	Diesel	0,001	4,350	0,510	0,496	0,256	0,464	0,264
2009	080700	Forestry	Gasoline	0,005	4,329	0,209	0,071	0,114	0,689	0,245
2009	080800	Industry	Diesel	0,001	4,350	0,510	0,496	0,256	0,464	0,264
2009	080800	Industry	Gasoline	0,005	4,329	0,209	0,071	0,114	0,689	0,245
2009	080800	Industry	LPG	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080900	Household and gardening	Gasoline	0,005	4,329	0,209	0,071	0,114	0,689	0,245
2009	081100	Commercial and institutional	Gasoline	0,005	4,329	0,209	0,071	0,114	0,689	0,245
2009	080501	Air traffic, Dom. < 3000 ft.	AvGas	0,005	4,329	0,209	0,071	0,114	0,689	0,245
2009	080501	Air traffic, Dom. < 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080502	Air traffic, Int. < 3000 ft.	AvGas	0,005	4,329	0,209	0,071	0,114	0,689	0,245
2009	080502	Air traffic, Int. < 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080503	Air traffic, Dom. > 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080504	Air traffic, Int. > 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000

PAH emissions for 1990 and 2008 in CollectER format.

Year	SNAP ID	Category		Fuel type	Dioxins/ g	Flouranthene kg	Benzo(b) kg	Benzo(k) kg	Benzo(a) kg	Benzo(g,h,i) kg	indeno(1,2,3-c,d) kg
1990	070101	Passenger cars	Highway	Diesel	0,001	15,021	0,917	0,831	1,003	1,949	0,946
1990	070101	Passenger cars	Highway	Gasoline	0,141	89,544	5,820	4,476	4,924	11,639	4,476
1990	070101	Passenger cars	Highway	LPG							
1990	070102	Passenger cars	Rural	Diesel	0,002	38,171	2,331	2,112	2,549	4,953	2,403
1990	070102	Passenger cars	Rural	Gasoline	0,357	226,652	14,730	11,328	12,462	29,465	11,328
1990	070102	Passenger cars	Rural	LPG							
1990	070103	Passenger cars	Urban	Diesel	0,002	30,655	1,871	1,696	2,047	3,978	1,930
1990	070103	Passenger cars	Urban	Gasoline	0,290	184,212	11,972	9,208	10,131	23,943	9,208
1990	070103	Passenger cars	Urban	LPG							
1990	070201	Light duty vehicles	Highway	Diesel	0,001	15,652	0,955	0,866	1,045	2,031	0,986
1990	070201	Light duty vehicles	Highway	Gasoline	0,003	2,140	0,139	0,107	0,118	0,278	0,107
1990	070201	Light duty vehicles	Highway	LPG	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	070202	Light duty vehicles	Rural	Diesel	0,003	54,776	3,344	3,031	3,659	7,108	3,449
1990	070202	Light duty vehicles	Rural	Gasoline	0,012	7,488	0,487	0,374	0,412	0,973	0,374
1990	070202	Light duty vehicles	Rural	LPG	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	070203	Light duty vehicles	Urban	Diesel	0,002	40,364	2,464	2,233	2,696	5,237	2,542
1990	070203	Light duty vehicles	Urban	Gasoline	0,009	5,554	0,361	0,278	0,305	0,722	0,278
1990	070203	Light duty vehicles	Urban	LPG	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	070301	Heavy duty vehicles	Highway	Diesel	0,010	19,916	5,025	7,445	0,930	0,742	1,302
1990	070301	Heavy duty vehicles	Highway	Gasoline							
1990	070302	Heavy duty vehicles	Rural	Diesel	0,019	36,955	9,325	13,813	1,725	1,380	2,415
1990	070302	Heavy duty vehicles	Rural	Gasoline							
1990	070303	Heavy duty vehicles	Urban	Diesel	0,012	23,322	5,884	8,716	1,088	0,871	1,524
1990	070303	Heavy duty vehicles	Urban	Gasoline							
1990	070400	Mopeds	Urban	Gasoline							
1990	070501	Motorcycles	Highway	Gasoline	0,001	0,714	0,046	0,036	0,039	0,093	0,036
1990	070502	Motorcycles	Rural	Gasoline	0,003	2,050	0,133	0,102	0,113	0,266	0,102
1990	070503	Motorcycles	Urban	Gasoline	0,004	2,653	0,172	0,133	0,146	0,345	0,133
1990	080100	Military		AvGas	0,000	0,021	0,001	0,000	0,001	0,003	0,001
1990	080100	Military		Diesel	0,000	0,642	0,083	0,083	0,042	0,080	0,042
1990	080100	Military		Gasoline	0,000	0,005	0,000	0,000	0,000	0,001	0,000
1990	080100	Military		Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080200	Railways		Diesel	0,003	5,477	1,396	1,559	0,230	0,197	0,358
1990	080200	Railways		Gasoline	0,000	0,000	0,000	0,000	0,000	0,000	0,000

Continued										
1990	080300	Inland waterways	Diesel	0,000	1,505	0,196	0,195	0,099	0,188	0,099
1990	080300	Inland waterways	Gasoline	0,002	1,338	0,065	0,022	0,035	0,213	0,076
1990	080402	National sea traffic	Diesel	0,063	39,218	3,383	1,586	0,793	7,558	6,237
1990	080402	National sea traffic	Residual oil	0,061	23,725	1,234	0,229	0,091	0,320	0,137
1990	080403	Fishing	Diesel	0,095	58,766	5,069	2,376	1,188	11,325	9,346
1990	080403	Fishing	Gasoline	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080403	Fishing	Residual oil	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080404	International sea traffic	Diesel	0,136	83,768	7,225	3,387	1,693	16,144	13,322
1990	080404	International sea traffic	Residual oil	0,373	114,596	5,563	2,503	1,947	7,232	5,563
1990	080501	Air traffic, Dom. < 3000 ft.	AvGas	0,001	0,454	0,022	0,007	0,012	0,072	0,026
1990	080501	Air traffic, Dom. < 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080502	Air traffic, Int. < 3000 ft.	AvGas	0,000	0,133	0,006	0,002	0,003	0,021	0,008
1990	080502	Air traffic, Int. < 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080503	Air traffic, Dom. > 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080504	Air traffic, Int. > 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080600	Agriculture	Diesel	0,012	72,442	9,413	9,375	4,780	9,073	4,786
1990	080600	Agriculture	Gasoline	0,004	3,068	0,148	0,051	0,081	0,488	0,173
1990	080700	Forestry	Diesel	0,000	0,638	0,083	0,083	0,042	0,080	0,042
1990	080700	Forestry	Gasoline	0,002	1,478	0,071	0,024	0,039	0,235	0,084
1990	080800	Industry	Diesel	0,007	44,610	5,797	5,773	2,943	5,587	2,947
1990	080800	Industry	Gasoline	0,001	0,758	0,037	0,012	0,020	0,121	0,043
1990	080800	Industry	LPG							
1990	080900	Household and gardening	Gasoline	0,003	2,316	0,112	0,038	0,061	0,369	0,131
1990	081100	Commercial and institutional	Gasoline	0,005	4,371	0,211	0,072	0,115	0,696	0,247
1990	080501	Air traffic, Dom. < 3000 ft.	AvGas	0,000	0,037	0,002	0,001	0,001	0,006	0,002
1990	080501	Air traffic, Dom. < 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080502	Air traffic, Int. < 3000 ft.	AvGas	0,000	0,024	0,001	0,000	0,001	0,004	0,001
1990	080502	Air traffic, Int. < 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080503	Air traffic, Dom. > 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1990	080504	Air traffic, Int. > 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000

Year	SNAP ID	Category		Fuel type	Dioxins/ g	Flouranthene kg	Benzo(b) kg	Benzo(k) kg	Benzo(a) kg	Benzo(g,h,i) kg	indeno(1,2,3-c,d) kg
2009	070101	Passenger cars	Highway	Diesel	0,000	80,817	4,932	4,471	5,398	10,488	5,089
2009	070101	Passenger cars	Highway	Gasoline	0,004	12,524	2,364	2,873	2,338	4,729	3,421
2009	070101	Passenger cars	Highway	LPG							
2009	070102	Passenger cars	Rural	Diesel	0,011	199,816	12,201	11,057	13,346	25,929	12,583
2009	070102	Passenger cars	Rural	Gasoline	0,010	30,393	5,779	7,030	5,717	11,563	8,374
2009	070102	Passenger cars	Rural	LPG							
2009	070103	Passenger cars	Urban	Diesel	0,008	131,086	8,005	7,253	8,753	17,011	8,255
2009	070103	Passenger cars	Urban	Gasoline	0,007	19,042	3,499	4,231	3,453	7,005	5,032
2009	070103	Passenger cars	Urban	LPG							
2009	070201	Light duty vehicles	Highway	Diesel	0,002	29,332	1,791	1,623	1,959	3,806	1,847
2009	070201	Light duty vehicles	Highway	Gasoline	0,000	0,343	0,052	0,061	0,051	0,105	0,071
2009	070201	Light duty vehicles	Highway	LPG	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	070202	Light duty vehicles	Rural	Diesel	0,005	93,648	5,718	5,182	6,254	12,152	5,896
2009	070202	Light duty vehicles	Rural	Gasoline	0,001	1,095	0,167	0,194	0,163	0,335	0,228
2009	070202	Light duty vehicles	Rural	LPG	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	070203	Light duty vehicles	Urban	Diesel	0,004	64,188	3,919	3,550	4,285	8,329	4,041
2009	070203	Light duty vehicles	Urban	Gasoline	0,001	0,747	0,114	0,133	0,111	0,229	0,156
2009	070203	Light duty vehicles	Urban	LPG	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	070301	Heavy duty vehicles	Highway	Diesel	0,012	22,852	5,764	8,542	1,067	0,854	1,494
2009	070301	Heavy duty vehicles	Highway	Gasoline							
2009	070302	Heavy duty vehicles	Rural	Diesel	0,019	37,547	9,474	14,036	1,753	1,400	2,456
2009	070302	Heavy duty vehicles	Rural	Gasoline							
2009	070303	Heavy duty vehicles	Urban	Diesel	0,011	21,659	5,464	8,094	1,011	0,808	1,417
2009	070303	Heavy duty vehicles	Urban	Gasoline							
2009	070400	Mopeds	Urban	Gasoline							
2009	070501	Motorcycles	Highway	Gasoline	0,002	1,501	0,098	0,075	0,083	0,195	0,075
2009	070502	Motorcycles	Rural	Gasoline	0,006	3,950	0,257	0,197	0,217	0,513	0,197
2009	070503	Motorcycles	Urban	Gasoline	0,008	4,805	0,312	0,240	0,264	0,625	0,240
2009	080100	Military		AvGas	0,000	0,022	0,001	0,000	0,001	0,003	0,001
2009	080100	Military		Diesel	0,001	4,781	0,561	0,545	0,281	0,510	0,290
2009	080100	Military		Gasoline	0,000	0,019	0,002	0,001	0,001	0,003	0,002
2009	080100	Military		Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080200	Railways		Diesel	0,002	4,390	1,119	1,250	0,185	0,158	0,287
2009	080200	Railways		Gasoline	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080300	Inland waterways		Diesel	0,001	4,359	0,512	0,497	0,256	0,465	0,265

Continued										
2009	080300	Inland waterways	Gasoline	0,002	1,528	0,074	0,025	0,040	0,243	0,086
2009	080402	National sea traffic	Diesel	0,052	32,016	2,761	1,294	0,647	6,170	5,091
2009	080402	National sea traffic	Residual oil	0,031	11,881	0,618	0,114	0,046	0,160	0,069
2009	080403	Fishing	Diesel	0,090	55,774	4,811	2,255	1,128	10,749	8,870
2009	080403	Fishing	Gasoline	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080403	Fishing	Residual oil	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080404	International sea traffic	Diesel	0,122	75,416	6,505	3,049	1,525	14,534	11,993
2009	080404	International sea traffic	Residual oil	0,126	38,796	1,883	0,847	0,659	2,448	1,883
2009	080501	Air traffic, Dom. < 3000 ft.	AvGas	0,000	0,315	0,015	0,005	0,008	0,050	0,018
2009	080501	Air traffic, Dom. < 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080502	Air traffic, Int. < 3000 ft.	AvGas	0,000	0,015	0,001	0,000	0,000	0,002	0,001
2009	080502	Air traffic, Int. < 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080503	Air traffic, Dom. > 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080504	Air traffic, Int. > 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080600	Agriculture	Diesel	0,012	72,407	8,497	8,255	4,257	7,731	4,400
2009	080600	Agriculture	Gasoline	0,003	2,169	0,105	0,036	0,057	0,345	0,123
2009	080700	Forestry	Diesel	0,000	0,692	0,081	0,079	0,041	0,074	0,042
2009	080700	Forestry	Gasoline	0,000	0,315	0,015	0,005	0,008	0,050	0,018
2009	080800	Industry	Diesel	0,007	44,736	5,250	5,100	2,630	4,777	2,718
2009	080800	Industry	Gasoline	0,001	0,509	0,025	0,008	0,013	0,081	0,029
2009	080800	Industry	LPG							
2009	080900	Household and gardening	Gasoline	0,004	3,733	0,180	0,061	0,098	0,594	0,211
2009	081100	Commercial and institutional	Gasoline	0,012	10,339	0,499	0,170	0,272	1,646	0,584
2009	080501	Air traffic, Dom. < 3000 ft.	AvGas	0,000	0,003	0,000	0,000	0,000	0,000	0,000
2009	080501	Air traffic, Dom. < 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080502	Air traffic, Int. < 3000 ft.	AvGas	0,000	0,002	0,000	0,000	0,000	0,000	0,000
2009	080502	Air traffic, Int. < 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080503	Air traffic, Dom. > 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000
2009	080504	Air traffic, Int. > 3000 ft.	Jet fuel	0,000	0,000	0,000	0,000	0,000	0,000	0,000

Annex 2B-15: Fuel consumption and emissions in CRF format

Fuel

IPCC ID	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Industry-Other (1A2f)	11,7	11,7	11,6	11,6	11,6	11,5	11,5	11,5	11,5	11,5	11,6	11,7	11,7	11,9	11,9
Civil Aviation (1A3a)	3,6	3,3	3,7	3,8	3,6	3,4	2,8	2,7	2,6	2,7	2,8	2,8	2,9	2,7	2,4
Road (1A3b)	111,2	117,5	117,7	118,4	119,7	126,3	132,0	134,4	136,1	142,9	144,2	146,6	149,5	152,0	154,0
Railways (1A3c)	4,9	4,9	4,4	4,6	4,2	4,0	4,1	4,3	4,5	4,1	4,1	4,1	4,0	3,3	3,1
Navigation (1A3d)	10,4	10,3	10,4	10,4	10,5	10,5	10,6	10,9	10,7	10,8	11,3	12,2	12,0	10,0	8,8
Comm./Inst. (1A4a)	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,1	1,1	1,1	1,1	1,2
Residential (1A4b)	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,6	0,6	0,6
Ag./for./fish. (1A4c)	24,4	26,0	23,8	25,5	25,3	25,7	25,7	24,3	23,8	22,9	23,4	22,2	21,0	20,4	21,1
Military (1A5)	5,5	4,3	5,0	2,7	2,3	1,6	3,9	1,9	3,3	3,5	3,4	2,4	2,3	2,8	2,5
Navigation int. (1A3d)	16,2	19,0	28,4	36,2	37,1	39,1	34,9	36,7	55,0	62,0	65,1	62,0	56,7	57,2	53,3
Civil Aviation int. (1A3a)	19,3	20,9	22,4	24,0	25,1	24,1	22,7	23,5	23,0	25,2	25,9	27,4	27,9	30,0	31,8

IPCC ID	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Industry-Other (1A2f)	12,0	12,1	12,3	12,4	12,5	13,0	13,9	14,8	15,1	11,2
Civil Aviation (1A3a)	2,1	2,3	2,0	1,9	1,8	1,9	2,0	2,2	2,2	2,2
Road (1A3b)	152,5	152,8	154,5	160,6	164,8	166,1	171,3	179,5	176,0	165,1
Railways (1A3c)	3,1	2,9	2,8	3,0	2,9	3,1	3,1	3,1	3,2	3,1
Navigation (1A3d)	7,9	7,9	7,7	7,7	7,9	7,8	7,8	7,8	7,9	8,0
Comm./Inst. (1A4a)	1,2	1,3	1,5	1,8	2,0	2,2	2,4	2,4	2,4	2,4
Residential (1A4b)	0,6	0,6	0,7	0,7	0,8	0,8	0,8	0,9	0,9	0,9
Ag./for./fish. (1A4c)	21,8	23,9	24,3	23,9	22,2	23,8	23,7	23,4	25,2	24,9
Military (1A5)	1,5	1,3	1,2	1,3	3,3	3,7	1,7	2,4	1,5	2,2
Navigation int. (1A3d)	54,6	43,3	35,5	37,5	30,2	30,7	40,8	42,7	36,6	20
Civil Aviation int. (1A3a)	32,6	33,1	28,6	29,7	34,0	35,7	35,9	36,8	36,8	32

Emissions

pol_name	IPCC ID	Unit	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
SO2	Industry-Other (1A2f)	[tonnes]	2402	1441	1440	1438	956	952	955	957	957	959	968	244	246	249	251
SO2	Civil Aviation (1A3a)	[tonnes]	82	77	85	86	83	77	64	62	61	63	63	65	68	62	56
SO2	Road (1A3b)	[tonnes]	11621	7862	7847	7857	5488	5767	5903	3820	1569	1669	1682	1721	1744	1768	1088
SO2	Railways (1A3c)	[tonnes]	1152	695	618	641	393	376	382	263	105	95	96	95	93	78	40
SO2	Navigation (1A3d)	[tonnes]	7480	7480	7484	7228	7231	6429	5111	3506	4410	4974	5588	4400	3650	2283	2051
SO2	Comm./Inst. (1A4a)	[tonnes]	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3
SO2	Residential (1A4b)	[tonnes]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SO2	Ag./for./fish. (1A4c)	[tonnes]	4766	3484	3173	3073	2269	2303	2317	2186	2150	2072	2120	978	853	856	931
SO2	Military (1A5)	[tonnes]	408	260	193	72	70	48	206	82	76	80	80	56	54	65	47
SO2	Navigation int. (1A3d)	[tonnes]	17037	20752	35647	46755	47058	41317	33277	30084	58492	58965	65049	61075	55822	46756	49282
SO2	Civil Aviation int. (1A3a)	[tonnes]	444	480	515	551	578	554	521	541	530	580	596	629	642	689	731
NOx	Industry-Other (1A2f)	[tonnes]	10903	10964	11011	11044	11065	11081	11282	11440	11558	11677	11882	12080	12248	12425	12262
NOx	Civil Aviation (1A3a)	[tonnes]	1203	1132	1237	1252	1208	1123	920	902	900	940	958	971	998	911	815
NOx	Road (1A3b)	[tonnes]	93787	99472	100001	101422	103009	109035	111706	109581	106554	105932	100249	95644	91557	87186	83506
NOx	Railways (1A3c)	[tonnes]	6025	6063	5391	5589	5145	4913	4995	5284	5485	4971	5015	4977	4846	4089	3730
NOx	Navigation (1A3d)	[tonnes]	13299	13339	13414	13486	13568	13649	13180	12882	12753	12999	13679	14757	13544	11175	8720
NOx	Comm./Inst. (1A4a)	[tonnes]	66	67	68	70	70	70	75	80	85	89	93	95	98	101	102
NOx	Residential (1A4b)	[tonnes]	31	32	33	34	34	34	36	38	40	42	43	45	46	48	49
NOx	Ag./for./fish. (1A4c)	[tonnes]	18159	19915	18153	20143	20342	21066	21722	20824	20763	20524	21442	21138	20176	20119	21495
NOx	Military (1A5)	[tonnes]	2353	2026	1627	992	882	495	1864	1014	1296	1279	1760	958	1197	1386	1074
NOx	Navigation int. (1A3d)	[tonnes]	22455	26921	42068	54983	56940	60639	53939	55808	87852	99296	105113	100507	93239	92360	89143
NOx	Civil Aviation int. (1A3a)	[tonnes]	5663	6129	6569	7035	7313	7016	6586	6846	6702	7317	7517	7904	8058	8662	9204
NMVOC	Industry-Other (1A2f)	[tonnes]	2422	2395	2368	2339	2304	2266	2231	2191	2147	2107	2088	2095	2083	2074	1997
NMVOC	Civil Aviation (1A3a)	[tonnes]	216	213	190	198	193	186	168	164	161	191	206	194	186	169	162
NMVOC	Road (1A3b)	[tonnes]	79097	79021	78423	78147	76478	80071	82252	80674	77375	73439	68119	63461	58265	52828	46451
NMVOC	Railways (1A3c)	[tonnes]	393	396	352	365	336	321	326	345	358	324	327	325	316	267	276
NMVOC	Navigation (1A3d)	[tonnes]	1560	1560	1592	1622	1654	1686	1719	1761	1786	1820	1879	1975	1969	1873	1776
NMVOC	Comm./Inst. (1A4a)	[tonnes]	2347	2333	2318	2303	2303	2303	2314	2302	2265	2285	2367	2458	2547	2636	2741
NMVOC	Residential (1A4b)	[tonnes]	1844	1833	1821	1809	1805	1801	1797	1792	1789	1785	1780	1774	1767	1759	1758
NMVOC	Ag./for./fish. (1A4c)	[tonnes]	6357	6417	6216	6284	6207	6149	5777	5298	4944	4638	4516	4208	3966	3691	3563
NMVOC	Military (1A5)	[tonnes]	587	457	172	483	309	53	162	87	122	119	148	90	103	114	105
NMVOC	Navigation int. (1A3d)	[tonnes]	825	974	1472	1892	1947	2060	1839	1928	2933	3318	3501	3343	3082	3102	2929
NMVOC	Civil Aviation int. (1A3a)	[tonnes]	261	288	313	342	361	331	309	316	309	308	343	360	365	386	395
CH4	Industry-Other (1A2f)	[tonnes]	63	63	62	61	61	60	58	57	56	54	53	53	53	53	51

Continued (1985-1999)

CH4	Civil Aviation (1A3a)	[tonnes]	8	8	8	8	8	7	6	6	6	7	7	7	7	7	6
CH4	Road (1A3b)	[tonnes]	2267	2327	2343	2368	2361	2503	2590	2574	2528	2472	2344	2231	2132	2032	1905
CH4	Railways (1A3c)	[tonnes]	15	15	14	14	13	12	13	13	14	12	13	12	12	10	11
CH4	Navigation (1A3d)	[tonnes]	30	30	31	31	32	32	33	34	34	35	36	38	38	35	34
CH4	Comm./Inst. (1A4a)	[tonnes]	104	102	100	99	99	99	97	95	92	90	89	89	89	89	90
CH4	Residential (1A4b)	[tonnes]	55	54	53	52	51	51	50	49	48	48	47	46	45	45	45
CH4	Ag./for./fish. (1A4c)	[tonnes]	155	154	147	146	142	139	132	123	116	110	106	100	94	89	88
CH4	Military (1A5)	[tonnes]	30	25	17	18	13	5	18	10	13	13	18	10	12	14	11
CH4	Navigation int. (1A3d)	[tonnes]	26	30	46	59	60	64	57	60	91	103	108	103	95	96	91
CH4	Civil Aviation int. (1A3a)	[tonnes]	25	27	30	32	33	31	29	30	29	31	35	37	38	40	41
CO	Industry-Other (1A2f)	[tonnes]	9863	9784	9702	9611	9502	9379	9294	9188	9070	8956	8910	8963	8939	8907	8647
CO	Civil Aviation (1A3a)	[tonnes]	1256	1241	1118	1167	1140	1098	989	955	930	1098	1180	1117	1085	973	932
CO	Road (1A3b)	[tonnes]	564556	538653	514377	477172	445400	453681	470593	453523	438888	408350	385944	373173	336203	313050	276439
CO	Railways (1A3c)	[tonnes]	1098	1105	982	1018	937	895	910	963	999	906	914	907	883	745	717
CO	Navigation (1A3d)	[tonnes]	5472	5473	5636	5797	5962	6126	6297	6491	6623	6805	7057	7246	7150	6983	6779
CO	Comm./Inst. (1A4a)	[tonnes]	31348	30972	30583	30181	30181	30181	29610	28987	28319	27809	27575	27800	28012	28211	28817
CO	Residential (1A4b)	[tonnes]	19086	18725	18352	17968	17789	17606	17238	16880	16708	16556	16422	16311	16217	16136	16286
CO	Ag./for./fish. (1A4c)	[tonnes]	61165	59707	57256	55768	53717	51734	48771	45427	42608	39735	37673	34858	32455	29823	27820
CO	Military (1A5)	[tonnes]	4171	3074	1306	3133	1936	423	1001	507	841	865	876	613	590	669	675
CO	Navigation int. (1A3d)	[tonnes]	2722	3214	4855	6243	6424	6796	6065	6361	9677	10946	11548	11030	10168	10233	9662
CO	Civil Aviation int. (1A3a)	[tonnes]	1103	1207	1289	1416	1564	1442	1357	1399	1388	1342	1421	1502	1564	1662	1743
CO2	Industry-Other (1A2f)	[ktonnes]	852	852	851	849	845	842	843	843	842	841	848	853	860	867	873
CO2	Civil Aviation (1A3a)	[ktonnes]	256	241	268	271	262	243	199	193	190	196	199	205	212	194	174
CO2	Road (1A3b)	[ktonnes]	8166	8631	8643	8700	8795	9282	9697	9870	9995	10491	10588	10766	10978	11167	11312
CO2	Railways (1A3c)	[ktonnes]	364	366	326	338	311	297	302	319	331	300	303	301	293	247	232
CO2	Navigation (1A3d)	[ktonnes]	784	784	787	790	793	796	803	817	803	814	850	917	898	745	655
CO2	Comm./Inst. (1A4a)	[ktonnes]	74	74	74	74	74	74	74	75	75	77	78	80	81	83	85
CO2	Residential (1A4b)	[ktonnes]	40	40	39	39	39	39	39	39	39	39	40	40	41	41	42
CO2	Ag./for./fish. (1A4c)	[ktonnes]	1806	1922	1758	1887	1874	1899	1903	1794	1760	1695	1728	1642	1554	1510	1564
CO2	Military (1A5)	[ktonnes]	402	316	361	196	165	119	287	141	237	252	252	176	171	204	182
CO2	Navigation int. (1A3d)	[ktonnes]	1238	1454	2179	2786	2854	3005	2673	2797	4214	4744	4976	4725	4326	4337	4053
CO2	Civil Aviation int. (1A3a)	[ktonnes]	1391	1503	1613	1725	1809	1736	1632	1693	1659	1818	1867	1971	2010	2159	2290
N2O	Industry-Other (1A2f)	[tonnes]	34	34	34	34	34	34	34	35	35	35	35	36	36	36	37
N2O	Civil Aviation (1A3a)	[tonnes]	10	10	11	11	11	10	9	9	9	9	10	11	11	9	9
N2O	Road (1A3b)	[tonnes]	268	281	281	284	287	302	321	341	355	386	408	429	448	453	457

Continued (1985-1999)

N2O	Railways (1A3c)	[tonnes]	10	10	9	9	9	8	8	9	9	8	8	8	8	7	6
N2O	Navigation (1A3d)	[tonnes]	48	48	48	48	48	48	49	50	49	49	51	55	54	44	39
N2O	Comm./Inst. (1A4a)	[tonnes]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
N2O	Residential (1A4b)	[tonnes]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
N2O	Ag./for./fish. (1A4c)	[tonnes]	81	87	78	85	85	87	88	83	81	79	81	77	71	70	74
N2O	Military (1A5)	[tonnes]	12	9	11	6	5	4	8	4	7	8	7	5	5	6	6
N2O	Navigation int. (1A3d)	[tonnes]	78	92	137	175	179	189	168	176	265	298	313	297	272	273	255
N2O	Civil Aviation int. (1A3a)	[tonnes]	47	50	54	58	61	59	56	58	57	63	64	69	70	75	80
NH3	Industry-Other (1A2f)	[tonnes]	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
NH3	Civil Aviation (1A3a)	[tonnes]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NH3	Road (1A3b)	[tonnes]	61	63	64	65	65	69	183	415	635	948	1245	1512	1887	2281	2578
NH3	Railways (1A3c)	[tonnes]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
NH3	Navigation (1A3d)	[tonnes]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NH3	Comm./Inst. (1A4a)	[tonnes]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NH3	Residential (1A4b)	[tonnes]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NH3	Ag./for./fish. (1A4c)	[tonnes]	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
NH3	Military (1A5)	[tonnes]	1	1	0	0	0	0	0	0	0	0	1	0	0	0	1
NH3	Navigation int. (1A3d)	[tonnes]		0						0	0						
NH3	Civil Aviation int. (1A3a)	[tonnes]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TSP	Industry-Other (1A2f)	[tonnes]	1823	1778	1733	1686	1634	1577	1533	1484	1433	1383	1349	1317	1284	1249	1193
TSP	Civil Aviation (1A3a)	[tonnes]	5	5	5	5	5	5	4	4	4	4	4	4	4	4	4
TSP	Road (1A3b)	[tonnes]	4341	4701	4708	4623	4676	4891	5026	4831	4791	4883	4670	4452	4027	3656	3331
TSP	Railways (1A3c)	[tonnes]	247	249	222	229	211	202	205	217	225	204	206	204	199	168	146
TSP	Navigation (1A3d)	[tonnes]	1099	1099	1103	1098	1103	898	710	519	660	762	919	723	670	451	417
TSP	Comm./Inst. (1A4a)	[tonnes]	24	24	24	24	24	24	24	23	22	23	24	25	27	28	29
TSP	Residential (1A4b)	[tonnes]	12	12	12	12	11	11	11	11	11	11	11	11	11	11	11
TSP	Ag./for./fish. (1A4c)	[tonnes]	2783	2820	2673	2723	2665	2628	2534	2362	2300	2119	2087	1892	1783	1633	1576
TSP	Military (1A5)	[tonnes]	100	100	49	18	26	11	112	66	62	54	114	44	70	73	44
TSP	Navigation int. (1A3d)	[tonnes]	2832	3448	5914	7810	7866	5531	4371	3999	8648	8194	10076	9968	9231	7717	8177
TSP	Civil Aviation int. (1A3a)	[tonnes]	23	24	26	28	30	28	27	28	27	29	30	32	32	35	37
PM10	Industry-Other (1A2f)	[tonnes]	1823	1778	1733	1686	1634	1577	1533	1484	1433	1383	1349	1317	1284	1249	1193
PM10	Civil Aviation (1A3a)	[tonnes]	5	5	5	5	5	5	4	4	4	4	4	4	4	4	4
PM10	Road (1A3b)	[tonnes]	4341	4701	4708	4623	4676	4891	5026	4831	4791	4883	4670	4452	4027	3656	3331
PM10	Railways (1A3c)	[tonnes]	247	249	222	229	211	202	205	217	225	204	206	204	199	168	146
PM10	Navigation (1A3d)	[tonnes]	1089	1089	1093	1088	1093	890	704	515	655	756	911	717	664	448	414

Continued (1985-1999)

PM10	Comm./Inst. (1A4a)	[tonnes]	24	24	24	24	24	24	24	23	22	23	24	25	27	28	29
PM10	Residential (1A4b)	[tonnes]	12	12	12	12	11	11	11	11	11	11	11	11	11	11	11
PM10	Ag./for./fish. (1A4c)	[tonnes]	2781	2818	2671	2721	2663	2626	2532	2360	2298	2117	2086	1891	1782	1632	1575
PM10	Military (1A5)	[tonnes]	100	100	49	18	26	11	112	66	62	54	114	44	70	73	44
PM10	Navigation int. (1A3d)	[tonnes]	2803	3413	5855	7732	7788	5476	4327	3959	8561	8112	9975	9869	9139	7639	8095
PM10	Civil Aviation int. (1A3a)	[tonnes]	23	24	26	28	30	28	27	28	27	29	30	32	32	35	37
PM2.5	Industry-Other (1A2f)	[tonnes]	1823	1778	1733	1686	1634	1577	1533	1484	1433	1383	1349	1317	1284	1249	1193
PM2.5	Civil Aviation (1A3a)	[tonnes]	5	5	5	5	5	5	4	4	4	4	4	4	4	4	4
PM2.5	Road (1A3b)	[tonnes]	4341	4701	4708	4623	4676	4891	5026	4831	4791	4883	4670	4452	4027	3656	3331
PM2.5	Railways (1A3c)	[tonnes]	247	249	222	229	211	202	205	217	225	204	206	204	199	168	146
PM2.5	Navigation (1A3d)	[tonnes]	1084	1084	1088	1083	1088	886	701	513	652	753	907	714	662	446	413
PM2.5	Comm./Inst. (1A4a)	[tonnes]	24	24	24	24	24	24	24	23	22	23	24	25	27	28	29
PM2.5	Residential (1A4b)	[tonnes]	12	12	12	12	11	11	11	11	11	11	11	11	11	11	11
PM2.5	Ag./for./fish. (1A4c)	[tonnes]	2780	2817	2670	2720	2662	2625	2531	2359	2297	2116	2085	1890	1781	1631	1574
PM2.5	Military (1A5)	[tonnes]	100	100	49	18	26	11	112	66	62	54	114	44	70	73	44
PM2.5	Navigation int. (1A3d)	[tonnes]	2789	3396	5825	7693	7748	5448	4305	3939	8518	8071	9925	9819	9093	7601	8054
PM2.5	Civil Aviation int. (1A3a)	[tonnes]	23	24	26	28	30	28	27	28	27	29	30	32	32	35	37
Arsenic	Industry-Other (1A2f)	[kg]						0	0	0	0	0	0	0	0	0	0
Arsenic	Civil Aviation (1A3a)	[kg]						0	0	0	0	0	0	0	0	0	0
Arsenic	Road (1A3b)	[kg]						1	1	1	1	1	1	1	1	1	1
Arsenic	Railways (1A3c)	[kg]						0	0	0	0	0	0	0	0	0	0
Arsenic	Navigation (1A3d)	[kg]						62	55	47	47	49	50	44	36	28	25
Arsenic	Comm./Inst. (1A4a)	[kg]						0	0	0	0	0	0	0	0	0	0
Arsenic	Residential (1A4b)	[kg]						0	0	0	0	0	0	0	0	0	0
Arsenic	Ag./for./fish. (1A4c)	[kg]						9	10	9	8	8	8	8	6	7	7
Arsenic	Military (1A5)	[kg]						0	0	0	0	0	0	0	0	0	0
Arsenic	Navigation int. (1A3d)	[kg]						353	292	267	465	496	505	325	417	357	369
Arsenic	Civil Aviation int. (1A3a)	[kg]						0	0	0	0	0	0	0	0	0	0
Cadmium	Industry-Other (1A2f)	[kg]						2	2	2	2	2	2	2	2	2	2
Cadmium	Civil Aviation (1A3a)	[kg]						0	0	0	0	0	0	0	0	0	0
Cadmium	Road (1A3b)	[kg]						26	27	28	28	30	30	30	31	31	32
Cadmium	Railways (1A3c)	[kg]						1	1	1	1	1	1	1	1	1	1
Cadmium	Navigation (1A3d)	[kg]						5	4	4	4	4	4	4	4	3	3
Cadmium	Comm./Inst. (1A4a)	[kg]						0	0	0	0	0	0	0	0	0	0
Cadmium	Residential (1A4b)	[kg]						0	0	0	0	0	0	0	0	0	0

Continued (1985-1999)												
Cadmium	Ag./for./fish. (1A4c)	[kg]	5	5	5	5	5	5	4	4	4	4
Cadmium	Military (1A5)	[kg]	0	0	0	0	0	0	0	0	0	0
Cadmium	Navigation int. (1A3d)	[kg]	23	20	19	31	34	35	20	29	26	26
Cadmium	Civil Aviation int. (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Chromium	Industry-Other (1A2f)	[kg]	7	7	7	7	7	7	7	7	7	7
Chromium	Civil Aviation (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Chromium	Road (1A3b)	[kg]	59	62	62	63	66	67	68	69	71	72
Chromium	Railways (1A3c)	[kg]	3	3	3	3	3	3	3	3	2	2
Chromium	Navigation (1A3d)	[kg]	28	25	23	22	23	24	22	19	15	14
Chromium	Comm./Inst. (1A4a)	[kg]	0	0	0	0	0	0	0	0	0	0
Chromium	Residential (1A4b)	[kg]	0	0	0	0	0	0	0	0	0	0
Chromium	Ag./for./fish. (1A4c)	[kg]	19	19	18	17	17	17	16	15	15	16
Chromium	Military (1A5)	[kg]	0	1	1	1	1	1	0	1	1	1
Chromium	Navigation int. (1A3d)	[kg]	147	123	115	195	210	214	131	178	157	160
Chromium	Civil Aviation int. (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Copper	Industry-Other (1A2f)	[kg]	5	5	5	5	5	5	6	6	6	6
Copper	Civil Aviation (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Copper	Road (1A3b)	[kg]	87	92	95	97	102	103	104	106	108	109
Copper	Railways (1A3c)	[kg]	2	2	2	2	2	2	2	2	2	1
Copper	Navigation (1A3d)	[kg]	63	56	48	47	49	50	45	36	29	26
Copper	Comm./Inst. (1A4a)	[kg]	1	1	1	1	1	1	1	1	1	1
Copper	Residential (1A4b)	[kg]	1	1	1	1	1	1	1	1	1	1
Copper	Ag./for./fish. (1A4c)	[kg]	18	18	17	16	16	16	17	14	14	15
Copper	Military (1A5)	[kg]	0	1	0	0	0	1	0	1	1	0
Copper	Navigation int. (1A3d)	[kg]	353	292	267	465	496	505	325	417	357	369
Copper	Civil Aviation int. (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Mercury	Industry-Other (1A2f)	[kg]	1	1	1	1	1	1	1	1	1	1
Mercury	Civil Aviation (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Mercury	Road (1A3b)	[kg]	21	22	22	23	24	24	24	25	25	25
Mercury	Railways (1A3c)	[kg]	0	1	1	1	1	1	1	0	0	0
Mercury	Navigation (1A3d)	[kg]	9	9	10	9	10	10	11	12	10	8
Mercury	Comm./Inst. (1A4a)	[kg]	0	0	0	0	0	0	0	0	0	0
Mercury	Residential (1A4b)	[kg]	0	0	0	0	0	0	0	0	0	0
Mercury	Ag./for./fish. (1A4c)	[kg]	12	12	11	10	10	10	10	8	8	9
Mercury	Military (1A5)	[kg]	0	0	0	0	0	0	0	0	0	0

Continued (1985-1999)												
Mercury	Navigation int. (1A3d)	[kg]	27	25	29	40	47	50	14	45	49	43
Mercury	Civil Aviation int. (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Nickel	Industry-Other (1A2f)	[kg]	2	2	2	2	2	2	2	2	2	2
Nickel	Civil Aviation (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Nickel	Road (1A3b)	[kg]	29	30	32	32	34	34	34	35	36	36
Nickel	Railways (1A3c)	[kg]	1	1	1	1	1	1	1	1	1	1
Nickel	Navigation (1A3d)	[kg]	3362	2889	2360	2359	2477	2492	2087	1520	1179	1077
Nickel	Comm./Inst. (1A4a)	[kg]	0	0	0	0	0	0	0	0	0	0
Nickel	Residential (1A4b)	[kg]	0	0	0	0	0	0	0	0	0	0
Nickel	Ag./for./fish. (1A4c)	[kg]	16	17	16	15	15	15	14	12	12	13
Nickel	Military (1A5)	[kg]	0	0	0	0	0	0	0	0	0	0
Nickel	Navigation int. (1A3d)	[kg]	20420	16701	14894	26627	28129	28488	19451	23291	19285	20431
Nickel	Civil Aviation int. (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Lead	Industry-Other (1A2f)	[kg]	12	12	12	12	12	12	12	12	12	12
Lead	Civil Aviation (1A3a)	[kg]	1534	1423	1378	1328	1639	1788	1640	1559	1399	1387
Lead	Road (1A3b)	[kg]	97614	75966	68886	29930	120	122	123	126	128	131
Lead	Railways (1A3c)	[kg]	4	5	5	5	5	5	5	4	4	4
Lead	Navigation (1A3d)	[kg]	35	34	33	32	33	34	35	32	26	23
Lead	Comm./Inst. (1A4a)	[kg]	1	1	1	1	1	1	1	1	1	1
Lead	Residential (1A4b)	[kg]	0	0	0	0	0	0	0	0	0	0
Lead	Ag./for./fish. (1A4c)	[kg]	38	38	36	35	34	35	33	30	29	31
Lead	Military (1A5)	[kg]	63	81	62	121	86	104	99	125	118	79
Lead	Navigation int. (1A3d)	[kg]	162	140	138	221	243	251	132	214	201	196
Lead	Civil Aviation int. (1A3a)	[kg]	490	465	452	456	153	175	126	145	145	124
Selenium	Industry-Other (1A2f)	[kg]	0	0	0	0	0	0	0	0	0	0
Selenium	Civil Aviation (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Selenium	Road (1A3b)	[kg]	0	0	0	0	1	1	1	1	1	1
Selenium	Railways (1A3c)	[kg]	0	0	0	0	0	0	0	0	0	0
Selenium	Navigation (1A3d)	[kg]	69	67	64	63	64	66	67	62	50	43
Selenium	Comm./Inst. (1A4a)	[kg]	0	0	0	0	0	0	0	0	0	0
Selenium	Residential (1A4b)	[kg]	0	0	0	0	0	0	0	0	0	0
Selenium	Ag./for./fish. (1A4c)	[kg]	37	38	35	33	33	33	32	25	26	30
Selenium	Military (1A5)	[kg]	0	0	0	0	0	0	0	0	0	0
Selenium	Navigation int. (1A3d)	[kg]	325	279	275	442	486	503	264	427	402	391
Selenium	Civil Aviation int. (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0

Continued (1985-1999)												
Zinc	Industry-Other (1A2f)	[kg]	419	420	420	419	419	422	425	428	432	435
Zinc	Civil Aviation (1A3a)	[kg]	6	5	5	5	6	7	6	6	5	5
Zinc	Road (1A3b)	[kg]	5119	5379	5549	5644	5917	5986	6037	6180	6285	6361
Zinc	Railways (1A3c)	[kg]	150	152	161	167	151	153	152	148	124	117
Zinc	Navigation (1A3d)	[kg]	191	187	184	183	188	195	202	193	165	151
Zinc	Comm./Inst. (1A4a)	[kg]	51	51	52	52	53	54	55	56	57	59
Zinc	Residential (1A4b)	[kg]	27	27	27	27	27	27	28	28	28	29
Zinc	Ag./for./fish. (1A4c)	[kg]	766	762	724	717	683	698	664	655	626	632
Zinc	Military (1A5)	[kg]	6	62	37	34	30	67	27	49	57	39
Zinc	Navigation int. (1A3d)	[kg]	744	643	638	1017	1121	1162	595	991	940	910
Zinc	Civil Aviation int. (1A3a)	[kg]	2	2	2	2	1	1	0	1	1	0
Dioxins/furans	Industry-Other (1A2f)	[g]	0	0	0	0	0	0	0	0	0	0
Dioxins/furans	Civil Aviation (1A3a)	[g]	0	0	0	0	0	0	0	0	0	0
Dioxins/furans	Road (1A3b)	[g]	1	1	1	1	1	1	1	1	0	0
Dioxins/furans	Railways (1A3c)	[g]	0	0	0	0	0	0	0	0	0	0
Dioxins/furans	Navigation (1A3d)	[g]	0	0	0	0	0	0	0	0	0	0
Dioxins/furans	Comm./Inst. (1A4a)	[g]	0	0	0	0	0	0	0	0	0	0
Dioxins/furans	Residential (1A4b)	[g]	0	0	0	0	0	0	0	0	0	0
Dioxins/furans	Ag./for./fish. (1A4c)	[g]	0	0	0	0	0	0	0	0	0	0
Dioxins/furans	Military (1A5)	[g]	0	0	0	0	0	0	0	0	0	0
Dioxins/furans	Navigation int. (1A3d)	[g]	1	0	0	1	1	1	1	1	1	1
Dioxins/furans	Civil Aviation int. (1A3a)	[g]	0	0	0	0	0	0	0	0	0	0
Flouranthene	Industry-Other (1A2f)	[kg]	45	44	45	46	45	46	46	46	46	46
Flouranthene	Civil Aviation (1A3a)	[kg]	0	0	0	0	1	1	1	0	0	0
Flouranthene	Road (1A3b)	[kg]	796	814	795	770	752	702	659	630	599	576
Flouranthene	Railways (1A3c)	[kg]	5	5	6	6	6	6	6	6	5	4
Flouranthene	Navigation (1A3d)	[kg]	66	68	71	70	70	74	82	82	67	58
Flouranthene	Comm./Inst. (1A4a)	[kg]	4	4	4	4	5	5	5	5	5	5
Flouranthene	Residential (1A4b)	[kg]	2	2	2	2	2	2	2	2	2	2
Flouranthene	Ag./for./fish. (1A4c)	[kg]	136	135	128	127	121	124	117	107	104	110
Flouranthene	Military (1A5)	[kg]	1	7	4	4	3	8	3	6	6	4
Flouranthene	Navigation int. (1A3d)	[kg]	198	184	205	288	334	355	344	316	338	304
Flouranthene	Civil Aviation int. (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Benzo(b) flouranthene	Industry-Other (1A2f)	[kg]	6	6	6	6	6	6	6	6	6	6
Benzo(b) flouranthene	Civil Aviation (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0

Continued (1985-1999)												
Benzo(b) flouranthene	Road (1A3b)	[kg]	66	68	67	66	67	64	63	62	61	60
Benzo(b) flouranthene	Railways (1A3c)	[kg]	1	1	1	2	1	1	1	1	1	1
Benzo(b) flouranthene	Navigation (1A3d)	[kg]	5	5	6	5	5	6	7	7	6	5
Benzo(b) flouranthene	Comm./Inst. (1A4a)	[kg]	0	0	0	0	0	0	0	0	0	0
Benzo(b) flouranthene	Residential (1A4b)	[kg]	0	0	0	0	0	0	0	0	0	0
Benzo(b) flouranthene	Ag./for./fish. (1A4c)	[kg]	15	15	14	14	13	13	13	12	11	12
Benzo(b) flouranthene	Military (1A5)	[kg]	0	1	1	1	0	1	0	1	1	1
Benzo(b) flouranthene	Navigation int. (1A3d)	[kg]	13	12	15	19	23	25	24	22	25	22
Benzo(b) flouranthene	Civil Aviation int. (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Benzo(k) flouranthene	Industry-Other (1A2f)	[kg]	6	6	6	6	6	6	6	6	6	6
Benzo(k) flouranthene	Civil Aviation (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Benzo(k) flouranthene	Road (1A3b)	[kg]	67	69	68	68	70	69	69	69	69	69
Benzo(k) flouranthene	Railways (1A3c)	[kg]	2	2	2	2	2	2	2	2	1	1
Benzo(k) flouranthene	Navigation (1A3d)	[kg]	2	2	2	2	2	3	3	3	3	2
Benzo(k) flouranthene	Comm./Inst. (1A4a)	[kg]	0	0	0	0	0	0	0	0	0	0
Benzo(k) flouranthene	Residential (1A4b)	[kg]	0	0	0	0	0	0	0	0	0	0
Benzo(k) flouranthene	Ag./for./fish. (1A4c)	[kg]	12	12	11	11	11	11	10	10	9	9
Benzo(k) flouranthene	Military (1A5)	[kg]	0	1	1	1	0	1	0	1	1	1
Benzo(k) flouranthene	Navigation int. (1A3d)	[kg]	6	6	7	9	11	11	11	10	12	10
Benzo(k) flouranthene	Civil Aviation int. (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Benzo(a) pyrene	Industry-Other (1A2f)	[kg]	3	3	3	3	3	3	3	3	3	3
Benzo(a) pyrene	Civil Aviation (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Benzo(a) pyrene	Road (1A3b)	[kg]	45	47	47	46	46	44	43	43	42	41
Benzo(a) pyrene	Railways (1A3c)	[kg]	0	0	0	0	0	0	0	0	0	0
Benzo(a) pyrene	Navigation (1A3d)	[kg]	1	1	1	1	1	1	2	2	1	1
Benzo(a) pyrene	Comm./Inst. (1A4a)	[kg]	0	0	0	0	0	0	0	0	0	0
Benzo(a) pyrene	Residential (1A4b)	[kg]	0	0	0	0	0	0	0	0	0	0
Benzo(a) pyrene	Ag./for./fish. (1A4c)	[kg]	6	6	6	6	5	5	5	5	5	5
Benzo(a) pyrene	Military (1A5)	[kg]	0	0	0	0	0	1	0	0	0	0
Benzo(a) pyrene	Navigation int. (1A3d)	[kg]	4	3	4	5	6	7	6	6	6	6
Benzo(a) pyrene	Civil Aviation int. (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Benzo(g,h,i) perylene	Industry-Other (1A2f)	[kg]	6	6	6	6	5	6	5	5	5	5
Benzo(g,h,i) perylene	Civil Aviation (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Benzo(g,h,i) perylene	Road (1A3b)	[kg]	96	99	98	96	96	91	87	85	83	81
Benzo(g,h,i) perylene	Railways (1A3c)	[kg]	0	0	0	0	0	0	0	0	0	0

Continued (1985-1999)

Benzo(g,h,i) perylene	Navigation (1A3d)	[kg]	8	9	11	10	10	11	13	14	11	10
Benzo(g,h,i) perylene	Comm./Inst. (1A4a)	[kg]	1	1	1	1	1	1	1	1	1	1
Benzo(g,h,i) perylene	Residential (1A4b)	[kg]	0	0	0	0	0	0	0	0	0	0
Benzo(g,h,i) perylene	Ag./for./fish. (1A4c)	[kg]	21	21	20	19	19	19	18	16	15	16
Benzo(g,h,i) perylene	Military (1A5)	[kg]	0	1	1	1	0	1	0	1	1	0
Benzo(g,h,i) perylene	Navigation int. (1A3d)	[kg]	23	23	29	36	44	48	48	44	51	44
Benzo(g,h,i) perylene	Civil Aviation int. (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
indeno(1,2,3-c,d) pyrene	Industry-Other (1A2f)	[kg]	3	3	3	3	3	3	3	3	3	3
indeno(1,2,3-c,d) pyrene	Civil Aviation (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
indeno(1,2,3-c,d) pyrene	Road (1A3b)	[kg]	44	45	46	46	47	46	45	46	46	46
indeno(1,2,3-c,d) pyrene	Railways (1A3c)	[kg]	0	0	0	0	0	0	0	0	0	0
indeno(1,2,3-c,d) pyrene	Navigation (1A3d)	[kg]	7	7	8	8	8	9	10	11	9	8
indeno(1,2,3-c,d) pyrene	Comm./Inst. (1A4a)	[kg]	0	0	0	0	0	0	0	0	0	0
indeno(1,2,3-c,d) pyrene	Residential (1A4b)	[kg]	0	0	0	0	0	0	0	0	0	0
indeno(1,2,3-c,d) pyrene	Ag./for./fish. (1A4c)	[kg]	14	15	14	13	13	13	12	11	11	11
indeno(1,2,3-c,d) pyrene	Military (1A5)	[kg]	0	0	0	0	0	1	0	0	0	0
indeno(1,2,3-c,d) pyrene	Navigation int. (1A3d)	[kg]	19	19	23	29	36	39	39	36	42	36
indeno(1,2,3-c,d) pyrene	Civil Aviation int. (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0

pol_name	IPCC ID	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
SO2	Industry-Other (1A2f)	[tonnes]	253	256	258	261	263	28	30	32	33	24
SO2	Civil Aviation (1A3a)	[tonnes]	49	52	45	44	41	43	46	51	52	50
SO2	Road (1A3b)	[tonnes]	352	353	357	371	381	77	79	83	81	76
SO2	Railways (1A3c)	[tonnes]	7	7	7	7	7	1	1	1	1	1
SO2	Navigation (1A3d)	[tonnes]	1844	1733	1582	1984	2319	2339	2431	1686	1510	1593
SO2	Comm./Inst. (1A4a)	[tonnes]	3	3	4	4	5	1	1	1	1	1
SO2	Residential (1A4b)	[tonnes]	1	1	2	2	2	0	0	0	0	0
SO2	Ag./for./fish. (1A4c)	[tonnes]	1021	1209	1237	1204	1022	852	800	690	419	392
SO2	Military (1A5)	[tonnes]	27	12	19	17	46	57	26	40	19	25
SO2	Navigation int. (1A3d)	[tonnes]	55367	43830	30036	30982	26540	34283	50417	25652	19326	7383
SO2	Civil Aviation int. (1A3a)	[tonnes]	750	761	657	683	781	822	824	845	845	739
NOx	Industry-Other (1A2f)	[tonnes]	12096	11869	11617	11214	10744	10664	10807	10667	9978	7137
NOx	Civil Aviation (1A3a)	[tonnes]	723	752	641	595	551	583	601	692	697	651
NOx	Road (1A3b)	[tonnes]	78585	75589	72264	71168	69121	65533	63829	61849	54591	46637

Continued (2000-2009)												
NOx	Railways (1A3c)	[tonnes]	3727	3396	3396	3540	3478	3724	3542	3555	2920	2603
NOx	Navigation (1A3d)	[tonnes]	8087	8197	8315	8443	8469	8634	8979	9057	9316	9534
NOx	Comm./Inst. (1A4a)	[tonnes]	104	112	124	138	155	177	199	215	222	220
NOx	Residential (1A4b)	[tonnes]	50	54	59	64	69	72	76	79	82	84
NOx	Ag./for./fish. (1A4c)	[tonnes]	22807	25787	26041	25297	22457	24018	22840	20896	22034	20802
NOx	Military (1A5)	[tonnes]	544	695	476	524	1279	1308	605	759	481	704
NOx	Navigation int. (1A3d)	[tonnes]	94441	75429	60383	65339	53439	56540	78012	83555	70401	35658
NOx	Civil Aviation int. (1A3a)	[tonnes]	9446	9601	8725	9085	10472	11026	11164	11411	11299	9854
NMVOC	Industry-Other (1A2f)	[tonnes]	1926	1873	1815	1754	1676	1620	1583	1498	1357	976
NMVOC	Civil Aviation (1A3a)	[tonnes]	156	155	151	144	158	165	156	164	148	168
NMVOC	Road (1A3b)	[tonnes]	39084	35413	31951	29419	25590	23290	20433	18073	15924	13685
NMVOC	Railways (1A3c)	[tonnes]	253	248	243	223	217	235	230	231	205	174
NMVOC	Navigation (1A3d)	[tonnes]	1731	1702	1661	1602	1534	1423	1305	1190	1096	1013
NMVOC	Comm./Inst. (1A4a)	[tonnes]	2845	3504	4188	4897	5631	5775	5922	6022	5844	5159
NMVOC	Residential (1A4b)	[tonnes]	1757	1824	1894	1972	2053	2084	2115	2134	2109	2071
NMVOC	Ag./for./fish. (1A4c)	[tonnes]	3414	3378	3199	2987	2698	2712	2662	2598	2631	2504
NMVOC	Military (1A5)	[tonnes]	55	54	46	45	100	106	51	68	40	55
NMVOC	Navigation int. (1A3d)	[tonnes]	3045	2433	1989	2130	1731	1792	2418	2563	2195	1160
NMVOC	Civil Aviation int. (1A3a)	[tonnes]	407	405	389	398	449	468	491	505	484	503
CH4	Industry-Other (1A2f)	[tonnes]	50	49	48	47	46	45	44	43	40	30
CH4	Civil Aviation (1A3a)	[tonnes]	5	6	5	5	6	7	6	7	6	10
CH4	Road (1A3b)	[tonnes]	1770	1645	1531	1449	1345	1224	1125	1018	859	712
CH4	Railways (1A3c)	[tonnes]	10	10	9	9	8	9	9	9	8	7
CH4	Navigation (1A3d)	[tonnes]	33	33	34	34	35	35	35	35	35	35
CH4	Comm./Inst. (1A4a)	[tonnes]	92	101	113	127	144	157	169	175	174	167
CH4	Residential (1A4b)	[tonnes]	45	48	51	55	60	62	64	65	66	66
CH4	Ag./for./fish. (1A4c)	[tonnes]	88	90	90	89	85	90	97	104	111	114
CH4	Military (1A5)	[tonnes]	6	6	5	5	12	12	6	7	4	5
CH4	Navigation int. (1A3d)	[tonnes]	94	75	62	66	54	55	75	79	68	36
CH4	Civil Aviation int. (1A3a)	[tonnes]	42	42	40	41	47	49	52	54	50	53
CO	Industry-Other (1A2f)	[tonnes]	8395	8227	8030	7842	7600	7497	7515	7383	7010	5123
CO	Civil Aviation (1A3a)	[tonnes]	895	891	863	835	858	861	842	902	824	758
CO	Road (1A3b)	[tonnes]	252115	240986	220720	211083	186503	178194	158413	141197	127495	110199
CO	Railways (1A3c)	[tonnes]	694	637	627	611	599	648	626	629	526	450
CO	Navigation (1A3d)	[tonnes]	6832	7034	7217	7408	7601	7631	7281	6915	6565	6213

Continued (2000-2009)												
CO	Comm./Inst. (1A4a)	[tonnes]	29423	32889	37681	43798	51239	58128	64197	67870	70290	72227
CO	Residential (1A4b)	[tonnes]	16451	17390	18463	19890	21444	22482	23547	24366	25092	25341
CO	Ag./for./fish. (1A4c)	[tonnes]	25842	24444	22573	20674	18579	17659	17417	18151	18995	19453
CO	Military (1A5)	[tonnes]	396	301	308	296	694	787	373	528	292	387
CO	Navigation int. (1A3d)	[tonnes]	10044	8025	6562	7025	5709	5912	7977	8454	7243	3826
CO	Civil Aviation int. (1A3a)	[tonnes]	1790	1795	1609	1668	1849	1913	1870	1933	2002	1791
CO2	Industry-Other (1A2f)	[ktonnes]	879	888	897	907	912	950	1021	1089	1109	823
CO2	Civil Aviation (1A3a)	[ktonnes]	154	163	141	138	128	135	143	161	162	156
CO2	Road (1A3b)	[ktonnes]	11203	11223	11352	11806	12115	12214	12587	13187	12938	12125
CO2	Railways (1A3c)	[ktonnes]	228	211	210	218	216	232	227	228	237	230
CO2	Navigation (1A3d)	[ktonnes]	588	587	578	576	588	585	588	586	593	598
CO2	Comm./Inst. (1A4a)	[ktonnes]	87	98	112	129	149	162	172	175	176	174
CO2	Residential (1A4b)	[ktonnes]	43	46	49	53	57	59	61	62	63	63
CO2	Ag./for./fish. (1A4c)	[ktonnes]	1615	1770	1794	1771	1642	1761	1752	1729	1865	1842
CO2	Military (1A5)	[ktonnes]	111	97	89	92	239	271	126	175	108	160
CO2	Navigation int. (1A3d)	[ktonnes]	4168	3304	2691	2853	2299	2352	3136	3292	2809	1487
CO2	Civil Aviation int. (1A3a)	[ktonnes]	2350	2384	2058	2141	2447	2574	2582	2647	2648	2314
N2O	Industry-Other (1A2f)	[tonnes]	37	38	38	38	39	40	43	46	47	35
N2O	Civil Aviation (1A3a)	[tonnes]	8	8	8	8	8	8	8	9	9	8
N2O	Road (1A3b)	[tonnes]	451	443	437	440	440	425	424	433	417	384
N2O	Railways (1A3c)	[tonnes]	6	6	6	6	6	6	6	6	7	6
N2O	Navigation (1A3d)	[tonnes]	34	34	34	33	34	34	34	34	35	35
N2O	Comm./Inst. (1A4a)	[tonnes]	1	1	2	2	2	2	3	3	3	3
N2O	Residential (1A4b)	[tonnes]	1	1	1	1	1	1	1	1	1	1
N2O	Ag./for./fish. (1A4c)	[tonnes]	78	88	90	88	80	87	86	83	91	89
N2O	Military (1A5)	[tonnes]	3	3	3	3	8	9	4	6	4	6
N2O	Navigation int. (1A3d)	[tonnes]	262	208	170	180	145	148	197	207	177	94
N2O	Civil Aviation int. (1A3a)	[tonnes]	82	82	72	75	85	89	89	91	91	79
NH3	Industry-Other (1A2f)	[tonnes]	2	2	2	2	2	2	2	3	3	2
NH3	Civil Aviation (1A3a)	[tonnes]	0	0	0	0	0	0	0	0	0	0
NH3	Road (1A3b)	[tonnes]	2767	2753	2699	2616	2518	2298	2127	1982	1794	1612
NH3	Railways (1A3c)	[tonnes]	1	1	1	1	1	1	1	1	1	1
NH3	Navigation (1A3d)	[tonnes]	0	0	0	0	0	0	0	0	0	0
NH3	Comm./Inst. (1A4a)	[tonnes]	0	0	0	0	0	0	0	0	0	0
NH3	Residential (1A4b)	[tonnes]	0	0	0	0	0	0	0	0	0	0

Continued (2000-2009)												
NH3	Ag./for./fish. (1A4c)	[tonnes]	3	3	3	3	3	3	3	4	4	4
NH3	Military (1A5)	[tonnes]	0	0	0	0	1	1	0	0	1	1
NH3	Navigation int. (1A3d)	[tonnes]										
NH3	Civil Aviation int. (1A3a)	[tonnes]	0	0	0	0	0	0	0	0	0	0
TSP	Industry-Other (1A2f)	[tonnes]	1135	1121	1098	1075	1037	1002	991	938	854	587
TSP	Civil Aviation (1A3a)	[tonnes]	3	4	3	3	3	3	3	3	3	3
TSP	Road (1A3b)	[tonnes]	2986	2760	2520	2457	2328	2233	2170	2083	1818	1523
TSP	Railways (1A3c)	[tonnes]	141	125	124	119	115	124	120	120	101	84
TSP	Navigation (1A3d)	[tonnes]	383	373	357	387	430	425	421	336	327	327
TSP	Comm./Inst. (1A4a)	[tonnes]	30	38	46	55	63	65	66	66	67	67
TSP	Residential (1A4b)	[tonnes]	11	11	12	13	13	13	14	14	14	14
TSP	Ag./for./fish. (1A4c)	[tonnes]	1507	1498	1428	1351	1244	1213	1144	1075	1044	992
TSP	Military (1A5)	[tonnes]	15	31	14	17	38	32	15	15	11	17
TSP	Navigation int. (1A3d)	[tonnes]	8791	7143	4988	4501	3978	5761	7888	2365	1873	820
TSP	Civil Aviation int. (1A3a)	[tonnes]	38	38	33	35	40	42	42	43	43	37
PM10	Industry-Other (1A2f)	[tonnes]	1135	1121	1098	1075	1037	1002	991	938	854	587
PM10	Civil Aviation (1A3a)	[tonnes]	3	4	3	3	3	3	3	3	3	3
PM10	Road (1A3b)	[tonnes]	2986	2760	2520	2457	2328	2233	2170	2083	1818	1523
PM10	Railways (1A3c)	[tonnes]	141	125	124	119	115	124	120	120	101	84
PM10	Navigation (1A3d)	[tonnes]	381	371	355	384	427	422	418	334	325	324
PM10	Comm./Inst. (1A4a)	[tonnes]	30	38	46	55	63	65	66	66	67	67
PM10	Residential (1A4b)	[tonnes]	11	11	12	13	13	13	14	14	14	14
PM10	Ag./for./fish. (1A4c)	[tonnes]	1505	1496	1426	1349	1242	1211	1142	1074	1043	990
PM10	Military (1A5)	[tonnes]	15	31	14	17	38	32	15	15	11	17
PM10	Navigation int. (1A3d)	[tonnes]	8703	7072	4938	4456	3938	5703	7809	2341	1854	812
PM10	Civil Aviation int. (1A3a)	[tonnes]	38	38	33	35	40	42	42	43	43	37
PM2.5	Industry-Other (1A2f)	[tonnes]	1135	1121	1098	1075	1037	1002	991	938	854	587
PM2.5	Civil Aviation (1A3a)	[tonnes]	3	4	3	3	3	3	3	3	3	3
PM2.5	Road (1A3b)	[tonnes]	2986	2760	2520	2457	2328	2233	2170	2083	1818	1523
PM2.5	Railways (1A3c)	[tonnes]	141	125	124	119	115	124	120	120	101	84
PM2.5	Navigation (1A3d)	[tonnes]	379	370	354	383	425	421	417	333	324	323
PM2.5	Comm./Inst. (1A4a)	[tonnes]	30	38	46	55	63	65	66	66	67	67
PM2.5	Residential (1A4b)	[tonnes]	11	11	12	13	13	13	14	14	14	14
PM2.5	Ag./for./fish. (1A4c)	[tonnes]	1504	1495	1425	1347	1241	1210	1141	1073	1042	989
PM2.5	Military (1A5)	[tonnes]	15	31	14	17	38	32	15	15	11	17

Continued (2000-2009)												
PM2.5	Navigation int. (1A3d)	[tonnes]	8659	7036	4913	4434	3918	5675	7770	2330	1845	808
PM2.5	Civil Aviation int. (1A3a)	[tonnes]	38	38	33	35	40	42	42	43	43	37
Arsenic	Industry-Other (1A2f)	[kg]	0	0	0	0	0	0	0	0	0	0
Arsenic	Civil Aviation (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Arsenic	Road (1A3b)	[kg]	1	1	1	1	1	1	1	1	1	1
Arsenic	Railways (1A3c)	[kg]	0	0	0	0	0	0	0	0	0	0
Arsenic	Navigation (1A3d)	[kg]	24	23	23	28	28	28	30	30	31	33
Arsenic	Comm./Inst. (1A4a)	[kg]	0	0	0	0	0	0	0	0	0	0
Arsenic	Residential (1A4b)	[kg]	0	0	0	0	0	0	0	0	0	0
Arsenic	Ag./for./fish. (1A4c)	[kg]	9	11	11	11	9	10	10	8	10	9
Arsenic	Military (1A5)	[kg]	0	0	0	0	0	0	0	0	0	0
Arsenic	Navigation int. (1A3d)	[kg]	422	329	227	257	213	250	381	424	326	127
Arsenic	Civil Aviation int. (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Cadmium	Industry-Other (1A2f)	[kg]	2	2	2	2	2	2	3	3	3	2
Cadmium	Civil Aviation (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Cadmium	Road (1A3b)	[kg]	32	32	32	34	35	35	36	37	37	35
Cadmium	Railways (1A3c)	[kg]	1	1	1	1	1	1	1	1	1	1
Cadmium	Navigation (1A3d)	[kg]	3	2	2	3	3	3	3	3	3	3
Cadmium	Comm./Inst. (1A4a)	[kg]	0	0	0	0	1	1	1	1	1	1
Cadmium	Residential (1A4b)	[kg]	0	0	0	0	0	0	0	0	0	0
Cadmium	Ag./for./fish. (1A4c)	[kg]	4	5	5	5	4	5	5	5	5	5
Cadmium	Military (1A5)	[kg]	0	0	0	0	0	0	0	0	0	0
Cadmium	Navigation int. (1A3d)	[kg]	29	23	17	18	15	17	24	27	21	9
Cadmium	Civil Aviation int. (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Chromium	Industry-Other (1A2f)	[kg]	7	7	7	8	8	8	9	9	9	7
Chromium	Civil Aviation (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Chromium	Road (1A3b)	[kg]	72	73	74	78	82	84	87	94	93	89
Chromium	Railways (1A3c)	[kg]	2	2	2	2	2	2	2	2	2	2
Chromium	Navigation (1A3d)	[kg]	13	12	12	14	14	14	15	15	15	16
Chromium	Comm./Inst. (1A4a)	[kg]	0	0	1	1	1	1	1	1	1	1
Chromium	Residential (1A4b)	[kg]	0	0	0	0	0	0	0	0	0	0
Chromium	Ag./for./fish. (1A4c)	[kg]	16	18	19	18	17	18	18	17	19	18
Chromium	Military (1A5)	[kg]	0	1	0	0	1	1	0	0	0	1
Chromium	Navigation int. (1A3d)	[kg]	179	140	100	111	92	106	157	174	136	56
Chromium	Civil Aviation int. (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0

Continued (2000-2009)												
Copper	Industry-Other (1A2f)	[kg]	6	6	6	6	6	6	7	7	7	5
Copper	Civil Aviation (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Copper	Road (1A3b)	[kg]	108	108	110	113	116	114	116	119	117	111
Copper	Railways (1A3c)	[kg]	1	1	1	1	1	1	1	1	1	1
Copper	Navigation (1A3d)	[kg]	25	24	24	29	29	29	31	31	32	34
Copper	Comm./Inst. (1A4a)	[kg]	1	1	1	2	2	2	2	2	2	2
Copper	Residential (1A4b)	[kg]	1	1	1	1	1	1	1	1	1	1
Copper	Ag./for./fish. (1A4c)	[kg]	16	18	18	18	16	17	17	16	18	17
Copper	Military (1A5)	[kg]	0	0	0	0	1	1	0	0	0	1
Copper	Navigation int. (1A3d)	[kg]	422	329	227	257	213	250	381	424	326	127
Copper	Civil Aviation int. (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Mercury	Industry-Other (1A2f)	[kg]	1	1	1	1	1	1	2	2	2	1
Mercury	Civil Aviation (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Mercury	Road (1A3b)	[kg]	25	25	25	26	26	26	27	28	27	25
Mercury	Railways (1A3c)	[kg]	0	0	0	0	0	0	0	0	0	0
Mercury	Navigation (1A3d)	[kg]	7	7	7	6	6	6	6	6	6	6
Mercury	Comm./Inst. (1A4a)	[kg]	0	0	0	0	0	0	0	0	0	0
Mercury	Residential (1A4b)	[kg]	0	0	0	0	0	0	0	0	0	0
Mercury	Ag./for./fish. (1A4c)	[kg]	11	13	13	13	10	12	12	10	12	11
Mercury	Military (1A5)	[kg]	0	0	0	0	0	0	0	0	0	0
Mercury	Navigation int. (1A3d)	[kg]	42	34	30	31	24	23	27	27	25	17
Mercury	Civil Aviation int. (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Nickel	Industry-Other (1A2f)	[kg]	2	2	2	2	2	2	3	3	3	2
Nickel	Civil Aviation (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Nickel	Road (1A3b)	[kg]	36	36	37	38	39	39	40	41	41	39
Nickel	Railways (1A3c)	[kg]	1	1	1	1	1	1	1	1	1	1
Nickel	Navigation (1A3d)	[kg]	1068	1036	1026	1374	1367	1371	1494	1479	1578	1687
Nickel	Comm./Inst. (1A4a)	[kg]	0	0	0	1	1	1	1	1	1	1
Nickel	Residential (1A4b)	[kg]	0	0	0	0	0	0	0	0	0	0
Nickel	Ag./for./fish. (1A4c)	[kg]	15	18	19	18	15	17	16	15	17	16
Nickel	Military (1A5)	[kg]	0	0	0	0	0	0	0	0	0	0
Nickel	Navigation int. (1A3d)	[kg]	23829	18510	12366	14147	11846	14256	22148	24842	18832	6924
Nickel	Civil Aviation int. (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Lead	Industry-Other (1A2f)	[kg]	13	13	13	13	13	14	15	16	16	12
Lead	Civil Aviation (1A3a)	[kg]	1369	1343	1328	1252	1304	1297	1245	1329	1182	991

Continued (2000-2009)												
Lead	Road (1A3b)	[kg]	130	132	135	143	149	151	157	168	168	161
Lead	Railways (1A3c)	[kg]	3	3	3	3	3	4	3	3	4	3
Lead	Navigation (1A3d)	[kg]	21	20	20	21	21	21	22	22	22	23
Lead	Comm./Inst. (1A4a)	[kg]	1	1	1	1	2	2	2	2	2	2
Lead	Residential (1A4b)	[kg]	0	0	1	1	1	1	1	1	1	1
Lead	Ag./for./fish. (1A4c)	[kg]	33	38	39	38	34	37	36	34	38	37
Lead	Military (1A5)	[kg]	114	89	106	79	84	60	47	81	40	66
Lead	Navigation int. (1A3d)	[kg]	210	166	126	137	112	121	172	186	151	70
Lead	Civil Aviation int. (1A3a)	[kg]	118	114	113	106	111	117	22	10	113	52
Selenium	Industry-Other (1A2f)	[kg]	0	0	0	0	0	0	0	0	0	0
Selenium	Civil Aviation (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Selenium	Road (1A3b)	[kg]	1	1	1	1	1	1	1	1	1	1
Selenium	Railways (1A3c)	[kg]	0	0	0	0	0	0	0	0	0	0
Selenium	Navigation (1A3d)	[kg]	39	38	37	39	40	40	41	40	42	43
Selenium	Comm./Inst. (1A4a)	[kg]	0	0	0	0	0	0	0	0	0	0
Selenium	Residential (1A4b)	[kg]	0	0	0	0	0	0	0	0	0	0
Selenium	Ag./for./fish. (1A4c)	[kg]	35	44	45	44	34	41	38	33	38	35
Selenium	Military (1A5)	[kg]	0	0	0	0	0	0	0	0	0	0
Selenium	Navigation int. (1A3d)	[kg]	421	331	252	274	224	243	345	372	302	140
Selenium	Civil Aviation int. (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Zinc	Industry-Other (1A2f)	[kg]	438	443	447	452	455	474	510	544	555	411
Zinc	Civil Aviation (1A3a)	[kg]	5	5	5	5	5	5	5	5	4	4
Zinc	Road (1A3b)	[kg]	6340	6366	6498	6756	6970	6948	7109	7456	7364	7052
Zinc	Railways (1A3c)	[kg]	115	106	106	110	109	117	114	115	119	116
Zinc	Navigation (1A3d)	[kg]	142	143	143	149	152	152	153	152	154	156
Zinc	Comm./Inst. (1A4a)	[kg]	60	68	77	89	103	112	119	121	122	121
Zinc	Residential (1A4b)	[kg]	29	32	34	36	39	41	42	43	44	44
Zinc	Ag./for./fish. (1A4c)	[kg]	630	658	663	660	646	669	680	699	739	744
Zinc	Military (1A5)	[kg]	14	33	17	22	53	48	24	26	24	42
Zinc	Navigation int. (1A3d)	[kg]	973	766	588	637	519	560	788	848	692	326
Zinc	Civil Aviation int. (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Dioxins/furans	Industry-Other (1A2f)	[g]	0	0	0	0	0	0	0	0	0	0
Dioxins/furans	Civil Aviation (1A3a)	[g]	0	0	0	0	0	0	0	0	0	0
Dioxins/furans	Road (1A3b)	[g]	0	0	0	0	0	0	0	0	0	0
Dioxins/furans	Railways (1A3c)	[g]	0	0	0	0	0	0	0	0	0	0

Continued (2000-2009)												
Dioxins/furans	Navigation (1A3d)	[g]	0	0	0	0	0	0	0	0	0	0
Dioxins/furans	Comm./Inst. (1A4a)	[g]	0	0	0	0	0	0	0	0	0	0
Dioxins/furans	Residential (1A4b)	[g]	0	0	0	0	0	0	0	0	0	0
Dioxins/furans	Ag./for./fish. (1A4c)	[g]	0	0	0	0	0	0	0	0	0	0
Dioxins/furans	Military (1A5)	[g]	0	0	0	0	0	0	0	0	0	0
Dioxins/furans	Navigation int. (1A3d)	[g]	1	1	0	0	0	0	1	1	0	0
Dioxins/furans	Civil Aviation int. (1A3a)	[g]	0	0	0	0	0	0	0	0	0	0
Flouranthene	Industry-Other (1A2f)	[kg]	48	48	49	49	50	52	56	60	61	45
Flouranthene	Civil Aviation (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Flouranthene	Road (1A3b)	[kg]	556	547	551	581	610	633	675	755	774	755
Flouranthene	Railways (1A3c)	[kg]	4	4	4	4	4	4	4	4	5	4
Flouranthene	Navigation (1A3d)	[kg]	52	51	50	49	50	50	49	49	50	50
Flouranthene	Comm./Inst. (1A4a)	[kg]	5	6	7	8	9	10	10	10	10	10
Flouranthene	Residential (1A4b)	[kg]	3	3	3	3	3	3	4	4	4	4
Flouranthene	Ag./for./fish. (1A4c)	[kg]	118	133	135	133	119	130	128	123	134	131
Flouranthene	Military (1A5)	[kg]	2	4	2	3	6	6	3	3	3	5
Flouranthene	Navigation int. (1A3d)	[kg]	298	238	208	215	171	164	203	205	187	114
Flouranthene	Civil Aviation int. (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Benzo(b) flouranthene	Industry-Other (1A2f)	[kg]	6	6	6	6	6	6	7	7	7	5
Benzo(b) flouranthene	Civil Aviation (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Benzo(b) flouranthene	Road (1A3b)	[kg]	59	58	58	61	64	65	68	74	74	70
Benzo(b) flouranthene	Railways (1A3c)	[kg]	1	1	1	1	1	1	1	1	1	1
Benzo(b) flouranthene	Navigation (1A3d)	[kg]	4	4	4	4	4	4	4	4	4	4
Benzo(b) flouranthene	Comm./Inst. (1A4a)	[kg]	0	0	0	0	0	0	0	1	1	0
Benzo(b) flouranthene	Residential (1A4b)	[kg]	0	0	0	0	0	0	0	0	0	0
Benzo(b) flouranthene	Ag./for./fish. (1A4c)	[kg]	12	13	13	13	12	13	13	13	14	14
Benzo(b) flouranthene	Military (1A5)	[kg]	0	0	0	0	1	1	0	0	0	1
Benzo(b) flouranthene	Navigation int. (1A3d)	[kg]	21	17	15	16	12	11	13	12	12	8
Benzo(b) flouranthene	Civil Aviation int. (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Benzo(k) flouranthene	Industry-Other (1A2f)	[kg]	6	5	5	6	6	6	6	7	7	5
Benzo(k) flouranthene	Civil Aviation (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Benzo(k) flouranthene	Road (1A3b)	[kg]	68	67	68	71	74	76	79	85	84	79
Benzo(k) flouranthene	Railways (1A3c)	[kg]	1	1	1	1	1	1	1	1	1	1
Benzo(k) flouranthene	Navigation (1A3d)	[kg]	2	2	2	2	2	2	2	2	2	2
Benzo(k) flouranthene	Comm./Inst. (1A4a)	[kg]	0	0	0	0	0	0	0	0	0	0

Continued (2000-2009)												
Benzo(k) flouranthene	Residential (1A4b)	[kg]	0	0	0	0	0	0	0	0	0	0
Benzo(k) flouranthene	Ag./for./fish. (1A4c)	[kg]	9	10	10	10	9	10	10	10	11	11
Benzo(k) flouranthene	Military (1A5)	[kg]	0	0	0	0	1	1	0	0	0	1
Benzo(k) flouranthene	Navigation int. (1A3d)	[kg]	10	8	7	7	6	5	6	6	6	4
Benzo(k) flouranthene	Civil Aviation int. (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Benzo(a) pyrene	Industry-Other (1A2f)	[kg]	3	3	3	3	3	3	3	4	4	3
Benzo(a) pyrene	Civil Aviation (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Benzo(a) pyrene	Road (1A3b)	[kg]	41	41	42	44	46	48	51	56	58	56
Benzo(a) pyrene	Railways (1A3c)	[kg]	0	0	0	0	0	0	0	0	0	0
Benzo(a) pyrene	Navigation (1A3d)	[kg]	1	1	1	1	1	1	1	1	1	1
Benzo(a) pyrene	Comm./Inst. (1A4a)	[kg]	0	0	0	0	0	0	0	0	0	0
Benzo(a) pyrene	Residential (1A4b)	[kg]	0	0	0	0	0	0	0	0	0	0
Benzo(a) pyrene	Ag./for./fish. (1A4c)	[kg]	5	5	5	5	5	5	5	5	6	5
Benzo(a) pyrene	Military (1A5)	[kg]	0	0	0	0	0	0	0	0	0	0
Benzo(a) pyrene	Navigation int. (1A3d)	[kg]	6	4	4	4	3	3	4	4	3	2
Benzo(a) pyrene	Civil Aviation int. (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Benzo(g,h,i) perylene	Industry-Other (1A2f)	[kg]	5	5	5	5	5	6	6	6	7	5
Benzo(g,h,i) perylene	Civil Aviation (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
Benzo(g,h,i) perylene	Road (1A3b)	[kg]	79	79	80	84	88	90	96	106	108	106
Benzo(g,h,i) perylene	Railways (1A3c)	[kg]	0	0	0	0	0	0	0	0	0	0
Benzo(g,h,i) perylene	Navigation (1A3d)	[kg]	8	8	8	7	7	7	7	7	7	7
Benzo(g,h,i) perylene	Comm./Inst. (1A4a)	[kg]	1	1	1	1	1	2	2	2	2	2
Benzo(g,h,i) perylene	Residential (1A4b)	[kg]	0	0	0	0	1	1	1	1	1	1
Benzo(g,h,i) perylene	Ag./for./fish. (1A4c)	[kg]	18	20	21	20	17	20	19	18	20	19
Benzo(g,h,i) perylene	Military (1A5)	[kg]	0	0	0	0	1	1	0	0	0	1
Benzo(g,h,i) perylene	Navigation int. (1A3d)	[kg]	40	32	31	31	24	21	23	21	22	17
Benzo(g,h,i) perylene	Civil Aviation int. (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
indeno(1,2,3-c,d) pyrene	Industry-Other (1A2f)	[kg]	3	3	3	3	3	3	3	4	4	3
indeno(1,2,3-c,d) pyrene	Civil Aviation (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0
indeno(1,2,3-c,d) pyrene	Road (1A3b)	[kg]	46	46	47	50	52	54	57	62	63	61
indeno(1,2,3-c,d) pyrene	Railways (1A3c)	[kg]	0	0	0	0	0	0	0	0	0	0
indeno(1,2,3-c,d) pyrene	Navigation (1A3d)	[kg]	7	7	6	6	6	6	6	6	6	6
indeno(1,2,3-c,d) pyrene	Comm./Inst. (1A4a)	[kg]	0	0	0	0	0	1	1	1	1	1
indeno(1,2,3-c,d) pyrene	Residential (1A4b)	[kg]	0	0	0	0	0	0	0	0	0	0
indeno(1,2,3-c,d) pyrene	Ag./for./fish. (1A4c)	[kg]	13	15	15	15	13	14	14	13	14	13

Continued (2000-2009)												
indeno(1,2,3-c,d) pyrene	Military (1A5)	[kg]	0	0	0	0	0	0	0	0	0	0
indeno(1,2,3-c,d) pyrene	Navigation int. (1A3d)	[kg]	33	26	25	25	20	17	19	17	18	14
indeno(1,2,3-c,d) pyrene	Civil Aviation int. (1A3a)	[kg]	0	0	0	0	0	0	0	0	0	0

Annex 2B-16: Uncertainty estimates

Uncertainty estimation, SO_2.

	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions in-troduced by emission factor uncertainty	Uncertainty in trend in national emissions in-troduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data Gg SO_2	Input data Gg SO_2	Input data %	Input data %	%	%	%	%	%	%	%
Road Transportation	SO_2	5767	82	2	50	50,040	3,498	- 0,024431002	0,0054	-1,2215501	0,015396936	1,22164714
Other mobile sources	SO_2	9216	1085	10	50	50,990	47,425	0,024375101	0,0724	1,21875506	1,024163247	1,5919404
Total		14983,405	1166,6516				2261,399					4,02669599
Total uncertainties					**Year (%):**		**47,554**			**Trend (%):**		**2,007**

Uncertainty estimation, NO_X.

	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data Gg NO_X	Input data Gg NO_X	Input data %	Input data %	%	%	%	%	%	%	%
Road Transportation	NO_X	106456	61250	2	50	50,040	30,371	-0,044630295	0,3895	-2,2315147	1,101640212	2,48862797
Other mobile sources	NO_X	50802	39667	10	100	100,499	39,503	0,044787734	0,2522	4,47877341	3,567250654	5,72579152
Total	NO_X	157258,18	100917,5				2482,854					38,9779577
Total uncertainties					**Year (%):**		**49,828**			**Trend (%):**		**6,243**

Uncertainty estimation, NMVOC.

	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data Gg NMVOC	Input data Gg NMVOC	Input data %	Input data %	%	%	%	%	%	%	%
Road Transportation	NMVOC	81541	17754	2	50	50,040	28,795	-0,086372485	0,1845	-4,3186242	0,521711922	4,35002284
Other mobile sources	NMVOC	14709	13099	10	100	100,499	42,668	0,0869713	0,1361	8,69713003	1,924613227	8,90753652
Total	NMVOC	96249,848	30852,285				2649,701					98,2669056
Total uncertainties					**Year (%):**		**51,475**			**Trend (%):**		**9,913**

Uncertainty estimation, CO.

	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data Gg CO	Input data Gg CO	Input data %	Input data %	%	%	%	%	%	%	%
Road Transportation	CO	458943	139272	2	50	50,040	26,162	-0,125520188	0,2417	-6,2760094	0,683653327	6,31313516
Other mobile sources	CO	117258	127111	10	100	100,499	47,955	0,126263004	0,2206	12,6263004	3,119768935	13,0060148
Total	CO	576201,37	266383,04				2984,168					209,012096
Total uncertainties					**Year (%):**		**54,628**			**Trend (%):**		**14,457**

Uncertainty estimation, NH_3.

	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data Gg NH_3	Input data Gg NH_3	Input data %	Input data %	%	%	%	%	%	%	%
Road Transportation	NH_3	70	1572	2	1000	1000,002	994,953	1,54409902	20,6421	1544,09902	58,38468994	1545,20243
Other mobile sources	NH_3	6	8	10	1000	1000,050	5,049	-1,557054143	0,1048	-1557,0541	1,481453291	1557,05485
Total	NH_3	76,133495	1579,5309				989956,597					4812070,36
Total uncertainties					**Year (%):**		**994,966**			**Trend (%):**		**2194**

Uncertainty estimation, TSP.

	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data Gg TSP	Input data Gg TSP	Input data %	Input data %	%	%	%	%	%	%	%
Road Transportation	TSP	6779	5166	2	50	50,040	34,650	0,079252823	0,4298	3,96264115	1,215632854	4,14491111
Other mobile sources	TSP	5240	2294	10	100	100,499	30,909	-0,079353885	0,1909	-7,9353885	2,69968805	8,38204671
Total	TSP	12018,727	7459,8782				2155,983					87,4389951
Total uncertainties					**Year (%):**		**46,433**			**Trend (%):**		**9,351**

Uncertainty estimation, Arsenic.

	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data kg	Input data kg	Input data %	Input data %	%	%	%	%	%	%	%
Road Transportation	Arsenic	0	0	2	1000	1000,002	0,000	0	0,0000	0	0	0
Other mobile sources	Arsenic	62	20	10	1000	1000,050	1000,050	0	0,3154	0	4,461082366	4,46108237
Total	Arsenic	62,035802	19,568955				1000100,000					19,9012559
Total uncertainties					**Year (%):**		**1000,050**			**Trend (%):**		**4,461**

Uncertainty estimation, Cadmium.

	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data kg	Input data kg	Input data %	Input data %	%	%	%	%	%	%	%
Road Transportation	Cadmium	29	41	2	1000	1000,002	763,982	0,12387662	0,9241	123,87662	2,613634772	123,904189
Other mobile sources	Cadmium	15	13	10	1000	1000,050	236,032	-0,124273874	0,2855	-124,27387	4,037210179	124,339434
Total	Cadmium	44,162276	53,415744				639378,944					30812,5429
Total uncertainties					**Year (%):**		**799,612**			**Trend (%):**		**175,535**

Uncertainty estimation, Chromium.

	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data kg	Input data kg	Input data %	Input data %	%	%	%	%	%	%	%
Road Transportation	Chromium	146	204	2	1000	1000,002	766,136	0,130950204	0,9171	130,950204	2,593991346	130,975894
Other mobile sources	Chromium	77	62	10	1000	1000,050	233,877	-0,131357432	0,2800	-131,35743	3,9591245	131,417083
Total	Chromium	222,5897	266,45474				641663,184					34425,1345
Total uncertainties					**Year (%):**		**801,039**			**Trend (%):**		**185,540**

Uncertainty estimation, Copper.

	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data kg	Input data kg	Input data %	Input data %	%	%	%	%	%	%	%
Road Transportation	Copper	4965	6942	2	1000	1000,002	802,317	0,062541589	1,0546	62,5415886	2,982850913	62,6126801
Other mobile sources	Copper	1617	1710	10	1000	1000,050	197,695	-0,062858991	0,2598	-62,858991	3,674765077	62,9663132
Total	Copper	6582,1835	8651,8997				682795,544					7885,10431
Total uncertainties					**Year (%):**		**826,314**			**Trend (%):**		**88,798**

Uncertainty estimation, Mercury.

	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data kg	Input data kg	Input data %	Input data %	%	%	%	%	%	%	%
Road Transportation	Mercury	0	0	2	1000	1000,002	0,000	0	0,0000	0	0	0
Other mobile sources	Mercury	17	12	10	1000	1000,050	1000,050	0	0,7207	0	10,19189852	10,1918985
Total	Mercury	16,931552	12,202164				1000100,000					103,874795
Total uncertainties					**Year (%):**		**1000,050**			**Trend (%):**		**10,192**

Uncertainty estimation, Nickel.

	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data kg	Input data kg	Input data %	Input data %	%	%	%	%	%	%	%
Road Transportation	Nickel	204	286	2	1000	1000,002	343,186	0,074282429	0,0920	74,2824287	0,260092577	74,282884
Other mobile sources	Nickel	2904	547	10	1000	1000,050	656,848	-0,073643299	0,1760	-73,643299	2,488927719	73,685346
Total	Nickel	3108,0281	832,7973				549225,356					10947,4771
Total uncertainties					**Year (%):**		**741,097**			**Trend (%):**		**104,630**

Uncertainty estimation, Lead.

	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data kg	Input data kg	Input data %	Input data %	%	%	%	%	%	%	%
Road Transportation	Lead	97510	50	2	1000	1000,002	38,207	-0,011208835	0,0005	-11,208835	0,001355191	11,2088354
Other mobile sources	Lead	6178	1251	10	1000	1000,050	961,842	0,011307508	0,0121	11,3075078	0,170574616	11,3087943
Total	Lead	103687,72	1300,3041				926598,884					253,526818
Total uncertainties					**Year (%):**		**962,600**			**Trend (%):**		**15,923**

Uncertainty estimation, Selenium.

	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data kg	Input data kg	Input data %	Input data %	%	%	%	%	%	%	%
Road Transportation	Selenium	29	41	2	1000	1000,002	391,116	0,135162131	0,2997	135,162131	0,847736324	135,16479
Other mobile sources	Selenium	107	64	10	1000	1000,050	608,915	-0,134395995	0,4666	-134,39599	6,598734386	134,557893
Total	Selenium	136,15561	104,33891				523749,345					36375,3471
Total uncertainties					**Year (%):**		**723,705**			**Trend (%):**		**190,723**

Uncertainty estimation, Zinc.

	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data kg	Input data kg	Input data %	Input data %	%	%	%	%	%	%	%
Road Transportation	Zinc	2921	4083	2	1000	1000,002	783,618	0,083962682	1,0031	83,9626819	2,837258016	84,0106064
Other mobile sources	Zinc	1150	1128	10	1000	1000,050	216,395	-0,084326984	0,2770	-84,326984	3,917332359	84,4179232
Total	Zinc	4070,5314	5210,7663				660883,327					14184,1678
Total uncertainties					**Year (%):**		**812,947**			**Trend (%):**		**119,097**

Uncertainty estimation, Dioxins.

	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data g dioxins	Input data g dioxins	Input data %	Input data %	%	%	%	%	%	%	%
Road Transportation	Dioxins	1	0	2	1000	1000,002	477,917	-0,092027886	0,1473	-92,027886	0,416679042	92,0288298
Other mobile sources	Dioxins	0	0	10	1000	1000,050	522,110	0,092539883	0,1609	92,5398827	2,275934696	92,5678657
Total	Dioxins	1,1053423	0,3407231				501003,542					17038,1153
Total uncertainties					**Year (%):**		**707,816**			**Trend (%):**		**130,530**

Uncertainty estimation, Flouranthene.

	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data kg	Input data kg	Input data %	Input data %	%	%	%	%	%	%	%
Road Transportation	Flouranthene	785	735	2	1000	1000,002	752,508	-0,002498291	0,7065	-2,4982907	1,99826313	3,19914238
Other mobile sources	Flouranthene	255	242	10	1000	1000,050	247,506	0,00251101	0,2324	2,51101022	3,286066983	4,13562674
Total	Flouranthene	1039,743	976,16557				627527,373					27,3379205
Total uncertainties					**Year (%):**		**792,166**			**Trend (%):**		**5,229**

Uncertainty estimation, Benzo(b) flouranthene.

	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data kg	Input data kg	Input data %	Input data %	%	%	%	%	%	%	%
Road Transportation	Benzo(b) flouranthene	65	73	2	1000	1000,002	744,546	0,038796111	0,7946	38,7961107	2,247448048	38,8611532
Other mobile sources	Benzo(b) flouranthene	27	25	10	1000	1000,050	255,468	-0,038956982	0,2726	-38,956982	3,855529022	39,1473059
Total	Benzo(b) flouranthene	92,122538	98,31501				619612,891					3042,70079
Total uncertainties					**Year (%):**		**787,155**			**Trend (%):**		**55,161**

Uncertainty estimation, Benzo(k) flouranthene.

	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data kg	Input data kg	Input data %	Input data %	%	%	%	%	%	%	%
Road Transportation	Benzo(k) flouranthene	66	85	2	1000	1000,002	804,847	0,058627338	0,9711	58,6273382	2,746549763	58,6916376
Other mobile sources	Benzo(k) flouranthene	21	21	10	1000	1000,050	195,165	-0,058926645	0,2355	-58,926645	3,329851082	59,0206522
Total	Benzo(k) flouranthene	87,445276	105,50343				685867,391					6928,14571
Total uncertainties					**Year (%):**		**828,171**			**Trend (%):**		**83,235**

Uncertainty estimation, Benzo(a) pyrene.

	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		kg	kg	%	%	%	%	%	%	%	%	%
Road Transportation	Benzo(a) pyrene	45	54	2	1000	1000,002	838,603	0,033257852	0,9802	33,2578515	2,772359729	33,3732028
Other mobile sources	Benzo(a) pyrene	11	10	10	1000	1000,050	161,407	-0,033463604	0,1886	-33,463604	2,667869945	33,5697825
Total	Benzo(a) pyrene	55,283486	64,616669				729306,859					2240,70097
Total uncertainties					**Year (%):**		**853,995**			**Trend (%):**		**47,336**

Uncertainty estimation, Benzo(g,h,i) perylene.

	Gas	Base year emission	Year t emission	Activity Data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		kg	kg	%	%	%	%	%	%	%	%	%
Road Transportation	Benzo(g,h,i) perylene	95	102	2	1000	1000,002	756,793	0,033416225	0,7771	33,4162249	2,198024105	33,4884367
Other mobile sources	Benzo(g,h,i) perylene	36	33	10	1000	1000,050	243,220	-0,033565527	0,2497	-33,565527	3,531868291	33,7508323
Total	Benzo(g,h,i) perylene	130,7031	134,21374				631892,155					2260,59408
Total uncertainties					**Year (%):**		**794,916**			**Trend (%):**		**47,546**

Uncertainty estimation, indeno(1,2,3-c,d) pyrene.

	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		kg	kg	%	%	%	%	%	%	%	%	%
Road Transportation	indeno(1,2,3-c,d) pyr.	43	59	2	1000	1000,002	731,326	0,111782192	0,8838	111,782192	2,499712828	111,810139
Other mobile sources	indeno(1,2,3-c,d) pyr.	24	22	10	1000	1000,050	268,689	- 0,112090122	0,3247	-112,09012	4,591751708	112,184133
Total	indeno(1,2,3-c,d) pyr.	67,312397	81,344866				607031,268					25086,7868
Total uncertainties					**Year (%):**		**779,122**			**Trend (%):**		**158,388**

Annex 2B-16: Uncertainty estimates

Uncertainty estimation, CO_2

	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		Gg	Gg	%	%	%	%	%	%	%	%	%
Road transport	CO_2	9282	12125	2	5	5,385	4,038	0,07890903	0,8923	0,3945	2,5237	2,5543
Military	CO_2	119	160	2	5	5,385	0,053	0,00135154	0,0118	0,0068	0,0333	0,0340
Railways	CO_2	297	230	2	5	5,385	0,077	-0,0090434	0,0169	-0,0452	0,0479	0,0659
Navigation (small boats)	CO_2	48	100	41	5	41,304	0,255	0,00315662	0,0074	0,0158	0,4263	0,4266
Navigation (large vessels)	CO_2	748	498	11	5	12,083	0,372	-0,0288336	0,0366	-0,1442	0,5699	0,5879
Fisheries	CO_2	591	557	2	5	5,385	0,185	-0,0107305	0,0410	-0,0537	0,1159	0,1277
Agriculture	CO_2	1272	1268	24	5	24,515	1,923	-0,0180755	0,0933	-0,0904	3,1679	3,1692
Forestry	CO_2	36	17	30	5	30,414	0,032	-0,0018672	0,0013	-0,0093	0,0533	0,0541
Industry (mobile)	CO_2	842	823	41	5	41,304	2,101	-0,0131393	0,0605	-0,0657	3,5104	3,5111
Residential	CO_2	39	63	35	5	35,355	0,138	0,00121225	0,0046	0,0061	0,2293	0,2294
Commercial/Institutional	CO_2	74	174	35	5	35,355	0,381	0,00637516	0,0128	0,0319	0,6351	0,6359
Civil aviation	CO_2	243	156	10	5	11,180	0,108	-0,0098053	0,0114	-0,0490	0,1619	0,1691
		13.589	16171				24,695					29,5293
Total uncertainties				**Year (%):**			**4,969**		**Trend (%):**			**5,434**

Uncertainty estimation, CH_4

	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		Mg	Mg	%	%	%	%	%	%	%	%	%
Road transport	CH_4	2503	712	2	40	40,050	24,873	-0,0935753	0,2447	-3,7430	0,6920	3,8065
Military	CH_4	5	5	2	100	100,020	0,461	0,00111679	0,0018	0,1117	0,0051	0,1118
Railways	CH_4	12	7	2	100	100,020	0,583	0,00062852	0,0023	0,0629	0,0065	0,0632
Navigation (small boats)	CH_4	17	24	41	100	108,079	2,298	0,00613552	0,0084	0,6136	0,4856	0,7825
Navigation (large vessels)	CH_4	16	11	11	100	100,603	0,960	0,00161214	0,0038	0,1612	0,0585	0,1715
Fisheries	CH_4	13	14	2	100	100,020	1,183	0,00288698	0,0047	0,2887	0,0132	0,2890
Agriculture	CH_4	105	97	24	100	102,840	8,711	0,01917488	0,0334	1,9175	1,1327	2,2270
Forestry	CH_4	21	4	30	100	104,403	0,338	-0,0015685	0,0013	-0,1568	0,0541	0,1659
Industry (mobile)	CH_4	60	30	41	100	108,079	2,832	0,0022373	0,0103	0,2237	0,5986	0,6390
Residential	CH_4	51	66	35	100	105,948	6,064	0,01564537	0,0226	1,5645	1,1162	1,9219
Commercial/Institutional	CH_4	99	167	35	100	105,948	15,468	0,04411703	0,0575	4,4117	2,8471	5,2506
Civil aviation	CH_4	7	10	10	100	100,499	0,855	0,00236894	0,0033	0,2369	0,0474	0,2416
		2908	1146				748,323					24,3784
Total uncertainties				**Year (%):**			**27,355**			**Trend (%):**		**4,937**

Uncertainty estimation, N_2O

	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		Mg	Mg	%	%	%	%	%	%	%	%	%
Road transport	N_2O	302	384	2	50	50,040	33,912	0,07793815	0,7764	3,8969	2,1959	4,4730
Military	N_2O	4	6	2	1000	1000,002	9,718	0,00255547	0,0111	2,5555	0,0315	2,5557
Railways	N_2O	8	6	2	1000	1000,002	11,192	-0,0061063	0,0128	-6,1063	0,0363	6,1064
Navigation (small boats)	N_2O	1	3	41	1000	1000,840	6,127	0,00410638	0,0070	4,1064	0,4066	4,1265
Navigation (large vessels)	N_2O	47	31	11	1000	1000,060	55,389	-0,045545	0,0634	-45,5450	0,9870	45,5557
Fisheries	N_2O	37	35	2	1000	1000,002	62,091	-0,0147174	0,0711	-14,7174	0,2012	14,7188
Agriculture	N_2O	49	54	24	1000	1000,288	94,554	-0,0057036	0,1083	-5,7036	3,6755	6,7853
Forestry	N_2O	1	1	30	1000	1000,450	0,956	-0,0002018	0,0011	-0,2018	0,0464	0,2071
Industry (mobile)	N_2O	34	35	41	1000	1000,840	61,511	-0,0088409	0,0704	-8,8409	4,0825	9,7379
Residential	N_2O	1	1	35	1000	1000,612	1,900	0,00074756	0,0022	0,7476	0,1077	0,7553
Commercial/Institutional	N_2O	1	3	35	1000	1000,612	4,685	0,00281993	0,0054	2,8199	0,2655	2,8324
Civil aviation	N_2O	10	8	10	1000	1000,050	14,275	-0,007459	0,0164	-7,4590	0,2313	7,4626
		495	567				21262,921					2569,9908
Total uncertainties				**Year (%):**			**145,818**		**Trend (%):**			**50,695**

Annex 3C Industrial Processes

No annexes for industrial processes in this submission.

Annex 3D Solvents

The National Atmospheric Inventory for Great Britain (http://www.naei.org.uk/) covers the following sectors and chemicals:

Total emission
Energy Production
Comm+ Residn Combusn.
Industrial Combustion
Production Processes
Extr & Distrib of Fossil Fuels
Solvent Use
Road Transport
Other Transp & Mach
Waste Treatment & Disp
Nature (Forests)

1 (1-methylethyl)cyclohexane
2 (1-methylpropyl)cyclohexane
3 (2-methyl-1-propyl)acetate
4 (2-methylbutyl)cyclohexane
5 (2-methylpropyl)cyclohexane
6 1-(2-butoxy-1-methyl-ethoxy)-2-propanol
7 1-(2-ethoxy-1-methyl-ethoxy)-2-propanol
8 1-(2-methoxy-1-methyl-ethoxy)2-propanol
9 1-(butoxyethoxy)-2-propanol
10 1,1,1-trichloroethane
11 1,1,1-trichlorotrifluoroethane
12 1,1,2,2-tetrachloroethane
13 1,1,2-trimethylcyclohexane
14 1,1,2-trimethylcyclopentane
15 1,1,3-trimethylcyclohexane
16 1,1,4,4-tetramethylcyclohexane
17 1,1-dichloroethane
18 1,1-dichloroethene
19 1,1-dichlorotetrafluoroethane
20 1,1-dimethylcyclohexane
21 1,1-dimethylcyclopentane
22 1,2,3,4-tetrahydronaphthalene
23 1,2,3,4-tetramethylbenzene
24 1,2,3,5-tetramethylbenzene
25 1,2,3,5-tetramethylcyclohexane
26 1,2,3-trichlorobenzene
27 1,2,3-trimethylbenzene
28 1,2,3-trimethylcyclohexane
29 1,2,3-trimethylcyclopentane
30 1,2,4,4-tetramethylcyclopentane
31 1,2,4,5-tetramethylbenzene
32 1,2,4-trichlorobenzene
33 1,2,4-trimethlycyclopentane
34 1,2,4-trimethylbenzene
35 1,2,4-trimethylcyclohexane
36 1,2,4-trimethylcyclopentane
37 1,2-diaminoethane

38 1,2-dibromoethane
39 1,2-dichlorobenzene
40 1,2-dichloroethane
41 1,2-dichloroethene
42 1,2-dichlorotetrafluoroethane
43 1,2-dimethyl-3-isopropylcyclopentane
44 1,2-dimethylcyclohexane
45 1,2-dimethylcyclopentane
46 1,2-ethanedioldiacetate
47 1,2-ethylmethylcyclopentane
48 1,2-propanediol
49 1,3,4,5,6-pentahydroxy-2-hexanone
50 1,3,5-trichlorobenzene
51 1,3,5-trimethylbenzene
52 1,3,5-trimethylcyclohexane
53 1,3-butadiene
54 1,3-dichlorobenzene
55 1,3-diethylbenzene
56 1,3-dimethyl-4-ethylbenzene
57 1,3-dimethyl-5-propylbenzene
58 1,3-dimethylcyclohexane
59 1,3-dimethylcyclopentane
60 1,3-dioxolane
61 1,3-ethylmethylcyclopentane
62 1,3-hexadiene
63 1,4-butyrolacetone
64 1,4-dichlorobenzene
65 1,4-diethylbenzene
66 1,4-dimethyl-2-isopropylbenzene
67 1,4-dimethylcyclohexane
68 1,4-dimethylpiperazine
69 1,4-dioxane
70 11-methyl-1-dodecanol
71 1-butanal
72 1-butanol
73 1-butene
74 1-butoxy-2-propanol
75 1-butyne
76 1-chloro-2,3-epoxypropane
77 1-chloro-4-nitrobenzene
78 1-chloropropane
79 1-decene
80 1-ethoxy-2-propanol
81 1-ethoxy-2-propyl acetate
82 1-ethyl-1,4-dimethylcyclohexane
83 1-ethyl-2,2,6-trimethylcyclohexane
84 1-ethyl-2,3-dimethylbenzene
85 1-ethyl-2,3-dimethylcyclohexane
86 1-ethyl-2-propylbenzene
87 1-ethyl-2-propylcyclohexane
88 1-ethyl-3,5-dimethylbenzene
89 1-ethyl-3-methylcyclohexane
90 1-ethyl-4-methylcyclohexane
91 1-ethylpropylbenzene
92 1-heptene

93 1-hexanal
94 1-hexene
95 1-hydrophenol
96 1-methoxy-2-ethanol
97 1-methoxy-2-propanol
98 1-methoxy-2-propyl acetate
99 1-methyl-1-phenylcyclopropane
100 1-methyl-1-propylcyclopentane
101 1-methyl-2-isopropylbenzene
102 1-methyl-2-propylbenzene
103 1-methyl-3-(isopropyl)benzene
104 1-methyl-3-isopropylcyclopentane
105 1-methyl-3-propylbenzene
106 1-methyl-4-isopropylbenzene
107 1-methyl-4-isopropylcyclohexane
108 1-methyl-4-tertbutylbenzene
109 1-methylbutylbenzene
110 1-methylindan
111 1-methylindene
112 1-nonene
113 1-octene
114 1-pentanal
115 1-pentanol
116 1-pentene
117 1-propanal
118 1-propanol
119 2-(2-aminoethylamino)ethanol
120 2-(2-butoxyethoxy)ethanol
121 2-(2-butoxyethoxy)ethyl acetate
122 2-(2-ethoxyethoxy)ethanol
123 2-(2-ethoxyethoxy)ethyl acetate
124 2-(2-hydroxy-ethoxy)ethanol
125 2-(2-hydroxy-propoxy)-1-propanol
126 2-(methoxyethoxy)ethanol
127 2,2,3,3-tetramethylhexane
128 2,2,4,6,6-pentamethylheptane
129 2,2,4-trimethyl-1,3-pentanediol
130 2,2,4-trimethylpentane
131 2,2,5-trimethylhexane
132 2,2-dimethylbutane
133 2,2-dimethylhexane
134 2,2-dimethylpentane
135 2,2-dimethylpropane
136 2,2′-iminodi(ethylamine)
137 2,2′-iminodiethanol
138 2,3,3,4-tetramethylpentane
139 2,3,3-trimethyl-1-butene
140 2,3,4-trimethylhexane
141 2,3,4-trimethylpentane
142 2,3,5-trimethylhexane
143 2,3-dimethylbutane
144 2,3-dimethylfuran
145 2,3-dimethylheptane
146 2,3-dimethylhexane
147 2,3-dimethylnonane

148 2,3-dimethyloctane
149 2,3-dimethylpentane
150 2,3-dimethylundecane
151 2,4,6-trichloro-1,3,5-triazine
152 2,4-difluoroaniline
153 2,4-dimethyl-1-(1-methylethyl)benzene
154 2,4-dimethylfuran
155 2,4-dimethylheptane
156 2,4-dimethylhexane
157 2,4-dimethylpentane
158 2,4-toluene diisocyanate
159 2,5-dimethyldecane
160 2,5-dimethylfuran
161 2,5-dimethylheptane
162 2,5-dimethylhexane
163 2,5-dimethyloctane
164 2,6-dimethyldecane
165 2,6-dimethylheptane
166 2,6-dimethyloctane
167 2,6-dimethylundecane
168 2,6-toluene diisocyanate
169 2,7-dimethyloctane
170 2-[2-(2-ethoxy-ethoxy)-ethoxy]ethanol
171 2-acetoxy-propyl acetate
172 2-aminoethanol
173 2-butanol
174 2-butanone
175 2-butanone oxime
176 2-butene
177 2-butoxyethanol
178 2-butoxyethyl acetate
179 2-chloroethanol
180 2-chloropropane
181 2-chlorotoluene
182 2-ethoxyethanol
183 2-ethoxyethyl acetate
184 2-ethoxypropanol
185 2-ethyl hexanol
186 2-ethyl-1,3-dimethylbenzene
187 2-ethyltoluene
188 2-hexoxyethanol
189 2-hydrophenol
190 2-isopropoxyethanol
191 2-methoxy-2-methylpropane
192 2-methoxyethanol
193 2-methoxyethyl acetate
194 2-methoxypropane
195 2-methyl benzaldehyde
196 2-methyl-1,3-dioxolane
197 2-methyl-1-butene
198 2-methyl-1-butylbenzene
199 2-methyl-1-pentene
200 2-methyl-1-propanol
201 2-methyl-2,4-pentanediol
202 2-methyl-2-butene

203 2-methyl-2-hexene
204 2-methyl-5-ethyloctane
205 2-methylbutanal
206 2-methylbutane
207 2-methyldecalin
208 2-methyldecane
209 2-methylfuran
210 2-methylheptane
211 2-methylhexane
212 2-methylnonane
213 2-methyloctane
214 2-methylpentane
215 2-methylpropanal
216 2-methylpropane
217 2-methylpropenal
218 2-methylpropene
219 2-methylpropyl acetate
220 2-methylpyridine
221 2-methylundecane
222 2-pentanone
223 2-pentene
224 2-phenoxy ethanol
225 2-phenylpropene
226 2-propanol
227 2-propen-1-ol
228 2-propyl acetate
229 3-(2-hydroxy-propoxy)-1-propanol
230 3,3,4-trimethylhexane
231 3,3,5-trimethylheptane
232 3,3-dimethylheptane
233 3,3-dimethyloctane
234 3,3-dimethylpentane
235 3,4-dimethylheptane
236 3,4-dimethylhexane
237 3,5-dimethyloctane
238 3,6-dimethyloctane
239 3,7-dimethylnonane
240 3A,4,7,7A-tetrahydro-4,7-methanoindene
241 3-chloro-4-fluoropicoline
242 3-chloropropene
243 3-chloropyridine
244 3-ethyl-2-methylheptane
245 3-ethyl-2-methylhexane
246 3-ethylheptane
247 3-ethylhexane
248 3-ethyloctane
249 3-ethylpentane
250 3-ethyltoluene
251 3-hydrophenol
252 3-methyl benzaldehyde
253 3-methyl-1-butene
254 3-methylbutanal
255 3-methylbutanol
256 3-methyldecane
257 3-methylfuran

258 3-methylheptane
259 3-methylhexane
260 3-methylnonane
261 3-methyloctane
262 3-methylpentane
263 3-methylundecane
264 3-pentanone
265 4,4-dimethylheptane
266 4,4′-methylenedianiline
267 4,5-dimethylnonane
268 4,6-dimethylindan
269 4,7-dimethylindan
270 4-4′-methylenediphenyl diisocyanate
271 4-bromophenyl acetate
272 4-chlorotoluene
273 4-ethyl morpholine
274 4-ethyl-1,2-dimethylbenzene
275 4-ethyloctane
276 4-ethyltoluene
277 4-methyl benzaldehyde
278 4-methyl-1,3-dioxol-2-one
279 4-methyl-1-pentene
280 4-methyl-2-pentanol
281 4-methyl-2-pentanone
282 4-methyl-4-hydroxy-2-pentanone
283 4-methyldecane
284 4-methylheptane
285 4-methylnonane
286 4-methyloctane
287 4-methylpentene
288 4-propylheptane
289 5-methyl-2-hexanone
290 5-methyldecane
291 5-methylnonane
292 5-methylundecane
293 6-ethyl-2-methyldecane
294 6-ethyl-2-methyloctane
295 6-methylundecane
296 8-methyl-1-nonanol
297 acenaphthene
298 acenaphthylene
299 acetaldehyde
300 acetic acid
301 acetic anhydride
302 acetone
303 acetonitrile
304 acetyl chloride
305 acetylene
306 acrolein
307 acrylamide
308 acrylic acid
309 acrylonitrile
310 aniline
311 anthanthrene
312 anthracene

313 atrazine
314 benzaldehyde
315 benzene
316 benzene-1,2,4-tricarboxylic acid 1,2-
317 benzo (a) anthracene
318 benzo (a) pyrene
319 benzo (b) fluoranthene
320 benzo (c) phenanthrene
321 benzo (e) pyrene
322 benzo (g,h,i) fluoranthene
323 benzo (g,h,i) perylene
324 benzo (k) fluoranthene
325 benzophenone
326 benzopyrenes
327 benzyl alcohol
328 benzyl chloride
329 biphenyl
330 bis(2-hydroxyethyl)ether
331 bis(chloromethyl)ether
332 bis(tributyltin) oxide
333 bromoethane
334 bromoethene
335 bromomethane
336 butane
337 butanethiols
338 butene
339 butoxyl
340 butyl acetate
341 butyl acrylate
342 butyl glycolate
343 butyl lactate
344 butylbenzene
345 butylcyclohexane
346 butyrolactone
347 C10 alkanes
348 C10 alkenes
349 C10 aromatic hydrocarbons
350 C10 cycloalkanes
351 C11 alkanes
352 C11 alkenes
353 C11 aromatic hydrocarbons
354 C11 cycloalkanes
355 C12 alkanes
356 C12 cycloalkanes
357 C13 alkanes
358 C13+ alkanes
359 C13+ aromatic hydrocarbons
360 C14 alkanes
361 C15 alkanes
362 C16 alkanes
363 C2-alkyl-anthracenes
364 C2-alkyl-benzanthracenes
365 C2-alkyl-benzophenanthrenes
366 C2-alkyl-chrysenes
367 C2-alkyl-phenanthrenes

368 C5 alkenes
369 C6 alkenes
370 C7 alkanes
371 C7 alkenes
372 C7 cycloalkanes
373 C8 alkanes
374 C8 alkenes
375 C8 cycloalkanes
376 C9 alkanes
377 C9 alkenes
378 C9 aromatic hydrocarbons
379 C9 cycloalkanes
380 camphor/fenchone
381 carbon disulphide
382 carbon tetrachloride
383 carbonyl sulphide
384 chlorobenzene
385 chlorobutane
386 chlorocyclohexane
387 chlorodifluoromethane
388 chloroethane
389 chloroethene
390 chloroethylene
391 chlorofluoromethane
392 chloromethane
393 chrysene
394 cis-1,3-dimethylcyclopentane
395 cis-2-butene
396 cis-2-hexene
397 cis-2-pentene
398 coronene
399 crotonaldehyde
400 cycloheptane
401 cyclohexanamine
402 cyclohexane
403 cyclohexanol
404 cyclohexanone
405 cyclopenta (c,d) pyrene
406 cyclopenta-anthracenes
407 cyclopentane
408 cyclopenta-phenanthrenes
409 cyclopentene
410 decalin
411 decane
412 diacetoneketogulonic acid
413 diazinon
414 dibenzanthracenes
415 dibenzo (a,h) anthracene
416 dibenzopyrenes
417 dichlorobutenes
418 dichlorodifluoromethane
419 dichlorofluoromethane
420 dichloromethane
421 dichlorvos
422 diethyl disulphide

423 diethyl ether
424 diethyl sulphate
425 diethylamine
426 diethylbenzene
427 difluoromethane
428 dihydroxyacetone
429 diisopropyl ether
430 diisopropylbenzene
431 dimethoxymethane
432 dimethyl disulphide
433 dimethyl esters
434 dimethyl ether
435 dimethyl sulphate
436 dimethyl sulphide
437 dimethylamine
438 dimethylbutene
439 dimethylcyclopentane
440 dimethylformamide
441 dimethylhexene
442 dimethylnonane
443 dimethylpentane
444 dipentene
445 dipropyl ether
446 dodecane
447 ethane
448 ethanethiol
449 ethanol
450 ethofumesate
451 ethyl acetate
452 ethyl acrylate
453 ethyl butanoate
454 ethyl chloroformate
455 ethyl hexanol
456 ethyl lactate
457 ethyl pentanoate
458 ethyl propionate
459 ethylamine
460 ethylbenzene
461 ethylcyclohexane
462 ethylcyclopentane
463 ethyldimethylbenzene
464 ethylene
465 ethylene glycol
466 ethylene oxide
467 ethylisopropylbenzene
468 fenitrothion
469 fluoranthene
470 fluorene
471 formaldehyde
472 formanilide
473 formic acid
474 fumaric acid
475 glycerol
476 glyoxal
477 heptadecane

478 heptane
479 hexachlorocyclohexane
480 hexachloroethane
481 hexadecane
482 hexafluoropropene
483 hexamethylcyclotrisiloxane
484 hexamethyldisilane
485 hexamethyldisiloxane
486 hexamethylenediamine
487 hexane
488 hexylcyclohexane
489 indan
490 indeno (1,2,3-c,d) pyrene
491 iodomethane
492 isobutylbenzene
493 isobutylcyclohexane
494 isopentylbenzene
495 isophorone
496 isoprene
497 isoprene + BVOC (1)
498 isopropylbenzene
499 isopropylcyclohexane
500 limonene
501 malathion
502 maleic anhydride
503 m-cresol
504 menthene
505 methacrylic acid
506 methanethiol
507 methanol
508 methyl acetate
509 methyl acrylate
510 methyl butanoate
511 methyl ethyl ether
512 methyl formate
513 methyl glyoxal
514 methyl methacrylate
515 methyl naphthalenes
516 methyl pentanoate
517 methyl styrene
518 methylamine
519 methyl-anthracenes
520 methyl-benzanthracenes
521 methyl-benzphenanthrenes
522 methylcyclodecane
523 methylcyclohexane
524 methylcyclopentane
525 methylethylbenzene
526 methyl-fluoranthenes
527 methylhexane
528 methylindane
529 methyl-phenanthrenes
530 methylpropene
531 methylpropylbenzene
532 methyltetralin

533 m-xylene
534 N-(hydroxymethyl) acrylamide
535 N,N-diethyl benzenamine
536 N,N-dimethyl benzenamine
537 naphthalene
538 naphthol
539 Nedocromil Sodium
540 nitrobenzene
541 nitromethane
542 nitropentane
543 nitropropane
544 N-methyl pyrrolidone
545 nonane
546 o-cresol
547 octahydroindan
548 octamethylcyclotetrasiloxane
549 octane
550 octylamine
551 o-xylene
552 palmitic acid
553 p-benzoquinone
554 p-cresol
555 pentadecane
556 pentafluoroethane
557 pentane
558 pentanethiols
559 pentylbenzene
560 pentylcyclohexane
561 permethrin
562 perylene
563 phenol
564 phenoxyacetic acid (phenoxy acid)
565 phenylacetic acid
566 phenylacetonitrile
567 phthalic anhydride
568 pine oil
569 polyethylene glycol
570 polyisobutene
571 polyvinyl chloride
572 potassium phenylacetate
573 propadiene
574 propane
575 propanetriol
576 propanoic acid
577 propionitrile
578 propyl acetate
579 propyl butanoate
580 propyl propionate
581 propylamine
582 propylbenzene
583 propylcyclohexane
584 propylcyclopentane
585 propylene
586 propylene oxide
587 propyne

588 p-xylene
589 pyrene
590 pyridine
591 salicylic acid
592 sec-butylbenzene
593 sec-butylcyclohexane
594 simazine
595 sodium 2-ethylhexanoate
596 sodium acetate
597 sodium phenylacetate
598 styrene
599 sulphanilamide
600 terpenes
601 tert-butylamine
602 tert-butylbenzene
603 tert-butylcyclohexane
604 tert-butylcyclopropane
605 tert-pentylbenzene
606 tetrachloroethene
607 tetradecane
608 tetrafluoroethene
609 tetrahydrofuran
611 tetramethylcyclohexane
612 toluene
613 toluene-2,3-diamine
614 toluene-2,4-diamine
615 toluene-2,4-diisocyanate
616 toluene-2,5-diamine
617 toluene-2,6-diamine
618 toluene-2,6-diisocyanate
619 toluene-3,4-diamine
620 toluene-3,5-diamine
621 trans-2-butene
622 trans-2-hexene
623 trans-2-pentene
624 trans-3-hexene
625 trialkyl phosphate
626 trichloroethene
627 trichlorofluoromethane
628 trichloromethane
629 tridecane
630 triethanolamine
631 triethylamine
632 trifluoroethene
633 trifluoromethane
634 trifluralin
635 trimethylamine
636 trimethylfluorosilane
637 tri-n-butyl phosphate
638 undecane
639 unspeciated alcohols
640 unspeciated aliphatic hydrocarbons
641 unspeciated alkanes
642 unspeciated alkenes
643 unspeciated amines

644 unspeciated aromatic hydrocarbons
645 unspeciated carboxylic acids
646 unspeciated cycloalkanes
647 unspeciated hydrocarbons
648 unspeciated ketones
649 urea
650 vinyl acetate
(1) BVOC- biogenic VOCs, such as alpha-pinene and other terpenes

Annex 3E Agriculture

Table 3E.1 Changes in housing type 1990 – 2009 - **Cattle**.

Dairy cattle:

Livestock categories	Housing type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	Tethered with urine and solid manure	35	35	34	33	32	31	30	30	30	30
	Tethered with slurry	44	43	43	43	43	42	42	36	30	30
	Loose-holding with beds, slatted floor	13	14	15	15	16	17	18	21	24	24
	Loose-holding with beds, slatted floor, scrape	1	1	1	1	1	1	1	2	3	3
	Loose-holding with beds, solid floor	3	3	3	3	3	3	3	3	3	3
	Deep litter (all)	0	0	0	0	0	0	0	0	0	0
	Deep litter, slatted floor	3	3	3	4	4	5	5	6	8	8
	Deep litter, slatted floor, scrape	0	0	0	0	0	0	0	0	1	1
	Deep litter, solid floor, scrape	1	1	1	1	1	1	1	2	1	1
	Loose-holding with beds, drained floor	0	0	0	0	0	0	0	0	0	0
	Loose-holding with beds, solid floor with tilt	0	0	0	0	0	0	0	0	0	0
	Deep litter, long eating space, solid floor	0	0	0	0	0	0	0	0	0	0
Continued	Housing type	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cattle	Tethered with urine and solid manure	18	15	12	8	6	12	12	7	6	5
	Tethered with slurry	28	25	23	18	16	14	14	10	9	7
	Loose-holding with beds, slatted floor	34	36	39	42	44	44	44	42	44	45
	Loose-holding with beds, slatted floor, scrape	3	4	4	5	6	11	11	20	20	21
	Loose-holding with beds, solid floor	6	9	11	16	17	11	11	13	14	14
	Deep litter (all)	0	0	0	0	0	2	2	2	2	2
	Deep litter, slatted floor	7	7	7	7	7	4	4	2	2	2
	Deep litter, slatted floor, scrape	1	1	1	1	1	2	2	2	1	1
	Deep litter, solid floor, scrape	3	3	3	3	3	0	0	0	0	0
	Loose-holding with beds, drained floor	0	0	0	0	0	0	0	0(0.1)	0(0.4)	0(0.3)
	Loose-holding with beds, solid floor with tilt	0	0	0	0	0	0	0	1	1	2
	Deep litter, long eating space, solid floor	0	0	0	0	0	0	0	1	1	1

Heifers:

Livestock categories	Housing type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Heifer calves, 0-6 mth.	Deep litter (boxes)	100	100	100	100	100	100	100	100	100	100
	Deep litter, solid floor	0	0	0	0	0	0	0	0	0	0
Heifer, 6 mth.-calving	Tethered with urine and solid manure	19	18	17	16	14	13	12	11	10	10
	Tethered with slurry	19	18	17	16	14	13	12	11	10	10
	Slatted floor-boxes	40	39	38	37	36	35	34	33	33	32
	Loose-housing with beds, slatted floor	4	4	5	6	6	7	8	10	12	13
	Deep litter (all)	3	3	2	2	2	1	1	0	0	0
	Deep litter, solid floor	9	12	13	14	16	18	22	24	24	24
	Deep litter, slatted floor	4	4	5	6	7	7	7	7	6	6
	Deep litter, slatted floor, scrape	1	1	1	1	1	1	1	1	2	2
	Deep litter, solid floor, scrape	1	1	2	2	2	3	3	3	3	3
	Loose-housing with beds, solid floor	0	0	0	0	0	0	0	0	0	0
	Loose-housing with beds, slatted floor, scrape	0	0	0	0	0	0	0	0	0	0
	Deep litter, long eating space, solid floor	0	0	0	0	0	0	0	0	0	0
	Boxes with sloping bedded floor	0	0	0	0	0	0	0	0	0	0
Continued	Housing type	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Heifer calves, 0-6 mth.	Deep litter (boxes)	100	89	84	83	80	93	93	96	96	96
	Deep litter, solid floor	0	11	16	17	20	7	7	4	4	4
Heifer, 6 mth.-calving	Tethered with urine and solid manure	9	8	7	7	5	14	14	7	6	6
	Tethered with slurry	9	8	7	7	5	5	5	2	2	2
	Slatted floor-boxes	32	31	30	30	29	23	23	38	37	35
	Loose-housing with beds, slatted floor	14	17	20	21	23	19	19	12	14	16
	Deep litter (all)	0	0	0	0	0	30	30	24	22	22
	Deep litter, solid floor	25	26	26	26	28	3	3	1	1	1
	Deep litter, slatted floor	6	5	5	5	5	3	3	2	2	2
	Deep litter, slatted floor, scrape	2	2	2	1	2	2	2	2	2	2
	Deep litter, solid floor, scrape	3	3	3	3	3	1	1	0	0	0
	Loose-housing with beds, solid floor	0	0	0	0	0	0	0	5	6	6
	Loose-housing with beds, slatted floor, scrape	0	0	0	0	0	0	0	5	6	6
	Deep litter, long eating space, solid floor	0	0	0	0	0	0	0	2	2	2
	Boxes with sloping bedded floor	0	0	0	0	0	0	0	0 (0.1)	0 (0.1)	0 (0.1)

Bulls:

Livestock categories	Housing type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Bull calves, 0-6 mth.	Deep litter (boxes)	100	100	100	100	100	100	100	100	100	100
	Deep litter, solid floor	0	0	0	0	0	0	0	0	0	0
Bull, 6 mth - 440 kg	Tethered with urine and solid manure	20	19	17	16	15	14	13	12	11	11
	Tethered with slurry	20	19	17	16	15	14	13	12	11	11
	Slatted floor-boxes	41	40	40	39	38	37	37	36	35	34
	Deep litter (all)	3	2	2	2	2	1	1	0	0	0
	Deep litter, solid floor	10	12	15	17	19	21	22	25	27	29
	Deep litter, slatted floor	4	5	6	7	8	8	9	10	11	10
	Deep litter, slatted floor, scrape	1	1	1	1	1	2	2	2	2	2
	Deep litter, solid floor, scrape	1	2	2	2	2	3	3	3	3	3
	Deep litter, long eating space, solid floor	0	0	0	0	0	0	0	0	0	0
	Boxes with sloping bedded floor	0	0	0	0	0	0	0	0	0	0
		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Bull calves, 0-6 mth.	Deep litter (boxes)	100	91	86	82	77	95	95	97	97	97
	Deep litter, solid floor	0	9	14	18	23	5	5	3	3	3
Bull, 6 mth - 440 kg	Tethered with urine and solid manure	10	9	8	8	7	9	9	4	4	3
	Tethered with slurry	10	9	8	8	7	2	2	1	1	1
	Slatted floor-boxes	33	32	31	30	28	31	31	30	30	27
	Deep litter (all)	0	0	0	0	0	47	47	57	58	60
	Deep litter, solid floor	33	37	41	45	48	8	8	5	4	4
	Deep litter, slatted floor	9	8	7	5	6	1	1	1	1	2
	Deep litter, slatted floor, scrape	2	2	2	1	1	0	0	1	1	2
	Deep litter, solid floor, scrape	3	3	3	3	3	2	2	0	0	0
	Deep litter, long eating space, solid floor	0	0	0	0	0	0	0	1	1	1
	Boxes with sloping bedded floor	0	0	0	0	0	0	0	0 (0.1)	0 (0.1)	0 (0.1)

Suckling cattle:

Livestock categories	Housing type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Suckling cattle	Tethered with urine and solid manure	10	10	10	10	10	10	10	10	10	10
	Deep litter (all)	73	69	66	62	59	55	52	48	45	45
	Deep litter, solid floor	17	21	24	28	31	35	38	42	45	45
	Tethered with slurry	0	0	0	0	0	0	0	0	0	0
	Deep litter, long eating space, solid floor	0	0	0	0	0	0	0	0	0	0
	Deep litter, slatted floor	0	0	0	0	0	0	0	0	0	0
	Deep litter, slatted floor, scrape	0	0	0	0	0	0	0	0	0	0
	Boxes with sloping bedded floor	0	0	0	0	0	0	0	0	0	0
Livestock categories	Housing type	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Suckling cattle	Tethered with urine and solid manure	9	8	7	4	5	30	30	18	16	15
	Deep litter (all)	45	44	43	44	43	35	35	66	68	68
	Deep litter, solid floor	46	48	50	52	52	35	35	2	2	3
	Tethered with slurry	0	0	0	0	0	0	0	9	9	9
	Deep litter, long eating space, solid floor	0	0	0	0	0	0	0	1	1	1
	Deep litter, slatted floor	0	0	0	0	0	0	0	1	1	1
	Deep litter, slatted floor, scrape	0	0	0	0	0	0	0	2	2	2
	Boxes with sloping bedded floor	0	0	0	0	0	0	0	1	1	1

Table 3E.1 - *Continued* Changes in housing type 1990 – 2009 - **Pigs**

Livestock categories	Housing type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Sows	Full slatted floor	9	10	10	11	12	12	13	14	14	14
	Partly slatted floor	56	57	57	57	57	57	57	57	57	57
	Solid floor	30	28	25	23	20	18	15	13	10	9
	Deep litter	5	5	5	6	6	7	7	8	8	9
	Deep litter + slatted floor	0	0	1	1	2	2	3	3	4	4
	Deep litter + solid floor	0	0	1	1	2	2	3	3	4	4
	Outdoor sows	0	0	1	1	1	2	2	2	3	3
Weaners	Fully slatted floor	54	57	60	56	54	51	49	46	43	40
	Partly slatted floor	20	20	20	24	27	31	34	37	41	45
	Solid floor	21	18	15	14	13	11	9	8	7	5
	Deep litter (to-climate housings)	5	5	5	5	5	5	5	5	5	5
	Deep litter + slatted floor	0	0	0	1	1	2	3	4	4	5
	Partly slatted and drained floor	0	0	0	0	0	0	0	0	0	0
Fattening pigs	Fully slatted floor	51	56	60	60	60	60	60	60	60	60
	Partly slatted floor	23	21	20	21	23	24	25	26	28	29
	Solid floor	22	19	15	14	12	11	9	8	6	5
	Deep litter	4	4	5	4	4	3	3	2	2	1
	Partly slatted floor and partly deep litter	0	0	0	1	1	2	3	4	4	5
	Partly slatted and drained floor	9	10	10	11	12	12	13	0	0	0
Continued		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Sows	Full slatted floor	13	13	13	12	12	13	13	14	14	15
	Partly slatted floor	56	55	54	53	51	70	70	74	75	75
	Solid floor	7	6	6	6	5	4	4	1	1	1
	Deep litter	10	10	10	10	11	2	2	2	1	1
	Deep litter + slatted floor	6	7	8	9	10	8	8	6	6	5
	Deep litter + solid floor	5	6	7	8	9	1	1	1	1	1
	Outdoor sows	3	3	2	2	2	2	2	2	2	2
Weaners	Fully slatted floor	38	36	35	33	31	23	23	26	23	22
	Partly slatted floor	47	49	50	52	54	66	66	63	67	68
	Solid floor	5	5	5	5	5	3	3	1	1	<1
	Deep litter (to-climate housings)	5	5	5	5	5	4	4	3	2	2
	Deep litter + slatted floor	5	5	5	5	5	4	4	0	0	0
	Partly slatted and drained floor	0	0	0	0	0	0	0	7	7	8
Fattening pigs	Fully slatted floor	58	57	56	55	53	49	49	53	53	54
	Partly slatted floor	31	33	34	35	38	38	38	34	35	35
	Solid floor	5	4	4	4	3	7	7	4	3	2
	Deep litter	1	1	1	1	1	5	5	4	3	2
	Partly slatted floor and partly deep litter	5	5	5	5	5	1	1	<1	<1	<1
	Partly slatted and drained floor	0	0	0	0	0	0	0	5	6	7

Table 3E.1 - *Continued* Changes in housing type 1990 – 2009 - **Poultry**

Livestock categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Free-range hens	0	1	2	4	5	6	7	8	9	9
Organic hens	0	1	2	4	5	6	7	10	12	15
Barn hens	11	11	12	12	12	13	14	15	17	18
Battery hens, manure shed	54	52	49	46	44	42	39	36	32	29
Battery hens, manure tank	12	12	11	10	9	8	7	6	5	5
Battery hens, manure cellar	23	23	24	24	25	25	26	25	25	24
Hens for production of brood egg	100	100	100	100	100	100	100	100	100	100
Pullet, consumption, net	17	16	15	14	13	12	11	10	8	7
Pullet, consumption, floor	57	58	59	60	61	62	63	64	66	67
Pullet, brood egg, floor	26	26	26	26	26	26	26	26	26	26
Broilers, (conv. 30 days)	0	0	0	0	0	0	0	0	0	0
Broilers, (conv. 32 days)	0	0	0	0	0	0	0	0	0	0
Broilers, (conv. 35 days)	0	0	0	0	0	0	0	0	0	0
Broilers, (conv. 40 days)	100	100	100	100	100	100	100	100	100	100
Broilers, (conv. 45 days)	0	0	0	0	0	0	0	0	0	0
Broilers, barn (56 days)	0	0	0	0	0	0	0	0	0	0
Organic broilers (81 days)	0	0	0	0	0	0	0	0	0	0
Turkey, male	50	50	50	50	50	50	50	50	50	50
Turkey, female	50	50	50	50	50	50	50	50	50	50
Ducks	100	100	100	100	100	100	100	100	100	100
Geese	100	100	100	100	100	100	100	100	100	100
Pheasant	100	100	100	100	100	100	100	100	100	100
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Free-range hens	9	9	7	8	7	7	7	8	9	10
organic hens	15	15	15	16	16	16	16	19	17	17
Barn hens	18	18	19	18	20	20	20	19	20	20
Battery hens, manure shed	26	26	23	23	20	20	20	36	39	39
Battery hens, manure tank	5	5	4	5	4	4	4	7	7	6
Battery hens, manure cellar	27	27	32	30	33	33	33	11	8	8
Hens for production of brood egg	100	100	100	100	100	100	100	100	100	100
Pullet, consumption, net	8	7	6	7	5	5	5	7	7	7
Pullet, consumption, floor	69	68	69	68	69	69	69	73	84	78
Pullet, brood egg, floor	23	25	25	25	26	26	26	20	9	15
Broilers, (conv. 30 days)	0	0	0	0	0	0	0	0	0	0
Broilers, (conv. 32 days)	0	0	0	0	0	0	0	1	4	7
Broilers, (conv. 35 days)	0	0	0	0	0	0	0	77	80	84
Broilers, (conv. 40 days)	100	100	100	100	100	99	99	22	16	9
Broilers, (conv. 45 days)	0	0	0	0	0	0	0	0	0	<1
Broilers, barn (56 days)	0	0	0	0	0	1	1	0	0	0
Organic broilers (81 days)	0	0	0	0	0	0	0	0	0	0
Turkey, male	50	50	50	50	50	50	50	50	50	50
Turkey, female	50	50	50	50	50	50	50	50	50	50
Ducks	100	100	100	100	100	100	100	100	100	100
Geese	100	100	100	100	100	100	100	100	100	100
Pheasant	100	100	100	100	100	100	100	100	100	100

Table 3E.1 - *Continued* Changes in housing type 1990 – 2009 - **Fur farming**

Livestock categories	Housing type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Mink	Slurry system	18	20	20	22	23	25	26	27	29	30
	Solid manure and urine	82	80	80	78	77	75	74	73	71	70
Foxes	Slurry system	0	0	0	0	0	0	0	0	0	0
	Solid manure and urine	100	100	100	100	100	100	100	100	100	100
Continued		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Mink	Slurry system	42	50	55	60	65	70	70	91	95	98
	Solid manure and urine	58	50	45	40	35	30	30	9	5	2
Foxes	Slurry system	2	5	10	15	30	0	0	0	0	0
	Solid manure and urine	98	95	90	85	70	100	100	100	100	100

Table 3E.1 - *Continued* Changes in housing type 1990 – 2009 - **Horses, sheep, goats and ostrich**

Livestock categories	Housing type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Horses, sheep, goats, ostrich	Deep litter	100	100	100	100	100	100	100	100	100	100
Continued		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Horses, sheep, goats, ostrich	Deep litter	100	100	100	100	100	100	100	100	100	100

Table 3E.1 - *Continued* Changes in housing type 1990 – 2009 - **Deer and pheasant**

Livestock categories	Housing type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Deer and pheasant	Pasture	100	100	100	100	100	100	100	100	100	100
Continued		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Deer and pheasant	Pasture	100	100	100	100	100	100	100	100	100	100

Reference: 1990 – 2004 = The Danish Agricultural Advisory Service, 2005-2009 = The Danish Plant Directorate

Table 3E.2 Number of animals allocated on subcategories for 1990-2009, 1 000 head

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy Cattle	753	742	712	714	700	702	701	670	669	640
Non-Dairy Cattle										
Bulls 0-6	217	218	214	212	199	190	190	176	169	153
Bulls 6-	263	248	251	253	226	213	216	193	185	175
Heifers 0-6	225	226	224	220	216	215	215	210	209	192
Heifers 6-	695	687	678	673	647	647	647	630	623	606
Suckling Cattle	87	101	112	124	118	122	124	125	122	122
Sheep	92	107	102	88	80	81	94	96	101	106
Goats										
Meat goat	7	7	7	7	7	7	7	7	8	8
Milk goat	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Mohair goat	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Horses										
< 300 kg	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
300-500 kg	80	81	81	82	83	84	85	86	87	88
500-700 kg	51	52	52	53	54	54	55	55	56	56
> 700 kg	4	4	4	4	4	4	4	4	4	4
Swine										
Sows	904	928	1.001	1.041	992	1.015	1.010	1.068	1.092	1.061
Weaners	4.881	4.995	5.304	5.690	5.514	5.613	5.511	5.804	5.352	5.189
Fattening pigs	3.712	3.859	4.150	4.837	4.417	4.456	4.320	4.511	5.651	5.376
Poultry										
Hens	4.381	3.903	3.923	4.304	5.380	4.366	4.786	4.047	3.663	3.719
Pullets	1.315	1.164	1.716	1.213	1.551	1.723	1.531	1.598	1.243	1.326
Broilers	9.802	10.020	12.619	13.399	12.023	12.585	12.907	12.510	13.118	14.923
Other poultry	750	846	782	982	897	946	663	838	651	1.042
Pheasant										
Pheasant hen	1	1	1	1	1	1	1	1	1	1
Pheasant chicken	1	1	1	1	1	1	1	1	1	1
Ostrich										
Ostrich hen	NO	NO	NO	0.0	0.1	0.1	0.1	0.2	0.2	0.3
Ostrich chicken	NO	NO	NO	1	2	3	4	5	6	8
Fur Farming										
Mink	2.233	2.094	2.261	1.524	1.813	1.834	1.901	2.194	2.328	2.077
Foxes	31	18	22	13	15	16	17	19	17	12
Deer	10	10	10	10	10	10	10	10	10	10

Continued										
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy Cattle	636	623	610	596	563	564	550	545	558	563
Non-Dairy Cattle										
Bulls 0-6	150	154	140	134	139	132	124	133	125	117
Bulls 6-	176	203	171	160	151	142	137	154	139	145
Heifers 0-6	185	176	169	162	156	148	143	144	151	151
Heifers 6-	598	620	587	561	529	483	480	484	485	526
Suckling Cattle	125	130	120	112	108	101	100	106	107	96
Sheep	112	119	117	121	124	126	128	124	117	116
Goats										
Meat goat	8	9	9	10	11	11	12	8	10	11
Milk goat	IE	IE	IE	IE	IE	IE	IE	3	1	1
Mohair goat	IE	IE	IE	IE	IE	IE	IE	2	4	4
Horses										
< 300 kg	IE	IE	IE	41	43	44	45	46	48	44
300-500 kg	89	91	94	56	58	60	61	63	65	60
500-700 kg	57	59	61	63	65	67	68	70	72	67
> 700 kg	5	5	5	5	5	5	5	6	6	5
Swine										
Sows	1 083	1 121	1 128	1 149	1 155	1 151	1 127	1 148	1 059	1 088
Weaners	5 330	5 669	5 771	5 917	6 016	6 165	6 142	6 268	5 893	5 882
Fattening pigs	5 508	5 818	5 833	5 883	6 061	6 218	6 092	6 307	5 785	5 399
Poultry										
Hens	3 720	3 769	3 686	3 743	3 731	3 241	2 818	3 223	3 590	3 345
Pullets	1 216	981	919	1 198	1 119	1 928	1 084	986	1 384	1 092
Broilers	16 047	15 597	15 129	12 211	11 286	11 905	12 924	11 758	9 737	14 787
Other poultry	849	889	846	691	513	559	599	775	696	452
Pheasant										
Pheasant hen	1	1	1	1	1	1	1	1	1	1
Pheasant chicken	1	1	1	1	1	1	1	1	1	1
Ostrich										
Ostrich hen	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0.02	0.02	0.01
Ostrich chicken	9	10	6	5	4	4	4	0.6	0.4	0.3
Fur Farming										
Mink	2 188	2 295	2 413	2 354	2 463	2 547	2 704	2 832	2 744	2 675
Foxes	11	9	8	7	8	5	4	5	3	2
Deer	10	11	10	10	10	10	10	10	10	9

IE = Included else ware (mane category)

NO = Not occurring

Table 3E.3 (a-d) NH_3 emission factors for housing units, 2009

a) **Cattle**

Stable type		Urine TAN	Slurry TAN	Solid manure Total N	Deep litter manure Total N
		Pct. loss of TAN ex animal		pct. loss of N ex animal	
Tethered	urine and solid manure	10	-	5	-
	slurry manure	-	6	-	-
Loose-housing with beds	slatted floor	-	16	-	-
	slatted floor and scrape	-	12	-	-
	solid floor	-	20	-	-
	drained floor	-	8	-	-
	solid floor with tilt and scrape	-	8	-	-
	solid floor with tilt	-	12	-	-
Deep litter	All	-	-	-	6
	solid floor	-	-	-	6
	slatted floor	-	16	-	6
	slatted floor and scrape	-	12	-	6
	solid floor and scrape	-	20	-	6
Boxes	sloping bedded floor	-	16	-	-
	slatted floor	-	16	-	-

b) **Swine**

	Stable type	Floor or manure type	Urine TAN	Slurry TAN	Solid manure Total N	Deep litter Total N
			Pct. loss of TAN ex animal		pct. loss of N ex animal	
Sows	Individual, mating and gestation	Partly slatted floor	-	13	-	-
		Full slatted floor	-	19	-	-
		Solid floor	21	-	16	-
	Group, mating and gestation	Deep litter	-	-	-	15
		Deep litter + slatted floor	-	16	-	15
		Deep litter + solid floor	-	19	-	15
		Partly slatted floor	-	16	-	-
	Farrowing crate	Full slatted floor	-	13	-	-
		Partly slatted floor	-	26	-	-
	Farrowing pen	Solid floor	20	-	15	-
		Partly slatted floor	-	22	15	-
Weaners		Full slatted floor	-	24	-	-
		Drained + partly slatted floor	-	21	-	-
		Deep litter (to-clima stables)	-	10	-	15
		Solid floor	37	-	25	-
		Deep litter	-	-	-	15
Fattening pigs		Partly slatted floor (50-75 % solid)	-	13	-	-
		Partly slatted floor (25-49% solid)	-	17	-	-
		Drained + partly slatted floor	-	21	-	-
		Full slatted floor	-	24	-	-
		Solid floor	27	-	18	-
		Deep litter, divided	-	18	-	15
		Deep litter	-	-	-	15

c) **Poultry**

	Stable type	Floor or manure type	Solid manure Total N	Deep litter Total N
			pct. loss of N ex animal	
Hens and pullets	Free-range, organic and barn	Deep pit	40	25
		Deep litter	-	28
		Manure belt	10	25
	Battery	Deep pit	12	-
		Manure belt	10	-
Broilers	Conventional	Deep litter	-	20
	Organic and barn	Deep litter	-	25
Turkeys, ducks and geese		Deep litter	-	20

d) **Other**

	Urine TAN	Slurry TAN	Solid manure Total N	Deep litter Total N
	Pct. loss of TAN ex animal		pct. loss of N ex animal	
Fur animals	35	47	35	-
Horses, sheep and goats	-	-	-	15

Table 3E.4 NH_3 emission factors for storage units, 2009

			Urine	Slurry[1]	Solid manure	Deep litter	Pct. of solid manure stored in heap on field
Cattle		Total N	2	2.1	4	1	35
		TAN	2.2	3.5	-	-	-
Pigs	Sows	Total N	2	2.4	19	6.5	50
		TAN	2.2	2.9	-	-	-
	Weaners	Total N	2	2.4	19	9.8	-
		TAN	2.2	2.9	-	-	-
	Fattening pigs	Total N	2	2.4	19	9,8	75
		TAN	2.2	2.9	-	-	-
Poultry	Hens and pullets	Total N	-	2	7.5	4.8	95
	Broilers	Total N	-	-	11.5	6.8	85
	Turkeys, ducks, and geese	Total N	-	-	-	6.8, 8(Turkeys)	-
Fur animals		Total N	0	3.1	11.5	-	-
		TAN	0	3.1	-	-	-
Sheep and goats		Total N	-	-	-	4	-
Horses		Total N	-	-	-	4	-

Table 3E.5 Feed units 1990-2009, FU per animal per year

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	5 549	5 633	5 718	5 803	5 890	5 896	5 899	5 902	5 941	5 940
Non-dairy cattle:										
Calves, bull	1 190	1 192	1 194	1 196	1 198	1 200	1 202	1 203	1 204	1 204
Calves, heifer	1 734	1 736	1 738	1 739	1 740	1 743	1 744	1 744	1 728	1 728
Bulls > ½ year	2 265	2 269	2 272	2 275	2 277	2 281	2 282	2 284	2 286	2 286
Heifer > ½ year	1 721	1 724	1 727	1 730	1 733	1 735	1 737	1 741	1 738	1 737
Suckling cattle	2 515	2 515	2 515	2 515	2 515	2 515	2 515	2 515	2 515	2 515
Sheep (mother sheep incl. lambs)	728	728	728	728	728	728	728	728	728	728
Goats (mother goats incl. kids)	669	669	669	669	669	669	669	669	669	669
Horses	1 995	1 995	1 995	1 995	1 995	1 995	1 995	1 995	1 995	1 995
Swine:										
Sows (incl. pigs < 7.4 kg)	1 300	1 300	1 300	1 300	1 300	1 300	1 300	1 300	1 340	1 340
Weaners (7.4 – 32 kg)	247	258	270	281	293	293	293	293	305	305
Fattening pigs (32 – 107 kg)	916	893	876	862	823	823	823	823	806	806
Other:										
Deer	668	668	668	668	668	668	668	668	668	668
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cattle	5 941	6 068	6 193	6 339	6 453	6 557	6 620	6 683	6 688	6 845
Non-dairy cattle:										
Calves, bull	1 205	1 228	1 228	1 225	1 227	1 228	1 225	1 227	1 230	1 230
Calves, heifer	1 728	1 727	1 727	1 707	1 707	1 820	1 931	2 043	2 043	2 040
Bulls > ½ year	2 287	2 306	2 306	2 310	2 306	2 310	2 312	2 311	2 314	2 318
Heifer > ½ year	1 737	1 747	1 747	1 753	1 753	1 851	1 951	2 048	2 048	2 046
Suckling cattle	2 515	2 515	2 515	2 515	2 378	2 378	2 378	2 417	2 417	2 417
Sheep (mother sheep incl. lambs)	728	728	728	728	728	728	728	728	728	728
Goats (mother goats incl. kids)	669	669	669	669	669	669	669	653	664	664
Horses	1 995	1 995	1 995	1 996	1 996	1 996	1 996	1 995	1 995	1 995
Swine:										
Sows (incl. pigs < 7.4 kg)	1 340	1 390	1 390	1 446	1 442	1 450	1 470	1 490	1 484	1 500
Weaners (7.4 – 32 kg)	305	305	305	292	301	307	320	324	337	317
Fattening pigs (32 – 107 kg)	806	829	829	824	827	823	844	861	844	855
Other:										
Deer	668	668	668	668	668	668	668	668	668	668

Table 3E.6 Gross energy per feed unit, MJ per FU

	BFU_{winter}	BFU_{summer}
Dairy cattle	18.3	18.3
Calves and bulls	18.3	18.83
Heifers	25.75	18.83
Suckling cattle	34.02	18.83
Sows	17.49	17.49
Weaners	16.46	16.46
Fattening pigs	17.25	17.25
Horses, sheep, goats and deer	29.95	18.83

Table 3E.7 Grazing animals 1990 – 2009, number of days on grass pr year.

Livestock category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	55	55	55	55	55	55	55	55	55	55
Heifer > ½ year	165	171	177	184	190	196	196	196	196	196
Suckling cattle	184	192	200	208	216	224	224	224	224	224
Sheep and gotas	265	265	265	265	265	265	265	265	265	265
Horses	183	183	183	183	183	183	183	183	183	183
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cattle	55	55	55	46	39	32	25	18	18	18
Heifer > ½ year	196	196	196	180	168	156	144	132	132	132
Suckling cattle	224	224	224	224	224	224	224	224	224	224
Sheep and gotas	265	265	265	265	265	265	265	265	265	265
Horses	183	183	183	183	183	183	183	183	183	183

Table 3E.8a Average gross energy intake (GE) 1990 – 2009, MJ pr head pr day.

Livestock category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	278.2	282.4	286.7	290.9	295.3	295.6	295.8	295.9	297.9	297.8
Non-dairy cattle (heifer)	107.2	106.8	106.4	106.0	105.6	105.2	105.2	105.5	105.3	105.2
Sheep (mother sheep incl. lambs)	43.6	43.6	43.6	43.6	43.6	43.6	43.6	43.6	43.6	43.6
Goats (mother goats incl. kids)	40.1	40.1	40.1	40.1	40.1	40.1	40.1	40.1	40.1	40.1
Horses	133.0	133.0	133.0	133.0	133.0	133.0	133.0	133.0	133.0	133.0
Swine (fattenig pig)	43.3	42.2	41.4	40.8	38.9	38.9	38.9	38.9	38.1	38.1
Other:										
Deer	34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cattle	297.9	304.2	310.5	317.8	323.5	328.7	331.9	335.1	335.3	343.2
Non-dairy cattle (heifer)	105.2	105.8	105.8	107.3	108.3	115.6	123.1	130.5	130.5	130.3
Sheep (mother sheep incl. lambs)	43.6	43.6	43.6	43.6	43.6	43.6	43.6	43.6	43.6	43.6
Goats (mother goats incl. kids)	40.1	40.1	40.1	40.1	40.1	40.1	40.1	39.1	39.8	39.8
Horses	133.0	133.0	133.0	133.0	133.0	133.0	133.0	133.0	133.0	133.0
Swine (fattening pig)	38.1	39.2	39.2	38.9	39.1	38.9	39.9	40.7	39.9	40.4
Other:										
Deer	34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5

Table 3E.8b Average gross energy intake (GE) 1990 – 2009, MJ pr head pr day – Subcategories for cattle and swine.

Subcategories for cattle and swine	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Cattle										
Dairy, large breed	285.8	289.9	294.1	298.3	302.4	302.4	302.4	302.4	304.1	304.1
Dairy, Jersey	237.2	240.6	244.0	247.4	250.7	250.7	250.7	250.7	253.2	253.2
Calves, bull	59.6	59.8	59.9	60.0	60.1	60.2	60.2	60.3	60.4	60.4
Calves, heifer	86.5	86.6	86.7	86.9	87.0	87.2	87.3	87.3	86.5	86.5
Bulls > ½ year	113.6	113.7	113.9	114.0	114.2	114.3	114.4	114.5	114.6	114.6
Heifer > ½ year	107.2	106.8	106.4	106.0	105.6	105.2	105.2	105.5	105.3	105.2
Suckling cattle	181.6	179.4	177.1	174.8	172.5	170.2	170.2	170.2	170.2	170.2
Swine										
Sows (incl. pigs < 7.4 kg)	62.3	62.3	62.3	62.3	62.3	62.3	62.3	62.3	64.2	64.2
Weaners (7.4 – 32 kg)	11.1	11.7	12.2	12.7	13.2	13.2	13.2	13.2	13.8	13.8
Fattening pigs (32 – 107 kg)	43.3	42.2	41.4	40.8	38.9	38.9	38.9	38.9	38.1	38.1
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Cattle										
Dairy, large breed	304.1	310.6	317.1	324.9	330.6	335.9	338.7	341.5	341.8	350.2
Dairy, Jersey	253.2	258.1	262.9	269.1	274.7	278.8	284.7	290.5	290.6	296.3
Calves, bull	60.4	61.5	61.5	61.4	61.5	61.6	61.4	61.5	61.7	61.7
Calves, heifer	86.5	85.7	85.7	85.6	85.6	91.3	96.8	102.4	102.4	102.3
Bulls > ½ year	114.7	115.6	115.6	115.8	115.6	115.8	115.9	115.8	116.0	116.2
Heifer > ½ year	105.2	105.8	105.8	107.3	108.3	115.6	123.1	130.5	130.5	130.3
Suckling cattle	170.2	170.2	170.2	170.2	160.9	160.9	160.9	163.6	163.6	163.6
Swine										
Sows (incl. pigs < 7.4 kg)	64.2	66.6	66.6	69.3	69.1	69.5	70.4	71.4	71.1	71.9
Weaners (7.4 – 32 kg)	13.8	13.8	13.8	13.2	13.6	13.8	14.4	14.6	15.2	14.3
Fattening pigs (32 – 107 kg)	38.1	39.2	39.2	38.9	39.1	38.9	39.9	40.7	39.9	40.4

Table 3E.9a VS daily excretion (average) 1990 – 2009, kg dm pr head pr day – CRF categories.

365 housing days	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Livestock category										
Dairy cattle	5.46	5.49	5.51	5.54	5.57	5.59	5.62	5.68	5.75	5.75
Non-dairy cattle (weighted average)	1.93	1.97	2.01	2.04	2.05	2.07	2.10	2.12	2.13	2.16
Sheep (mother sheep incl. lambs)	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12
Goats (mother goats incl. kids)	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06
Horses	3.67	3.67	3.67	3.67	3.67	3.67	3.67	3.67	3.67	3.67
Swine (weighted average)	0.23	0.23	0.23	0.23	0.22	0.22	0.22	0.22	0.21	0.21
Poultry (weighted average)	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Fur farming	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Deer	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Livestock category										
Dairy cattle	5.70	5.70	5.88	6.02	6.14	6.37	6.28	6.13	6.07	6.20
Non-dairy cattle (weighted average)	2.19	2.24	2.26	2.65	2.66	2.70	2.73	2.87	2.83	2.81
Sheep (mother sheep incl. lambs)	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12
Goats (mother goats incl. kids)	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.07	1.07
Horses	3.67	3.67	3.67	3.65	3.65	3.65	3.65	3.65	3.65	3.65
Swine (weighted average)	0.21	0.21	0.22	0.22	0.22	0.22	0.22	0.22	0.21	0.20
Poultry (weighted average)	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Fur farming	0.08	0.08	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Deer	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72

Table 3E.9b VS daily excretion (average) 1990 – 2009, kg dm pr head pr day – Subcategories.

365 housing days	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Cattle:										
Dairy cattle	5.46	5.49	5.51	5.54	5.57	5.59	5.62	5.68	5.75	5.75
Calves, bull	1.49	1.49	1.50	1.50	1.50	1.50	1.50	1.50	1.51	1.51
Bulls > ½ year	1.95	2.03	2.12	2.21	2.29	2.38	2.46	2.55	2.66	2.69
Calves, heifer	1.68	1.68	1.68	1.69	1.69	1.69	1.69	1.69	1.69	1.69
Heifer > ½ year	1.97	2.00	2.03	2.06	2.09	2.11	2.16	2.18	2.18	2.18
Suckling cattle	6.72	6.51	6.30	6.09	5.88	5.67	5.65	5.63	5.61	5.61
Swine:										
Sows (incl. pigs < 7.5 kg)	0.45	0.43	0.44	0.44	0.44	0.45	0.46	0.47	0.48	0.49
Piglets (7.5 – 30 kg)	0.11	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Slaughtering pigs (30 – 104 kg)	0.34	0.34	0.34	0.34	0.33	0.33	0.33	0.33	0.32	0.32
Poultry:										
Hens	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Pullet	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Broilers	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Turkeys, geese and ducks	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Cattle:										
Dairy cattle	5.70	5.70	5.88	6.02	6.14	6.37	6.28	6.13	6.07	6.20
Calves, bull	1.51	1.53	1.53	1.52	1.53	1.53	1.53	1.53	1.53	1.53
Bulls > ½ year	2.80	2.93	3.03	3.07	3.20	3.60	3.61	4.01	3.89	4.03
Calves, heifer	1.69	1.69	1.69	1.69	1.69	1.69	1.70	1.80	1.80	1.80
Heifer > ½ year	2.20	2.21	2.20	2.58	2.69	2.70	2.75	2.99	2.96	2.80
Suckling cattle	5.64	5.66	5.95	6.04	5.52	4.91	4.91	4.14	4.19	4.22
Swine:										
Sows (incl. pigs < 7.5 kg)	0.51	0.52	0.56	0.59	0.59	0.36	0.36	0.34	0.33	0.33
Piglets (7.5 – 30 kg)	0.10	0.10	0.10	0.10	0.10	0.10	0.09	0.10	0.10	0.10
Slaughtering pigs (30 – 104 kg)	0.32	0.32	0.33	0.33	0.33	0.35	0.35	0.35	0.33	0.33
Poultry:										
Hens	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03
Pullet	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Broilers	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Turkeys, geese and ducks	0.02	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.02	0.02

Table 3E.10a Calculation of lower CH_4 emission as a consequence of biogas treated slurry.

Year	Biogas treated slurry, 1000 Gg	Cattle slurry, 1000 Gg	Pig slurry, 1000 Gg	VS cattle slurry, 1000 Gg	VS pig slurry, 1000 Gg	CH_4 emission, untreated cattle slurry, Gg	CH_4 emission, treated cattle slurry, Gg	Lower CH_4 emission, cattle slurry, Gg	CH_4 emis- sion, un- treated pig slurry, Gg	CH_4 emission, tretaed pig slurry, Gg	Lower CH_4 emission, pig slurry, Gg	**Lower CH_4 emission total, Gg**
1990	0.19	0.09	0.10	0.007	0.005	0.113	0.087	0.026	0.154	0.092	0.062	**0.088**
1991	0.32	0.14	0.18	0.012	0.009	0.191	0.146	0.045	0.259	0.155	0.104	**0.149**
1992	0.39	0.18	0.21	0.014	0.010	0.233	0.178	0.054	0.316	0.189	0.127	**0.181**
1993	0.46	0.21	0.25	0.017	0.012	0.274	0.210	0.064	0.372	0.223	0.150	**0.214**
1994	0.54	0.24	0.30	0.020	0.014	0.322	0.247	0.075	0.437	0.261	0.176	**0.251**
1995	0.64	0.29	0.35	0.024	0.017	0.382	0.292	0.089	0.518	0.310	0.208	**0.298**
1996	0.69	0.31	0.38	0.026	0.019	0.411	0.315	0.096	0.558	0.334	0.225	**0.321**
1997	0.83	0.37	0.46	0.031	0.022	0.495	0.379	0.116	0.672	0.402	0.270	**0.386**
1998	1.01	0.45	0.56	0.037	0.027	0.602	0.461	0.141	0.817	0.489	0.329	**0.470**
1999	1.04	0.47	0.57	0.039	0.028	0.620	0.475	0.145	0.842	0.503	0.338	**0.483**
2000	1.16	0.52	0.64	0.043	0.031	0.692	0.530	0.162	0.939	0.561	0.377	**0.539**
2001	1.26	0.57	0.69	0.047	0.034	0.751	0.576	0.176	1.020	0.610	0.410	**0.586**
2002	1.44	0.65	0.79	0.053	0.039	0.859	0.658	0.201	1.165	0.697	0.469	**0.669**
2003	1.76	0.79	0.97	0.065	0.047	1.049	0.804	0.245	1.424	0.851	0.573	**0.818**
2004	1.88	0.85	1.03	0.070	0.050	1.121	0.859	0.262	1.521	0.910	0.612	**0.874**
2005	1.93	0.87	1.06	0.072	0.052	1.151	0.882	0.269	1.562	0.934	0.628	**0.897**
2006	2.14	0.96	1.18	0.079	0.057	1.276	0.978	0.298	1.732	1.035	0.696	**0.995**
2007	2.15	0.97	1.18	0.080	0.058	1.282	0.982	0.300	1.740	1.040	0.700	**1.000**
2008	2.19	0.99	1.20	0.081	0.059	1.306	1.000	0.305	1.772	1.060	0.713	**1.018**
2009	2.39	1.08	1.31	0.089	0.064	1.425	1.092	0.333	1.934	1.156	0.778	**1.111**

Table 3E.10b Calculation of lower N_2Oemission as a consequence of biogas treated slurry.

Year	Biogas treated slurry, 1000 Gg	Cattle slurry, 1000 Gg	Pig slurry, 1000 Gg	N_2O emission, untreated cattle slurry, Gg	N_2O emission treated cattle slurry, Gg	Lower N_2O emission, cattle slurry, Gg	N_2O emission untretaed pig slurry, Gg	N_2Oemission treated pig slurry, Gg	Lower N_2O emission, pig slurry, Gg	**Lower N_2O emission total, Gg**
1990	0.19	0.09	0.10	0.006	0.004	0.002	0.007	0.004	0.003	**0.005**
1991	0.32	0.14	0.18	0.010	0.006	0.004	0.012	0.007	0.005	**0.008**
1992	0.39	0.18	0.21	0.012	0.008	0.004	0.015	0.009	0.006	**0.010**
1993	0.46	0.21	0.25	0.014	0.009	0.005	0.017	0.010	0.007	**0.012**
1994	0.54	0.24	0.30	0.016	0.010	0.006	0.020	0.012	0.008	**0.014**
1995	0.64	0.29	0.35	0.019	0.012	0.007	0.024	0.014	0.010	**0.017**
1996	0.69	0.31	0.38	0.021	0.013	0.008	0.026	0.015	0.010	**0.018**
1997	0.83	0.37	0.46	0.025	0.016	0.009	0.031	0.018	0.013	**0.022**
1998	1.01	0.45	0.56	0.031	0.019	0.011	0.038	0.022	0.015	**0.026**
1999	1.04	0.47	0.57	0.031	0.020	0.011	0.039	0.023	0.016	**0.027**
2000	1.16	0.52	0.64	0.035	0.022	0.013	0.043	0.026	0.018	**0.030**
2001	1.26	0.57	0.69	0.038	0.024	0.014	0.047	0.028	0.019	**0.033**
2002	1.44	0.65	0.79	0.044	0.028	0.016	0.054	0.032	0.022	**0.038**
2003	1.76	0.79	0.97	0.053	0.034	0.019	0.065	0.039	0.027	**0.046**
2004	1.88	0.85	1.03	0.057	0.036	0.021	0.070	0.041	0.029	**0.049**
2005	1.93	0.87	1.06	0.058	0.037	0.021	0.072	0.042	0.029	**0.051**
2006	2.14	0.96	1.18	0.065	0.041	0.024	0.080	0.047	0.033	**0.056**
2007	2.15	0.97	1.18	0.065	0.041	0.024	0.080	0.047	0.033	**0.056**
2008	2.19	0.99	1.20	0.066	0.042	0.024	0.081	0.048	0.033	**0.057**
2009	2.39	1.08	1.31	0.072	0.046	0.026	0.089	0.053	0.036	**0.063**

Table 3E.11 Background data for calculation of N content in nitrogen fixing crops.

Crop	Dry matter content[1]	N-content in dm[1]	Straw yield in pct. of grain yield[2]	Share, root + stubble[3]	Share of N in crop which is fixed[3]	N-fixed
	pct.	pct.	pct.	pct.	pct.	kg N/tonnes harvested
Based on yield						
Field peas, grain	85	3.97		25	75	
Field peas, straw	87	1.15	60			
Legumes grown to maturity, in total						37.3
Lucerne	21	3.04		60	75	7.7
Crops for silage	23	2.64		25	80	6.1
Legumes, marrow-stem kale and green fodder	23	2.64		25	80	6.1
Grass and clover fields as well as fields sown with an under crop	13	4.00		75	90	8.2
Peas for conservation[4]	23	2.64		25	80	6.1
Fields with aftermath	13	4.00		75	90	8.2
Based on area	kg N/ha/year					
Seed of leguminous grass crops:						
Red clover	200					
White clover	180					
Black medick	180					

[1] Feedstuff table (DAAC, 2000)

[2] Kyllingsbæk (2000)

[3] Kristensen (2002) and Kyllingsbæk (2000)

[4] Assumed that peas constitute 80% of the total area

Table 3E.12 Estimated share of nitrogen fixing plants in crops.

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999-2009
								pct.							
Cereals for silage															
Share of peas (whole-crop)	15	20	20	25	25	30	30	35	35	40	40	45	45	50	50
Share of peas in whole-crop	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Legumes, marrow-stem kale and other green fodder															
Share with legumes:	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
of which share with peas	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Peas for conservation	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
Grass in rotation															
Share of clover grass fields	64	66	68	70	72	74	76	78	80	82	84	85	86	87	88
Clover percentage in the clover grass fields	20	20	20	20	20	20	20	20	20	20	22	24	26	28	30
Grass not in a rotation															
Clover percentage	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Fields with aftermath															
Share with clover grass	64	66	68	70	72	74	76	78	80	82	84	85	86	87	88
Clover percentage	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30

Table 3E.13 Background data for estimation of N_2O emission from crop residue 2009.

	Stubble	Husks	Top	Leafs	Nitrogen content in crop residue	
Crop type	kg N pr ha	kg N pr ha	kg N pr ha	kg N pr ha	kg N pr ha pr year	Gg N pr year
Winter wheat	6.3	10.7	-	-	17.0	12.18
Spring wheat	6.3	7.4	-	-	13.7	0.13
Winter rye	6.3	10.7	-	-	17.0	0.72
Triticale	6.3	10.7	-	-	17.0	0.81
Winter barley	6.3	5.9	-	-	12.2	1.72
Spring barley	6.3	4.1	-	-	10.4	4.61
Oats	6.3	4.1	-	-	10.4	0.56
Winter rape	4.4	-	-	-	4.4	0.71
Spring rape	4.4	-	-	-	4.4	0.00
Potatoes (top), non-harvest	-	-	48.7	-	48.7	1.85
Beet (top), non-harvest	-	-	56.7[a]	-	56.7	2.43
Straw, non-harvest	-	-	-	-	6.9[a]	10.01
Pulse	11.3	-	-	-	11.3	0.07
Lucerne	32.3	-	-	-	10.8	0.06
Maize – for green fodder	6.3	-	-	-	6.3	1.06
Cereal – for green fodder	6.3	-	-	-	6.3	0.35
Peas for conservation	11.3	-	-	-	11.3	0.04
Vegetables	11.3	-	-	-	11.3	0.09
Grass field legumes	11.3	-	-	-	5.7	0.03
Grass- and clover fiel in rotation	32.3		-	10.0	26.2	7.99
Grass- and clover field out of rotation	38.8		-	20.0	20.0	3.83
Catch crop	6.3	-	-	-	6.3	0.72
Seeds of grass crops	6.3	10.7	-	-	13.9	1.13
Set-a-side	38.8	-	-	15.0	18.9	0.11
Total N from crop residue						51.21

[a] express the yield for 2009 - varies from year to year. Based on yield data from Statistics Denmark and N-content from the feeding plan.

Reference: Djurhuus and Hansen 2003

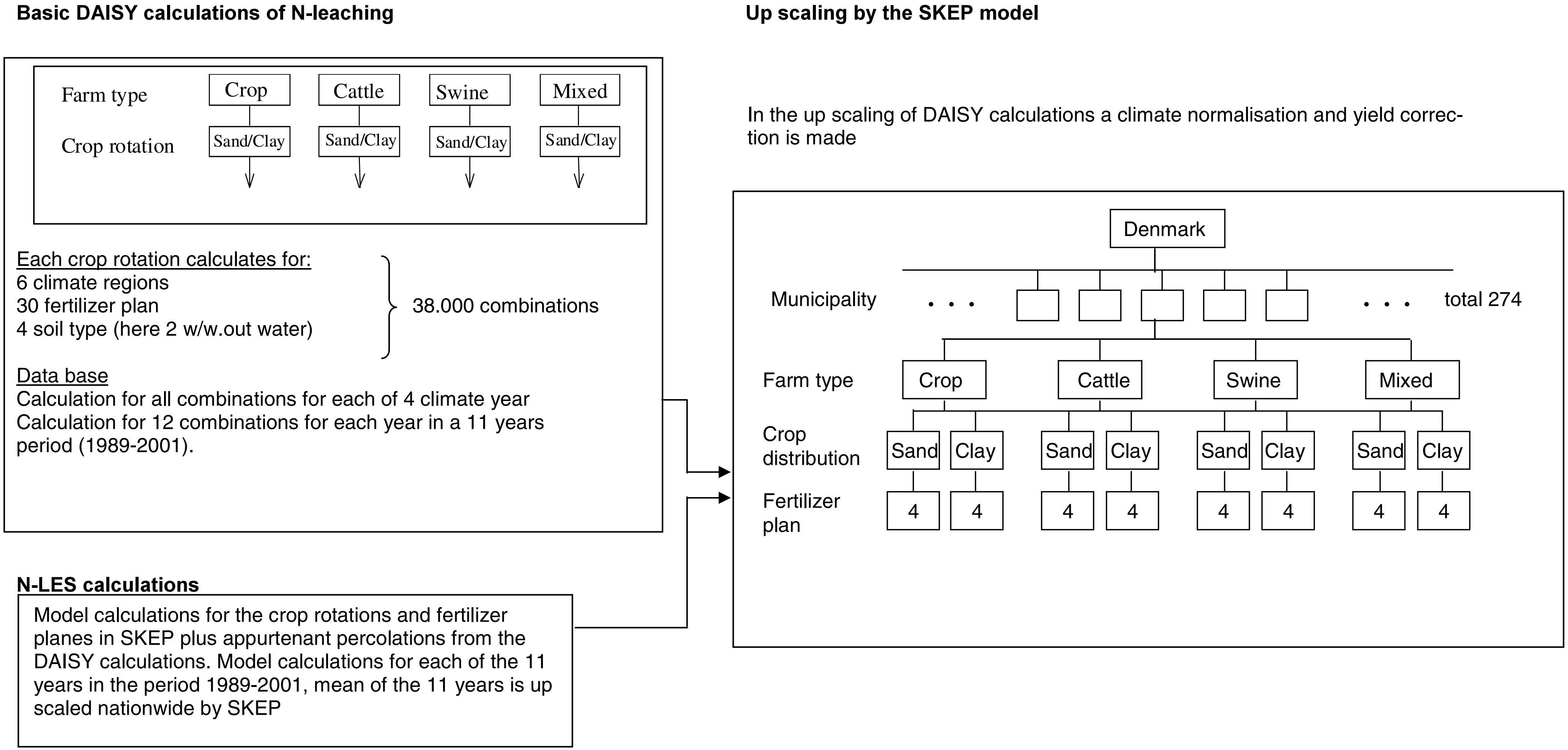
Table 3E.14 Area of agricultural land, 1990 – 2009, ha

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Garden centre, fruit and berries	11 687	11 644	12 474	12 093	12 809	12 135	12 009	11 314	10 657	10 803
Agriculture crops excl. grass in rotation	2 294 434	2 280 150	2 264 485	2 226 709	2 018 694	2 039 330	2 052 275	2 117 040	2 104 327	2 042 373
Vegetables grown in the open	16 105	15 703	16 365	15 419	12 633	12 584	10 799	9 375	10 046	10 329
Permanent grass	217 235	212 030	207 932	197 229	316 668	207 122	192 851	167 600	156 260	159 530
Fallow	0	0	0	0	0	216 493	190 701	147 400	141 432	182 905
Grass in rotation	248 815	250 129	255 069	287 109	330 370	238 384	257 398	235 285	249 128	238 107
Sum	2 788 276	2 769 656	2 756 325	2 738 559	2 691 174	2 726 048	2 716 033	2 688 014	2 671 850	2 644 047
Continued	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Garden centre, fruit and berries	11 050	11 424	10 723	11 107	10 887	10 682	10 499	10 738	11 106	9 651
Agriculture crops excl. grass in rotation	2 021 092	2 038 848	2 045 759	2 040 648	2 058 899	2 065 948	2 062 352	2 029 577	2 084 866	2 081 876
Vegetables grown in the open	10 628	9 456	8 755	9 782	9 635	9 431	9 930	9 818	11 048	11 463
Permanent grass	166 261	173 702	177 546	177 635	172 536	192 968	189 384	196 630	189 962	191 529
Fallow	191 295	201 817	204 721	206 584	196 972	175 200	167 502	153 570	70 662	5 699
Grass in rotation	246 656	240 320	218 000	211 950	196 375	253 007	270 840	262 429	300 251	305 476
Sum	2 646 982	2 675 567	2 665 504	2 657 706	2 645 304	2 707 236	2 710 507	2 662 762	2 667 895	2 605 694

Nitrogen leaching and Run-off

Calculations of nitrogen lost by leaching from groundwater are based on two models described in Børgesen and Grant (2003) (in Danish). The model SKEP/DAISY is a dynamic model, N-LES is an empirical model and SKEP is an up scaling model. The SKEP/DAISY calculations were done for 10 scenarios (the years 1984, 1989 and 1995-2002) and the N-LES calculations were done for an 11 year period (1990-2000). Both calculations were up scaled nation wide. The key parameters for the models were land use, nitrogen from synthetic fertilizer and manure, application practice for manure and NH_3 evaporation at application of manure (SKEP/DAISY only). The calculations were normalised to an average climate. A schematic overview of the models is seen below.

Figure 3E.1: Model calculation of nitrogen leaching from groundwater nationwide by SKEP/DAISY and N-LES



Annex 3F LULUCF

This year all information is included in Chapter 7 and Chapter 11 of the NIR.

Annex 3G Waste

6 A. Solid Waste Disposal on Land

In Table 3G.1 results from the calculations by the FOD model for the years 1970-1979 is presented to illustrate how the model performs: The left two columns represent the time-series of potential emissions. The actual emissions are in the next column as total. In the "from year"columns are put the contribution of emissions from individual previous years to the actual years emission (the Total). The contribution from the deposited waste in 1970 with its potential emission in 1970 (= 110.0) to the actual emissions in 1970 is 0, since in this model formulation the emission starts the year after. In 1971 the contribution from the 1970 deposited waste is 5.31. In 1972 it is 5.06 and so on. Summing up the contribution from the potential of the year 1970 until 1984 equals 55 corresponding to a half-life time of 14 years; i.e. half of the potential emission of 110.0 in 1970 is emitted after 14 years. The reason for in this illustration to go back in time to from 1970 to 1984 is simply that this is a way in one illustration in a small table to illustrate the behaviours of the model.

Table 3G.1 Results from the FOD model 1970-1984.

	Emissioner [kt]																									
		Actual																								
			From year																							
Year	Po ten tiel	Total	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1970	110.0	41.0	3.09	3.28	3.48	3.70	3.92	4.16	4.41	4.68	4.96	5.27														
1971	111.0	44.3	2.94	3.12	3.32	3.52	3.73	3.96	4.20	4.46	4.73	5.01	5.31													
1972	112.0	47.5	2.80	2.97	3.16	3.35	3.55	3.77	4.00	4.24	4.50	4.77	5.06	5.36												
1973	113.0	50.6	2.67	2.83	3.00	3.19	3.38	3.59	3.80	4.04	4.28	4.54	4.81	5.10	5.41											
1974	114.0	53.6	2.54	2.69	2.86	3.03	3.22	3.41	3.62	3.84	4.07	4.32	4.58	4.86	5.15	5.46										
1975	115.0	56.6	2.42	2.56	2.72	2.89	3.06	3.25	3.45	3.65	3.88	4.11	4.36	4.62	4.90	5.19	5.51									
1976	116.0	59.4	2.30	2.44	2.59	2.75	2.91	3.09	3.28	3.48	3.69	3.91	4.15	4.40	4.66	4.94	5.24	5.56								
1977	117.0	62.1	2.19	2.32	2.46	2.61	2.77	2.94	3.12	3.31	3.51	3.72	3.95	4.19	4.44	4.71	4.99	5.29	5.60							
1978	118.0	64.8	2.08	2.21	2.34	2.49	2.64	2.80	2.97	3.15	3.34	3.54	3.76	3.98	4.22	4.48	4.75	5.03	5.33	5.65						
1979	119.0	67.3	1.98	2.10	2.23	2.37	2.51	2.66	2.83	3.00	3.18	3.37	3.58	3.79	4.02	4.26	4.52	4.79	5.08	5.38	5.70					
1980	120.0	69.8	1.89	2.00	2.12	2.25	2.39	2.54	2.69	2.85	3.03	3.21	3.40	3.61	3.83	4.06	4.30	4.56	4.83	5.12	5.42	5.75				
1981	121.0	72.3	1.79	1.90	2.02	2.14	2.28	2.41	2.56	2.72	2.88	3.05	3.24	3.43	3.64	3.86	4.09	4.34	4.60	4.87	5.16	5.47	5.80			
1982	122.0	74.6	1.71	1.81	1.92	2.04	2.17	2.30	2.44	2.58	2.74	2.91	3.08	3.27	3.46	3.67	3.89	4.13	4.37	4.64	4.91	5.21	5.52	5.84		
1983	123.0	76.9	1.63	1.72	1.83	1.94	2.06	2.19	2.32	2.46	2.61	2.77	2.93	3.11	3.30	3.50	3.71	3.93	4.16	4.41	4.68	4.95	5.25	5.56	5.89	
1984	124.0	79.1	1.55	1.64	1.74	1.85	1.96	2.08	2.21	2.34	2.48	2.63	2.79	2.96	3.14	3.33	3.53	3.74	3.96	4.20	4.45	4.72	5.00	5.29	5.61	5.94
											total		55.0													

The result of summing this table horizontally in the "from years" columns is the total actual emission of that year.

6 B. Wastewater Handling

Table 3G.2 presents the percent uncertainties on the individual parameters used for calculating the uncertainties associated with activity data and emission factors used for estimating the methane and nitrous oxide emissions from category 6.B Wastewater Handling. References are given to the equations presented in Chapter 8.3.2.

Table 3G.2 Input parameter uncertainties, %.

Input parameters and equations	Uncertainty, %*	Reference
$CH_{4,\ sewer+MB}$		Eq. 8.3.2
$EF_{sewer+MB}=B_o*MCF_{sewer+MB}$	**32**	
B_o	30	IPCC, 2006
$MCF_{sewer+MB}$	10	IPCC, 2006
$Ac_{sewer+MB}$	**33**	
TOW	33	Table 3G.3
$CH_{4,\ AD}$		Eq. 8.3.3
$EF_{AD}=B_o*MCF_{AD}*f_{AD}$	**34**	
B_o	30	IPCC, 2000
MCF_{AD}	10	IPCC, 2006
F_{AD}	12	Table 3G.4
Ac_{AD}	**33**	
TOW	33	Table 3G.3
$CH_{4,\ st}$		Eq. 8.3.4
$EF_{st}=MCF_{st}*B_o$	**36**	
MCF_{st}	10	IPCC, 2006
B_o	30	IPCC, 2000
$Ac_{st}=f_{nc}*P*DOC_{st}$	**31**	
f_{nc}	5	IPCC, 2000
DOC_{st}	30	IPCC, 2006
P	5	IPCC, 2000
N_2O,direct		Eq. 8.3.6
$EF_{N2O,direct}$	27	Table 3G.5
$Ac_{N2O,direct}$	39/5	Table 3G.5
$m_{N,influent}$	39/5	Table 3G.5
N_2O,indirect		Eq. 8.3.7
$EF_{N2Oindirect}$	17	Table 3G.5
$D_{N.WWTP}$	39/5	Table 3G.5

*Numbers given as x/y represents different uncertainty levels for 1990 and 2009, respectively.

Table 3G.3 presents activity data on the total degradable organic matter (TOW) in the influent wastewater at the Danish WWTPs. The average uncertainty throughout the time-series is 33 %; the value that has been used as and approximation for the input parameter uncertainty on TOW data for the Tier 2 uncertainty model.

Table 3G.3 TOW data derived based on monitoring of the chemical (COD) and biological oxygen demand (BOD) in the influent waste water at the Danish WWTPs, Gg and resulting uncertainties, %.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
TOW data derived from reported BOD data, DEPA reports*				100,00						132,00
TOW data derived from reported COD data, DEPA reports*										148,50
TOW time-series, IPCC default methodology*	96,62	96,39	96,71	99,42	107,97	116,59	125,28	134,02	142,80	136,51
TOW data derived from reported BOD data in the DWQPD	96,21	109,01	109,30	93,50	124,53	123,79	136,16	134,05	143,07	137,22
TOW data derived from reported COD data in the DWQPD	78,77	87,22	84,61	80,69	203,16	121,03	123,61	128,48	131,29	137,78
Uncertainty, %	52	56	56	43	81	57	56	54	53	4
TOW data derived from reported BOD data, DEPA reports	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
TOW data derived from reported COD data, DEPA reports	144,38	144,38	144,38	144,38	144,38	144,38	144,38	144,38	144,38	144,38
TOW time-series, IPCC defalt methodology*	138,60	138,60	138,60	138,60	138,60	138,60	138,60	138,60	138,60	138,60
TOW data derived from reported BOD data in the DWQPD	151,15	151,15	151,15	151,15	151,15	151,15	151,15	151,15	151,15	151,15
TOW data derived from reported COD data in the DWQPD	150,94	150,94	150,94	150,94	150,94	150,94	150,94	150,94	150,94	150,94
Uncertainty, %	5	5	29	9	16	13	18	12	21	16

*The default IPCCC methodology corrected for the contribution from industries to the influent TOW have been used in the inventory for the years 1990-1998. The average of the BOD and COD derived TOW data have been used in the inventory for the years 1999-2009. Data are reported in Chapter 8.3, Table 8.3.3.

The national TOW data calculated based on data extracted from the Danish Waste water Quality Parameter Database (DWQPD) represents 100% completeness, but the calculation procedures still need verification by purpose of obtaining better agreement with the data reported by the Danish EPA.

Table 3G.4 Data on amount of sludge treated in anaerobic processes for approximation of the input parameter f_{AD} which is the fraction of sludge treated in anaerobic closed systems (cf. Eq. 8.3.3, Chapter 8.3.2).

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
% treated anaerobically (WW)	29	29	29	29	29	29	32	36	31	30
Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
% treated anaerobically (WW)	41	41	29	34	31	34	34	34	34	34

Based on the data presented in Table 3G.4, the average percent uncertainty of the fraction of sludge treated in anaerobic closed systems is estimated to be 12%.

Data have been estimated based on reported data in the Danish Sludge database. For the years 2006-2009 the percent wet weight sludge treated in anaerobic processes has been set equal to the value for 2005 due to low reporting frequencies in the years 2006-2009.

Table 3G.5 Estimated direct N2O emissions, population number and derived emission factors in units of g N_2O/ person.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
N_2O, direct emission [tonnes]	88	92	87	90	88	88	88	88	88	88
Population [1000]	5 135	5 135	5 135	5 135	5 135	5 135	5 135	5 135	5 135	5 135
EF [g N_2O/person]	17	18	17	17	23	26	26	26	29	28
Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
N_2O, direct emission [tonnes]	161	165	211	168	150	193	152	185	256	153
Population [1000]	5 330	5 349	5 368	5 384	5 398	5 411	5 427	5 447	5 476	5 482
EF [g N_2O/person]	30	31	39	31	28	36	28	34	47	28

Based on the time trend emission data for the direct N2O emission an average uncertainty of the EF has been derived calculated as the standard deviation on EF values across the whole time-series divided by the time trend average EF value and multiplied by 100%. A resulting uncertainty of 27 % has been used as approximation for the uncertainty of EF for the direct N_2O emissions.

Table 3G.6 Uncertainties on the effluent amount of N derived from reported tonnes N in effluent waste water from WWTPs. Data extracted from the Danish Waste water Quality Parameter Database (DWQPD) and form DEPA reports, respectively.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Effluent N, DEPA reports	16 884	15 111	13 071	10 787	10 241	8 938	6 387	4 851	5 162	5 135
Effluent N, DWQPD	7 499	6 882	5 365	4 176	4 853	5 152	4 074	3 947	4 516	4 220
% uncertainty effluents	39	39	42	43	37	30	26	13	9	13
Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Effluent N, DEPA reports	4 653	4 221	4 528	3 614	4 027	3 831	3 634	4 358	3 575	4 025
Effluent N, DWQPD	3 996	4 360	4 993	3 644	3 688	3 517	3 648	4 407	3 771	3 765
% uncertainty effluents	10	2	7	1	6	6	0	1	4	5

Similar uncertainty levels has been used for the activity data on the amount of influent N as no other data sources are available then the DWQPD.

The uncertainty of the emission factor for effluent N is based on average of the range provided in the IPCC guidelines (IPCC, 2000 and 2006).

Annex 4 CO_2 reference approach and comparison with sectoral approach, and relevant information on the national energy balance

Please refer to Annex 3A.

Annex 5 Assessment of completeness and (potential) sources and sinks of greenhouse gas emissions and removals excluded

GHG inventory

The Danish greenhouse gas emission inventories for 1990-2009 include all sources identified by the Revised 1996 IPCC Guidelines and the 2000 IPCC Good Practice Guidance. Some very minor sources have not been estimated due to lack of methodology, activity data or emission factors, i.e.:

In the Solvent and other product use sector currently only N_2O emissions from anaesthesia are included in CRF category 3D, Denmark will try to obtain activity data for other uses of N_2O. N_2O emissions from anaesthesia are only included from 2005 onwards.

Methane and nitrous oxide emissions from manure management have not been estimated for ostriches and pheasants. There is no default factors provided in the revised 1996 IPCC Guidelines or IPCC GPG.

Direct and indirect CH_4 emissions from agricultural soils are not estimated. Direct and indirect soil emissions are considered of minor importance for CH_4. No methodology is recommended in IPCC-GPG.

In the LULUCF sector emissions/removals from living biomass in settlements remaining settlements and emissions/removals from living biomass and soils in partly water covered wetlands are currently not estimated due to the lack of available data. The lack of data availability is also an issue for other aspects of LULUCF, e.g. harvested wood products. For more detail please see chapter 7.

In the Waste sector CO_2 emissions from managed waste disposal on land are not estimated. According to the 1996 IPCC Guidelines: "Decomposition of organic material derived from biomass sources (e.g., crops, forests), which are regrown on an annual basis is the primary source of CO_2 released from waste. Hence, these CO_2 emissions are not treated as net emissions from waste in the IPCC Methodology."

Emissions of N_2O from accidental fires are reported as not estimated due to lack of emission factors.

KP-LULUCF inventory

The KP-LULUCF inventory is considered complete. Please see chapter 11 for further documentation.

Annex 6 Additional information to be considered as part of the annual inventory submission and the supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol or other useful reference information

Tables A6.1 to A6.5 below contain the information publically available in this report. Table A6.6 includes the list of discrepancies identified by the ITL.

Table A6.1 Total quantities of Kyoto Protocol units by account type at beginning of reported year.

	Unit type					
Account type	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Party holding accounts	229 445 248	331 424	NO	266 286	NO	NO
Entity holding accounts	45 202 064	7042	NO	1 534 083	NO	NO
Article 3.3/3.4 net source cancellation accounts	NO	NO	NO	NO		
Non-compliance cancellation accounts	NO	NO	NO	NO		
Other cancellation accounts	10 394	NO	NO	NO	NO	NO
Retirement account	26171207	NO	NO	375 230	NO	NO
tCER replacement account for expiry	NO	NO	NO	NO	NO	
lCER replacement account for expiry	NO	NO	NO	NO		
lCER replacement account for reversal of storage	NO	NO	NO	NO		NO
lCER replacement account for non-submission of certification report	NO	NO	NO	NO		NO
Total	300 828 913	338 466	NO	2 175 599	NO	NO

Table A6.2a Annual internal transactions.

Transaction type	Additions						Subtractions					
	Unit type						Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Article 6 issuance and conversion												
Party-verified projects		NO					NO		NO			
Independently verified projects		NO					NO		NO			
Article 3.3 and 3.4 issuance or cancellation												
3.3 Afforestation and reforestation			NO				NO	NO	NO	NO		
3.3 Deforestation			NO				NO	NO	NO	NO		
3.4 Forest management			NO				NO	NO	NO	NO		
3.4 Cropland management			NO				NO	NO	NO	NO		
3.4 Grazing land management			NO				NO	NO	NO	NO		
3.4 Revegetation			NO				NO	NO	NO	NO		
Article 12 afforestation and reforestation												
Replacement of expired tCERs							NO	NO	NO	NO	NO	
Replacement of expired lCERs							NO	NO	NO	NO		
Replacement for reversal of storage							NO	NO	NO	NO		NO
Replacement for non-submission of certification report							NO	NO	NO	NO		NO
Other cancellation							138 813	13 374	NO	72	NO	NO
Sub-total		NO	NO				138 813	13 374	NO	72	NO	NO

Table A6.2a Annual internal transactions.

Transaction type	Retirement					
	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Retirement	25 322 171	NO	NO	162 743	NO	NO

Table A6.2b Annual external transactions.

Transfers and acquisitions	Additions - Unit type AAUs	ERUs	RMUs	CERs	tCERs	lCERs	Subtractions - Unit type AAUs	ERUs	RMUs	CERs	tCERs	lCERs
LT	207 660	83 803	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
NZ	22 000	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
SI	20 033	NO	NO	NO	NO	NO	126	43 000	NO	37 300	NO	NO
CH	750 000	426 392	NO	1 942 077	NO	NO	NO	53 803	NO	785 354	NO	NO
CZ	2 098 629	771 854	NO	21 197	NO	NO	3 960 723	29 982	NO	226 165	NO	NO
ES	7 392 111	NO	NO	NO	NO	NO	121 371	NO	NO	262 786	NO	NO
BE	699 985	NO	NO	18 000	NO	NO	42 854	NO	NO	283 078	NO	NO
EE	955 006	NO	NO	NO	NO	NO	16 129 506	NO	NO	NO	NO	NO
FR	29 353 527	47 818	NO	1 737 793	NO	NO	8 468 616	100 485	NO	3 810 609	NO	NO
IT	6 249 814	50 000	NO	451 000	NO	NO	40 456 901	50 000	NO	1 348 000	NO	NO
FI	2 293 000	NO	NO	100 000	NO	NO	515 000	NO	NO	718 000	NO	NO
GR	1	NO	NO	NO	NO	NO	156 001	NO	NO	NO	NO	NO
CDM	NO	NO	NO	613 374	NO	NO	NO	NO	NO	NO	NO	NO
HU	2 482 755	NO	NO	NO	NO	NO	338 006	NO	NO	106 658	NO	NO
IE	373 000	NO	NO	1	NO	NO	28 000	NO	NO	220 666	NO	NO
LV	316 038	NO	NO	NO	NO	NO	103 791	NO	NO	223 000	NO	NO
NO	5 377 686	NO	NO	250 000	NO	NO	19 984 001	NO	NO	1 033 660	NO	NO
PT	58 000	NO	NO	6 000	NO	NO	5 000	NO	NO	NO	NO	NO
SE	4 140 883	84 182	NO	NO	NO	NO	1 800 411	NO	NO	128 000	NO	NO
AT	2 791 208	1 766	NO	NO	NO	NO	62 468	NO	NO	102 878	NO	NO
BG	118 501	1 520 382	NO	NO	NO	NO	1	NO	NO	NO	NO	NO
DE	55 109 899	100 000	NO	1 616 553	NO	NO	62 189 111	NO	NO	3 747 000	NO	NO
GB	77 895 043	472 243	NO	9 286 413	NO	NO	28 721 086	217 046	NO	7 983 540	NO	NO
LI	2 646 787	NO	NO	NO	NO	NO	17 368 926	NO	NO	120 800	NO	NO
RO	15 062 936	426 052	NO	56 600	NO	NO	9 345 450	240 068	NO	1 248 021	NO	NO
PL	4 593 713	629 129	NO	95 385	NO	NO	3 234 376	257 544	NO	1 715 035	NO	NO
UA	266 500	579 800	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
NL	12 381 174	151 454	NO	11 924 906	NO	NO	38 951 877	369 971	NO	3 818 602	NO	NO
SK	263 771	NO	NO	5 842	NO	NO	289 000	14 704	NO	89 647	NO	NO
Sub-total	233 919 660	5 344 875	NO	28 125 141	NO	NO	252 272 602	1 376 603	NO	28 008 799	NO	NO
Additional information												
Independently verified ERUs								NO				

Table A6.2c Total annual transactions.

Total (Sum of tables 2a and 2b)	233 919 660	5 344 875	NO	28 125 141	NO	NO	252 411 415	1 389 977	NO	28 008 871	NO	NO

Table A6.3 Expiry, cancellation and replacement.

	Expiry, cancellation and requirement to replace		**Replacement**					
	Unit type		**Unit type**					
Transaction or event type	**tCERs**	**lCERs**	**AAUs**	**ERUs**	**RMUs**	**CERs**	**tCERs**	**lCERs**
Temporary CERs (tCERS)								
Expired in retirement and replacement accounts	NO							
Replacement of expired tCERs			NO	NO	NO	NO	NO	
Expired in holding accounts	NO							
Cancellation of tCERs expired in holding accounts	NO							
Long-term CERs (lCERs)								
Expired in retirement and replacement accounts		NO						
Replacement of expired lCERs			NO	NO	NO	NO		
Expired in holding accounts		NO						
Cancellation of lCERs expired in holding accounts		NO						
Subject to replacement for reversal of storage		NO						
Replacement for reversal of storage			NO	NO	NO	NO		NO
Subject to replacement for non-submission of certification report		NO						
Replacement for non-submission of certification report			NO	NO	NO	NO		NO
Total			NO	NO	NO	NO	NO	NO

Table A6.4 Total quantities of Kyoto Protocol units by account type at end of reported year.

	Unit type					
Account type	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Party holding accounts	207 147 842	4 108 696	NO	447 341	NO	NO
Entity holding accounts	23 685 544	184 668	NO	1 306 555	NO	NO
Article 3.3/3.4 net source cancellation accounts	NO	NO	NO	NO		
Non-compliance cancellation accounts	NO	NO	NO	NO		
Other cancellation accounts	149 207	13 374	NO	72	NO	NO
Retirement account	51 493 378	NO	NO	537 973	NO	NO
tCER replacement account for expiry	NO	NO	NO	NO	NO	
lCER replacement account for expiry	NO	NO	NO	NO		
lCER replacement account for reversal of storage	NO	NO	NO	NO		NO
lCER replacement account for non-submission of certification report	NO	NO	NO	NO		NO
Total	282 475 971	4 306 738	NO	2 291 941	NO	NO

Table A6.5 (a). Summary information on additions and subtractions

	Additions - Unit type						Subtractions – Unit type					
Starting values	AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Issuance pursuant to Article 3.7 and 3.8	276 838 955											
Non-compliance cancellation							NO	NO	NO	NO		
Carry-over	NO	NO		NO								
Sub-total	276 838 955	NO		NO			NO	NO	NO	NO		
Annual transactions												
Year 0 (2007)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 1 (2008)	191 772 275	NO	NO	27 439 229	NO	NO	174 391 031	NO	NO	23 971 973	NO	NO
Year 2 (2009)	881 590 260	524 201	NO	32 057 896	NO	NO	874 991 940	185 735	NO	33 349 553	NO	NO
Year 3 (2010)	233 919 660	5 344 875	NO	28 125 141	NO	NO	252 411 415	1 389 977	NO	28 008 871	NO	NO
Year 4 (2011)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 5 (2012)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 6 (2013)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 7 (2014)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 8 (2015)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sub-total	1 307 282 195	5 869 076	NO	87 622 266	NO	NO	1 301 794 386	1 575 712	NO	85 330 397	NO	NO
Total	1 584 121 150	5 869 076	NO	87 622 266	NO	NO	1 301 794 386	1 575 712	NO	85 330 397	NO	NO

Table A6.5 (b). Summary information on replacement

	Requirement for Replacement – Unit type		Replacement – Unit type					
	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Previous CPs			NO	NO	NO	NO	NO	NO
Year 1 (2008)		NO	NO	NO	NO	NO	NO	NO
Year 2 (2009)		NO	NO	NO	NO	NO	NO	NO
Year 3 (2010)		NO	NO	NO	NO	NO	NO	NO
Year 4 (2011)		NO	NO	NO	NO	NO	NO	NO
Year 5 (2012)	NO	NO	NO	NO	NO	NO	NO	NO
Year 6 (2013)	NO	NO	NO	NO	NO	NO	NO	NO
Year 7 (2014)	NO	NO	NO	NO	NO	NO	NO	NO
Year 8 (2015)	NO	NO	NO	NO	NO	NO	NO	NO
Total	NO	NO	NO	NO	NO	NO	NO	NO

Table A6.5 (c). Summary information on retirement

	Retirement – Unit type					
Year	**AAUs**	**ERUs**	**RMUs**	**CERs**	**tCERs**	**lCERs**
Year 1 (2008)	NO	NO	NO	NO	NO	NO
Year 2 (2009)	26 171 207	NO	NO	375 230	NO	NO
Year 3 (2010)	25 322 171	NO	NO	162 743	NO	NO
Year 4 (2011)	NO	NO	NO	NO	NO	NO
Year 5 (2012)	NO	NO	NO	NO	NO	NO
Year 6 (2013)	NO	NO	NO	NO	NO	NO
Year 7 (2014)	NO	NO	NO	NO	NO	NO
Year 8 (2015)	NO	NO	NO	NO	NO	NO
Total	51 493 378	NO	NO	537 973	NO	NO

Table A.6.6 List of discrepancies										
DES Response Code	Average Number of occurrences per transaction (X 100,000)		Transaction Number	Proposal Date Time	Transaction Type	Final State	Explanation	Units Involved abbreviated		
	Reported Year	Prior to the Reported Year						Serial Number	Unit Type	Quantity
4003	1104,83	946,57	DK542897	02-02-2010 12:05	Internal Transfer	Terminated	The raise of the response code 4003 is due to a fault in the old transaction message flow. No response code has been raised since April 2010, after the implementation of the new transaction message flow.	GB-3792960726-3792961725	AAU	1000
			DK544278	09-02-2010 14:52	External Transfer	Terminated		GB-3702173837-3702174306	AAU	470
								GB-3702174307-3702176324	AAU	2018
								GB-3705566428-3705568386	AAU	1959
								GB-3705777620-3705778172	AAU	553
			DK544279	09-02-2010 14:55	External Transfer	Terminated		GB-3702173837-3702174306	AAU	470
								GB-3702174307-3702176324	AAU	2018
								GB-3705566428-3705568386	AAU	1959
								GB-3705777620-3705778172	AAU	553
			DK544281	09-02-2010 15:01	External Transfer	Terminated		GB-3702173837-3702174306	AAU	470
								GB-3702174307-3702176324	AAU	2018
								GB-3705566428-3705568386	AAU	1959
								GB-3705777620-3705778172	AAU	553
			DK544284	09-02-2010 15:55	External Transfer	Terminated		GB-3702173837-3702174306	AAU	470
								GB-3702174307-3702176324	AAU	2018
								GB-3705566428-3705568386	AAU	1959
								GB-3705777620-3705778172	AAU	553
			DK544285	09-02-2010 15:55	External Transfer	Terminated		GB-3702173837-3702174306	AAU	470
								GB-3702174307-3702176324	AAU	2018
								GB-3705566428-3705568386	AAU	1959
								GB-3705777620-3705778172	AAU	553
			DK544289	09-02-2010 16:10	External Transfer	Terminated		GB-3702173837-3702174306	AAU	470
								GB-3702174307-3702176324	AAU	2018
								GB-3705566428-3705568386	AAU	1959
								GB-3705777620-3705778172	AAU	553

Continued

	DK544390	09-02-2010 16:28	External Transfer	Terminated		GB-3702173837-3702174306	AAU	470
						GB-3702174307-3702176324	AAU	2018
						GB-3705566428-3705568386	AAU	1959
						GB-3705777620-3705778172	AAU	553
	DK544393	09-02-2010 16:33	External Transfer	Terminated		GB-3702173837-3702174306	AAU	470
						GB-3702174307-3702176324	AAU	2018
						GB-3705566428-3705568386	AAU	1959
						GB-3705777620-3705778172	AAU	553
	DK544394	09-02-2010 16:34	External Transfer	Terminated		GB-3702173837-3702174306	AAU	470
						GB-3702174307-3702176324	AAU	2018
						GB-3705566428-3705568386	AAU	1959
						GB-3705777620-3705778172	AAU	553
	DK544399	09-02-2010 16:40	External Transfer	Terminated		GB-3705777620-3705778172	AAU	553
	DK544396	09-02-2010 16:40	External Transfer	Terminated		GB-3702173837-3702174306	AAU	470
	DK544397	09-02-2010 16:40	External Transfer	Terminated		GB-3702174307-3702176324	AAU	2018
	DK544398	09-02-2010 16:40	External Transfer	Terminated		GB-3705566428-3705568386	AAU	1959
	DK544496	10-02-2010 07:35	External Transfer	Terminated		DE-2018239157-2018259156	AAU	20000
						DE-2018259157-2018260156	AAU	1000
						DE-3635559002-3635561001	AAU	2000
						DE-3635561002-3635565589	AAU	4588
						PT-2274048820-2274050819	AAU	2000
						RO-2550426298-2550426709	AAU	412
	DK544499	10-02-2010 08:57	External Transfer	Terminated		DE-2018239157-2018259156	AAU	20000
						DE-2018259157-2018260156	AAU	1000
						DE-3635559002-3635561001	AAU	2000
						DE-3635561002-3635565589	AAU	4588
						PT-2274048820-2274050819	AAU	2000
	DK544499	10-02-2010 08:57	External Transfer	Terminated		RO-2550426298-2550426709	AAU	412
	DK544577	10-02-2010 09:15	External Transfer	Terminated		DE-2018239157-2018259156	AAU	20000
						DE-2018259157-2018260156	AAU	1000
						DE-3635559002-3635561001	AAU	2000

Continued

						DE-3635561002-3635565589	AAU	4588
						PT-2274048820-2274050819	AAU	2000
						RO-2550426298-2550426709	AAU	412
		DK544579	10-02-2010 09:48	Internal Transfer	Terminated	SI-119165001-119190000	AAU	25000
		DK544580	10-02-2010 09:51	Internal Transfer	Terminated	SI-119165001-119190000	AAU	25000
		DK544582	10-02-2010 09:52	Internal Transfer	Terminated	SI-119165001-119190000	AAU	25000
		DK544584	10-02-2010 09:57	External Transfer	Terminated	DE-2018239157-2018259156	AAU	20000
						DE-2018259157-2018260156	AAU	1000
						DE-3635559002-3635561001	AAU	2000
						DE-3635561002-3635564589	AAU	3588
						PT-2274048820-2274050819	AAU	2000
						RO-2550426298-2550426709	AAU	412
		DK544585	10-02-2010 09:59	Internal Transfer	Terminated	SI-119165001-119190000	AAU	25000
		DK544588	10-02-2010 10:12	Internal Transfer	Terminated	SI-119165001-119190000	AAU	25000
		DK544590	10-02-2010 10:31	Internal Transfer	Terminated	SI-119165001-119190000	AAU	25000
		DK544591	10-02-2010 10:37	External Transfer	Terminated	DE-2018239157-2018259156	AAU	20000
						DE-2018259157-2018260156	AAU	1000
						DE-3635559002-3635561001	AAU	2000
						DE-3635561002-3635564589	AAU	3588
						GB-3761983351-3761985350	AAU	2000
						PT-2274048820-2274050819	AAU	2000
						RO-2550426298-2550426709	AAU	412
		DK544598	10-02-2010 11:55	Internal Transfer	Terminated	SI-119165001-119190000	AAU	25000
		DK544678	10-02-2010 12:16	External Transfer	Terminated	DE-2018239157-2018259156	AAU	20000
						DE-2018259157-2018260156	AAU	1000
						DE-3635559002-3635561001	AAU	2000
						DE-3635561002-3635564589	AAU	3588
						GB-3761983351-3761985350	AAU	2000
						GB-3761986351-3761987350	AAU	1000
						PT-2274048820-2274050819	AAU	2000
						RO-2550426298-2550426709	AAU	412

Continued								
		DK544689	10-02-2010 13:09	External Transfer	Terminated	DE-2018239157-2018259156	AAU	20000
						DE-2018259157-2018260156	AAU	1000
						DE-3635559002-3635561001	AAU	2000
						DE-3635561002-3635564589	AAU	3588
						GB-3761983351-3761984350	AAU	1000
						PT-2274048820-2274050819	AAU	2000
						RO-2550426298-2550426709	AAU	412
		DK544696	10-02-2010 14:14	External Transfer	Terminated	DE-2018239157-2018259156	AAU	20000
						DE-2018259157-2018260156	AAU	1000
						DE-3635559002-3635561001	AAU	2000
						DE-3635561002-3635564589	AAU	3588
						GB-3761983351-3761984350	AAU	1000
						GB-3761986351-3761987350	AAU	1000
						PT-2274048820-2274050819	AAU	2000
						RO-2550426298-2550426709	AAU	412
		DK544784	10-02-2010 14:59	External Transfer	Terminated	DE-2018239157-2018259156	AAU	20000
						DE-2018259157-2018260156	AAU	1000
						DE-3635559002-3635561001	AAU	2000
						DE-3635561002-3635564589	AAU	3588
						GB-3761983351-3761984350	AAU	1000
						PT-2274048820-2274050819	AAU	2000
						RO-2550426298-2550426709	AAU	412
		DK544793	10-02-2010 15:21	Internal Transfer	Terminated	SI-119165001-119190000	AAU	25000
		DK544797	10-02-2010 15:35	External Transfer	Terminated	DE-2018239157-2018259156	AAU	20000
						DE-2018259157-2018260156	AAU	1000
						DE-3635559002-3635561001	AAU	2000
						DE-3635561002-3635564589	AAU	3588
						PT-2274048820-2274050819	AAU	2000
						RO-2550426298-2550426709	AAU	412
		DK544888	10-02-2010 17:10	External Transfer	Terminated	DE-2018239157-2018259156	AAU	20000
						DE-2018259157-2018260156	AAU	1000

Continued

							DE-3635559002-3635561001	AAU	2000
							DE-3635561002-3635562589	AAU	1588
							PT-2274048820-2274050819	AAU	2000
							RO-2550426298-2550426709	AAU	412
		DK545891	15-02-2010 16:20	Internal Transfer	Terminated		BR-17184974-17189157	Terminated	4184
							BR-17189158-17193157	Terminated	4000
							BR-17193158-17198728	Terminated	5571
							BR-17198729-17203157	Terminated	4429
							BR-18759226-18770770	Terminated	11545
							BR-20950185-20972565	Terminated	22381
							BR-30168807-30172181	Terminated	3375
							BR-31445280-31449794	Terminated	4515
		DK546498	18-02-2010 11:36	External Transfer	Terminated		SK-447347782-447348473	AAU	692
							SK-449653287-449653594	AAU	308
		DK547481	19-02-2010 14:28	External Transfer	Terminated		CZ-1261058426-1261062415	AAU	3990
							FI-498444979-498444988	AAU	10
							FI-508938590-508939596	AAU	1007
							FR-3302416111-3302416314	AAU	204
							FR-3304308243-3304308436	AAU	194
							FR-3308247380-3308247577	AAU	198
							FR-3313716468-3313716677	AAU	210
							FR-3332764848-3332765031	AAU	184
							FR-3335656569-3335656775	AAU	207
							FR-3336267059-3336267258	AAU	200
							FR-3337496972-3337497219	AAU	248
							FR-3342273768-3342273967	AAU	200
							FR-3350774907-3350775102	AAU	196
							FR-3398258979-3398259158	AAU	180
							FR-3398268064-3398268309	AAU	246
							FR-3398788964-3398789189	AAU	226
							FR-3400454546-3400454732	AAU	187

Continued

FR-3415956666-3415956909	AAU	244
FR-3416687619-3416687837	AAU	219
FR-3419164373-3419164573	AAU	201
GB-3508340935-3508341177	AAU	243
GB-3526287941-3526288172	AAU	232
GB-3528361457-3528361681	AAU	225
GB-3530453303-3530453525	AAU	223
GB-3548926447-3548926653	AAU	207
GB-3701580580-3701580768	AAU	189
GB-3971634817-3971635027	AAU	211
GB-3973752646-3973752731	AAU	86
GB-3974549787-3974554786	AAU	5000
GR-350180399-350184398	AAU	4000
IT-3081383428-3081387199	AAU	3772
NL-3210172276-3210174503	AAU	2228
PL-2983631643-2983632161	AAU	519
PL-3198979417-3198984416	AAU	5000
PL-3249815770-3249818703	AAU	2934
PL-3249820770-3249822835	AAU	2066
PL-3297069029-3297072342	AAU	3314
RO-2577505067-2577505436	AAU	370
RO-2601067695-2601068999	AAU	1305
RO-2601128805-2601128996	AAU	192
RO-2601144628-2601144844	AAU	217
RO-2601208300-2601208478	AAU	179
RO-2601208479-2601208738	AAU	260
RO-2620768526-2620771867	AAU	3342
RO-2620798813-2620799679	AAU	867
RO-2622266257-2622268524	AAU	2268
RO-2627755442-2627756441	AAU	1000
RO-2627756442-2627757441	AAU	1000

Continued									
		DK551995	02-03-2010 12:16	External Transfer	Terminated		RO-2428368068-2428370067	AAU	2000
							RO-2428370068-2428375067	AAU	5000
							RO-2428375068-2428393305	AAU	18238
							RO-2428395068-2428397067	AAU	2000
							RO-2429985099-2429992098	AAU	7000
							RO-2429992099-2430005098	AAU	13000
							RO-2430056099-2430057098	AAU	1000
							RO-2430614386-2430617385	AAU	3000
							RO-2500934665-2500935989	AAU	1325
							RO-2571943011-2571944010	AAU	1000
							RO-2571944011-2571944598	AAU	588
							RO-2572472800-2572476221	AAU	3422
							RO-2572476222-2572478571	AAU	2350
							RO-2572478572-2572478648	AAU	77
		DK552289	02-03-2010 16:48	Internal Transfer	Terminated		ES-2083946073-2083956072	AAU	10000
		DK554584	18-03-2010 15:09	External Transfer	Terminated		CZ-1050026309-1050029398	AAU	3090
							CZ-1130497397-1130503367	AAU	5971
							CZ-1189740367-1189745561	AAU	5195
							CZ-1257814041-1257820040	AAU	6000
							DK-1700245840-1700251839	AAU	6000
							DK-1708313329-1708319203	AAU	5875
							DK-1708971263-1708977229	AAU	5967
							ES-1769795278-1769800504	AAU	5227
							ES-2095507237-2095512873	AAU	5637
							FI-513577628-513582641	AAU	5014
							FR-3109836237-3109842162	AAU	5926
							GB-3654176706-3654182325	AAU	5620
							GB-3761960383-3761966350	AAU	5968
							GB-3972079914-3972085006	AAU	5093
							GB-3977402594-3977408251	AAU	5658
							GB-3988422190-3988427199	AAU	5010

Continued

						HU-593057320-593062455	AAU	5136
						HU-595803613-595808662	AAU	5050
						IT-2703249981-2703255980	AAU	6000
						IT-2884493064-2884498771	AAU	5708
						IT-2989543942-2989549011	AAU	5070
						IT-3015140865-3015146864	AAU	6000
						IT-3015161665-3015166864	AAU	5200
						IT-3015182802-3015188801	AAU	6000
						PL-2978978305-2978983304	AAU	5000
						PL-3198490417-3198496189	AAU	5773
						PL-3198850417-3198852458	AAU	2042
						RO-2429849099-2429854950	AAU	5852
						RO-2429965099-2429971098	AAU	6000
						RO-2429985099-2429991098	AAU	6000
						RO-2465147292-2465152427	AAU	5136
						RO-2600709446-2600711553	AAU	2108
						RO-2600711554-2600715570	AAU	4017
						SK-410823419-410829418	AAU	6000
						SK-445957471-445963058	AAU	5588
		DK554585	18-03-2010 15:12	External Transfer	Terminated	CZ-1050026309-1050029398	AAU	3090
						CZ-1130497397-1130503367	AAU	5971
						CZ-1189740367-1189745561	AAU	5195
						CZ-1257814041-1257820040	AAU	6000
						DK-1700245840-1700251839	AAU	6000
						DK-1708313329-1708319203	AAU	5875
						DK-1708971263-1708977229	AAU	5967
						ES-1769795278-1769800504	AAU	5227
						ES-2095507237-2095512873	AAU	5637
						FI-513577628-513582641	AAU	5014
						FR-3109836237-3109842162	AAU	5926
						GB-3654176706-3654182325	AAU	5620

Continued

						GB-3761960383-3761966350	AAU	5968
						GB-3972079914-3972085006	AAU	5093
						GB-3977402594-3977408251	AAU	5658
						GB-3988422190-3988427199	AAU	5010
						HU-593057320-593062455	AAU	5136
						HU-595803613-595808662	AAU	5050
						IT-2703249981-2703255980	AAU	6000
						IT-2884493064-2884498771	AAU	5708
						IT-2989543942-2989549011	AAU	5070
						IT-3015140865-3015146864	AAU	6000
						IT-3015161665-3015166864	AAU	5200
						IT-3015182802-3015188801	AAU	6000
						PL-2978978305-2978983304	AAU	5000
						PL-3198490417-3198496189	AAU	5773
						PL-3198850417-3198852458	AAU	2042
						RO-2429849099-2429854950	AAU	5852
						RO-2429965099-2429971098	AAU	6000
						RO-2429985099-2429991098	AAU	6000
						RO-2465147292-2465152427	AAU	5136
						RO-2600709446-2600711553	AAU	2108
						RO-2600711554-2600715570	AAU	4017
						SK-410823419-410829418	AAU	6000
						SK-445957471-445963058	AAU	5588
	DK554589	18-03-2010 15:15	External Transfer	Terminated		CZ-1050026309-1050029398	AAU	3090
						CZ-1130497397-1130503367	AAU	5971
						CZ-1189740367-1189745561	AAU	5195
						CZ-1257814041-1257820040	AAU	6000
						DK-1700245840-1700251839	AAU	6000
						DK-1708313329-1708319203	AAU	5875
						DK-1708971263-1708977229	AAU	5967
						ES-1769795278-1769800504	AAU	5227

Continued

					ES-2095507237-2095512873	AAU	5637
					FI-513577628-513582641	AAU	5014
					FR-3109836237-3109842162	AAU	5926
					GB-3654176706-3654182325	AAU	5620
					GB-3761960383-3761966350	AAU	5968
					GB-3972079914-3972085006	AAU	5093
					GB-3977402594-3977408251	AAU	5658
					GB-3988422190-3988427199	AAU	5010
					HU-593057320-593062455	AAU	5136
					HU-595803613-595808662	AAU	5050
					IT-2703249981-2703255980	AAU	6000
					IT-2884493064-2884498771	AAU	5708
					IT-2989543942-2989549011	AAU	5070
					IT-3015140865-3015146864	AAU	6000
					IT-3015161665-3015166864	AAU	5200
					IT-3015182802-3015188801	AAU	6000
					PL-2978978305-2978983304	AAU	5000
					PL-3198490417-3198496189	AAU	5773
					PL-3198850417-3198852458	AAU	2042
					RO-2429849099-2429854950	AAU	5852
					RO-2429965099-2429971098	AAU	6000
					RO-2429985099-2429991098	AAU	6000
					RO-2465147292-2465152427	AAU	5136
					RO-2600709446-2600711553	AAU	2108
					RO-2600711554-2600715570	AAU	4017
					SK-410823419-410829418	AAU	6000
					SK-445957471-445963058	AAU	5588
	DK554590	18-03-2010 15:20	External Transfer	Terminated	CZ-1050026309-1050029398	AAU	3090
					CZ-1189740367-1189745561	AAU	5195
					FI-513577628-513582641	AAU	5014
					GB-3972079914-3972085006	AAU	5093

Continued

						GB-3988422190-3988427199	AAU	5010
						HU-593057320-593062455	AAU	5136
						HU-595803613-595808662	AAU	5050
						IT-2989543942-2989549011	AAU	5070
						IT-3015161665-3015166652	AAU	4988
						PL-2978978305-2978983304	AAU	5000
						RO-2465147292-2465152427	AAU	5136
						RO-2600709446-2600711553	AAU	2108
						RO-2600711554-2600715570	AAU	4017
		DK554592	18-03-2010 15:22	External Transfer	Terminated	CZ-1050026309-1050029398	AAU	3090
						CZ-1189740367-1189745549	AAU	5183
						FI-513577628-513582641	AAU	5014
						GB-3972079914-3972085006	AAU	5093
						GB-3988422190-3988427199	AAU	5010
						HU-593057320-593062455	AAU	5136
						HU-595803613-595808662	AAU	5050
						IT-2989543942-2989549011	AAU	5070
						PL-2978978305-2978983304	AAU	5000
						RO-2465147292-2465152427	AAU	5136
						RO-2600709446-2600711553	AAU	2108
						RO-2600711554-2600715570	AAU	4017
		DK557183	30-03-2010 14:45	External Transfer	Terminated	ES-1967063009-1967063014	AAU	6
						RO-2429822317-2429822322	AAU	6
		DK559378	13-04-2010 13:03	External Transfer	Terminated	BR-30322360-30325305	Terminated	2946
		DK559379	13-04-2010 13:06	External Transfer	Terminated	BR-30322360-30322360	Terminated	1
		DK559380	13-04-2010 13:08	External Transfer	Terminated	BR-30322360-30322360	Terminated	1
		DK559386	13-04-2010 13:28	Internal Transfer	Terminated	DE-3578078883-3578082882	AAU	4000
						DE-3635529002-3635534001	AAU	5000
						DE-3635541895-3635546501	AAU	4607
						FR-3418352349-3418353348	AAU	1000
						GB-3405772627-3405775317	AAU	2691

Continued

						GB-3405965505-3405970504	AAU	5000
						GB-3406085505-3406085641	AAU	137
						GB-3406085642-3406088072	AAU	2431
						GB-3406103505-3406106504	AAU	3000
						GB-3406181121-3406182979	AAU	1859
						GB-3512564040-3512566539	AAU	2500
						GB-3512930979-3512931934	AAU	956
						GB-3549059011-3549064256	AAU	5246
						GB-3549391653-3549396798	AAU	5146
						GB-3654233088-3654235340	AAU	2253
						GB-3654235341-3654238783	AAU	3443
						GB-3654390326-3654393316	AAU	2991
						GB-3654709326-3654714325	AAU	5000
						GB-3704199267-3704204368	AAU	5102
						GB-3708165863-3708171353	AAU	5491
						GB-3720981146-3720986097	AAU	4952
						GB-3724587388-3724592387	AAU	5000
						GB-3759731034-3759732176	AAU	1143
						GB-3761744351-3761746350	AAU	2000
						GB-3771772816-3771773143	AAU	328
						GB-3773170682-3773174473	AAU	3792
						GB-3782853141-3782858958	AAU	5818
						GB-3792620726-3792621725	AAU	1000
						GB-3792621726-3792626725	AAU	5000
						GB-3792931726-3792934839	AAU	3114
						PL-3201544965-3201554964	AAU	10000
	DK559387	13-04-2010 13:31	Internal Transfer	Terminated		DE-3578078883-3578082882	AAU	4000
						GB-3406085642-3406088072	AAU	2431
						GB-3549059011-3549064256	AAU	5246
						GB-3549391653-3549396798	AAU	5146
						GB-3654233088-3654235340	AAU	2253

Continued

							GB-3654235341-3654238783	AAU	3443
							GB-3654390326-3654393316	AAU	2991
							GB-3654709326-3654714325	AAU	5000
							GB-3704199267-3704204368	AAU	5102
							GB-3708165863-3708171353	AAU	5491
							GB-3759731034-3759732176	AAU	1143
							GB-3771772816-3771773143	AAU	328
							GB-3773170682-3773174473	AAU	3792
							GB-3782853141-3782856774	AAU	3634
		DK559388	13-04-2010 13:36	Internal Transfer	Terminated		GB-3549059011-3549064075	AAU	5065
							GB-3759731034-3759732176	AAU	1143
							GB-3773170682-3773174473	AAU	3792
		DK559389	13-04-2010 13:39	External Transfer	Terminated		DE-3578078883-3578082882	AAU	4000
							GB-3405965505-3405965685	AAU	181
							GB-3406085642-3406088072	AAU	2431
							GB-3549059011-3549064075	AAU	5065
							GB-3549391653-3549396798	AAU	5146
							GB-3654233088-3654235340	AAU	2253
							GB-3654235341-3654238783	AAU	3443
							GB-3654390326-3654393316	AAU	2991
							GB-3654709326-3654714325	AAU	5000
							GB-3704199267-3704204368	AAU	5102
							GB-3708165863-3708171353	AAU	5491
							GB-3759731034-3759732176	AAU	1143
							GB-3771772816-3771773143	AAU	328
							GB-3773170682-3773174473	AAU	3792
							GB-3782853141-3782856774	AAU	3634
		DK559391	13-04-2010 13:43	Internal Transfer	Terminated		GB-3549059011-3549064075	AAU	5065
							GB-3759731034-3759732176	AAU	1143
							GB-3773170682-3773174473	AAU	3792
		DK559392	13-04-2010 13:48	External Transfer	Terminated		GB-3549059011-3549064075	AAU	5065

Continued

						GB-3759731034-3759732176	AAU	1143
						GB-3773170682-3773174473	AAU	3792
	DK559393	13-04-2010 13:53	Internal Transfer	Terminated		GB-3759731034-3759732033	AAU	1000
	DK559394	13-04-2010 14:00	Internal Transfer	Terminated		GB-3759731034-3759731533	AAU	500
	DK559395	13-04-2010 14:05	Internal Transfer	Terminated		GB-3759731034-3759731533	AAU	500
	DK559395	13-04-2010 14:05	Internal Transfer	Terminated		GB-3773170682-3773171181	AAU	500
	DK559477	13-04-2010 14:23	Internal Transfer	Terminated		GB-3759731034-3759731533	AAU	500
						GB-3773170682-3773171181	AAU	500
	DK559478	13-04-2010 14:31	External Transfer	Terminated		GB-3759731034-3759731533	AAU	500
						GB-3773170682-3773171181	AAU	500
	DK559481	13-04-2010 14:36	Internal Transfer	Terminated		GB-3549059011-3549064075	AAU	5065
						GB-3708165863-3708169797	AAU	3935
						GB-3759731034-3759731533	AAU	500
						GB-3773170682-3773171181	AAU	500
	DK559483	13-04-2010 14:45	Internal Transfer	Terminated		GB-3708169798-3708170797	AAU	1000
	DK559484	13-04-2010 14:49	External Transfer	Terminated		GB-3708169798-3708170241	AAU	444
						GB-3708170798-3708171353	AAU	556
	DK559485	13-04-2010 14:59	Internal Transfer	Terminated		GB-3549059011-3549064075	AAU	5065
						GB-3654233088-3654235340	AAU	2253
						GB-3654709326-3654710414	AAU	1089
						GB-3704199267-3704204368	AAU	5102
						GB-3708165863-3708169797	AAU	3935
						GB-3708169798-3708170241	AAU	444
						GB-3708170242-3708170797	AAU	556
						GB-3708170798-3708171353	AAU	556
						GB-3759731034-3759731533	AAU	500
						GB-3773170682-3773171181	AAU	500
	DK559486	13-04-2010 15:01	External Transfer	Terminated		GB-3549059011-3549064075	AAU	5065
						GB-3654233088-3654235340	AAU	2253
						GB-3654710415-3654714325	AAU	3911
						GB-3704199267-3704201546	AAU	2280

Continued

						GB-3708165863-3708169797	AAU	3935
						GB-3708169798-3708170241	AAU	444
						GB-3708170242-3708170797	AAU	556
						GB-3708170798-3708171353	AAU	556
						GB-3759731034-3759731533	AAU	500
						GB-3773170682-3773171181	AAU	500
	DK559487	13-04-2010 15:02	Internal Transfer	Terminated		GB-3708170798-3708170803	AAU	6
	DK559488	13-04-2010 15:08	Internal Transfer	Terminated		GB-3654710415-3654713858	AAU	3444
						GB-3708169798-3708170241	AAU	444
						GB-3708170242-3708170797	AAU	556
						GB-3708170798-3708170803	AAU	6
						GB-3708170804-3708171353	AAU	550
	DK559489	13-04-2010 15:10	External Transfer	Terminated		RO-2432367601-2432369859	AAU	2259
						RO-2465085983-2465105423	AAU	19441
	DK559490	13-04-2010 15:16	Internal Transfer	Terminated		GB-3549059011-3549064075	AAU	5065
						GB-3549391653-3549392741	AAU	1089
						GB-3654233088-3654235340	AAU	2253
						GB-3654709326-3654710414	AAU	1089
						GB-3654710415-3654713858	AAU	3444
						GB-3654713859-3654714325	AAU	467
						GB-3704199267-3704201546	AAU	2280
						GB-3704201547-3704204368	AAU	2822
						GB-3708165863-3708169797	AAU	3935
						GB-3708169798-3708170241	AAU	444
						GB-3708170242-3708170797	AAU	556
						GB-3708170798-3708170803	AAU	6
						GB-3708170804-3708171353	AAU	550
						GB-3759731034-3759731533	AAU	500
						GB-3773170682-3773171181	AAU	500
	DK559491	13-04-2010 15:24	Internal Transfer	Terminated		GB-3549392742-3549394452	AAU	1711
						GB-3654710415-3654713858	AAU	3444

Continued

						GB-3654713859-3654714325	AAU	467
						GB-3704201547-3704204368	AAU	2822
						GB-3708169798-3708170241	AAU	444
						GB-3708170242-3708170797	AAU	556
						GB-3708170798-3708170803	AAU	6
						GB-3708170804-3708171353	AAU	550
		DK559492	13-04-2010 15:39	Internal Transfer	Terminated	GB-3654710415-3654713858	AAU	3444
						GB-3704201547-3704203546	AAU	2000
						GB-3708169798-3708170241	AAU	444
						GB-3708170242-3708170797	AAU	556
						GB-3708170798-3708170803	AAU	6
						GB-3708170804-3708171353	AAU	550
		DK559493	13-04-2010 15:46	Internal Transfer	Terminated	GB-3549392742-3549394452	AAU	1711
						GB-3549394453-3549396274	AAU	1822
						GB-3654710415-3654713858	AAU	3444
						GB-3654713859-3654714325	AAU	467
						GB-3704201547-3704203546	AAU	2000
						GB-3708169798-3708170241	AAU	444
						GB-3708170242-3708170797	AAU	556
						GB-3708170798-3708170803	AAU	6
						GB-3708170804-3708171353	AAU	550
		DK559494	13-04-2010 15:55	External Transfer	Terminated	BR-30322360-30322360	Terminated	1
		DK559495	13-04-2010 16:08	Internal Transfer	Terminated	GB-3549392742-3549394452	AAU	1711
						GB-3549394453-3549395274	AAU	822
						GB-3654710415-3654713858	AAU	3444
						GB-3654713859-3654714325	AAU	467
						GB-3704201547-3704203546	AAU	2000
						GB-3708169798-3708170241	AAU	444
						GB-3708170242-3708170797	AAU	556
						GB-3708170798-3708170803	AAU	6
						GB-3708170804-3708171353	AAU	550

Continued

		DK559496	13-04-2010 16:17	Internal Transfer	Terminated	GB-3549392742-3549394452	AAU	1711
						GB-3549394453-3549395274	AAU	822
						GB-3654710415-3654713858	AAU	3444
						GB-3654713859-3654714325	AAU	467
						GB-3704201547-3704203546	AAU	2000
						GB-3708169798-3708170241	AAU	444
						GB-3708170242-3708170797	AAU	556
						GB-3708170798-3708170803	AAU	6
						GB-3708170804-3708171353	AAU	550
		DK559497	13-04-2010 16:20	Internal Transfer	Terminated	GB-3549392742-3549394452	AAU	1711
						GB-3549394453-3549395274	AAU	822
						GB-3654710415-3654713858	AAU	3444
						GB-3654713859-3654714325	AAU	467
						GB-3704201547-3704203546	AAU	2000
						GB-3708169798-3708170241	AAU	444
						GB-3708170242-3708170797	AAU	556
						GB-3708170798-3708170803	AAU	6
						GB-3708170804-3708171353	AAU	550
		DK559498	13-04-2010 16:33	Internal Transfer	Terminated	GB-3708170242-3708170685	AAU	444
						GB-3708170798-3708170803	AAU	6
						GB-3708170804-3708171353	AAU	550
		DK559499	13-04-2010 16:35	Internal Transfer	Terminated	AT-1611889319-1611891510	AAU	2192
		DK559577	13-04-2010 16:35	Internal Transfer	Terminated	AT-1580167202-1580170009	AAU	2808
		DK559579	13-04-2010 16:49	Internal Transfer	Terminated	DK-1711767660-1711768480	AAU	821
						GB-3549392742-3549394452	AAU	1711
						GB-3549394453-3549395274	AAU	822
						GB-3549395275-3549396274	AAU	1000
						GB-3549396275-3549396798	AAU	524
						GB-3654710415-3654713858	AAU	3444
						GB-3654713859-3654714325	AAU	467
						GB-3704201547-3704203546	AAU	2000

Continued

								GB-3704203547-3704204368	AAU	822
								GB-3708169798-3708170241	AAU	444
								GB-3708170242-3708170685	AAU	444
								GB-3708170798-3708170803	AAU	6
								GB-3708170804-3708171353	AAU	550
								HU-580069638-580073676	AAU	4039
								HU-588878583-588880437	AAU	1855
								HU-603582772-603587122	AAU	4351
								HU-603606098-603606746	AAU	649
								IE-500462686-500462748	AAU	63
								IE-508441350-508441501	AAU	152
								IE-512504305-512504579	AAU	275
								IE-512594198-512594487	AAU	290
								IE-512620129-512620288	AAU	160
								IE-514315550-514315660	AAU	111
			DK559585	13-04-2010 16:54	External Transfer	Terminated		IE-514315550-514315660	AAU	111
			DK559586	13-04-2010 16:54	External Transfer	Terminated		IE-478643319-478644003	AAU	685
			DK559580	13-04-2010 16:54	External Transfer	Terminated		IE-500462686-500462748	AAU	63
			DK559583	13-04-2010 16:54	External Transfer	Terminated		IE-512594198-512594487	AAU	290
			DK559581	13-04-2010 16:54	External Transfer	Terminated		IE-508441350-508441501	AAU	152
			DK559582	13-04-2010 16:54	External Transfer	Terminated		IE-512504305-512504579	AAU	275
			DK559584	13-04-2010 16:54	External Transfer	Terminated		IE-512620129-512620288	AAU	160
			DK559688	13-04-2010 17:46	External Transfer	Terminated		ES-2085420821-2085510820	AAU	90000
			DK559689	13-04-2010 17:49	External Transfer	Terminated		ES-2085420821-2085510820	AAU	90000
								ES-2085510821-2085520820	AAU	10000
			DK559690	13-04-2010 17:55	External Transfer	Terminated		ES-2085420821-2085430820	AAU	10000
4010	1104,83	946,57	DK542897	02-02-2010 12:05	Internal Transfer	Terminated	The raise of the response code 4010 is a direct consequence of the raise of the response code 4003. Note that the same set of transactions is reported for both response codes.	GB-3792960726-3792961725	AAU	1000
			DK544278	09-02-2010 14:52	External Transfer	Terminated		GB-3702173837-3702174306	AAU	470
								GB-3702174307-3702176324	AAU	2018
								GB-3705566428-3705568386	AAU	1959

Continued

						GB-3705777620-3705778172	AAU	553
	DK544279	09-02-2010 14:55	External Transfer	Terminated		GB-3702173837-3702174306	AAU	470
						GB-3702174307-3702176324	AAU	2018
						GB-3705566428-3705568386	AAU	1959
						GB-3705777620-3705778172	AAU	553
	DK544281	09-02-2010 15:01	External Transfer	Terminated		GB-3702173837-3702174306	AAU	470
						GB-3702174307-3702176324	AAU	2018
						GB-3705566428-3705568386	AAU	1959
						GB-3705777620-3705778172	AAU	553
	DK544284	09-02-2010 15:55	External Transfer	Terminated		GB-3702173837-3702174306	AAU	470
						GB-3702174307-3702176324	AAU	2018
						GB-3705566428-3705568386	AAU	1959
						GB-3705777620-3705778172	AAU	553
	DK544285	09-02-2010 15:55	External Transfer	Terminated		GB-3702173837-3702174306	AAU	470
						GB-3702174307-3702176324	AAU	2018
						GB-3705566428-3705568386	AAU	1959
						GB-3705777620-3705778172	AAU	553
	DK544289	09-02-2010 16:10	External Transfer	Terminated		GB-3702173837-3702174306	AAU	470
						GB-3702174307-3702176324	AAU	2018
						GB-3705566428-3705568386	AAU	1959
						GB-3705777620-3705778172	AAU	553
	DK544390	09-02-2010 16:28	External Transfer	Terminated		GB-3702173837-3702174306	AAU	470
						GB-3702174307-3702176324	AAU	2018
						GB-3705566428-3705568386	AAU	1959
						GB-3705777620-3705778172	AAU	553
	DK544393	09-02-2010 16:33	External Transfer	Terminated		GB-3702173837-3702174306	AAU	470
						GB-3702174307-3702176324	AAU	2018
						GB-3705566428-3705568386	AAU	1959
						GB-3705777620-3705778172	AAU	553
	DK544394	09-02-2010 16:34	External Transfer	Terminated		GB-3702173837-3702174306	AAU	470
						GB-3702174307-3702176324	AAU	2018

Continued

						GB-3705566428-3705568386	AAU	1959
						GB-3705777620-3705778172	AAU	553
	DK544399	09-02-2010 16:40	External Transfer	Terminated		GB-3705777620-3705778172	AAU	553
	DK544396	09-02-2010 16:40	External Transfer	Terminated		GB-3702173837-3702174306	AAU	470
	DK544397	09-02-2010 16:40	External Transfer	Terminated		GB-3702174307-3702176324	AAU	2018
	DK544398	09-02-2010 16:40	External Transfer	Terminated		GB-3705566428-3705568386	AAU	1959
	DK544496	10-02-2010 07:35	External Transfer	Terminated		DE-2018239157-2018259156	AAU	20000
						DE-2018259157-2018260156	AAU	1000
						DE-3635559002-3635561001	AAU	2000
						DE-3635561002-3635565589	AAU	4588
						PT-2274048820-2274050819	AAU	2000
						RO-2550426298-2550426709	AAU	412
	DK544499	10-02-2010 08:57	External Transfer	Terminated		DE-2018239157-2018259156	AAU	20000
						DE-2018259157-2018260156	AAU	1000
						DE-3635559002-3635561001	AAU	2000
						DE-3635561002-3635565589	AAU	4588
						PT-2274048820-2274050819	AAU	2000
	DK544499	10-02-2010 08:57	External Transfer	Terminated		RO-2550426298-2550426709	AAU	412
	DK544577	10-02-2010 09:15	External Transfer	Terminated		DE-2018239157-2018259156	AAU	20000
						DE-2018259157-2018260156	AAU	1000
						DE-3635559002-3635561001	AAU	2000
						DE-3635561002-3635565589	AAU	4588
						PT-2274048820-2274050819	AAU	2000
						RO-2550426298-2550426709	AAU	412
	DK544579	10-02-2010 09:48	Internal Transfer	Terminated		SI-119165001-119190000	AAU	25000
	DK544580	10-02-2010 09:51	Internal Transfer	Terminated		SI-119165001-119190000	AAU	25000
	DK544582	10-02-2010 09:52	Internal Transfer	Terminated		SI-119165001-119190000	AAU	25000
	DK544584	10-02-2010 09:57	External Transfer	Terminated		DE-2018239157-2018259156	AAU	20000
						DE-2018259157-2018260156	AAU	1000
						DE-3635559002-3635561001	AAU	2000
						DE-3635561002-3635564589	AAU	3588

Continued

						PT-2274048820-2274050819	AAU	2000
						RO-2550426298-2550426709	AAU	412
	DK544585	10-02-2010 09:59	Internal Transfer	Terminated		SI-119165001-119190000	AAU	25000
	DK544588	10-02-2010 10:12	Internal Transfer	Terminated		SI-119165001-119190000	AAU	25000
	DK544590	10-02-2010 10:31	Internal Transfer	Terminated		SI-119165001-119190000	AAU	25000
	DK544591	10-02-2010 10:37	External Transfer	Terminated		DE-2018239157-2018259156	AAU	20000
						DE-2018259157-2018260156	AAU	1000
						DE-3635559002-3635561001	AAU	2000
						DE-3635561002-3635564589	AAU	3588
						GB-3761983351-3761985350	AAU	2000
						PT-2274048820-2274050819	AAU	2000
						RO-2550426298-2550426709	AAU	412
	DK544598	10-02-2010 11:55	Internal Transfer	Terminated		SI-119165001-119190000	AAU	25000
	DK544678	10-02-2010 12:16	External Transfer	Terminated		DE-2018239157-2018259156	AAU	20000
						DE-2018259157-2018260156	AAU	1000
						DE-3635559002-3635561001	AAU	2000
						DE-3635561002-3635564589	AAU	3588
						GB-3761983351-3761985350	AAU	2000
						GB-3761986351-3761987350	AAU	1000
						PT-2274048820-2274050819	AAU	2000
						RO-2550426298-2550426709	AAU	412
	DK544689	10-02-2010 13:09	External Transfer	Terminated		DE-2018239157-2018259156	AAU	20000
						DE-2018259157-2018260156	AAU	1000
						DE-3635559002-3635561001	AAU	2000
						DE-3635561002-3635564589	AAU	3588
						GB-3761983351-3761984350	AAU	1000
						PT-2274048820-2274050819	AAU	2000
						RO-2550426298-2550426709	AAU	412
	DK544696	10-02-2010 14:14	External Transfer	Terminated		DE-2018239157-2018259156	AAU	20000
						DE-2018259157-2018260156	AAU	1000
						DE-3635559002-3635561001	AAU	2000

Continued

						DE-3635561002-3635564589	AAU	3588
						GB-3761983351-3761984350	AAU	1000
						GB-3761986351-3761987350	AAU	1000
						PT-2274048820-2274050819	AAU	2000
						RO-2550426298-2550426709	AAU	412
	DK544784	10-02-2010 14:59	External Transfer	Terminated		DE-2018239157-2018259156	AAU	20000
						DE-2018259157-2018260156	AAU	1000
						DE-3635559002-3635561001	AAU	2000
						DE-3635561002-3635564589	AAU	3588
						GB-3761983351-3761984350	AAU	1000
						PT-2274048820-2274050819	AAU	2000
						RO-2550426298-2550426709	AAU	412
	DK544793	10-02-2010 15:21	Internal Transfer	Terminated		SI-119165001-119190000	AAU	25000
	DK544797	10-02-2010 15:35	External Transfer	Terminated		DE-2018239157-2018259156	AAU	20000
						DE-2018259157-2018260156	AAU	1000
						DE-3635559002-3635561001	AAU	2000
						DE-3635561002-3635564589	AAU	3588
						PT-2274048820-2274050819	AAU	2000
						RO-2550426298-2550426709	AAU	412
	DK544888	10-02-2010 17:10	External Transfer	Terminated		DE-2018239157-2018259156	AAU	20000
						DE-2018259157-2018260156	AAU	1000
						DE-3635559002-3635561001	AAU	2000
						DE-3635561002-3635562589	AAU	1588
						PT-2274048820-2274050819	AAU	2000
						RO-2550426298-2550426709	AAU	412
	DK545891	15-02-2010 16:20	Internal Transfer	Terminated		BR-17184974-17189157	Terminated	4184
						BR-17189158-17193157	Terminated	4000
						BR-17193158-17198728	Terminated	5571
						BR-17198729-17203157	Terminated	4429
						BR-18759226-18770770	Terminated	11545
						BR-20950185-20972565	Terminated	22381

Continued

						BR-30168807-30172181	Terminated	3375
						BR-31445280-31449794	Terminated	4515
		DK546498	18-02-2010 11:36	External Transfer	Terminated	SK-447347782-447348473	AAU	692
						SK-449653287-449653594	AAU	308
		DK547481	19-02-2010 14:28	External Transfer	Terminated	CZ-1261058426-1261062415	AAU	3990
						FI-498444979-498444988	AAU	10
						FI-508938590-508939596	AAU	1007
						FR-3302416111-3302416314	AAU	204
						FR-3304308243-3304308436	AAU	194
						FR-3308247380-3308247577	AAU	198
						FR-3313716468-3313716677	AAU	210
						FR-3332764848-3332765031	AAU	184
						FR-3335656569-3335656775	AAU	207
						FR-3336267059-3336267258	AAU	200
						FR-3337496972-3337497219	AAU	248
						FR-3342273768-3342273967	AAU	200
						FR-3350774907-3350775102	AAU	196
						FR-3398258979-3398259158	AAU	180
						FR-3398268064-3398268309	AAU	246
						FR-3398788964-3398789189	AAU	226
						FR-3400454546-3400454732	AAU	187
						FR-3415956666-3415956909	AAU	244
						FR-3416687619-3416687837	AAU	219
						FR-3419164373-3419164573	AAU	201
						GB-3508340935-3508341177	AAU	243
						GB-3526287941-3526288172	AAU	232
						GB-3528361457-3528361681	AAU	225
						GB-3530453303-3530453525	AAU	223
						GB-3548926447-3548926653	AAU	207
						GB-3701580580-3701580768	AAU	189
						GB-3971634817-3971635027	AAU	211

Continued								
						GB-3973752646-3973752731	AAU	86
						GB-3974549787-3974554786	AAU	5000
						GR-350180399-350184398	AAU	4000
						IT-3081383428-3081387199	AAU	3772
						NL-3210172276-3210174503	AAU	2228
						PL-2983631643-2983632161	AAU	519
						PL-3198979417-3198984416	AAU	5000
						PL-3249815770-3249818703	AAU	2934
						PL-3249820770-3249822835	AAU	2066
						PL-3297069029-3297072342	AAU	3314
						RO-2577505067-2577505436	AAU	370
						RO-2601067695-2601068999	AAU	1305
						RO-2601128805-2601128996	AAU	192
						RO-2601144628-2601144844	AAU	217
						RO-2601208300-2601208478	AAU	179
						RO-2601208479-2601208738	AAU	260
						RO-2620768526-2620771867	AAU	3342
						RO-2620798813-2620799679	AAU	867
						RO-2622266257-2622268524	AAU	2268
						RO-2627755442-2627756441	AAU	1000
						RO-2627756442-2627757441	AAU	1000
		DK551995	02-03-2010 12:16	External Transfer	Terminated	RO-2428368068-2428370067	AAU	2000
						RO-2428370068-2428375067	AAU	5000
						RO-2428375068-2428393305	AAU	18238
						RO-2428395068-2428397067	AAU	2000
						RO-2429985099-2429992098	AAU	7000
						RO-2429992099-2430005098	AAU	13000
						RO-2430056099-2430057098	AAU	1000
						RO-2430614386-2430617385	AAU	3000
						RO-2500934665-2500935989	AAU	1325
						RO-2571943011-2571944010	AAU	1000

Continued

							RO-2571944011-2571944598	AAU	588
							RO-2572472800-2572476221	AAU	3422
							RO-2572476222-2572478571	AAU	2350
							RO-2572478572-2572478648	AAU	77
		DK552289	02-03-2010 16:48	Internal Transfer	Terminated		ES-2083946073-2083956072	AAU	10000
		DK554584	18-03-2010 15:09	External Transfer	Terminated		CZ-1050026309-1050029398	AAU	3090
							CZ-1130497397-1130503367	AAU	5971
							CZ-1189740367-1189745561	AAU	5195
							CZ-1257814041-1257820040	AAU	6000
							DK-1700245840-1700251839	AAU	6000
							DK-1708313329-1708319203	AAU	5875
							DK-1708971263-1708977229	AAU	5967
							ES-1769795278-1769800504	AAU	5227
							ES-2095507237-2095512873	AAU	5637
							FI-513577628-513582641	AAU	5014
							FR-3109836237-3109842162	AAU	5926
							GB-3654176706-3654182325	AAU	5620
							GB-3761960383-3761966350	AAU	5968
							GB-3972079914-3972085006	AAU	5093
							GB-3977402594-3977408251	AAU	5658
							GB-3988422190-3988427199	AAU	5010
							HU-593057320-593062455	AAU	5136
							HU-595803613-595808662	AAU	5050
							IT-2703249981-2703255980	AAU	6000
							IT-2884493064-2884498771	AAU	5708
							IT-2989543942-2989549011	AAU	5070
							IT-3015140865-3015146864	AAU	6000
							IT-3015161665-3015166864	AAU	5200
							IT-3015182802-3015188801	AAU	6000
							PL-2978978305-2978983304	AAU	5000
							PL-3198490417-3198496189	AAU	5773

Continued

						PL-3198850417-3198852458	AAU	2042
						RO-2429849099-2429854950	AAU	5852
						RO-2429965099-2429971098	AAU	6000
						RO-2429985099-2429991098	AAU	6000
						RO-2465147292-2465152427	AAU	5136
						RO-2600709446-2600711553	AAU	2108
						RO-2600711554-2600715570	AAU	4017
						SK-410823419-410829418	AAU	6000
						SK-445957471-445963058	AAU	5588
		DK554585	18-03-2010 15:12	External Transfer	Terminated	CZ-1050026309-1050029398	AAU	3090
						CZ-1130497397-1130503367	AAU	5971
						CZ-1189740367-1189745561	AAU	5195
						CZ-1257814041-1257820040	AAU	6000
						DK-1700245840-1700251839	AAU	6000
						DK-1708313329-1708319203	AAU	5875
						DK-1708971263-1708977229	AAU	5967
						ES-1769795278-1769800504	AAU	5227
						ES-2095507237-2095512873	AAU	5637
						FI-513577628-513582641	AAU	5014
						FR-3109836237-3109842162	AAU	5926
						GB-3654176706-3654182325	AAU	5620
						GB-3761960383-3761966350	AAU	5968
						GB-3972079914-3972085006	AAU	5093
						GB-3977402594-3977408251	AAU	5658
						GB-3988422190-3988427199	AAU	5010
						HU-593057320-593062455	AAU	5136
						HU-595803613-595808662	AAU	5050
						IT-2703249981-2703255980	AAU	6000
						IT-2884493064-2884498771	AAU	5708
						IT-2989543942-2989549011	AAU	5070
						IT-3015140865-3015146864	AAU	6000

Continued

						IT-3015161665-3015166864	AAU	5200
						IT-3015182802-3015188801	AAU	6000
						PL-2978978305-2978983304	AAU	5000
						PL-3198490417-3198496189	AAU	5773
						PL-3198850417-3198852458	AAU	2042
						RO-2429849099-2429854950	AAU	5852
						RO-2429965099-2429971098	AAU	6000
						RO-2429985099-2429991098	AAU	6000
						RO-2465147292-2465152427	AAU	5136
						RO-2600709446-2600711553	AAU	2108
						RO-2600711554-2600715570	AAU	4017
						SK-410823419-410829418	AAU	6000
						SK-445957471-445963058	AAU	5588
		DK554589	18-03-2010 15:15	External Transfer	Terminated	CZ-1050026309-1050029398	AAU	3090
						CZ-1130497397-1130503367	AAU	5971
						CZ-1189740367-1189745561	AAU	5195
						CZ-1257814041-1257820040	AAU	6000
						DK-1700245840-1700251839	AAU	6000
						DK-1708313329-1708319203	AAU	5875
						DK-1708971263-1708977229	AAU	5967
						ES-1769795278-1769800504	AAU	5227
						ES-2095507237-2095512873	AAU	5637
						FI-513577628-513582641	AAU	5014
						FR-3109836237-3109842162	AAU	5926
						GB-3654176706-3654182325	AAU	5620
						GB-3761960383-3761966350	AAU	5968
						GB-3972079914-3972085006	AAU	5093
						GB-3977402594-3977408251	AAU	5658
						GB-3988422190-3988427199	AAU	5010
						HU-593057320-593062455	AAU	5136
						HU-595803613-595808662	AAU	5050

Continued

							IT-2703249981-2703255980	AAU	6000
							IT-2884493064-2884498771	AAU	5708
							IT-2989543942-2989549011	AAU	5070
							IT-3015140865-3015146864	AAU	6000
							IT-3015161665-3015166864	AAU	5200
							IT-3015182802-3015188801	AAU	6000
							PL-2978978305-2978983304	AAU	5000
							PL-3198490417-3198496189	AAU	5773
							PL-3198850417-3198852458	AAU	2042
							RO-2429849099-2429854950	AAU	5852
							RO-2429965099-2429971098	AAU	6000
							RO-2429985099-2429991098	AAU	6000
							RO-2465147292-2465152427	AAU	5136
							RO-2600709446-2600711553	AAU	2108
							RO-2600711554-2600715570	AAU	4017
							SK-410823419-410829418	AAU	6000
							SK-445957471-445963058	AAU	5588
		DK554590	18-03-2010 15:20	External Transfer	Terminated		CZ-1050026309-1050029398	AAU	3090
							CZ-1189740367-1189745561	AAU	5195
							FI-513577628-513582641	AAU	5014
							GB-3972079914-3972085006	AAU	5093
							GB-3988422190-3988427199	AAU	5010
							HU-593057320-593062455	AAU	5136
							HU-595803613-595808662	AAU	5050
							IT-2989543942-2989549011	AAU	5070
							IT-3015161665-3015166652	AAU	4988
							PL-2978978305-2978983304	AAU	5000
							RO-2465147292-2465152427	AAU	5136
							RO-2600709446-2600711553	AAU	2108
							RO-2600711554-2600715570	AAU	4017
		DK554592	18-03-2010 15:22	External Transfer	Terminated		CZ-1050026309-1050029398	AAU	3090

Continued

							CZ-1189740367-1189745549	AAU	5183
							FI-513577628-513582641	AAU	5014
							GB-3972079914-3972085006	AAU	5093
							GB-3988422190-3988427199	AAU	5010
							HU-593057320-593062455	AAU	5136
							HU-595803613-595808662	AAU	5050
							IT-2989543942-2989549011	AAU	5070
							PL-2978978305-2978983304	AAU	5000
							RO-2465147292-2465152427	AAU	5136
							RO-2600709446-2600711553	AAU	2108
							RO-2600711554-2600715570	AAU	4017
		DK557183	30-03-2010 14:45	External Transfer	Terminated		ES-1967063009-1967063014	AAU	6
							RO-2429822317-2429822322	AAU	6
		DK559378	13-04-2010 13:03	External Transfer	Terminated		BR-30322360-30325305	Terminated	2946
		DK559379	13-04-2010 13:06	External Transfer	Terminated		BR-30322360-30322360	Terminated	1
		DK559380	13-04-2010 13:08	External Transfer	Terminated		BR-30322360-30322360	Terminated	1
		DK559386	13-04-2010 13:28	Internal Transfer	Terminated		DE-3578078883-3578082882	AAU	4000
							DE-3635529002-3635534001	AAU	5000
							DE-3635541895-3635546501	AAU	4607
							FR-3418352349-3418353348	AAU	1000
							GB-3405772627-3405775317	AAU	2691
							GB-3405965505-3405970504	AAU	5000
							GB-3406085505-3406085641	AAU	137
							GB-3406085642-3406088072	AAU	2431
							GB-3406103505-3406106504	AAU	3000
							GB-3406181121-3406182979	AAU	1859
							GB-3512564040-3512566539	AAU	2500
							GB-3512930979-3512931934	AAU	956
							GB-3549059011-3549064256	AAU	5246
							GB-3549391653-3549396798	AAU	5146
							GB-3654233088-3654235340	AAU	2253

Continued

						GB-3654235341-3654238783	AAU	3443
						GB-3654390326-3654393316	AAU	2991
						GB-3654709326-3654714325	AAU	5000
						GB-3704199267-3704204368	AAU	5102
						GB-3708165863-3708171353	AAU	5491
						GB-3720981146-3720986097	AAU	4952
						GB-3724587388-3724592387	AAU	5000
						GB-3759731034-3759732176	AAU	1143
						GB-3761744351-3761746350	AAU	2000
						GB-3771772816-3771773143	AAU	328
						GB-3773170682-3773174473	AAU	3792
						GB-3782853141-3782858958	AAU	5818
						GB-3792620726-3792621725	AAU	1000
						GB-3792621726-3792626725	AAU	5000
						GB-3792931726-3792934839	AAU	3114
						PL-3201544965-3201554964	AAU	10000
	DK559387	13-04-2010 13:31	Internal Transfer	Terminated		DE-3578078883-3578082882	AAU	4000
						GB-3406085642-3406088072	AAU	2431
						GB-3549059011-3549064256	AAU	5246
						GB-3549391653-3549396798	AAU	5146
						GB-3654233088-3654235340	AAU	2253
						GB-3654235341-3654238783	AAU	3443
						GB-3654390326-3654393316	AAU	2991
						GB-3654709326-3654714325	AAU	5000
						GB-3704199267-3704204368	AAU	5102
						GB-3708165863-3708171353	AAU	5491
						GB-3759731034-3759732176	AAU	1143
						GB-3771772816-3771773143	AAU	328
						GB-3773170682-3773174473	AAU	3792
						GB-3782853141-3782856774	AAU	3634
	DK559388	13-04-2010 13:36	Internal Transfer	Terminated		GB-3549059011-3549064075	AAU	5065

Continued

						GB-3759731034-3759732176	AAU	1143
						GB-3773170682-3773174473	AAU	3792
	DK559389	13-04-2010 13:39	External Transfer	Terminated		DE-3578078883-3578082882	AAU	4000
						GB-3405965505-3405965685	AAU	181
						GB-3406085642-3406088072	AAU	2431
						GB-3549059011-3549064075	AAU	5065
						GB-3549391653-3549396798	AAU	5146
						GB-3654233088-3654235340	AAU	2253
						GB-3654235341-3654238783	AAU	3443
						GB-3654390326-3654393316	AAU	2991
						GB-3654709326-3654714325	AAU	5000
						GB-3704199267-3704204368	AAU	5102
						GB-3708165863-3708171353	AAU	5491
						GB-3759731034-3759732176	AAU	1143
						GB-3771772816-3771773143	AAU	328
						GB-3773170682-3773174473	AAU	3792
						GB-3782853141-3782856774	AAU	3634
	DK559391	13-04-2010 13:43	Internal Transfer	Terminated		GB-3549059011-3549064075	AAU	5065
						GB-3759731034-3759732176	AAU	1143
						GB-3773170682-3773174473	AAU	3792
	DK559392	13-04-2010 13:48	External Transfer	Terminated		GB-3549059011-3549064075	AAU	5065
						GB-3759731034-3759732176	AAU	1143
						GB-3773170682-3773174473	AAU	3792
	DK559393	13-04-2010 13:53	Internal Transfer	Terminated		GB-3759731034-3759732033	AAU	1000
	DK559394	13-04-2010 14:00	Internal Transfer	Terminated		GB-3759731034-3759731533	AAU	500
	DK559395	13-04-2010 14:05	Internal Transfer	Terminated		GB-3759731034-3759731533	AAU	500
	DK559395	13-04-2010 14:05	Internal Transfer	Terminated		GB-3773170682-3773171181	AAU	500
	DK559477	13-04-2010 14:23	Internal Transfer	Terminated		GB-3759731034-3759731533	AAU	500
						GB-3773170682-3773171181	AAU	500
	DK559478	13-04-2010 14:31	External Transfer	Terminated		GB-3759731034-3759731533	AAU	500
						GB-3773170682-3773171181	AAU	500

Continued								
		DK559481	13-04-2010 14:36	Internal Transfer	Terminated	GB-3549059011-3549064075	AAU	5065
						GB-3708165863-3708169797	AAU	3935
						GB-3759731034-3759731533	AAU	500
						GB-3773170682-3773171181	AAU	500
		DK559483	13-04-2010 14:45	Internal Transfer	Terminated	GB-3708169798-3708170797	AAU	1000
		DK559484	13-04-2010 14:49	External Transfer	Terminated	GB-3708169798-3708170241	AAU	444
						GB-3708170798-3708171353	AAU	556
		DK559485	13-04-2010 14:59	Internal Transfer	Terminated	GB-3549059011-3549064075	AAU	5065
						GB-3654233088-3654235340	AAU	2253
						GB-3654709326-3654710414	AAU	1089
						GB-3704199267-3704204368	AAU	5102
						GB-3708165863-3708169797	AAU	3935
						GB-3708169798-3708170241	AAU	444
						GB-3708170242-3708170797	AAU	556
						GB-3708170798-3708171353	AAU	556
						GB-3759731034-3759731533	AAU	500
						GB-3773170682-3773171181	AAU	500
		DK559486	13-04-2010 15:01	External Transfer	Terminated	GB-3549059011-3549064075	AAU	5065
						GB-3654233088-3654235340	AAU	2253
						GB-3654710415-3654714325	AAU	3911
						GB-3704199267-3704201546	AAU	2280
						GB-3708165863-3708169797	AAU	3935
						GB-3708169798-3708170241	AAU	444
						GB-3708170242-3708170797	AAU	556
						GB-3708170798-3708171353	AAU	556
						GB-3759731034-3759731533	AAU	500
						GB-3773170682-3773171181	AAU	500
		DK559487	13-04-2010 15:02	Internal Transfer	Terminated	GB-3708170798-3708170803	AAU	6
		DK559488	13-04-2010 15:08	Internal Transfer	Terminated	GB-3654710415-3654713858	AAU	3444
						GB-3708169798-3708170241	AAU	444
						GB-3708170242-3708170797	AAU	556

Continued

							GB-3708170798-3708170803	AAU	6
							GB-3708170804-3708171353	AAU	550
		DK559489	13-04-2010 15:10	External Transfer	Terminated		RO-2432367601-2432369859	AAU	2259
							RO-2465085983-2465105423	AAU	19441
		DK559490	13-04-2010 15:16	Internal Transfer	Terminated		GB-3549059011-3549064075	AAU	5065
							GB-3549391653-3549392741	AAU	1089
							GB-3654233088-3654235340	AAU	2253
							GB-3654709326-3654710414	AAU	1089
							GB-3654710415-3654713858	AAU	3444
							GB-3654713859-3654714325	AAU	467
							GB-3704199267-3704201546	AAU	2280
							GB-3704201547-3704204368	AAU	2822
							GB-3708165863-3708169797	AAU	3935
							GB-3708169798-3708170241	AAU	444
							GB-3708170242-3708170797	AAU	556
							GB-3708170798-3708170803	AAU	6
							GB-3708170804-3708171353	AAU	550
							GB-3759731034-3759731533	AAU	500
							GB-3773170682-3773171181	AAU	500
		DK559491	13-04-2010 15:24	Internal Transfer	Terminated		GB-3549392742-3549394452	AAU	1711
							GB-3654710415-3654713858	AAU	3444
							GB-3654713859-3654714325	AAU	467
							GB-3704201547-3704204368	AAU	2822
							GB-3708169798-3708170241	AAU	444
							GB-3708170242-3708170797	AAU	556
							GB-3708170798-3708170803	AAU	6
							GB-3708170804-3708171353	AAU	550
		DK559492	13-04-2010 15:39	Internal Transfer	Terminated		GB-3654710415-3654713858	AAU	3444
							GB-3704201547-3704203546	AAU	2000
							GB-3708169798-3708170241	AAU	444
							GB-3708170242-3708170797	AAU	556

Continued

						GB-3708170798-3708170803	AAU	6
						GB-3708170804-3708171353	AAU	550
	DK559493	13-04-2010 15:46	Internal Transfer	Terminated		GB-3549392742-3549394452	AAU	1711
						GB-3549394453-3549396274	AAU	1822
						GB-3654710415-3654713858	AAU	3444
						GB-3654713859-3654714325	AAU	467
						GB-3704201547-3704203546	AAU	2000
						GB-3708169798-3708170241	AAU	444
						GB-3708170242-3708170797	AAU	556
						GB-3708170798-3708170803	AAU	6
						GB-3708170804-3708171353	AAU	550
	DK559494	13-04-2010 15:55	External Transfer	Terminated		BR-30322360-30322360	Terminated	1
	DK559495	13-04-2010 16:08	Internal Transfer	Terminated		GB-3549392742-3549394452	AAU	1711
						GB-3549394453-3549395274	AAU	822
						GB-3654710415-3654713858	AAU	3444
						GB-3654713859-3654714325	AAU	467
						GB-3704201547-3704203546	AAU	2000
						GB-3708169798-3708170241	AAU	444
						GB-3708170242-3708170797	AAU	556
						GB-3708170798-3708170803	AAU	6
						GB-3708170804-3708171353	AAU	550
	DK559496	13-04-2010 16:17	Internal Transfer	Terminated		GB-3549392742-3549394452	AAU	1711
						GB-3549394453-3549395274	AAU	822
						GB-3654710415-3654713858	AAU	3444
						GB-3654713859-3654714325	AAU	467
						GB-3704201547-3704203546	AAU	2000
						GB-3708169798-3708170241	AAU	444
						GB-3708170242-3708170797	AAU	556
						GB-3708170798-3708170803	AAU	6
						GB-3708170804-3708171353	AAU	550
	DK559497	13-04-2010 16:20	Internal Transfer	Terminated		GB-3549392742-3549394452	AAU	1711

Continued

						GB-3549394453-3549395274	AAU	822
						GB-3654710415-3654713858	AAU	3444
						GB-3654713859-3654714325	AAU	467
						GB-3704201547-3704203546	AAU	2000
						GB-3708169798-3708170241	AAU	444
						GB-3708170242-3708170797	AAU	556
						GB-3708170798-3708170803	AAU	6
						GB-3708170804-3708171353	AAU	550
		DK559498	13-04-2010 16:33	Internal Transfer	Terminated	GB-3708170242-3708170685	AAU	444
						GB-3708170798-3708170803	AAU	6
						GB-3708170804-3708171353	AAU	550
		DK559499	13-04-2010 16:35	Internal Transfer	Terminated	AT-1611889319-1611891510	AAU	2192
		DK559577	13-04-2010 16:35	Internal Transfer	Terminated	AT-1580167202-1580170009	AAU	2808
		DK559579	13-04-2010 16:49	Internal Transfer	Terminated	DK-1711767660-1711768480	AAU	821
						GB-3549392742-3549394452	AAU	1711
						GB-3549394453-3549395274	AAU	822
						GB-3549395275-3549396274	AAU	1000
						GB-3549396275-3549396798	AAU	524
						GB-3654710415-3654713858	AAU	3444
						GB-3654713859-3654714325	AAU	467
						GB-3704201547-3704203546	AAU	2000
						GB-3704203547-3704204368	AAU	822
						GB-3708169798-3708170241	AAU	444
						GB-3708170242-3708170685	AAU	444
						GB-3708170798-3708170803	AAU	6
						GB-3708170804-3708171353	AAU	550
						HU-580069638-580073676	AAU	4039
						HU-588878583-588880437	AAU	1855
						HU-603582772-603587122	AAU	4351
						HU-603606098-603606746	AAU	649
						IE-500462686-500462748	AAU	63

Continued

								IE-508441350-508441501	AAU	152
								IE-512504305-512504579	AAU	275
								IE-512594198-512594487	AAU	290
								IE-512620129-512620288	AAU	160
								IE-514315550-514315660	AAU	111
			DK559585	13-04-2010 16:54	External Transfer	Terminated		IE-514315550-514315660	AAU	111
			DK559586	13-04-2010 16:54	External Transfer	Terminated		IE-478643319-478644003	AAU	685
			DK559580	13-04-2010 16:54	External Transfer	Terminated		IE-500462686-500462748	AAU	63
			DK559583	13-04-2010 16:54	External Transfer	Terminated		IE-512594198-512594487	AAU	290
			DK559581	13-04-2010 16:54	External Transfer	Terminated		IE-508441350-508441501	AAU	152
			DK559582	13-04-2010 16:54	External Transfer	Terminated		IE-512504305-512504579	AAU	275
			DK559584	13-04-2010 16:54	External Transfer	Terminated		IE-512620129-512620288	AAU	160
			DK559688	13-04-2010 17:46	External Transfer	Terminated		ES-2085420821-2085510820	AAU	90000
			DK559689	13-04-2010 17:49	External Transfer	Terminated		ES-2085420821-2085510820	AAU	90000
								ES-2085510821-2085520820	AAU	10000
			DK559690	13-04-2010 17:55	External Transfer	Terminated		ES-2085420821-2085430820	AAU	10000

Annex 7 Tables 6.1 and 6.2 of the IPCC good practice guidance

IPCC Source category	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty i trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data Gg CO_2 eq	Input data Gg CO_2 eq	Input data %	Input data %	%	%	%	%	%	%	%
Stationary Combustion, Coal	CO_2	23 834	15 726	1	1	1.421	0.373	-0.059	0.220	-0.065	0.280	0.288
Stationary Combustion, BKB	CO_2	11	1	3	5	5.831	0.000	0.000	0.000	-0.001	0.000	0.001
Stationary Combustion, Coke	CO_2	138	81	2	5	5.385	0.007	0.000	0.001	-0.002	0.003	0.004
Stationary Combustion, Fossil waste	CO_2	394	1266	5	25	25.452	0.538	0.013	0.018	0.328	0.120	0.349
Stationary Combustion, Petroleum coke	CO_2	410	550	2	5	5.381	0.049	0.003	0.008	0.014	0.022	0.026
Stationary Combustion, Residual oil	CO_2	2440	1077	1	2	2.184	0.039	-0.014	0.015	-0.027	0.019	0.033
Stationary Combustion, Gas oil	CO_2	4547	1792	3	4	4.721	0.141	-0.028	0.025	-0.113	0.089	0.144
Stationary Combustion, Kerosene	CO_2	366	8	3	5	5.657	0.001	-0.004	0.000	-0.021	0.000	0.021
Stationary Combustion, LPG	CO_2	164	88	2	5	5.477	0.008	-0.001	0.001	-0.003	0.004	0.005
Stationary Combustion, Refinery gas	CO_2	816	876	1	2	2.236	0.033	0.003	0.012	0.005	0.017	0.018
Stationary Combustion, Natural gas	CO_2	4335	9380	1	0	1.083	0.170	0.080	0.131	0.032	0.187	0.190
Stationary Combustion, SOLID	CH_4	13	4	1	100	100.005	0.007	0.000	0.000	-0.009	0.000	0.009
Stationary Combustion, LIQUID	CH_4	3	1	1	100	100.006	0.002	0.000	0.000	-0.001	0.000	0.001
Stationary Combustion, GAS	CH_4	3	6	1	100	100.005	0.010	0.000	0.000	0.005	0.000	0.005
Natural gas fuelled engines, GAS	CH_4	1	192	1	2	2.236	0.007	0.003	0.003	0.005	0.004	0.007
Stationary Combustion, WASTE	CH_4	1	1	5	100	100.125	0.002	0.000	0.000	0.000	0.000	0.000
Stationary Combustion, BIOMASS	CH_4	105	148	20	100	101.948	0.252	0.001	0.002	0.083	0.058	0.101
Biogas fuelled engines, BIOMASS	CH_4	0	28	4	10	10.673	0.005	0.000	0.000	0.004	0.002	0.004
Stationary Combustion, SOLID	N_2O	68	43	1	400	400.001	0.286	0.000	0.001	-0.080	0.001	0.080

Continued												
IPCC Source category	Gas	Base year emission	Year t emission	Activity data uncer-tainty	Emission factor uncer-tainty	Combined uncer-tainty	Combined un-certainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty i trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data Gg CO_2 eq	Input data Gg CO_2 eq	Input data %	Input data %	%	%	%	%	%	%	%
Stationary Combustion, LIQUID	N_2O	40	16	1	1000	1000.001	0.263	0.000	0.000	-0.252	0.000	0.252
Stationary Combustion, GAS	N_2O	16	41	1	750	750.001	0.510	0.000	0.001	0.285	0.001	0.285
Stationary Combustion, WASTE	N_2O	7	16	5	400	400.031	0.106	0.000	0.000	0.054	0.002	0.054
Stationary Combustion, BIOMASS	N_2O	38	81	2	1000	1000.002	1.348	0.001	0.001	0.686	0.004	0.686
Transport, Road transport	CO_2	9282	12125	2	5	5.385	1.091	0.061	0.170	0.304	0.480	0.568
Transport, Military	CO_2	119	160	2	5	5.385	0.014	0.001	0.002	0.004	0.006	0.008
Transport, Railways	CO_2	297	230	2	5	5.385	0.021	0.000	0.003	-0.001	0.009	0.009
Transport, Navigation (small boats)	CO_2	48	100	41	5	41.304	0.069	0.001	0.001	0.004	0.081	0.081
Transport, Navigation (large vessels)	CO_2	748	498	11	5	12.083	0.100	-0.002	0.007	-0.009	0.108	0.109
Transport, Fisheries	CO_2	591	557	2	5	5.385	0.050	0.001	0.008	0.004	0.022	0.022
Transport, Agriculture	CO_2	1272	1268	24	5	24.515	0.519	0.003	0.018	0.014	0.603	0.603
Transport, Forestry	CO_2	36	17	30	5	30.414	0.009	0.000	0.000	-0.001	0.010	0.010
Transport, Industry (mobile)	CO_2	842	823	41	5	41.304	0.568	0.002	0.012	0.008	0.668	0.668
Transport, Residential	CO_2	39	63	35	5	35.355	0.037	0.000	0.001	0.002	0.044	0.044
Transport, Commercial/institutional	CO_2	74	174	35	5	35.355	0.103	0.002	0.002	0.008	0.121	0.121
Transport, Civil aviation	CO_2	243	156	10	5	11.180	0.029	-0.001	0.002	-0.003	0.031	0.031
Transport, Road transport	CH_4	53	15	2	40	40.050	0.010	0.000	0.000	-0.016	0.001	0.016
Transport, Military	CH_4	0	0	2	100	100.020	0.000	0.000	0.000	0.000	0.000	0.000
Transport, Railways	CH_4	0	0	2	100	100.020	0.000	0.000	0.000	0.000	0.000	0.000
Transport, Navigation (small boats)	CH_4	0	1	41	100	108.079	0.001	0.000	0.000	0.000	0.000	0.001
Transport, Navigation (large vessels)	CH_4	0	0	11	100	100.603	0.000	0.000	0.000	0.000	0.000	0.000

Continued												
IPCC Source category	Gas	Base year emission	Year t emission	Activity data uncer-tainty	Emission factor uncer-tainty	Combined uncer-tainty	Combined un-certainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty i trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data Gg CO_2 eq	Input data Gg CO_2 eq	Input data %	Input data %	%	%	%	%	%	%	%
Transport, Fisheries	CH_4	0	0	2	100	100.020	0.000	0.000	0.000	0.000	0.000	0.000
Transport, Agriculture	CH_4	2	2	24	100	102.840	0.004	0.000	0.000	0.000	0.001	0.001
Transport, Forestry	CH_4	0	0	30	100	104.403	0.000	0.000	0.000	0.000	0.000	0.000
Transport, Industry (mobile)	CH_4	1	1	41	100	108.079	0.001	0.000	0.000	-0.001	0.001	0.001
Transport, Residential	CH_4	1	1	35	100	105.948	0.002	0.000	0.000	0.001	0.001	0.001
Transport, Commer-cial/institutional	CH_4	2	4	35	100	105.948	0.006	0.000	0.000	0.002	0.002	0.003
Transport, Civil aviation	CH_4	0	0	10	100	100.499	0.000	0.000	0.000	0.000	0.000	0.000
Transport, Road transport	N_2O	93	119	2	50	50.040	0.100	0.001	0.002	0.029	0.005	0.029
Transport, Military	N_2O	1	2	2	1000	1000.002	0.029	0.000	0.000	0.010	0.000	0.010
Transport, Railways	N_2O	3	2	2	1000	1000.002	0.033	0.000	0.000	-0.002	0.000	0.002
Transport, Navigation (small boats)	N_2O	0	1	41	1000	1000.840	0.018	0.000	0.000	0.010	0.001	0.011
Transport, Navigation (large vessels)	N_2O	15	10	11	1000	1000.060	0.163	0.000	0.000	-0.035	0.002	0.035
Transport, Fisheries	N_2O	11	11	2	1000	1000.002	0.182	0.000	0.000	0.018	0.000	0.018
Transport, Agriculture	N_2O	15	17	24	1000	1000.288	0.278	0.000	0.000	0.053	0.008	0.054
Transport, Forestry	N_2O	0	0	30	1000	1000.450	0.003	0.000	0.000	0.000	0.000	0.000
Transport, Industry (mobile)	N_2O	11	11	41	1000	1000.840	0.181	0.000	0.000	0.027	0.009	0.028
Transport, Residential	N_2O	0	0	35	1000	1000.612	0.006	0.000	0.000	0.002	0.000	0.002
Transport, Commer-cial/institutional	N_2O	0	1	35	1000	1000.612	0.014	0.000	0.000	0.008	0.001	0.008
Transport, Civil aviation	N_2O	3	3	10	1000	1000.050	0.042	0.000	0.000	-0.002	0.000	0.002
1.B.2. Flaring in refinery	CO_2	24	17	11	5	12.083	0.003	0.000	0.000	0.000	0.004	0.004
1.B.2. Flaring off-shore	CO_2	276	241	8	5	9.014	0.036	0.000	0.003	0.001	0.036	0.036
1.B.2. Flaring in refinery	CH_4	1	0	11	15	18.601	0.000	0.000	0.000	0.000	0.000	0.000
1.B.2. Flaring off-shore	CH_4	0	1	8	5	9.014	0.000	0.000	0.000	0.000	0.000	0.000
1.B.2. Refinery processes	CH_4	1	45	1	125	125.004	0.094	0.001	0.001	0.077	0.001	0.077
1.B.2. Land based activities	CH_4	17	29	2	40	40.050	0.019	0.000	0.000	0.008	0.001	0.008

Continued												
IPCC Source category	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty i trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data Gg CO_2 eq	Input data Gg CO_2 eq	Input data %	Input data %	%	%	%	%	%	%	%
1.B.2. Off-shore activities	CH_4	15	37	2	30	30.067	0.019	0.000	0.001	0.010	0.001	0.011
1.B.2. Transmission of natural gas	CH_4	4	0	15	5	15.811	0.000	0.000	0.000	0.000	0.000	0.000
1.B.2. Distribution of natural gas	CH_4	5	3	25	10	26.926	0.001	0.000	0.000	0.000	0.001	0.001
1.B.2. Flaring in refinery	N_2O	0	1	15	5	15.811	0.000	0.000	0.000	0.000	0.000	0.000
1.B.2. Flaring off-shore	N_2O	0	0	11	500	500.121	0.000	0.000	0.000	0.000	0.000	0.000
2A1 Cement production	CO_2	1	1	8	500	500.056	0.005	0.000	0.000	0.000	0.000	0.000
2A2 Lime production	CO_2	882	764	1	2	2.236	0.029	0.000	0.011	0.001	0.015	0.015
2A3 Limestone and dolomite use	CO_2	116	43	5	5	7.071	0.005	-0.001	0.001	-0.004	0.004	0.006
2A5 Asphalt roofing	CO_2	14	38	5	5	7.071	0.004	0.000	0.001	0.002	0.004	0.004
2A6 Road paving with asphalt	CO_2	0	0	5	25	25.495	0.000	0.000	0.000	0.000	0.000	0.000
2A7 Glass and Glass wool	CO_2	2	2	5	25	25.495	0.001	0.000	0.000	0.000	0.000	0.000
2B5 Catalysts/Fertilizers, Pesticides and Sulphuric acid	CO_2	55	34	5	2	5.385	0.003	0.000	0.000	0.000	0.003	0.003
2C1 Iron and steel production	CO_2	1	2	5	5	7.071	0.000	0.000	0.000	0.000	0.000	0.000
2D2 Food and Drink	CO_2	28	0	5	5	7.071	0.000	0.000	0.000	-0.002	0.000	0.002
2G Lubricants	CO_2	4	2	5	5	7.071	0.000	0.000	0.000	0.000	0.000	0.000
2B2 Nitric acid production	N_2O	50	31	2	5	5.385	0.003	0.000	0.000	-0.001	0.001	0.001
2F Consumption of HFC	HFC	1043	0	2	25	25.080	0.000	-0.012	0.000	-0.306	0.000	0.306
2F Consumption of PFC	PFC	218	799	10	50	50.990	0.680	0.009	0.011	0.431	0.158	0.459
2F Consumption of SF6	SF6	107	37	10	50	50.990	0.031	-0.001	0.001	-0.037	0.007	0.038
3.A Paint application	CO_2	26	9	10	15	18.028	0.003	0.000	0.000	-0.003	0.002	0.003
3.B Degreasing and dry cleaning	CO_2	0	0	10	15	18.028	0.000	0.000	0.000	0.000	0.000	0.000
3.C Chemical products, manufacturing and processing	CO_2	23	12	10	15	18.028	0.004	0.000	0.000	-0.001	0.002	0.003

Continued												
IPCC Source category	Gas	Base year emission	Year t emission	Activity data uncer-tainty	Emission factor uncer-tainty	Combined uncer-tainty	Combined un-certainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty i trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		Gg CO_2 eq	Gg CO_2 eq	%	%	%	%	%	%	%	%	%
3.D.5 Other	CO_2	86	44	10	20	22.361	0.016	0.000	0.001	-0.008	0.009	0.012
3.D.5 Consumption of fire-works	CO_2	0	0	8	300	300.107	0.001	0.000	0.000	0.001	0.000	0.001
3.D.5 Consumption of fire-works	CH_4	0	0	8	300	300.107	0.000	0.000	0.000	0.000	0.000	0.000
3.D.1 Other - Use of N_2O for Anaesthesia	N_2O	0	34	5	5	7.071	0.004	0.000	0.000	0.002	0.003	0.004
3.D.5 Consumption of fire-works	N_2O	1	3	8	300	300.107	0.016	0.000	0.000	0.011	0.001	0.011
4.A Enteric Fermentation	CH_4	3249	2859	2	20	20.100	0.960	0.002	0.040	0.038	0.113	0.119
4.B Manure Management	CH_4	976	1228	5	20	20.616	0.423	0.006	0.017	0.115	0.122	0.167
4.F Field burning af agricul-tural residues	CH_4	2	3	25	50	55.902	0.003	0.000	0.000	0.001	0.001	0.002
4.B Manure Management	N_2O	604	426	22	50	54.772	0.390	-0.001	0.006	-0.056	0.189	0.197
4.D1.1 Syntehetic Fertilizer	N_2O	2395	1196	25	100	103.121	2.060	-0.011	0.017	-1.134	0.596	1.281
4.D1.2 Animal waste applied to soils	N_2O	1097	1163	30	100	104.403	2.029	0.003	0.016	0.342	0.691	0.771
4.D1.3 N-fixing crops	N_2O	269	248	20	100	101.980	0.422	0.000	0.003	0.031	0.098	0.103
4.D1.4 Crop Residue	N_2O	361	312	20	100	101.980	0.531	0.000	0.004	0.013	0.123	0.124
4.D1.5 Cultivation of histosols	N_2O	171	164	20	100	101.980	0.279	0.000	0.002	0.028	0.065	0.070
4.D.2 Grassing animals	N_2O	311	213	25	100	103.199	0.367	-0.001	0.003	-0.067	0.107	0.127
4.D3 Atmospheric deposition	N_2O	465	296	19	100	101.736	0.503	-0.001	0.004	-0.131	0.110	0.171
4.D3 Leaching	N_2O	2455	1416	20	100	101.980	2.412	-0.009	0.020	-0.898	0.561	1.058
4.D1.6 Sewage sludge and Industrial waste used as fertil-iser	N_2O	28	81	20	100	101.980	0.138	0.001	0.001	0.081	0.032	0.087
4.F Field Burning of Agricul-tural Residues	N_2O	1	1	25	50	55.902	0.001	0.000	0.000	0.000	0.001	0.001
5.A.1 Broadleaves	CO_2	-659	-1012	15	50	52.202	-0.882	-0.006	-0.014	-0.322	-0.300	0.440
5.A.1 Conifers	CO_2	-66	-1579	15	50	52.202	-1.377	-0.021	-0.022	-1.067	-0.469	1.165

Continued												
IPCC Source category	Gas	Base year emission	Year t emission	Activity data uncer-tainty	Emission factor uncer-tainty	Combined uncertainty	Combined un-certainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty i trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data Gg CO_2 eq	Input data Gg CO_2 eq	Input data %	Input data %	%	%	%	%	%	%	%
5.A.2 Broadleaves	CO_2	3	-78	15	50	52.202	-0.068	-0.001	-0.001	-0.057	-0.023	0.061
5.A.2 Conifers	CO_2	7	-67	15	50	52.202	-0.058	-0.001	-0.001	-0.051	-0.020	0.055
5IID Forest Land.	N_2O	16	12	30	75	80.777	0.016	0.000	0.000	-0.001	0.007	0.007
5.B Cropland, Living biomass	CO_2	174	76	10	50	50.990	0.065	-0.001	0.001	-0.049	0.015	0.051
5.B Mineral soils	CO_2	6	1	10	50	50.990	0.001	0.000	0.000	-0.003	0.000	0.003
5.B Organic soils	CO_2	1054	-198	10	75	75.664	-0.250	-0.015	-0.003	-1.135	-0.039	1.135
5.B Disturbance, Land con-verted to cropland	N_2O	1343	1282	10	90	90.554	1.939	0.002	0.018	0.197	0.254	0.321
5.C Grassland, Living biomass	CO_2	3	0	50	75	90.139	0.001	0.000	0.000	-0.002	0.000	0.002
5.C Grassland, Dead organic matter	CO_2	304	35	10	50	50.990	0.030	-0.003	0.000	-0.154	0.007	0.154
5.C Grassland, Mineral soils	CO_2	32	3	10	50	50.990	0.002	0.000	0.000	-0.017	0.001	0.017
5.C Grassland, Organic soils	CO_2	1	24	10	75	75.664	0.031	0.000	0.000	0.025	0.005	0.025
5.D Wetlands, Living biomass	CO_2	137	137	10	90	90.554	0.208	0.000	0.002	0.028	0.027	0.039
5.D Wetlands, Dead organic matter	CO_2	0	-11	10	50	50.990	-0.010	0.000	0.000	-0.008	-0.002	0.008
5.D Wetlands, Soils	CO_2	0	0	10	100	100.499	0.000	0.000	0.000	0.000	0.000	0.000
5IID Wetlands. Peatland	N_2O	86	16	10	100	100.499	0.027	-0.001	0.000	-0.078	0.003	0.078
5.E Settlements, Living bio-mass	CO_2	0	0	10	100	100.499	0.000	0.000	0.000	0.000	0.000	0.000
5IV Cropland Limestone	CO_2	90	55	10	50	50.990	0.047	0.000	0.001	-0.014	0.011	0.018
6 A. Solid Waste Disposal on Land	CH_4	623	186	0	0	0.000	0.000	-0.005	0.003	0.000	0.000	0.000
6 B. Wastewater Handling	CH_4	66	75	44	78	89.554	0.112	0.000	0.001	0.021	0.065	0.068
5 B. Wastewater Handling - Direct	N_2O	27	47	37	98	104.752	0.083	0.000	0.001	0.034	0.035	0.048
6 B. Wastewater Handling - Indirect	N_2O	82	34	59	39	70.725	0.040	0.000	0.000	-0.019	0.039	0.044
6.D Accidental fires, buildings	CO_2	15	18	10	500	500.100	0.147	0.000	0.000	0.033	0.003	0.033

Continued												
IPCC Source category	Gas	Base year emission	Year t emission	Activity data uncer-tainty	Emission factor uncer-tainty	Combined uncertainty	Combined un-certainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty i trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		Gg CO_2 eq	Gg CO_2 eq	%	%	%	%	%	%	%	%	%
6.D Accidental fires, vehicles	CO_2	7	10	10	500	500.100	0.084	0.000	0.000	0.031	0.002	0.031
6.C Incineration of corpses	CH_4	0	0	1	150	150.003	0.000	0.000	0.000	0.000	0.000	0.000
6.C Incineration of carcasses	CH_4	0	0	40	150	155.242	0.000	0.000	0.000	0.000	0.000	0.000
6.D Compost production	CH_4	27	78	40	100	107.703	0.140	0.001	0.001	0.077	0.062	0.099
6.D Compost production	N_2O	0	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6.D Accidental fires, buildings	N_2O	0	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6.D Accidental fires, vehicles	N_2O	0	0	10	700	700.071	0.005	0.000	0.000	0.002	0.000	0.002
Total		71 442	59 867				32.484					8.994
Total uncertainties				Overall uncertainty i the year (%):			5.699				Trend uncertainty (%):	2.999

Annex 8 Annual emission inventories 1990-2008 CRF Table 10 for Denmark

Up until NIR 2004, NERI included the full CRF tables in the NIR report itself as well as the CRF submitted as spreadsheet files. Since NIR 2005 only the trend tables (CRF Table 10 sheet 1-5) have been included in the NIR as Tables A8.1-.5. These tables are copied from the CRF 2008 spreadsheet file, Tables 10.1-10.5. The full CRF tables 1990-2008 are submitted as spreadsheets separately, as well as the xml file generated by the CRF Reporter tool. Notice that this tool defines the base year regarding emissions in the sense of the Climate Change Convention (not as in the Kyoto protocol) which is the emissions in 1990.

Table A8.1.

TABLE 10 EMISSION TRENDS
CO_2

Inventory 2009
Submission 2011 v1.2
DENMARK

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
1. Energy	**51.343,17**	**61.815,18**	**56.004,61**	**58.341,68**	**62.284,42**	**59.111,92**	**72.343,63**	**62.818,29**	**58.770,22**	**56.129,39**
A. Fuel Combustion (Sectoral Approach)	51.043,28	61.222,59	55.393,36	57.807,51	61.758,58	58.697,11	71.888,00	62.177,69	58.295,45	55.119,85
1. Energy Industries	25.952,03	34.775,18	29.834,71	31.386,98	35.520,81	32.045,56	44.315,68	35.194,26	31.540,61	28.443,33
2. Manufacturing Industries and Construction	5.411,69	5.965,18	5.873,84	5.767,48	5.723,10	5.828,68	6.006,77	6.059,09	6.078,64	6.166,94
3. Transport	10.617,27	11.000,90	11.199,63	11.319,46	11.802,20	11.939,54	12.188,14	12.380,86	12.352,55	12.373,26
4. Other Sectors	8.943,27	9.194,63	8.344,39	9.096,46	8.460,47	8.631,43	9.201,49	8.372,64	8.119,63	7.953,97
5. Other	119,01	286,69	140,79	237,13	252,01	251,89	175,92	170,83	204,03	182,35
B. Fugitive Emissions from Fuels	299,88	592,59	611,25	534,17	525,84	414,81	455,63	640,60	474,76	1.009,54
1. Solid Fuels	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
2. Oil and Natural Gas	299,88	592,59	611,25	534,17	525,84	414,81	455,63	640,60	474,76	1.009,54
2. Industrial Processes	**1.152,16**	**1.328,76**	**1.447,10**	**1.466,42**	**1.491,69**	**1.497,33**	**1.602,60**	**1.768,30**	**1.707,37**	**1.686,07**
A. Mineral Products	1.068,76	1.246,16	1.365,59	1.382,84	1.406,09	1.405,22	1.513,28	1.680,99	1.614,87	1.595,03
B. Chemical Industry	0,80	0,80	0,80	0,80	0,80	0,80	1,45	0,87	0,56	0,58
C. Metal Production	28,45	28,45	28,45	30,97	33,50	38,56	35,19	35,01	42,19	43,04
D. Other Production	4,45	4,49	4,14	4,26	4,36	3,91	3,80	4,29	4,90	4,71
E. Production of Halocarbons and SF_6										
F. Consumption of Halocarbons and SF_6										
G. Other	49,71	48,86	48,12	47,55	46,95	48,84	48,89	47,15	44,85	42,72
3. Solvent and Other Product Use	135,16	131,04	126,92	122,78	118,66	107,19	119,44	106,71	99,99	99,05
4. Agriculture										
A. Enteric Fermentation										
B. Manure Management										
C. Rice Cultivation										
D. Agricultural Soils										
E. Prescribed Burning of Savannas										
F. Field Burning of Agricultural Residues										
G. Other										
5. Land Use, Land-Use Change and Forestry[(2)]	**3.135,78**	**1.929,90**	**3.698,42**	**452,56**	**2.327,66**	**1.661,28**	**495,98**	**1.698,41**	**670,74**	**2.775,35**
A. Forest Land	-714,42	-856,25	-737,50	-978,60	-804,24	-964,48	-936,49	-976,59	-1.046,38	-603,80
B. Cropland	3.199,86	2.410,69	3.978,49	1.159,04	2.741,86	2.370,26	1.107,80	2.376,73	1.452,91	2.813,57
C. Grassland	474,29	233,12	297,74	163,26	273,57	165,96	205,48	168,70	170,68	416,62
D. Wetlands	86,54	78,21	77,79	65,29	43,76	45,97	64,75	86,01	49,95	36,51
E. Settlements	89,50	64,13	81,90	43,57	72,71	43,57	54,45	43,57	43,57	112,45
F. Other Land	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
G. Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
6. Waste	**22,02**	**22,66**	**24,17**	**22,43**	**22,75**	**25,41**	**25,82**	**24,66**	**23,19**	**24,54**
A. Solid Waste Disposal on Land	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
B. Waste-water Handling										
C. Waste Incineration	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
D. Other	22,02	22,66	24,17	22,43	22,75	25,41	25,82	24,66	23,19	24,54
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Total CO_2 emissions including net CO_2 from LULUCF	**55.788,29**	**65.227,54**	**61.301,22**	**60.405,87**	**66.245,18**	**62.403,13**	**74.587,48**	**66.416,38**	**61.271,51**	**60.714,39**
Total CO_2 emissions excluding net CO_2 from LULUCF	**52.652,51**	**63.297,64**	**57.602,79**	**59.953,31**	**63.917,52**	**60.741,85**	**74.091,50**	**64.717,97**	**60.600,77**	**57.939,04**
Memo Items:										
International Bunkers	**4.741,07**	**4.304,98**	**4.490,18**	**5.872,79**	**6.561,69**	**6.843,24**	**6.696,52**	**6.336,50**	**6.495,96**	**6.343,36**
Aviation	1.736,10	1.632,12	1.693,19	1.658,84	1.817,70	1.867,05	1.971,08	2.010,44	2.158,98	2.290,07
Marine	3.004,96	2.672,87	2.796,99	4.213,95	4.744,00	4.976,19	4.725,44	4.326,06	4.336,98	4.053,30
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 Emissions from Biomass	4.595,94	4.971,19	5.177,44	5.362,97	5.343,61	5.575,08	5.862,98	6.069,66	6.103,72	6.428,96

Table A8.1 *continued.*

TABLE 10 EMISSION TRENDS

CO_2

Inventory 2009

Submission 2011 v1.2

DENMARK

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
1. Energy	**51.654,74**	**53.457,06**	**53.044,65**	**58.183,64**	**52.657,84**	**49.098,40**	**57.012,57**	**52.176,23**	**49.155,27**	**47.274,33**
A. Fuel Combustion (Sectoral Approach)	50.992,38	52.748,87	52.449,00	57.568,09	51.973,76	48.599,77	56.534,31	51.758,13	48.779,31	47.016,65
1. Energy Industries	25.414,45	26.714,63	26.918,04	31.583,62	25.765,82	22.565,68	30.463,16	25.827,12	23.704,55	23.698,24
2. Manufacturing Industries and Construction	5.953,38	6.034,52	5.748,26	5.673,36	5.736,27	5.438,12	5.562,58	5.389,47	4.904,74	3.914,77
3. Transport	12.172,68	12.184,44	12.281,88	12.738,19	13.047,03	13.165,94	13.544,09	14.160,80	13.929,15	13.109,02
4. Other Sectors	7.341,33	7.718,40	7.412,05	7.480,94	7.185,62	7.159,23	6.838,02	6.205,88	6.133,25	6.134,62
5. Other	110,53	96,87	88,78	91,98	239,02	270,80	126,46	174,87	107,62	159,99
B. Fugitive Emissions from Fuels	662,36	708,19	595,65	615,55	684,08	498,63	478,27	418,10	375,96	257,69
1. Solid Fuels	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
2. Oil and Natural Gas	662,36	708,19	595,65	615,55	684,08	498,63	478,27	418,10	375,96	257,69
2. Industrial Processes	**1.701,05**	**1.702,65**	**1.701,10**	**1.569,31**	**1.688,48**	**1.604,34**	**1.649,24**	**1.647,33**	**1.359,53**	**916,19**
A. Mineral Products	1.616,07	1.611,71	1.656,22	1.526,73	1.643,77	1.543,71	1.607,40	1.605,51	1.320,47	880,95
B. Chemical Industry	0,65	0,83	0,55	1,05	3,01	3,01	2,18	2,16	2,40	2,13
C. Metal Production	40,73	46,68	NA,NO	NA,NO	NA,NO	15,58	NA,NO	NA,NO	NA,NO	NA,NO
D. Other Production	3,90	4,95	4,47	4,49	3,97	4,46	2,17	1,72	2,67	1,92
E. Production of Halocarbons and SF_6										
F. Consumption of Halocarbons and SF_6										
G. Other	39,70	38,49	39,86	37,03	37,73	37,59	37,49	37,94	34,01	31,19
3. Solvent and Other Product Use	99,06	87,08	87,32	79,20	77,35	74,59	70,75	63,42	64,82	64,63
4. Agriculture										
A. Enteric Fermentation										
B. Manure Management										
C. Rice Cultivation										
D. Agricultural Soils										
E. Prescribed Burning of Savannas										
F. Field Burning of Agricultural Residues										
G. Other										
5. Land Use, Land-Use Change and Forestry(2)	**2.894,72**	**2.766,21**	**3.633,19**	**2.886,80**	**2.285,58**	**3.576,33**	**2.900,92**	**-100,50**	**-2.127,92**	**-1.130,61**
A. Forest Land	524,50	483,60	221,29	307,86	44,54	-64,73	-465,94	-3.256,31	-4.874,22	-2.736,44
B. Cropland	1.934,64	1.852,56	3.131,15	2.202,45	1.891,10	3.356,74	3.078,90	2.888,90	2.500,76	1.346,95
C. Grassland	317,64	308,42	185,56	265,54	241,26	195,48	194,63	195,98	197,58	199,15
D. Wetlands	33,63	40,22	48,75	42,27	47,22	40,93	39,16	16,72	-6,44	4,99
E. Settlements	84,31	81,42	46,44	68,68	61,47	47,91	54,18	54,20	54,41	54,75
F. Other Land	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
G. Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
6. Waste	**24,33**	**24,08**	**23,56**	**25,38**	**23,14**	**23,96**	**25,05**	**25,99**	**28,48**	**27,67**
A. Solid Waste Disposal on Land	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
B. Waste-water Handling										
C. Waste Incineration	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
D. Other	24,33	24,08	23,56	25,38	23,14	23,96	25,05	25,99	28,48	27,67
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Total CO_2 emissions including net CO_2 from LULUCF	**56.373,90**	**58.037,08**	**58.489,82**	**62.744,32**	**56.732,39**	**54.377,63**	**61.658,54**	**53.812,47**	**48.480,18**	**47.152,22**
Total CO_2 emissions excluding net CO_2 from LULUCF	**53.479,17**	**55.270,87**	**54.856,63**	**59.857,53**	**54.446,81**	**50.801,29**	**58.757,61**	**53.912,97**	**50.608,10**	**48.282,82**
Memo Items:										
International Bunkers	**6.517,37**	**5.687,39**	**4.748,87**	**4.993,99**	**4.746,13**	**4.926,38**	**5.718,11**	**5.939,16**	**5.456,88**	**3.800,44**
Aviation	2.349,78	2.383,53	2.057,98	2.140,57	2.447,45	2.573,89	2.581,61	2.647,21	2.647,51	2.313,84
Marine	4.167,59	3.303,86	2.690,89	2.853,42	2.298,68	2.352,50	3.136,50	3.291,95	2.809,37	1.486,60
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 Emissions from Biomass	6.724,53	7.427,29	7.921,66	8.957,68	9.650,30	10.361,49	10.720,32	11.689,14	11.801,89	11.885,87

Table A8.2.

TABLE 10 EMISSION TRENDS
CH_4

Inventory 2009
Submission 2011 v1.2
DENMARK

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
1. Energy	10,99	12,31	12,25	12,71	18,94	25,17	29,29	29,22	30,44	30,78
A. Fuel Combustion (Sectoral Approach)	8,92	9,74	9,79	10,03	16,02	21,84	26,03	25,75	27,03	26,93
1. Energy Industries	0,50	0,64	0,72	0,87	6,11	11,39	14,47	13,87	15,25	15,36
2. Manufacturing Industries and Construction	0,40	0,45	0,47	0,51	0,37	0,47	0,89	0,89	0,98	0,97
3. Transport	2,55	2,64	2,63	2,58	2,53	2,40	2,29	2,19	2,08	1,96
4. Other Sectors	5,46	5,99	5,96	6,06	7,01	7,57	8,37	8,80	8,70	8,64
5. Other	0,01	0,02	0,01	0,01	0,01	0,02	0,01	0,01	0,01	0,01
B. Fugitive Emissions from Fuels	2,07	2,57	2,46	2,68	2,91	3,33	3,26	3,47	3,41	3,86
1. Solid Fuels	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
2. Oil and Natural Gas	2,07	2,57	2,46	2,68	2,91	3,33	3,26	3,47	3,41	3,86
2. Industrial Processes	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**
A. Mineral Products	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA
B. Chemical Industry	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
C. Metal Production	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
D. Other Production										
E. Production of Halocarbons and SF_6										
F. Consumption of Halocarbons and SF_6										
G. Other	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
3. Solvent and Other Product Use										
4. Agriculture	**201,26**	**201,99**	**201,38**	**205,12**	**199,95**	**199,36**	**199,34**	**194,28**	**195,93**	**189,28**
A. Enteric Fermentation	154,69	154,52	152,10	153,80	149,19	148,51	147,83	142,75	142,69	137,06
B. Manure Management	46,47	47,39	49,20	51,23	50,67	50,74	51,42	51,42	53,11	52,08
C. Rice Cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Agricultural Soils	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
E. Prescribed Burning of Savannas	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
F. Field Burning of Agricultural Residues	0,09	0,09	0,09	0,09	0,09	0,10	0,10	0,11	0,14	0,13
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Land Use, Land-Use Change and Forestry	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**
A. Forest Land	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
B. Cropland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Grassland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Wetlands	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
E. Settlements	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
F. Other Land	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
G. Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
6. Waste	**57,45**	**58,90**	**59,74**	**60,75**	**59,35**	**57,62**	**57,98**	**56,10**	**54,56**	**56,70**
A. Solid Waste Disposal on Land	52,90	54,21	54,90	55,78	54,20	52,56	52,55	50,33	48,71	50,45
B. Waste-water Handling	3,15	3,16	3,17	3,19	3,23	3,27	3,34	3,41	3,42	3,40
C. Waste Incineration	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
D. Other	1,40	1,53	1,67	1,78	1,92	1,78	2,09	2,36	2,43	2,86
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Total CH_4 emissions including CH_4 from LULUCF	**269,69**	**273,21**	**273,37**	**278,59**	**278,24**	**282,15**	**286,61**	**279,60**	**280,94**	**276,76**
Total CH_4 emissions excluding CH_4 from LULUCF	**269,69**	**273,21**	**273,37**	**278,59**	**278,24**	**282,15**	**286,61**	**279,60**	**280,94**	**276,76**
Memo Items:										
International Bunkers	0,09	0,09	0,09	0,12	0,13	0,14	0,14	0,13	0,14	0,13
Aviation	0,03	0,03	0,03	0,03	0,03	0,04	0,04	0,04	0,04	0,04
Marine	0,06	0,06	0,06	0,09	0,10	0,11	0,10	0,10	0,10	0,09
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 Emissions from Biomass										

Table A8.2 *continued.*

TABLE 10 EMISSION TRENDS

CH_4

Inventory 2009

Submission 2011 v1.2

DENMARK

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
1. Energy	30,51	31,52	30,95	30,71	31,36	29,81	29,89	28,04	27,55	24,80
A. Fuel Combustion (Sectoral Approach)	26,54	27,36	26,77	26,42	26,25	24,70	23,48	21,95	21,50	19,25
1. Energy Industries	14,64	15,54	15,12	14,40	14,08	12,40	11,49	9,57	10,17	8,87
2. Manufacturing Industries and Construction	1,19	1,23	1,15	1,12	1,14	1,06	0,92	0,70	0,74	0,69
3. Transport	1,82	1,69	1,58	1,50	1,39	1,27	1,18	1,07	0,91	0,76
4. Other Sectors	8,89	8,88	8,91	9,40	9,63	9,96	9,89	10,61	9,68	8,93
5. Other	0,01	0,01	0,00	0,00	0,01	0,01	0,01	0,01	0,00	0,01
B. Fugitive Emissions from Fuels	3,97	4,15	4,18	4,29	5,11	5,11	6,41	6,08	6,05	5,55
1. Solid Fuels	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
2. Oil and Natural Gas	3,97	4,15	4,18	4,29	5,11	5,11	6,41	6,08	6,05	5,55
2. Industrial Processes	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**
A. Mineral Products	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA
B. Chemical Industry	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
C. Metal Production	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
D. Other Production										
E. Production of Halocarbons and SF_6										
F. Consumption of Halocarbons and SF_6										
G. Other	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
3. Solvent and Other Product Use										
4. Agriculture	**189,61**	**195,43**	**192,84**	**191,20**	**187,91**	**186,05**	**184,92**	**191,79**	**191,30**	**194,75**
A. Enteric Fermentation	135,80	139,04	135,66	133,79	129,52	129,08	129,17	132,34	133,15	136,14
B. Manure Management	53,69	56,25	57,06	57,27	58,25	56,83	55,61	59,33	58,03	58,47
C. Rice Cultivation	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Agricultural Soils	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
E. Prescribed Burning of Savannas	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
F. Field Burning of Agricultural Residues	0,13	0,13	0,11	0,13	0,14	0,14	0,14	0,13	0,12	0,14
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Land Use, Land-Use Change and Forestry	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**
A. Forest Land	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
B. Cropland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Grassland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Wetlands	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
E. Settlements	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
F. Other Land	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
G. Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
6. Waste	**57,43**	**58,42**	**56,63**	**58,93**	**54,89**	**55,26**	**58,37**	**57,98**	**57,34**	**56,90**
A. Solid Waste Disposal on Land	50,91	51,81	50,16	52,25	48,41	48,52	51,44	50,65	50,32	49,49
B. Waste-water Handling	3,51	3,52	3,44	3,51	3,49	3,52	3,52	3,54	3,55	3,56
C. Waste Incineration	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
D. Other	3,02	3,09	3,03	3,17	3,00	3,22	3,41	3,80	3,48	3,86
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Total CH_4 emissions including CH_4 from LULUCF	**277,55**	**285,36**	**280,42**	**280,84**	**274,16**	**271,12**	**273,18**	**277,81**	**276,19**	**276,45**
Total CH_4 emissions excluding CH_4 from LULUCF	**277,55**	**285,36**	**280,42**	**280,84**	**274,16**	**271,12**	**273,18**	**277,81**	**276,19**	**276,45**
Memo Items:										
International Bunkers	0,14	0,12	0,10	0,11	0,10	0,10	0,13	0,13	0,12	0,09
Aviation	0,04	0,04	0,04	0,04	0,05	0,05	0,05	0,05	0,05	0,05
Marine	0,09	0,08	0,06	0,07	0,05	0,06	0,07	0,08	0,07	0,04
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 Emissions from Biomass										

Table A8.3.

TABLE 10 EMISSION TRENDS
N_2O

Inventory 2009
Submission 2011 v1.2
DENMARK

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
1. Energy	**1,05**	**1,18**	**1,15**	**1,18**	**1,21**	**1,22**	**1,38**	**1,31**	**1,26**	**1,26**
A. Fuel Combustion (Sectoral Approach)	1,04	1,18	1,15	1,17	1,21	1,21	1,38	1,31	1,25	1,25
1. Energy Industries	0,27	0,35	0,32	0,33	0,38	0,36	0,49	0,42	0,38	0,38
2. Manufacturing Industries and Construction	0,17	0,19	0,19	0,17	0,15	0,14	0,14	0,14	0,14	0,14
3. Transport	0,37	0,39	0,41	0,42	0,45	0,48	0,50	0,52	0,51	0,51
4. Other Sectors	0,23	0,24	0,23	0,24	0,23	0,23	0,23	0,22	0,21	0,21
5. Other	0,00	0,01	0,00	0,01	0,01	0,01	0,01	0,00	0,01	0,01
B. Fugitive Emissions from Fuels	0,00	0,01	0,01	0,00	0,00	0,00	0,00	0,01	0,00	0,01
1. Solid Fuels	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
2. Oil and Natural Gas	0,00	0,01	0,01	0,00	0,00	0,00	0,00	0,01	0,00	0,01
2. Industrial Processes	**3,36**	**3,08**	**2,72**	**2,56**	**2,60**	**2,92**	**2,69**	**2,74**	**2,60**	**3,07**
A. Mineral Products	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA
B. Chemical Industry	3,36	3,08	2,72	2,56	2,60	2,92	2,69	2,74	2,60	3,07
C. Metal Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Other Production										
E. Production of Halocarbons and SF_6										
F. Consumption of Halocarbons and SF_6										
G. Other	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
3. Solvent and Other Product Use	0,00	0,00	0,00	0,00	0,00	0,01	0,01	0,00	0,01	0,01
4. Agriculture	**26,31**	**25,69**	**24,98**	**24,50**	**24,42**	**23,38**	**21,63**	**21,53**	**22,29**	**21,31**
A. Enteric Fermentation										
B. Manure Management	1,95	1,93	1,94	1,94	1,89	1,83	1,84	1,85	1,89	1,85
C. Rice Cultivation										
D. Agricultural Soils	24,36	23,75	23,03	22,56	22,53	21,55	19,79	19,68	20,39	19,46
E. Prescribed Burning of Savannas	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
F. Field Burning of Agricultural Residues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Land Use, Land-Use Change and Forestry	**0,06**	**0,05**	**0,06**	**0,05**	**0,05**	**0,05**	**0,05**	**0,05**	**0,05**	**0,06**
A. Forest Land	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,04
B. Cropland	0,01	0,00	0,01	0,00	0,01	0,00	0,00	0,00	0,00	0,01
C. Grassland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Wetlands	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
E. Settlements	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
F. Other Land	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
G. Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
6. Waste	**0,39**	**0,38**	**0,35**	**0,41**	**0,44**	**0,42**	**0,37**	**0,36**	**0,39**	**0,40**
A. Solid Waste Disposal on Land										
B. Waste-water Handling	0,35	0,34	0,31	0,36	0,39	0,37	0,31	0,30	0,31	0,30
C. Waste Incineration	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
D. Other	0,04	0,04	0,04	0,05	0,05	0,05	0,06	0,07	0,08	0,11
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Total N_2O emissions including N_2O from LULUCF	**31,18**	**30,39**	**29,26**	**28,71**	**28,73**	**27,99**	**26,13**	**26,00**	**26,58**	**26,11**
Total N_2O emissions excluding N_2O from LULUCF	**31,12**	**30,34**	**29,20**	**28,66**	**28,67**	**27,94**	**26,08**	**25,95**	**26,54**	**26,05**
Memo Items:										
International Bunkers	**0,25**	**0,22**	**0,23**	**0,32**	**0,36**	**0,38**	**0,37**	**0,34**	**0,35**	**0,34**
Aviation	0,06	0,06	0,06	0,06	0,06	0,06	0,07	0,07	0,08	0,08
Marine	0,19	0,17	0,18	0,27	0,30	0,31	0,30	0,27	0,27	0,26
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 Emissions from Biomass										

Table A8.3 *continued*.

TABLE 10 EMISSION TRENDS
N_2O

Inventory 2009
Submission 2011 v1.2
DENMARK

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
1. Energy	**1,22**	**1,25**	**1,26**	**1,32**	**1,27**	**1,24**	**1,33**	**1,30**	**1,26**	**1,20**
A. Fuel Combustion (Sectoral Approach)	1,22	1,25	1,26	1,31	1,26	1,24	1,32	1,29	1,26	1,20
1. Energy Industries	0,36	0,38	0,39	0,43	0,38	0,35	0,42	0,37	0,36	0,36
2. Manufacturing Industries and Construction	0,14	0,14	0,14	0,13	0,13	0,12	0,14	0,13	0,12	0,10
3. Transport	0,50	0,49	0,48	0,49	0,49	0,47	0,47	0,48	0,47	0,43
4. Other Sectors	0,22	0,24	0,24	0,26	0,25	0,28	0,29	0,30	0,30	0,30
5. Other	0,00	0,00	0,00	0,00	0,01	0,01	0,00	0,01	0,00	0,01
B. Fugitive Emissions from Fuels	0,01	0,01	0,00	0,01	0,01	0,00	0,00	0,00	0,00	0,00
1. Solid Fuels	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
2. Oil and Natural Gas	0,01	0,01	0,00	0,01	0,01	0,00	0,00	0,00	0,00	0,00
2. Industrial Processes	**3,24**	**2,86**	**2,50**	**2,89**	**1,71**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**
A. Mineral Products	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA
B. Chemical Industry	3,24	2,86	2,50	2,89	1,71	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
C. Metal Production	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Other Production										
E. Production of Halocarbons and SF_6										
F. Consumption of Halocarbons and SF_6										
G. Other	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
3. Solvent and Other Product Use	0,01	0,01	0,01	0,01	0,02	0,05	0,13	0,13	0,10	0,12
4. Agriculture	**20,42**	**19,83**	**19,56**	**18,23**	**18,86**	**18,63**	**18,13**	**18,42**	**18,64**	**17,79**
A. Enteric Fermentation										
B. Manure Management	1,75	1,78	1,74	1,69	1,72	1,74	1,66	1,53	1,45	1,38
C. Rice Cultivation										
D. Agricultural Soils	18,67	18,05	17,82	16,54	17,14	16,89	16,47	16,88	17,19	16,41
E. Prescribed Burning of Savannas	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
F. Field Burning of Agricultural Residues	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Land Use, Land-Use Change and Forestry	**0,06**	**0,05**	**0,04**	**0,05**	**0,05**	**0,04**	**0,04**	**0,04**	**0,04**	**0,04**
A. Forest Land	0,04	0,04	0,04	0,04	0,04	0,04	0,04	0,04	0,04	0,04
B. Cropland	0,02	0,01	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00
C. Grassland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Wetlands	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
E. Settlements	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
F. Other Land	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
G. Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
6. Waste	**0,45**	**0,43**	**0,51**	**0,44**	**0,37**	**0,41**	**0,37**	**0,43**	**0,48**	**0,39**
A. Solid Waste Disposal on Land										
B. Waste-water Handling	0,32	0,30	0,35	0,28	0,27	0,30	0,26	0,30	0,36	0,26
C. Waste Incineration	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
D. Other	0,13	0,13	0,16	0,16	0,10	0,10	0,11	0,13	0,12	0,13
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Total N_2O emissions including N_2O from LULUCF	**25,40**	**24,43**	**23,88**	**22,93**	**22,27**	**20,37**	**20,00**	**20,31**	**20,52**	**19,55**
Total N_2O emissions excluding N_2O from LULUCF	**25,34**	**24,38**	**23,84**	**22,88**	**22,22**	**20,33**	**19,96**	**20,27**	**20,48**	**19,51**
Memo Items:										
International Bunkers	**0,34**	**0,29**	**0,24**	**0,25**	**0,23**	**0,24**	**0,29**	**0,30**	**0,27**	**0,17**
Aviation	0,08	0,08	0,07	0,07	0,08	0,09	0,09	0,09	0,09	0,08
Marine	0,26	0,21	0,17	0,18	0,14	0,15	0,20	0,21	0,18	0,09
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 Emissions from Biomass										

Table A8.4.

TABLE 10 EMISSION TRENDS
HFCs, PFCs and SF_6

Inventory 2009
Submission 2011 v1.2
DENMARK

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
Emissions of HFCs(3) - (Gg CO_2 equivalent)	**NA,NE,NO**	**NA,NE,NO**	**3,44**	**93,93**	**134,53**	**217,73**	**329,30**	**323,75**	**411,20**	**504,04**
HFC-23	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-32	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NO	NA,NO	0,00	0,00	0,00	0,00	0,00
HFC-41	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-43-10mee	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-125	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NO	0,00	0,00	0,01	0,02	0,02	0,03
HFC-134	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-134a	NA,NE,NO	NA,NE,NO	0,00	0,07	0,10	0,15	0,20	0,17	0,21	0,23
HFC-152a	NA,NE,NO	NA,NE,NO	0,00	0,03	0,05	0,04	0,03	0,02	0,01	0,04
HFC-143	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-143a	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NO	0,00	0,00	0,01	0,01	0,02	0,03
HFC-227ea	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-236fa	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-245ca	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
Unspecified mix of listed HFCs(4) - (Gg CO_2 equivalent)	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
Emissions of PFCs(3) - (Gg CO_2 equivalent)	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**0,05**	**0,50**	**1,66**	**4,12**	**9,10**	**12,48**
CF_4	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
C_2F_6	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
C_3F_8	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NO	0,00	0,00	0,00	0,00	0,00	0,00
C_4F_{10}	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
$c\text{-}C_4F_8$	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
C_5F_{12}	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
C_6F_{14}	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
Unspecified mix of listed PFCs(4) - (Gg CO_2 equivalent)	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
Emissions of SF6(3) - (Gg CO_2 equivalent)	**44,45**	**63,50**	**89,15**	**101,17**	**122,06**	**107,34**	**60,96**	**73,06**	**59,42**	**65,36**
SF_6	0,00	0,00	0,00	0,00	0,01	0,00	0,00	0,00	0,00	0,00

Table A8.4 *continued*.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
Emissions of HFCs(3) - (Gg CO_2 equivalent)	**606,74**	**650,46**	**676,24**	**700,70**	**755,23**	**802,31**	**823,26**	**849,90**	**852,72**	**798,84**
HFC-23	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00	0,00	0,00	0,00
HFC-32	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,02	0,02	0,02
HFC-41	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-43-10mee	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-125	0,04	0,05	0,05	0,05	0,06	0,07	0,07	0,07	0,08	0,07
HFC-134	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-134a	0,25	0,27	0,28	0,27	0,29	0,29	0,29	0,29	0,29	0,25
HFC-152a	0,02	0,01	0,01	0,00	0,01	0,00	0,00	0,00	0,00	0,00
HFC-143	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-143a	0,04	0,04	0,04	0,05	0,05	0,06	0,06	0,07	0,07	0,06
HFC-227ea	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-236fa	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
HFC-245ca	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
Unspecified mix of listed HFCs(4) - (Gg CO_2 equivalent)	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
Emissions of PFCs(3) - (Gg CO_2 equivalent)	**17,89**	**22,13**	**22,17**	**19,34**	**15,90**	**13,90**	**15,68**	**15,36**	**12,79**	**14,18**
CF_4	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00	0,00	0,00	0,00
C_2F_6	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
C_3F_8	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
C_4F_{10}	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
$c\text{-}C_4F_8$	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00	0,00	0,00	0,00
C_5F_{12}	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
C_6F_{14}	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
Unspecified mix of listed PFCs(4) - (Gg CO_2 equivalent)	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
Emissions of SF6(3) - (Gg CO_2 equivalent)	**59,23**	**30,40**	**25,01**	**31,37**	**33,15**	**21,75**	**35,99**	**30,35**	**31,60**	**36,69**
SF_6	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Table A8.5

TABLE 10 EMISSION TRENDS SUMMARY

Inventory 2009
Submission 2011 v1.2
DENMARK

GREENHOUSE GAS EMISSIONS	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)									
CO_2 emissions including net CO_2 from LULUCF	55.788,29	65.227,54	61.301,22	60.405,87	66.245,18	62.403,13	74.587,48	66.416,38	61.271,51	60.714,39
CO_2 emissions excluding net CO_2 from LULUCF	52.652,51	63.297,64	57.602,79	59.953,31	63.917,52	60.741,85	74.091,50	64.717,97	60.600,77	57.939,04
CH_4 emissions including CH_4 from LULUCF	5.663,58	5.737,41	5.740,77	5.850,30	5.842,94	5.925,15	6.018,81	5.871,65	5.899,67	5.812,01
CH_4 emissions excluding CH_4 from LULUCF	5.663,58	5.737,41	5.740,77	5.850,30	5.842,94	5.925,15	6.018,81	5.871,65	5.899,67	5.812,01
N_2O emissions including N_2O from LULUCF	9.665,01	9.420,88	9.071,56	8.899,86	8.906,22	8.677,55	8.099,04	8.058,75	8.241,17	8.094,21
N_2O emissions excluding N_2O from LULUCF	9.646,02	9.403,88	9.053,54	8.884,66	8.889,24	8.662,74	8.083,68	8.044,30	8.226,91	8.075,63
HFCs	NA,NE,NO	NA,NE,NO	3,44	93,93	134,53	217,73	329,30	323,75	411,20	504,04
PFCs	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	0,05	0,50	1,66	4,12	9,10	12,48
SF_6	44,45	63,50	89,15	101,17	122,06	107,34	60,96	73,06	59,42	65,36
Total (including LULUCF)	**71.161,33**	**80.449,34**	**76.206,14**	**75.351,14**	**81.250,97**	**77.331,40**	**89.097,25**	**80.747,72**	**75.892,06**	**75.202,50**
Total (excluding LULUCF)	**68.006,57**	**78.502,43**	**72.489,70**	**74.883,38**	**78.906,33**	**75.655,30**	**88.585,91**	**79.034,86**	**75.207,06**	**72.408,57**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)									
1. Energy	51.897,95	62.439,67	56.619,70	58.974,00	63.058,57	60.017,42	73.386,12	63.838,15	59.799,35	57.165,21
2. Industrial Processes	2.239,52	2.347,10	2.383,28	2.456,45	2.554,84	2.726,75	2.828,85	3.017,46	2.993,60	3.218,15
3. Solvent and Other Product Use	135,93	132,06	128,01	123,75	119,83	108,99	121,09	108,01	102,11	103,05
4. Agriculture	12.383,77	12.204,69	11.971,30	11.903,27	11.767,57	11.435,83	10.890,64	10.755,39	11.023,34	10.581,54
5. Land Use, Land-Use Change and Forestry(5)	3.154,77	1.946,91	3.716,44	467,75	2.344,64	1.676,10	511,34	1.712,86	685,00	2.793,93
6. Waste	1.349,40	1.378,91	1.387,41	1.425,92	1.405,52	1.366,32	1.359,21	1.315,85	1.288,67	1.340,62
7. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (including LULUCF)(5)	**71.161,33**	**80.449,34**	**76.206,14**	**75.351,14**	**81.250,97**	**77.331,40**	**89.097,25**	**80.747,72**	**75.892,06**	**75.202,50**

Table A8.5 *continued.*

TABLE 10 EMISSION TRENDS SUMMARY

Inventory 2009
Submission 2011 v1.2
DENMARK

GREENHOUSE GAS EMISSIONS	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	CO_2 equivalent (Gg)									
CO_2 emissions including net CO_2 from LULUCF	56.373,90	58.037,08	58.489,82	62.744,32	56.732,39	54.377,63	61.658,54	53.812,47	48.480,18	47.152,22
CO_2 emissions excluding net CO_2 from LULUCF	53.479,17	55.270,87	54.856,63	59.857,53	54.446,81	50.801,29	58.757,61	53.912,97	50.608,10	48.282,82
CH_4 emissions including CH_4 from LULUCF	5.828,60	5.992,49	5.888,88	5.897,59	5.757,37	5.693,47	5.736,68	5.834,07	5.800,01	5.805,53
CH_4 emissions excluding CH_4 from LULUCF	5.828,60	5.992,49	5.888,88	5.897,59	5.757,37	5.693,47	5.736,68	5.834,07	5.800,01	5.805,53
N_2O emissions including N_2O from LULUCF	7.875,33	7.573,48	7.404,16	7.107,65	6.902,65	6.314,92	6.200,04	6.297,39	6.361,79	6.059,35
N_2O emissions excluding N_2O from LULUCF	7.855,52	7.557,35	7.390,50	7.092,71	6.888,37	6.301,72	6.186,91	6.284,44	6.349,02	6.046,76
HFCs	606,74	650,46	676,24	700,70	755,23	802,31	823,26	849,90	852,72	798,84
PFCs	17,89	22,13	22,17	19,34	15,90	13,90	15,68	15,36	12,79	14,18
SF_6	59,23	30,40	25,01	31,37	33,15	21,75	35,99	30,35	31,60	36,69
Total (including LULUCF)	**70.761,67**	**72.306,04**	**72.506,29**	**76.500,99**	**70.196,69**	**67.223,99**	**74.470,19**	**66.839,54**	**61.539,08**	**59.866,80**
Total (excluding LULUCF)	**67.847,15**	**69.523,69**	**68.859,44**	**73.599,25**	**67.896,82**	**63.634,45**	**71.556,14**	**66.927,10**	**63.654,24**	**60.984,82**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	CO_2 equivalent (Gg)									
1. Energy	52.674,14	54.507,82	54.085,62	59.236,22	53.709,06	50.109,48	58.051,79	53.166,81	50.125,16	48.167,48
2. Industrial Processes	3.388,40	3.290,94	3.198,59	3.215,39	3.023,48	2.442,32	2.524,17	2.542,94	2.256,64	1.765,89
3. Solvent and Other Product Use	101,97	89,38	90,16	82,83	82,54	90,84	111,16	103,03	94,75	101,64
4. Agriculture	10.312,60	10.250,98	10.114,42	9.665,85	9.792,64	9.681,85	9.503,08	9.738,29	9.797,16	9.605,52
5. Land Use, Land-Use Change and Forestry(5)	2.914,53	2.782,35	3.646,85	2.901,74	2.299,86	3.589,53	2.914,05	-87,55	-2.115,16	-1.118,02
6. Waste	1.370,03	1.384,57	1.370,64	1.398,96	1.289,11	1.309,98	1.365,94	1.376,03	1.380,53	1.344,29
7. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (including LULUCF)(5)	**70.761,67**	**72.306,04**	**72.506,29**	**76.500,99**	**70.196,69**	**67.223,99**	**74.470,19**	**66.839,54**	**61.539,08**	**59.866,80**

Annex 9 Methodology applied for the greenhouse gas inventory for the Faroe Islands

Introduction

This report covers the Faroese part of the National Inventory Report for the Kingdom of Denmark.

This report is made by the Faroese Environment Agency FEA. This is the first report of its kind.

Background information on greenhouse gas inventories and climate change

Each year the Faroe Islands is obligated to report its emission of greenhouse gases (GHG), according to the requirements of the United Nations Framework Convention on Climate Change (UNFCCC). The Kingdom of Denmark (which includes Denmark, Greenland and the Faroe Islands as geographical areas) has signed the UNCCC.

When Denmark ratified the Kyoto Protocol, it was with territorial reservation for the Faroe Islands. Since the reservation has not been lifted, the requirements for reporting are only those related to the UNFCCC convention.

The Faroese emission figures are part of the emission total for the Kingdom of Denmark, and emission data are subsequently submitted to the UNFCCC.

The first emission inventories for the Faroe Islands were made using an average method based upon the total use of fossil fuels in the Faroe Islands and consequently the inventories have only included total estimates of CO_2 emissions. Later, the inventories were done according to IPCC guidelines. The FEA has since 2008 yearly reported GHG emissions to NERI. Last year was the first time the emissions were reported using the CFR Reporter.

The GHGs reported are:

- Carbon dioxide CO_2
- Methane CH_4
- Nitrous Oxide N_2O
- Hydrofluorocarbons HFCs
- Perfluorocarbons PFCs
- Sulphur hexaflouride SF_6

A description of the institutional arrangement for inventory preparation

FEA, a subsidiary of the Ministry of the Interior, is responsible for the annual preparation and submission to the UNFCCC of the Faroe Islands' contribution to the Kingdom of Denmark National Inventory Report and the GHG inventories in the Common Reporting Format in accordance with the UNFCCC Guidelines. The inventory is done with guidance from and in co-operation with NERI.

The work concerning the annual greenhouse gas emission inventory is carried out in co-operation with other Faroese ministries, research institutes, organisations and companies:

- *Statistics Faroe Islands (Ministry of Finance)* Annual statistics on liquid fuel sale, fuel usage for electricity and heat production, and statistics on livestock (sheep and cows).
- *Municipal Waste Plants* Data on amount of incinerated waste.
- *Electricity producing company* Data on import of F-gases (SF_6).
- *Atlantic Airways* Data for fuel usage for domestic flights and international flights to and from the Faroe Islands.
- *Refrigeration companies* Data on import of F-gases (HFCs).
- *Oil companies – licence holders* Data on use of fuel oil in connection with exploration (deep water) drilling in Faroese territorial waters.

In January 2010, NERI and FEA made a formal agreement about data delivery.

Brief description of the process of inventory preparation. Data collection and processing, data storage and archiving

The activity data for fuel sale and for fuel usage by large combustion plants, as well as for the number of livestock (sheep and cows) are collected and stored at Statistics Faroe Islands. Each year, FEA receives new data for fuel sale and fuel usage for the previous year. Numbers of livestock is accessible on the homepage of Statistics Faroe Islands, www.hagstova.fo.

Other activity data are delivered by plants owned by municipalities or private companies.

After receiving the data, the material is placed on servers at FEA. The servers are subject to routine backup services. Material that has been backed up is archived safely. All data is archived in the electronic journal of the agency.

The emission factors are yearly received from NERI Denmark, sent by email to the FEA as Excel files. In addition to copying the factors to spreadsheet files, the e-mails are archived in the electronic journal.

Last year's submission (1990-2008) was the first time activity data and emissions were reported in the CRF format. This improvement has meant higher data security and limited the potential for errors in the reporting. The emission inventory is both reported in the form of an xml file and as CRF Excel tables.

Brief general description of methodologies and data sources used

The GHG inventory for the Faroe Islands includes the following sectors:

- Energy sector (CRF sector 1)
- Industrial processes (CRF sector 2)
- Agriculture (CRF sector 4)
- Waste (CRF sector 5) (all emissions allocated to the Energy sector)

The applied methodologies follow the IPCC Guidelines and IPCC Good Practice Guidance, and generally the Tier 1 method is applied and default emissions factor used. The exception is in calculating the emission from waste incineration. A brief general description of methodologies is included below for the different sectors.

The methods and the emission factors used in the inventory are shown in Table 3 (emission factors for CO_2, CH_4 and N_2O in the Energy and Agriculture sector) and Table 4 (emission factors for HFCs and SF_6 in the sector for Industrial Processes).

Table 3 Methods and emission factors used for calculating CO_2, CH_4 and N_2O emissions in the Energy and Agriculture sectors.

GHG CATEGORIES	CO_2		CH_4		N_2O	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
1. Energy	**CS,T1**	**CS,D**	**CS,T1**	**CS,D**	**CS,T1**	**CS,D**
A. Fuel Combustion	CS,T1	CS,D	CS,T1	CS,D	CS,T1	CS,D
1. Energy Industries	CS,T1	CS,D	CS,T1	CS,D	CS,T1	CS,D
2. Manufacturing Industries and Construction	T1	D	T1	D	T1	D
3. Transport	T1	D	T1	D	T1	D
4. Other Sectors	T1	D	T1	D	T1	D
5. Other	NA	NA	NA	NA	NA	NA
4. Agriculture			**T1**	**D**	**D,T1**	**D**
A. Enteric Fermentation			T1	D		
B. Manure Management			T1	D	T1	D
C. Rice Cultivation			NA	NA		
D. Agricultural Soils			NA	NA	D	D
E. Prescribed Burning of Savannas						
F. Field Burning of Agricultural Residues			NA	NA	NA	NA
G. Other			NA	NA	NA	NA

Table 4 Methods and Emission factors used for calculating HFCs and SF6 emissions in the Industrial Processes sector.

GHG CATEGORIES	HFCs		SF_6	
	Method applied	Emission factor	Method applied	Emission factor
2. Industrial Processes	**T1**	**D**	**T1**	**D**
A. Mineral Products				
B. Chemical Industry				
C. Metal Production			NA	NA
D. Other Production				
E. Production of Halocarbons and SF_6	**NA**	**NA**	**NA**	**NA**
F. Consumption of Halocarbons and SF_6	**T1**	**D**	**T1**	**D**
G. Other	**NA**	**NA**	**NA**	**NA**

Energy sector

All emissions in the Energy sector are from Fuel combustion (1.A.1), and in these categories:

- 1A1a Main Activity Electricity and Heat Production (incl. Waste)
- 1A1c Manufacture of Solid fuels and Other Energy Industries
- 1A2 Manufacturing Industry and Construction
- 1A3a Civil aviation
- 1A3b Road transport
- 1A3d Navigation
- 1A4a Commercial/Institutional
- 1A4b Residential
- 1A4c Agriculture, Forestry, Fishing

Statistics Faroe Islands provides the information on fuel sales by fuel type (in m^3) and divided into eight main groups (original titles: Fishing vessels, Other ships, Transportation, Industry, Trading and Service, Residential and Communities, Institutions and Public power), each group again divided into subgroups.

The fuel data delivered by Statistics Faroe Islands originate from several sources. The main data sources are the two oil companies in the Faroe Islands. Fuel data not included in sales information from the companies are provided directly by the industry.

Since the data on fuel sale are not fully arranged according to IPCC guidelines, the FEA rearranges the data to comply with the guidelines.

In some cases, it is not possible to rearrange the data to fully comply with the IPCC guidelines. This is the case for foreign fishing vessels. According to the guidelines all emissions resulting from fuel used in coastal and deep sea fishing should be allocated to the country delivering the fuel. The oil companies selling fuel to foreign fishing vessels do not have a system to register the type of the ship. Thus, in the inventory, emissions from foreign fishing vessels are allocated to International bunkers. This means that the emission from fishing vessels in reality is higher than in the inventory and emission from International bunkering is smaller. In accordance with a new Executive Order from December 2010 on reporting of fuels, etc., FEA can obtain more detailed information from oil companies on sale of fuel to fishing vessels. This will give the possibility for more correct inventories.

The inventory includes all oil bunkered on Faroese territory, excluding oil bunkered at open sea by international companies, i.e., from foreign supplier to foreign customer.

Emission factors

Emissions from fuel combustion come from two main sources: stationary and mobile combustion. Stationary combustion means fuel combustion related to industrial processes, house heating and oil exploration. Mobile combustion includes the combustion in engines used for propulsion in the various modes of transport such as road transport, marine activities and aviation.

Emissions are calculated by multiplying fuel consumption data with an emission factor (e.g., in tonnes emission per GJ fuel). The emission factors used for stationary, transport, waste and aviation are country specific and provided by NERI. Other emissions factors used in the energy sector are IPCC default.

Road transport

The emission factors for road traffic are calculated by NERI. The Danish results are modified for Faroese traffic conditions such as other gross vehicle weights for heavy-duty vehicles and no highway driving conditions. The emissions factors are also modified because no biofuel is used in the Faroe Islands, unlike in Denmark.

Aviation

As the Faroe Islands has accepted the United Nations Climate Convention as a part of the Kingdom of Denmark, aviation between Denmark and the Faroe Islands is to be reported as domestic aviation.

The Faroese airline company, Atlantic Airways, delivers data for use of jet fuel bunkered in the Faroe Islands. The data is divided by destination: flights to destinations inside the Kingdom of Denmark, i.e., Denmark and Greenland (Domestic Aviation), and outside the Danish Kingdom, e.g., Iceland, Norway and Great Britain (International Aviation). Fuel refuelled outside the Faroe Islands is not included in the Faroese inventory.

The emission factors for aviation are made by NERI. Due to lack of flight statistics the factors have not been updated for recent years. The emission will be recalculated when better flight statistics become available.

Industrial processes

Emissions from Industrial processes are allocated to these categories:

- 2F1 Refrigeration and Air Conditioning
- 2G1 Electrical equipment

The inventory follows the principles in the IPCC Guidelines and the IPCC Good Practice Guidance, with at Tier 1 methodology. The emissions factors are IPPC default.

FEA conducts annual surveys on the consumption (import) of HFCs and SF_6 (since 2003). An estimate of the consumption has been done for the years 1990-2002.

There has been no consumption of PFCs in the Faroe Islands.

Solvent and other product use

Since no data are available, emissions from solvent and other product use are not calculated.

Agriculture

GHG emissions from agriculture are calculated for following categories:

- 4A Enteric fermentation
- 4B Manure management
- 4D2 Agricultural Soil - Grassing animals

The inventory follows the principles in the IPCC Guidelines and the IPCC Good Practice Guidance. Method: Tier 1. All emission factors used for agriculture are IPCC standard values. The emissions are calculated with support from NERI. Activity data is accessible on the homepage of Statistics Faroe Islands.

Waste

The GHG emission from waste incineration is calculated using country specific methodology. Emission factors relative to emissions of CO_2, N_2O and CH_4 from waste incineration in 1990-2009 are listed in Table 5 and heating values for waste incineration are listed in Table 4.

Table 5 Emission factors for waste incineration.

	Fossil waste	CO_2 EMF - fossil	CO_2 EMF - biogen	CH_4 EMF - tot	N_2O EMF - tot
	%	Kg pr GJ	Kg pr GJ	G pr GJ	G pr GJ
1990	32,2	25,4	86,7	6	4
1991	32,2	25,4	86,7	6	4
1992	35,4	27,9	84,2	6	4
1993	36,9	29,1	83,0	6	4
1994	36,9	29,1	83,0	6	4
1995	39,3	31,0	81,1	6	4
1996	41,2	32,5	79,6	6	4
1997	41,2	32,5	79,6	6	4
1998	41,2	32,5	79,6	6	4
1999	41,2	32,5	79,6	6	4
2000	41,2	32,5	79,6	6	4
2001	41,2	32,5	79,6	6	4
2002	41,2	32,5	79,6	6	4
2003	41,2	32,5	79,6	6	4
2004	41,2	32,5	79,6	6	4
2005	41,2	32,5	79,6	6	4
2006	41,2	32,5	79,6	6	4
2007	41,2	32,5	79,6	6	4
2008	41,2	32,5	79,6	6	4
2009	41,2	32,5	79,6	6	4

Table 4 Heating values (GJ pr t) for waste.

Year	Heating values GJ pr t
1990	8,2
1991	8,2
1992	9,0
1993	9,4
1994	9,4
1995	10,0
1996	10,5
1997	10,5
1998	10,5
1999	10,5
2000	10,5
2001	10,5
2002	10,5
2003	10,5
2004	10,5
2005	10,5
2006	10,5
2007	10,5
2008	10,5
2009	10,5

Brief description of key categories

No key category analysis (KCA) has been carried out for the Faroe Islands inventory.

Information on QA/QC plan including verification and treatment of confidential issues where relevant

A number of measures are in place to ensure the quality of the greenhouse gas inventory for the Faroe Islands.

The general QC activities include:

- Check that data from Statistics Faroe Islands and other data deliverers are correctly transferred to emissions spreadsheets.
- Check that data are correctly moved between data processing steps, e.g., it is ensured that the data are imported correctly from the emission spreadsheets /databases to the CRF Reporter.
- The time-series are analysed. Any large fluctuations are investigated and explained /corrected.
- The completeness of the inventory is checked utilising the completeness checker incorporated in the CRF Reporter.

These types of QC checks are recommended as Tier 1 QC checks in the IPCC Good Practice Guidance (IPCC, 2000).

No confidential issues are relevant.

General uncertainty evaluation, including data on the overall uncertainty for the inventory totals

No uncertainty evaluation has been made for the Faroese inventory.

General assessment of the completeness

In general, the inventory is complete. Recalculation in the 2009 inventory in water-born navigation and in International bunkers for the years 2001-2008, implied incompleteness, since it was not possible at the time of delivery to complete the recalculation back to 1990. Data for 1990-2000 in these categories will be recalculated before the next inventory reporting in 2012.

References

Lastein, L. & Winther, M. 2003: Emissions of greenhouse gases and long-range transboundary air pollutants in the Faroe Islands 1990-2001. National Environmental Research Institute, Denmark. 62 p. – NERI Technical Report no. 477. Available at: http://technicalreports.dmu.dk

Winther, M. 2001: 1998 Fuel Use and Emissions for Danish IFR Flights. Environmental Project no. 628, 2001. 112 p. Danish EPA. Prepared by the National Environmental Research Institute, Denmark. Electronic report at homepage of Danish EPA. Available at: http://www.mst.dk/udgiv/Publications/2001/87-7944-661-2/html/

Trends in Greenhouse Gas Emissions

The trend tables 1990-2009 for CO_2, CH_4, N_2O, F-gases and CO_2 equivalents (CRF: Table10) are presented in Annex 1.

Description and interpretation of emission trends for aggregated greenhouse gas emissions

To be completed in the next submission.

Description and interpretation of emission trends by gas

Figure 1 shows the composition of greenhouse gas emissions (CO_2, N_2O, CH_4, HFCs and SF_6) in 2009, calculated in GWP values. CO_2 accounted for 92 % of the total greenhouse gas emission in 2009, the N_2O and CH_4 emissions both contributed 3 %, while HFCs and SF_6 emissions contributed 2 % and 0.03 %, respectively.

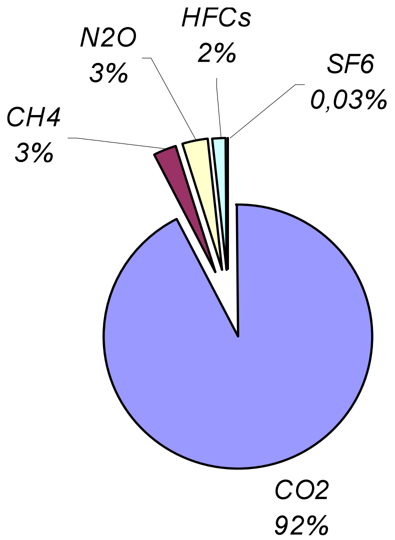


Figure 1 Emissions of GHG in CO2 equivalents distributed on type of gas for 2009.

Figure 2 shows the total emissions of greenhouse gases (in CO_2 equivalents) in the time period 1990-2009. The total emission has increased by 12 % from 1990-2009. From 1990 to 1993 a decrease is observed, due to the economic crisis in the Faroe Islands. From 2001 to 2006, the emissions were rather stabile. After a slight increase in the emissions in 2007, a significant decrease was observed in 2008 and 2009 due to fewer emissions from fishing vessels. The reason was less fishing effort because of increasing oil prices, the falling price of fish and because of fewer vessels in the fishing fleet. In 2009, the emissions were 4.1 % below the base year.

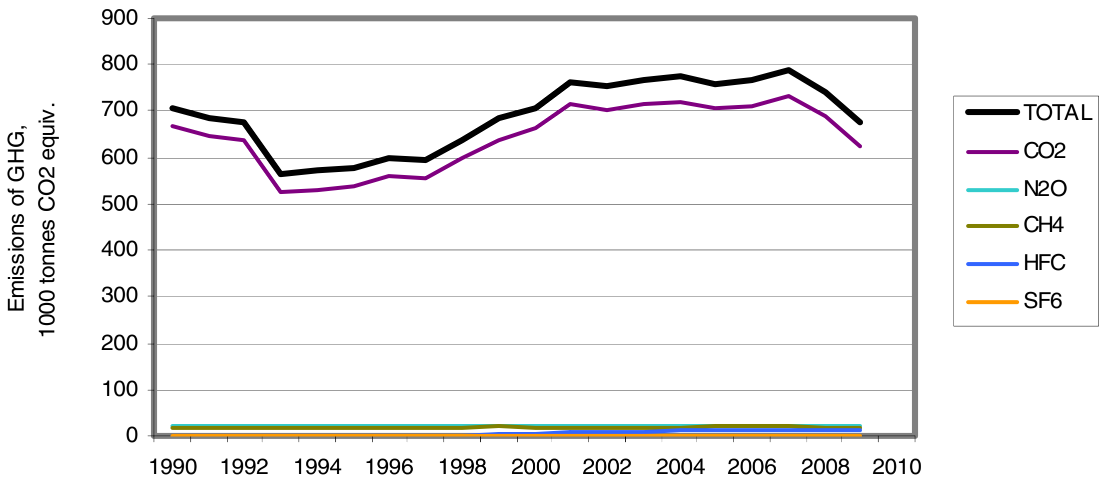


Figure 2 GHG emission in CO_2 equivalents, time-series 1990-2009.

Carbon dioxide

The emission of CO_2 is from fuel consumption only. The trend in the emission of CO_2 is nearly identical with the total emission of GHG in the Faroe Islands. After the economic decline in the 1990s the emissions rose and were rather constant until 2008 and 2009, where the effort in the fishing fleet was reduced. Figure 3 shows the trends in CO_2 emissions in the period from 1990 to 2009.

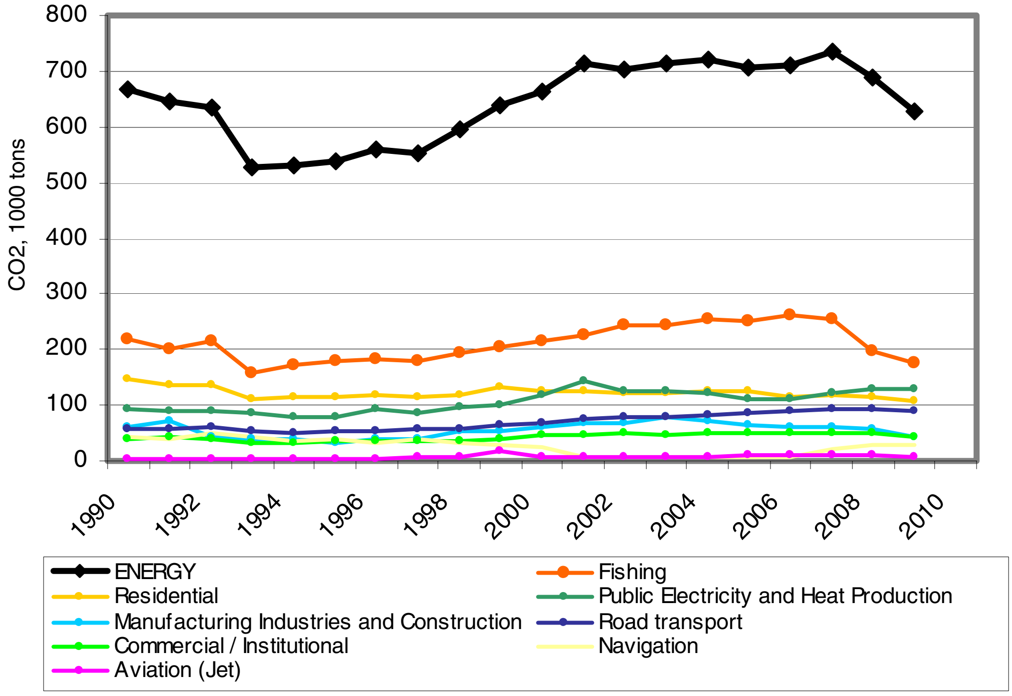


Figure 3 Total CO_2 emissions, time-series for 1990-2009.

Figure 4 shows how the emissions are distributed between categories. In 2009 28 % of the CO_2 emissions came from fishing vessels. Public electricity and heat production accounted for 19 %, households for 17 % and road transport for 15 % of the total CO_2 emission.

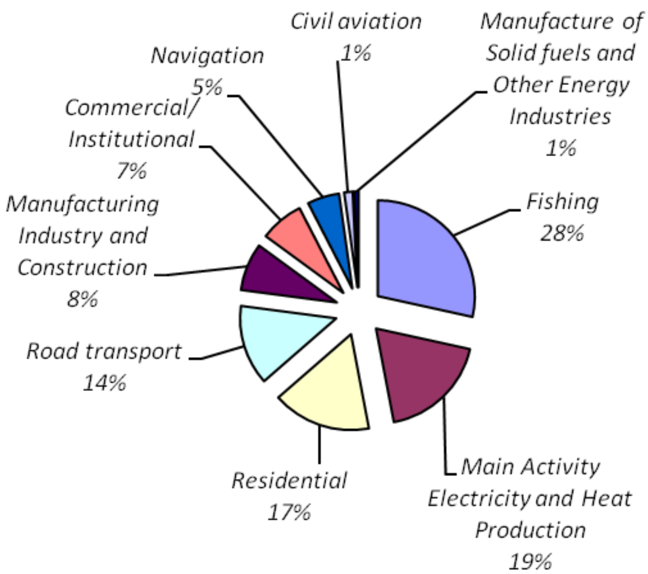


Figure 4 Emissions of CO2 in the Energy sector, divided in fuel consumption categories, 2009.

Nitrous oxide

Figure 4 shows the emissions of nitrous oxide in the Faroe Islands 1990-2009. Most of the N_2O is from the agriculture sector. The decline in the fishing industry is reflected in the decrease in N_2O emissions in 2008 and 2009.

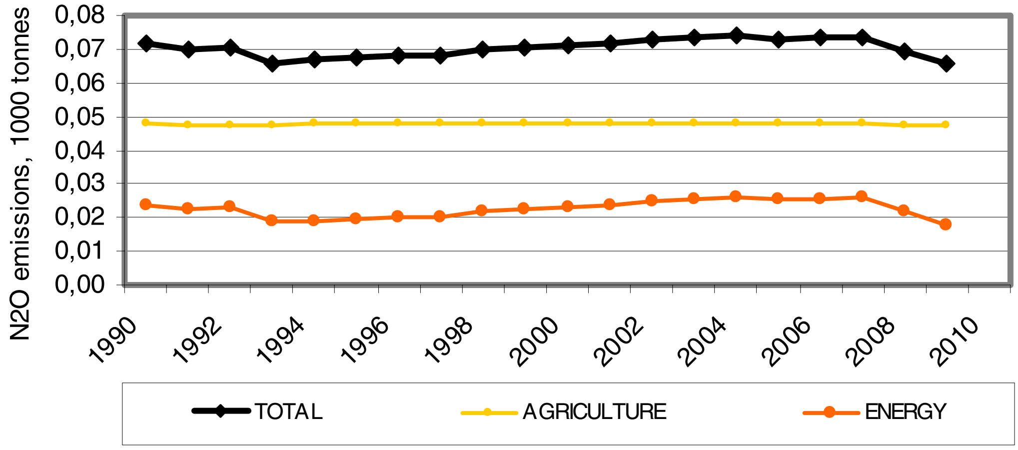


Figure 5 N_2O emissions, time-series for 1990-2009.

Methane

Figure 6 shows the emissions of methane in the Faroe Islands 1990-2009. Most of the methane emission is from the agriculture sector. Most of the emission of CH_4 in the energy sector is due to aviation activity.

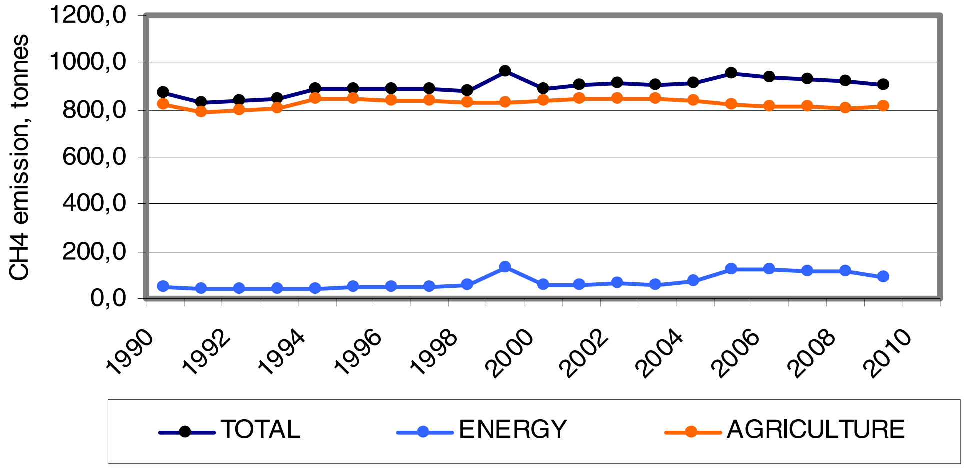


Figure 6 CH_4 emissions, time-series for 1990-2009.

HFCs, PFCs and SF_6

Figure 7 shows the emissions of F-gases, HFCs and SF_6 respectively in the years 1990-2009. Most of the emission is HFCs, which are used for refrigeration purposes, as substitutes for HCFCs. After the emissions increased in the period 1996-2005, the emissions were rather stabile at around 12,000 tonnes of CO_2 equivalents until 2009, when a decline was observed.

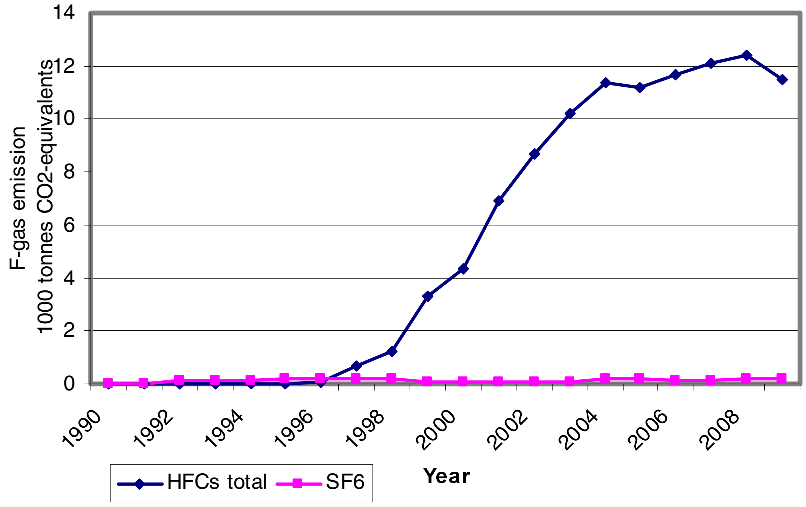


Figure 7 F-gas emissions, time-series for 1990-2009.

The import of SF_6 is increasing year by year; in 2009 the actual emission was 210 tonnes CO_2 equivalents.

PFC has never been in use in the Faroe Islands.

Description and interpretation of emission trends by source

In 2009, 94 % of all GHG emissions were from the Energy sector, including waste-incineration. 5 % were from agriculture and 2 % from Industrial processes, see Figure 8.

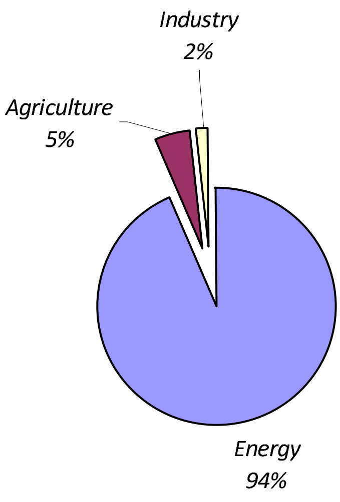


Figure 8 Emissions of GHG in CO_2 equivalents distributed by main sectors, 2009.

The fluctuations in the GHG emissions in the Energy sector are decisive for the fluctuations in the total GHG emissions, see Figure 9. The emissions from the Agriculture sector and from Industrial processes are relative small and constant.

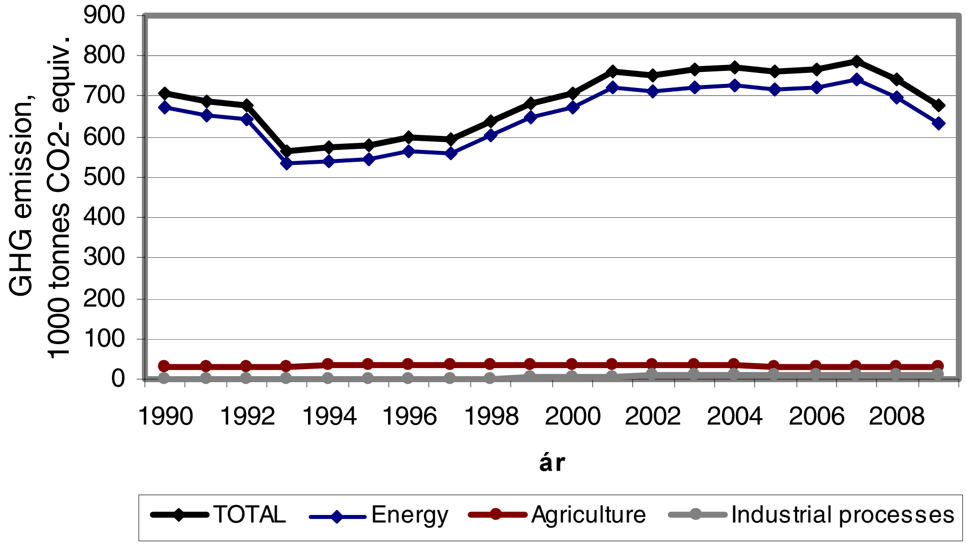


Figure 9 GHG emissions in CO_2 equivalents, main sectors, time-series 1990-2009.

Description and interpretation of emission trends for indirect greenhouse gases and SO_2

Emission trends for indirect greenhouse gases and SO_2 have not been made for the Faroe Islands.

Energy (CRF sector 1)

Overview of the sector

Fuel consumption on the Faroe Islands can be seen in Figure 10. Most of the fuel is used by fishing vessels.

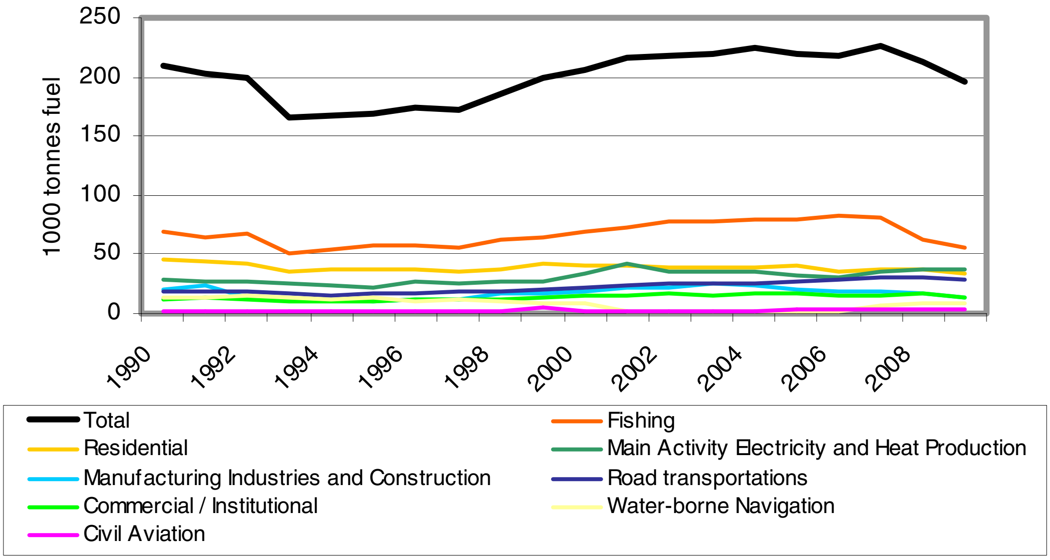


Figure 10 Fuel consumption (tonnes) in the Energy sector, including waste incineration.

The pattern in Figure 10 is also seen in Figure 11. The emissions of GHG in the Energy sector is a reflection of fuel consumption.

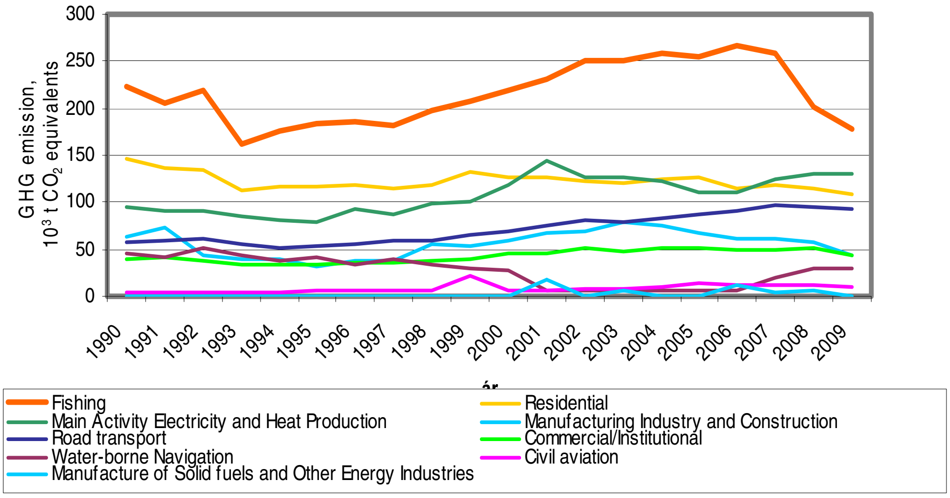


Figure 11 GHG emissions in CO_2 equivalents, categories in the Energy sector, 1990-2009.

Figure 12 shows how the emissions of GHG were divided between groups of fuel users. Fishing vessels, Electricity production, Residential and Road transport had 27, 20, 17 and 15 % of the emissions in the Energy sector in 2009.

Waste incineration has been included under sector 1A1a (Electricity and Heat production).

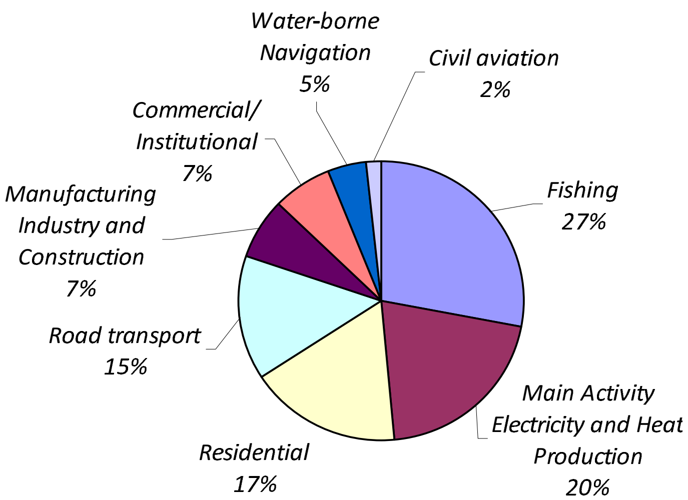


Figure 12 GHG emissions in CO_2 equivalents; Energy sector divided in categories, 2009.

Fugitive emissions (CRF sector 1B)

Fugitive emissions of GHG gases are estimated to be very limited on the Faroe Islands. These emissions have not been calculated.

Industrial Processes (CRF Sector 2)

There is no chemical industry, no metal production, no production of F-gases and no mineral production (other than road paving with asphalt) on the Faroe Islands. The only industrial processes leading to GHG emissions on the Faroe Islands is the use of F-gases. Since no data is available on paving roads with asphalt, the emissions of GHG from road paving are not included in the inventory.

Overview of the sector

Figure 13 shows the GHG emissions from industrial processes on the Faroe Islands. The increase in emissions, starting in 1996 is due to use of HFCs in refrigeration.

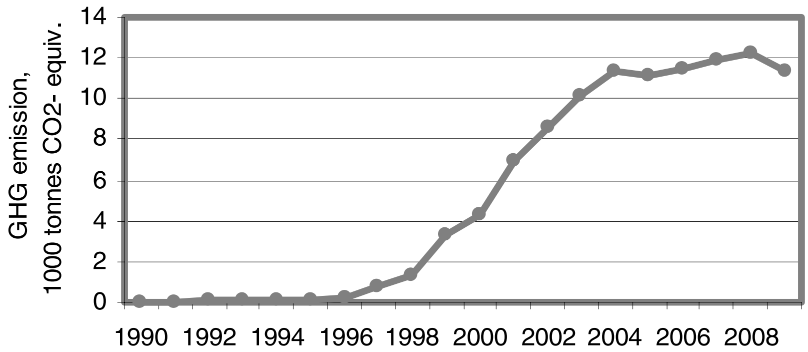


Figure 13 GHG emissions in CO_2 equivalents, Industrial processes, 1990-2009.

Mineral products (2A)

There is no mineral production in the Faroe Islands, other than paving roads with asphalt. No data is available for paving roads with asphalt.

Chemical industry (2B)

No chemical industry with GHG emission is located in the Faroe Islands.

Metal production (2C)

No metal production industry is located in the Faroe Islands.

Production of Halocarbons and SF_6 (2E)

There is no production of halocarbons and SF_6 in the Faroe Islands.

Metal Production (2C) and Consumption of Halocarbons and SF_6 (2F)

Of the total GHG emissions, 2 % are due to emissions of F-gasses, which are potent greenhouse gases. A part of the emission is HFC gasses, which are used for refrigeration purposes and SF_6 used in electrical equipment.

In order to use the CRF Reporter, all emissions of HFCs needed to be calculated in units of mass, see Tabel 6 Emissions of HFCs from Refrigeration and Air Conditioning, 1990-2009 (tonnes).

Tabel 6 Emissions of HFCs from Refrigeration and Air Conditioning, 1990-2009 (tonnes).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Domestic refrigeration										
HFC-134a	NO	NO	NO	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Commercial refrigeration										
HFC-134a	NO	NO	NO	0,00	0,00	0,00	0,00	0,01	0,02	0,03
HFC-32	NO	NO	NO	0,00	0,00	0,00	0,00	0,00	0,01	0,05
HFC-125	NO	NO	NO	0,00	0,00	0,00	0,00	0,01	0,03	0,09
HFC-143a	NO	NO	NO	0,00	0,00	0,00	0,00	0,01	0,02	0,04
Industrial refrigeration										
HFC-134a	NO	NO	NO	0,00	0,00	0,00	0,00	0,03	0,06	0,11
HFC-125	NO	NO	NO	0,00	0,00	0,00	0,00	0,07	0,12	0,23
HFC-143a	NO	NO	NO	0,00	0,00	0,00	0,00	0,08	0,15	0,28
Mobile Air Conditioning										
HFC-134a	NO	NO	NO	NO	NO	NO	NO	NO	0,01	0,70
CONTINUED	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Domestic refrigeration										
HFC-134a	0,00	0,00	0,00	0,01	0,01	0,01	0,01	0,01	0,01	0,01
Commercial refrigeration										
HFC-134a	0,05	0,07	0,10	0,12	0,13	0,14	0,13	0,13	0,14	0,17
HFC-32	0,09	0,16	0,22	0,28	0,33	0,32	0,31	0,30	0,28	0,26
HFC-125	0,15	0,25	0,35	0,43	0,50	0,51	0,50	0,50	0,57	0,60
HFC-143a	0,06	0,09	0,12	0,15	0,17	0,19	0,19	0,22	0,32	0,37
Industrial refrigeration										
HFC-134a	0,16	0,28	0,36	0,43	0,48	0,45	0,39	0,36	0,34	0,28
HFC-125	0,33	0,59	0,75	0,88	0,99	0,97	1,03	1,06	1,01	0,84
HFC-143a	0,39	0,70	0,89	1,05	1,17	1,15	1,22	1,25	1,19	0,99
Mobile Air Conditioning										
HFC-134a	0,70	0,70	0,70	0,70	0,68	0,59	0,64	0,76	0,83	0,89

The HFC emissions are reported with the following assumptions:

- Domestic refrigeration is use in freezers and refrigerators.
- Commercial refrigeration is use in landbased units.
- Industrial refrigeration is use on ships.
- Mobile air conditioning is use in cars, buses and trucks.

Figure 14 shows the emissions of SF6 and four types of specific HFCs.

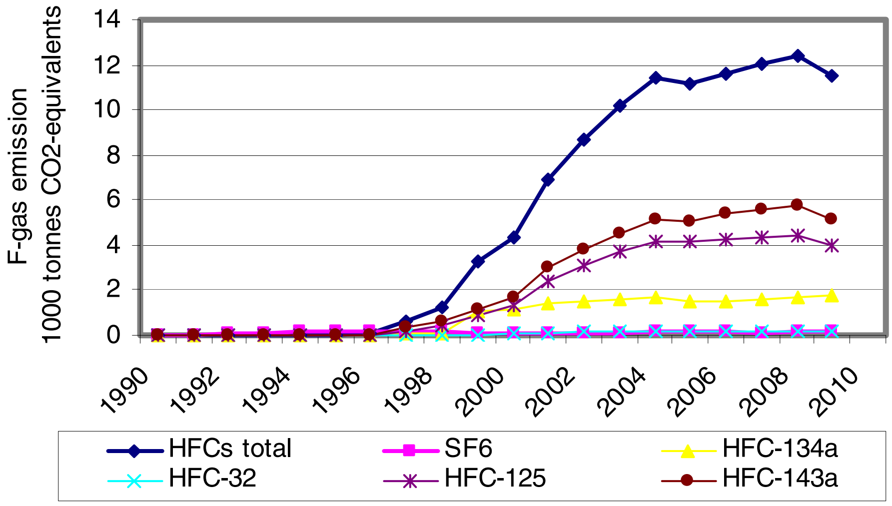


Figure 14 Emission of F-gases (HFCs and SF_6) in CO_2 equivalents, time-series for 1990-2009.

Other (2G)

No emissions are in the category "Other".

Uncertainty

Estimations of the uncertainties for Industrial processes have not been done.

Solvents and other product use (CRF Sector 3)

Overview of the sector

Since no data are available for this sector, no emissions are calculated. The expected emissions are low.

Agriculture (CRF Sector 4)

Overview

The emission of methane and nitrous oxides are from enteric fermentation, manure management and from animals grassing on agricultural soil. The sources are cattle and sheep. Figure 15 shows the number of cattle in the Faroe Islands from 1990 to 2009. The number of sheep is 78.940, which is the carrying capacity for sheep on the Faroe Islands. There are no data on the exact number of sheep.

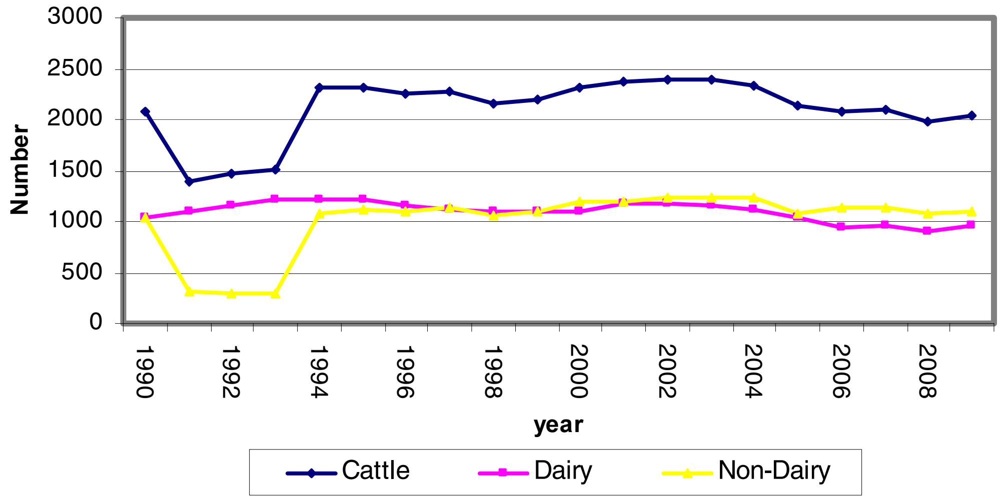


Figure 15 Number of cattle (dairy and non-dairy cows), time-series for 1990-2009.

4 % of the total GHG emissions on the Faroe Islands are due to agriculture. Agricultural soil emits N_2O. Manure management causes emissions of N_2O and CH_4.

Figure 16 shows the total emissions from the Agriculture sector.

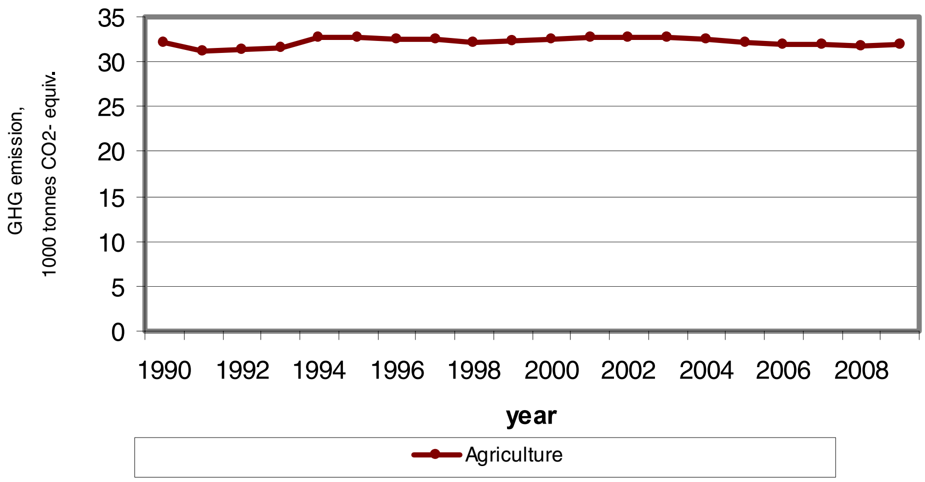


Figure 16 GHG emissions in CO_2 equivalents, Agriculture sector, 1990-2009

CH_4 emission from Enteric Fermentation (CRF Sector 4A)

To be completed in the next submission.

CH_4 and N_2O emission from Manure Management (CRF Sector 4B)

Figure 17 shows N_2O emissions from manure management on the Faroe Islands.

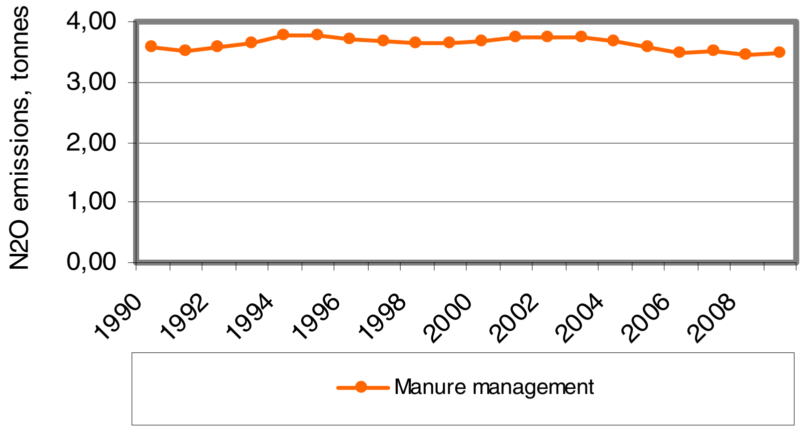


Figure 17 N_2O emission from Manure management, time-series 1990-2009.

N_2O emission from Agricultural Soils (CRF Sector 4D)

The emission from sheep and cows grazing on agricultural soil is 44 tonnes N_2O per year. This corresponds to 13,700 tonnes of CO_2 equivalents. Figure 18 shows the N_2O emissions from agricultural soil. Since the number of sheep is constant over time, the emissions are also constant.

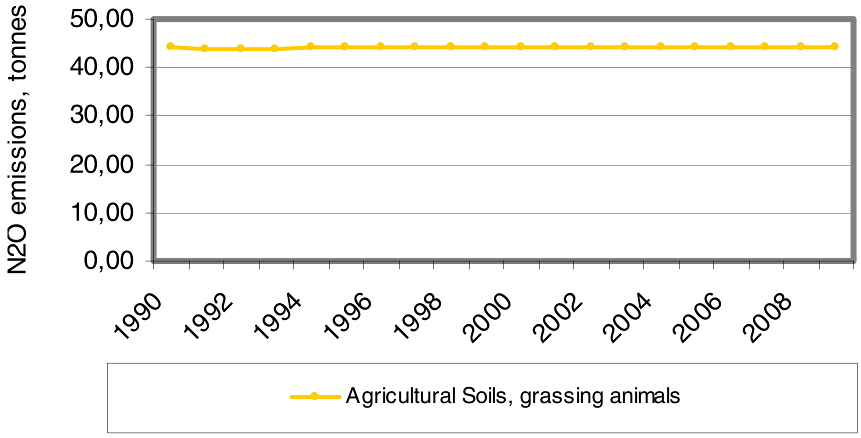


Figure 18 N_2O emissions (tonnes) from Agricultural Soils, grazing animals, time-series 1990-2009.

NMVOC emission

The emission of NMVOC is not calculated.

Uncertainties

The uncertainties have not been calculated.

Recalculation

No recalculations were made in the Agriculture sector.

Planned improvements

Include emissions from animal categories other than cattle and sheep.

Land Use, Land Use Change and Forestry (CRF Sector 5)

No emissions are calculated for land use, land-use change and forestry.

Waste Sector (CRF Sector 6)

Overview of the Waste sector

Only emissions from waste incineration have been calculated. The emissions have been allocated to the energy sector in accordance with the IPCC Guidelines.

Solid Waste Disposal on Land (CRF Source Category 6A)

A number of land-based solid waste disposals facilities are located on the Faroe Islands. The GHG emissions from these depots have not been calculated.

Wastewater Handling (CRF Source Category 6B)

In the Faroe Islands, most households have a septic tank. Industrial wastewater, e.g., from the fishing industry, is treated mechanically. Only one wastewater handling plant is treating the water chemically and biologically.

GHG emissions from wastewater handling are not calculated.

Waste Incineration (CRF Source Category 6C)

There are two waste incineration plants on the Faroe Islands, one in Hoyvík and one in Leirvík. Both plants are considered energy recovery operations and therefore the emissions have been allocated to the energy sector in accordance with the IPCC Guidelines.

Figure 19 shows the amounts of waste incinerated on the Faroe Islands 1990-2009.

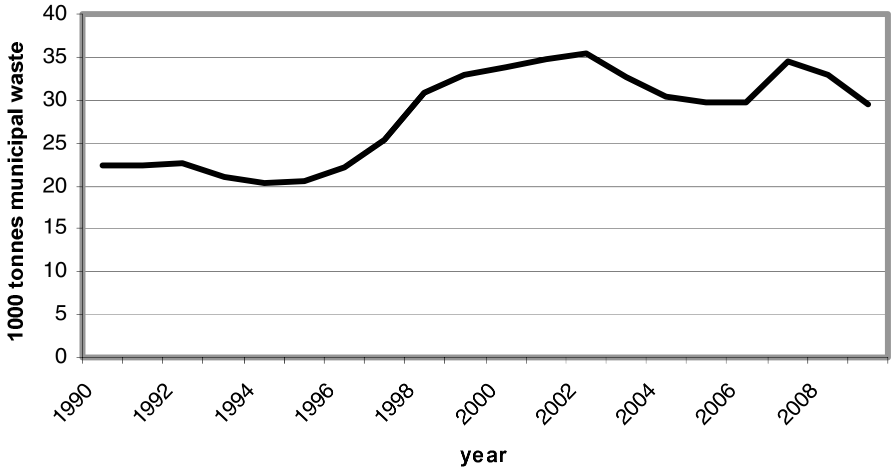


Figure 19 Incineration of municipal waste on the Faroe Islands, 1990-2009.

Emission from waste incineration has been included under sector 1A1a.

Waste Other (CRF Source Category 6D)

There are no activities and emissions in Waste Other.

Other (CRF sector 7)

In CRF sector 7, there are no activities and emissions or removals for the inventory of the Faroe Islands.

Recalculations and improvements

Since the 2011 submission is the second submission in which the Faroe Islands has submitted the data in the CRF format, the 2011 submission is the first submission with recalculations.

Explanations and justifications for recalculations

The following recalculations and improvements to the emission inventories have been made since the emission reporting in 2009.

Energy

Road transport

All recalculations for road transport are due to use of new updated emission factors (delivered by NERI). Since fuel with biofuel has not been sold in the Faroe Islands (unlike in Denmark) the emission factor for CO_2 was corrected to 73 and 74 kg per KJ for diesel (2008) and gasoline (2006-2008), respectively.

Water-born navigation

Emissions from fuel sold to non-domestic passenger liners “cruise ships”, and to non-domestic cargo ships have by mistake been reported as water-born navigation. The error is for the whole time-series, 1990-2008. In the 2009 submission these emissions are reported as International bunkering. Note that the recalculation was only done for the years 2001-2008. In next submission the recalculation will be done for 1990-2000.

International bunkering

Emissions from passenger liners and cargo ships have been included in the emissions for International bunkering, see text above (water-born navigation).

In addition, fuel bunkered by foreign water-born navigation vessels and fuel sold by the Faroese oil companies, but bunkered outside the Faroe Islands have now been included in the emissions for International bunkering. These data have not been reported before.

Implications for emission levels

The recalculations imply decreased emissions in water-born navigation and increased emission in International bunkering.

Implications for emission trends, including time-series consistency

The time-series for Water-born navigation and for International bunkering are inconsistent over time, since the recalculations were only done for 2001-2009. Emissions 1990-2000 are not comparable with emissions 2001-2009. In the next submission these time-series will be corrected and consistent.

Recalculations. Including those in response to the review process, and planned improvements to the inventory (e.g. institutional arrangements. inventory preparations)

This will be completed in the 2012 submission.

Annexes

Annex 1 The trend tables 1990-2009 for CO_2, CH_4, N_2O, F-gases and CO_2 equivalents (CRF Table 10)

TABLE 10 EMISSION TRENDS

CO_2

Inventory 2009

Submission 2011 v1.1

FAROE ISLANDS

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
1. Energy	**665,54**	**646,40**	**636,60**	**526,81**	**531,73**	**538,08**	**558,38**	**553,92**	**597,11**	**638,84**
A. Fuel Combustion (Sectoral Approach)	665,54	646,40	636,60	526,81	531,73	538,08	558,38	553,92	597,11	638,84
1. Energy Industries	94,77	91,29	91,16	84,66	80,58	78,00	92,80	86,69	97,18	99,16
2. Manufacturing Industries and Construction	61,86	73,18	43,32	39,27	38,35	31,89	37,91	37,70	53,97	52,54
3. Transport	105,12	103,34	114,48	99,53	90,86	97,89	93,15	102,43	95,69	110,34
4. Other Sectors	403,79	378,59	387,64	303,34	321,93	330,30	334,52	327,09	350,26	376,80
5. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Fugitive Emissions from Fuels	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
1. Solid Fuels	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
2. Oil and Natural Gas	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
2. Industrial Processes	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**
A. Mineral Products	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
B. Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal Production	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
D. Other Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E. Production of Halocarbons and SF_6										
F. Consumption of Halocarbons and SF_6										
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
4. Agriculture										
A. Enteric Fermentation										
B. Manure Management										
C. Rice Cultivation										
D. Agricultural Soils										
E. Prescribed Burning of Savannas										
F. Field Burning of Agricultural Residues										
G. Other										
5. Land Use, Land-Use Change and Forestry[(2)]	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**
A. Forest Land	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
B. Cropland	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
C. Grassland	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
D. Wetlands	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
E. Settlements	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
F. Other Land	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6. Waste	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**
A. Solid Waste Disposal on Land	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
B. Waste-water Handling										
C. Waste Incineration	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Total CO_2 emissions including net CO_2 from LULUCF	**665,54**	**646,40**	**636,60**	**526,81**	**531,73**	**538,08**	**558,38**	**553,92**	**597,11**	**638,84**
Total CO_2 emissions excluding net CO_2 from LULUCF	**665,54**	**646,40**	**636,60**	**526,81**	**531,73**	**538,08**	**558,38**	**553,92**	**597,11**	**638,84**
Memo Items:										
International Bunkers	**NA,NE,NO**	**0,13**	**105,34**	**142,73**	**140,14**	**131,72**	**142,31**	**138,26**	**112,50**	**121,93**
Aviation	NO	0,13	0,13	0,13	0,13	0,13	0,29	0,29	0,44	0,59
Marine	NA,NE,NO	NA,NE,NO	105,21	142,60	140,01	131,59	142,02	137,96	112,06	121,34
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 Emissions from Biomass	15,90	15,92	17,18	16,41	15,83	16,65	18,46	21,21	25,71	27,56

TABLE 10 EMISSION TRENDS

CO_2

Inventory 2009

Submission 2011 v1.1

FAROE ISLANDS

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
1. Energy	**662,74**	**713,76**	**702,94**	**713,91**	**719,57**	**705,46**	**714,13**	**733,65**	**687,37**	**626,14**
A. Fuel Combustion (Sectoral Approach)	662,74	713,76	702,94	713,91	719,57	705,46	714,13	733,65	687,37	626,14
1. Energy Industries	117,66	161,67	125,13	131,86	121,36	110,85	120,70	127,14	135,19	129,50
2. Manufacturing Industries and Construction	59,30	66,66	67,57	78,02	73,31	65,26	59,68	60,64	55,75	42,92
3. Transport	99,17	86,25	92,62	90,72	95,62	101,69	108,38	124,66	132,48	127,87
4. Other Sectors	386,60	399,18	417,61	413,30	429,28	427,67	425,37	421,21	363,96	325,86
5. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Fugitive Emissions from Fuels	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
1. Solid Fuels	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
2. Oil and Natural Gas	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
2. Industrial Processes	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**
A. Mineral Products	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
B. Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal Production	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
D. Other Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
E. Production of Halocarbons and SF_6										
F. Consumption of Halocarbons and SF_6										
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
4. Agriculture										
A. Enteric Fermentation										
B. Manure Management										
C. Rice Cultivation										
D. Agricultural Soils										
E. Prescribed Burning of Savannas										
F. Field Burning of Agricultural Residues										
G. Other										
5. Land Use, Land-Use Change and Forestry(2)	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**
A. Forest Land	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
B. Cropland	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
C. Grassland	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
D. Wetlands	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
E. Settlements	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
F. Other Land	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6. Waste	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**
A. Solid Waste Disposal on Land	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
B. Waste-water Handling										
C. Waste Incineration	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Total CO_2 emissions including net CO_2 from LULUCF	**662,74**	**713,76**	**702,94**	**713,91**	**719,57**	**705,46**	**714,13**	**733,65**	**687,37**	**626,14**
Total CO_2 emissions excluding net CO_2 from LULUCF	**662,74**	**713,76**	**702,94**	**713,91**	**719,57**	**705,46**	**714,13**	**733,65**	**687,37**	**626,14**
Memo Items:										
International Bunkers	**136,46**	**255,54**	**161,53**	**145,22**	**150,64**	**152,39**	**92,37**	**93,17**	**70,54**	**60,65**
Aviation	0,88	1,48	1,15	1,25	1,15	1,21	1,29	1,05	1,00	0,75
Marine	135,59	254,06	160,38	143,97	149,49	151,19	91,09	92,12	69,54	59,91
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 Emissions from Biomass	28,18	28,99	29,53	27,24	25,48	24,88	24,86	28,86	27,51	24,74

TABLE 10 EMISSION TRENDS
CH_4

Inventory 2009
Submission 2011 v1.1
FAROE ISLANDS

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
1. Energy	0,05	0,04	0,04	0,04	0,04	0,05	0,05	0,05	0,05	0,14
A. Fuel Combustion (Sectoral Approach)	0,05	0,04	0,04	0,04	0,04	0,05	0,05	0,05	0,05	0,14
1. Energy Industries	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
2. Manufacturing Industries and Construction	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
3. Transport	0,04	0,04	0,04	0,04	0,04	0,04	0,04	0,05	0,05	0,13
4. Other Sectors	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
5. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Fugitive Emissions from Fuels	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
1. Solid Fuels	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
2. Oil and Natural Gas	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
2. Industrial Processes	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**
A. Mineral Products	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
B. Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal Production	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
D. Other Production										
E. Production of Halocarbons and SF_6										
F. Consumption of Halocarbons and SF_6										
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use										
4. Agriculture	**0,82**	**0,79**	**0,80**	**0,80**	**0,84**	**0,84**	**0,84**	**0,84**	**0,83**	**0,83**
A. Enteric Fermentation	0,78	0,76	0,76	0,77	0,81	0,81	0,80	0,80	0,79	0,79
B. Manure Management	0,04	0,03	0,03	0,03	0,04	0,04	0,04	0,04	0,04	0,04
C. Rice Cultivation	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
D. Agricultural Soils	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
E. Prescribed Burning of Savannas	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
F. Field Burning of Agricultural Residues	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Land Use, Land-Use Change and Forestry	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**
A. Forest Land	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
B. Cropland	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
C. Grassland	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
D. Wetlands	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
E. Settlements	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
F. Other Land	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6. Waste	**E,NA,NE,NO**	**E,NA,NE,NO**	**E,NA,NE,NO**	**E,NA,NE,NO**	**E,NA,NE,NO**	**E,NA,NE,NO**	**E,NA,NE,NO**	**E,NA,NE,NO**	**E,NA,NE,NO**	**E,NA,NE,NO**
A. Solid Waste Disposal on Land	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
B. Waste-water Handling	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
C. Waste Incineration	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA
D. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Total CH_4 emissions including CH_4 from LULUCF	**0,87**	**0,83**	**0,84**	**0,84**	**0,89**	**0,89**	**0,89**	**0,89**	**0,88**	**0,97**
Total CH_4 emissions excluding CH_4 from LULUCF	**0,87**	**0,83**	**0,84**	**0,84**	**0,89**	**0,89**	**0,89**	**0,89**	**0,88**	**0,97**
Memo Items:										
International Bunkers	NA,NE,NO	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,01
Aviation	NO	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Marine	NA,NE,NO	NA,NE,NO	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 Emissions from Biomass										

TABLE 10 EMISSION TRENDS
CH_4

Inventory 2009
Submission 2011 v1.1
FAROE ISLANDS

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
1. Energy	0,05	0,06	0,06	0,06	0,07	0,13	0,12	0,11	0,11	0,09
A. Fuel Combustion (Sectoral Approach)	0,05	0,06	0,06	0,06	0,07	0,13	0,12	0,11	0,11	0,09
1. Energy Industries	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
2. Manufacturing Industries and Construction	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
3. Transport	0,05	0,05	0,06	0,05	0,07	0,12	0,11	0,11	0,11	0,09
4. Other Sectors	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
5. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Fugitive Emissions from Fuels	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
1. Solid Fuels	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
2. Oil and Natural Gas	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
2. Industrial Processes	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**
A. Mineral Products	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
B. Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal Production	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
D. Other Production										
E. Production of Halocarbons and SF_6										
F. Consumption of Halocarbons and SF_6										
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use										
4. Agriculture	**0,84**	**0,84**	**0,85**	**0,85**	**0,84**	**0,82**	**0,81**	**0,82**	**0,81**	**0,81**
A. Enteric Fermentation	0,80	0,81	0,81	0,81	0,80	0,79	0,78	0,78	0,77	0,78
B. Manure Management	0,04	0,04	0,04	0,04	0,04	0,04	0,03	0,04	0,03	0,03
C. Rice Cultivation	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
D. Agricultural Soils	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
E. Prescribed Burning of Savannas	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
F. Field Burning of Agricultural Residues	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Land Use, Land-Use Change and Forestry	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**
A. Forest Land	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
B. Cropland	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
C. Grassland	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
D. Wetlands	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
E. Settlements	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
F. Other Land	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6. Waste	**E,NA,NE,NO**	**E,NA,NE,NO**	**E,NA,NE,NO**	**E,NA,NE,NO**	**E,NA,NE,NO**	**E,NA,NE,NO**	**E,NA,NE,NO**	**E,NA,NE,NO**	**E,NA,NE,NO**	**E,NA,NE,NO**
A. Solid Waste Disposal on Land	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
B. Waste-water Handling	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
C. Waste Incineration	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA
D. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Total CH_4 emissions including CH_4 from LULUCF	**0,89**	**0,90**	**0,91**	**0,91**	**0,91**	**0,95**	**0,94**	**0,93**	**0,92**	**0,91**
Total CH_4 emissions excluding CH_4 from LULUCF	**0,89**	**0,90**	**0,91**	**0,91**	**0,91**	**0,95**	**0,94**	**0,93**	**0,92**	**0,91**
Memo Items:										
International Bunkers	0,01	0,02	0,01	0,01	0,01	0,02	0,01	0,01	0,01	0,01
Aviation	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01
Marine	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 Emissions from Biomass										

TABLE 10 EMISSION TRENDS

N_2O

Inventory 2009

Submission 2011 v1.1

FAROE ISLANDS

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
1. Energy	**0,02**	**0,02**	**0,02**	**0,02**	**0,02**	**0,02**	**0,02**	**0,02**	**0,02**	**0,02**
A. Fuel Combustion (Sectoral Approach)	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02
1. Energy Industries	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
2. Manufacturing Industries and Construction	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
3. Transport	0,00	0,00	0,01	0,00	0,00	0,00	0,00	0,01	0,00	0,00
4. Other Sectors	0,02	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01
5. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Fugitive Emissions from Fuels	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
1. Solid Fuels	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
2. Oil and Natural Gas	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
2. Industrial Processes	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**
A. Mineral Products	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
B. Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D. Other Production										
E. Production of Halocarbons and SF_6										
F. Consumption of Halocarbons and SF_6										
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
4. Agriculture	**0,05**	**0,05**	**0,05**	**0,05**	**0,05**	**0,05**	**0,05**	**0,05**	**0,05**	**0,05**
A. Enteric Fermentation										
B. Manure Management	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
C. Rice Cultivation										
D. Agricultural Soils	0,04	0,04	0,04	0,04	0,04	0,04	0,04	0,04	0,04	0,04
E. Prescribed Burning of Savannas	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
F. Field Burning of Agricultural Residues	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Land Use, Land-Use Change and Forestry	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**
A. Forest Land	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
B. Cropland	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
C. Grassland	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
D. Wetlands	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
E. Settlements	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
F. Other Land	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6. Waste	**IE,NA,NE**	**IE,NA,NE**	**IE,NA,NE**	**IE,NA,NE**	**IE,NA,NE**	**IE,NA,NE**	**IE,NA,NE**	**IE,NA,NE**	**IE,NA,NE**	**IE,NA,NE**
A. Solid Waste Disposal on Land										
B. Waste-water Handling	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
C. Waste Incineration	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA
D. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Total N_2O emissions including N_2O from LULUCF	**0,07**	**0,07**	**0,07**	**0,07**	**0,07**	**0,07**	**0,07**	**0,07**	**0,07**	**0,07**
Total N_2O emissions excluding N_2O from LULUCF	**0,07**	**0,07**	**0,07**	**0,07**	**0,07**	**0,07**	**0,07**	**0,07**	**0,07**	**0,07**
Memo Items:										
International Bunkers	**NA,NE,NO**	**0,00**	**0,01**	**0,01**	**0,01**	**0,01**	**0,01**	**0,01**	**0,01**	**0,01**
Aviation	NO	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Marine	NA,NE,NO	NA,NE,NO	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 Emissions from Biomass										

TABLE 10 EMISSION TRENDS
N_2O

Inventory 2009
Submission 2011 v1.1
FAROE ISLANDS

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
1. Energy	**0,02**	**0,02**	**0,02**	**0,03**	**0,03**	**0,03**	**0,03**	**0,03**	**0,02**	**0,02**
A. Fuel Combustion (Sectoral Approach)	0,02	0,02	0,02	0,03	0,03	0,03	0,03	0,03	0,02	0,02
1. Energy Industries	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
2. Manufacturing Industries and Construction	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
3. Transport	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,00
4. Other Sectors	0,01	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,01	0,01
5. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B. Fugitive Emissions from Fuels	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
1. Solid Fuels	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
2. Oil and Natural Gas	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
2. Industrial Processes	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**
A. Mineral Products	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
B. Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
D. Other Production										
E. Production of Halocarbons and SF_6										
F. Consumption of Halocarbons and SF_6										
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3. Solvent and Other Product Use	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
4. Agriculture	**0,05**	**0,05**	**0,05**	**0,05**	**0,05**	**0,05**	**0,05**	**0,05**	**0,05**	**0,05**
A. Enteric Fermentation										
B. Manure Management	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
C. Rice Cultivation										
D. Agricultural Soils	0,04	0,04	0,04	0,04	0,04	0,04	0,04	0,04	0,04	0,04
E. Prescribed Burning of Savannas	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
F. Field Burning of Agricultural Residues	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5. Land Use, Land-Use Change and Forestry	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**	**NA,NE**
A. Forest Land	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
B. Cropland	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
C. Grassland	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
D. Wetlands	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
E. Settlements	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
F. Other Land	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6. Waste	**IE,NA,NE**	**IE,NA,NE**	**IE,NA,NE**	**IE,NA,NE**	**IE,NA,NE**	**IE,NA,NE**	**IE,NA,NE**	**IE,NA,NE**	**IE,NA,NE**	**IE,NA,NE**
A. Solid Waste Disposal on Land										
B. Waste-water Handling	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
C. Waste Incineration	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA
D. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Total N_2O emissions including N_2O from LULUCF	**0,07**	**0,07**	**0,07**	**0,07**	**0,07**	**0,07**	**0,07**	**0,07**	**0,07**	**0,07**
Total N_2O emissions excluding N_2O from LULUCF	**0,07**	**0,07**	**0,07**	**0,07**	**0,07**	**0,07**	**0,07**	**0,07**	**0,07**	**0,07**
Memo Items:										
International Bunkers	**0,01**	**0,02**	**0,01**	**0,01**	**0,01**	**0,01**	**0,01**	**0,01**	**0,00**	**0,00**
Aviation	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Marine	0,01	0,02	0,01	0,01	0,01	0,01	0,01	0,01	0,00	0,00
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CO_2 Emissions from Biomass										

TABLE 10 EMISSION TRENDS
HFCs, PFCs and SF_6

Inventory 2009

Submission 2011 v1.1

FAROE ISLANDS

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
Emissions of HFCs[(3)] - (Gg CO_2 equivalent)	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**0,02**	**0,02**	**0,06**	**0,66**	**1,22**	**3,29**
HFC-23	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
HFC-32	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	0,00	0,00	0,00	0,00
HFC-41	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
HFC-43-10mee	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
HFC-125	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	0,00	0,00	0,00	0,00
HFC-134	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
HFC-134a	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	0,00	0,00	0,00	0,00	0,00	0,00
HFC-152a	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
HFC-143	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
HFC-143a	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	0,00	0,00	0,00	0,00
HFC-227ea	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
HFC-236fa	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
HFC-245ca	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
Unspecified mix of listed HFCs[(4)] - (Gg CO_2 equivalent)	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
Emissions of PFCs[(3)] - (Gg CO_2 equivalent)	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**
CF_4	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
C_2F_6	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
C_3F_8	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
C_4F_{10}	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
$c-C_4F_8$	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
C_5F_{12}	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
C_6F_{14}	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
Unspecified mix of listed PFCs[(4)] - (Gg CO_2 equivalent)	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
Emissions of SF6[(3)] - (Gg CO_2 equivalent)	**NA,NE,NO**	**NA,NE,NO**	**0,12**	**0,13**	**0,14**	**0,15**	**0,17**	**0,18**	**0,19**	**0,09**
SF_6	NA,NE,NO	NA,NE,NO	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

TABLE 10 EMISSION TRENDS
HFCs, PFCs and SF_6

Inventory 2009

Submission 2011 v1.1

FAROE ISLANDS

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)	(Gg)
Emissions of HFCs[(3)] - (Gg CO_2 equivalent)	**4,35**	**6,93**	**8,69**	**10,21**	**11,40**	**11,20**	**11,66**	**12,09**	**12,40**	**11,12**
HFC-23	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
HFC-32	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
HFC-41	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
HFC-43-10mee	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
HFC-125	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
HFC-134	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
HFC-134a	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
HFC-152a	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
HFC-143	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
HFC-143a	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
HFC-227ea	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
HFC-236fa	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
HFC-245ca	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
Unspecified mix of listed HFCs[(4)] - (Gg CO_2 equivalent)	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
Emissions of PFCs[(3)] - (Gg CO_2 equivalent)	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**
CF_4	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
C_2F_6	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
C_3F_8	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
C_4F_{10}	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
$c\text{-}C_4F_8$	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
C_5F_{12}	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
C_6F_{14}	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
Unspecified mix of listed PFCs[(4)] - (Gg CO_2 equivalent)	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
Emissions of SF6[(3)] - (Gg CO_2 equivalent)	**0,08**	**0,08**	**0,09**	**0,08**	**0,19**	**0,15**	**0,14**	**0,13**	**0,16**	**0,21**
SF_6	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

TABLE 10 EMISSION TRENDS
SUMMARY

Inventory 2009
Submission 2011 v1.1
FAROE ISLANDS

GREENHOUSE GAS EMISSIONS	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)									
CO_2 emissions including net CO_2 from LULUCF	665,54	646,40	636,60	526,81	531,73	538,08	558,38	553,92	597,11	638,84
CO_2 emissions excluding net CO_2 from LULUCF	665,54	646,40	636,60	526,81	531,73	538,08	558,38	553,92	597,11	638,84
CH_4 emissions including CH_4 from LULUCF	18,21	17,47	17,63	17,72	18,62	18,72	18,63	18,65	18,52	20,28
CH_4 emissions excluding CH_4 from LULUCF	18,21	17,47	17,63	17,72	18,62	18,72	18,63	18,65	18,52	20,28
N_2O emissions including N_2O from LULUCF	22,22	21,61	21,84	20,47	20,82	20,99	21,07	21,12	21,61	21,91
N_2O emissions excluding N_2O from LULUCF	22,22	21,61	21,84	20,47	20,82	20,99	21,07	21,12	21,61	21,91
HFCs	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	0,02	0,02	0,06	0,66	1,22	3,29
PFCs	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
SF_6	NA,NE,NO	NA,NE,NO	0,12	0,13	0,14	0,15	0,17	0,18	0,19	0,09
Total (including LULUCF)	**705,97**	**685,48**	**676,18**	**565,13**	**571,32**	**577,97**	**598,30**	**594,53**	**638,65**	**684,40**
Total (excluding LULUCF)	**705,97**	**685,48**	**676,18**	**565,13**	**571,32**	**577,97**	**598,30**	**594,53**	**638,65**	**684,40**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)									
1. Energy	673,94	654,32	644,70	533,49	538,55	545,17	565,63	561,26	605,01	648,74
2. Industrial Processes	NA,NE,NO	NA,NE,NO	0,12	0,13	0,16	0,18	0,22	0,83	1,41	3,38
3. Solvent and Other Product Use	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
4. Agriculture	32,04	31,16	31,36	31,51	32,61	32,62	32,45	32,44	32,22	32,28
5. Land Use, Land-Use Change and Forestry(5)	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
6. Waste	E,NA,NE,NO	E,NA,NE,NO	E,NA,NE,NO	E,NA,NE,NO	E,NA,NE,NO	E,NA,NE,NO	E,NA,NE,NO	E,NA,NE,NO	E,NA,NE,NO	E,NA,NE,NO
7. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (including LULUCF)(5)	**705,97**	**685,48**	**676,18**	**565,13**	**571,32**	**577,97**	**598,30**	**594,53**	**638,65**	**684,40**

TABLE 10 EMISSION TRENDS Inventory 2009

SUMMARY Submission 2011 v1.1

FAROE ISLANDS

GREENHOUSE GAS EMISSIONS	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	CO_2 equivalent (Gg)									
CO_2 emissions including net CO_2 from LULUCF	662,74	713,76	702,94	713,91	719,57	705,46	714,13	733,65	687,37	626,14
CO_2 emissions excluding net CO_2 from LULUCF	662,74	713,76	702,94	713,91	719,57	705,46	714,13	733,65	687,37	626,14
CH_4 emissions including CH_4 from LULUCF	18,71	18,98	19,11	19,04	19,21	19,97	19,66	19,57	19,33	19,07
CH_4 emissions excluding CH_4 from LULUCF	18,71	18,98	19,11	19,04	19,21	19,97	19,66	19,57	19,33	19,07
N_2O emissions including N_2O from LULUCF	22,10	22,31	22,57	22,81	22,90	22,67	22,79	22,81	21,53	20,36
N_2O emissions excluding N_2O from LULUCF	22,10	22,31	22,57	22,81	22,90	22,67	22,79	22,81	21,53	20,36
HFCs	4,35	6,93	8,69	10,21	11,40	11,20	11,66	12,09	12,40	11,12
PFCs	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
SF_6	0,08	0,08	0,09	0,08	0,19	0,15	0,14	0,13	0,16	0,21
Total (including LULUCF)	**707,97**	**762,06**	**753,39**	**766,04**	**773,27**	**759,45**	**768,37**	**788,25**	**740,80**	**676,90**
Total (excluding LULUCF)	**707,97**	**762,06**	**753,39**	**766,04**	**773,27**	**759,45**	**768,37**	**788,25**	**740,80**	**676,90**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	CO_2 equivalent (Gg)									
1. Energy	671,09	722,41	711,93	723,09	729,16	715,96	724,67	744,07	696,53	633,69
2. Industrial Processes	4,43	7,01	8,78	10,29	11,59	11,36	11,80	12,22	12,56	11,33
3. Solvent and Other Product Use	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
4. Agriculture	32,45	32,64	32,68	32,66	32,53	32,14	31,90	31,96	31,71	31,88
5. Land Use, Land-Use Change and Forestry[(5)]	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
6. Waste	E,NA,NE,NO	E,NA,NE,NO	E,NA,NE,NO	E,NA,NE,NO	E,NA,NE,NO	E,NA,NE,NO	E,NA,NE,NO	E,NA,NE,NO	E,NA,NE,NO	E,NA,NE,NO
7. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total (including LULUCF)[(5)]	**707,97**	**762,06**	**753,39**	**766,04**	**773,27**	**759,45**	**768,37**	**788,25**	**740,80**	**676,90**

NERI **National Environmental Research Institute**
DMU Danmarks Miljøundersøgelser

National Environmental Research Institute, NERI, is a part of Aarhus University.

At NERI's website www.neri.dk you'll find information regarding ongoing research and development projects.

NERI undertakes research, monitoring and consultancy within environment and nature.

Furthermore the website contains a database of publications including scientific articles, reports, conference contributions etc. produced by NERI staff members.

Further information: www.neri.dk

National Environmental Research Institute
Frederiksborgvej 399
PO Box 358
DK-4000 Roskilde
Denmark
Tel: +45 4630 1200
Fax: +45 4630 1114

Management
Department of Arctic Environment
Department of Atmospheric Environment
Department of Environmental Chemistry and Microbiology
Department of Marine Ecology
Department of Policy Analysis

National Environmental Research Institute
Vejlsøvej 25
PO Box 314
DK-8600 Silkeborg
Denmark
Tel: +45 8920 1400
Fax: +45 8920 1414

Department of Freshwater Ecology
Department of Terrestrial Ecology

National Environmental Research Institute
Grenåvej 14, Kalø
DK-8410 Rønde
Denmark
Tel: +45 8920 1700
Fax: +45 8920 1514

Department of Wildlife Ecology and Biodiversity

NERI Technical Reports

NERI's website www.neri.dk contains a list of all published technical reports along with other NERI publications. All recent reports can be downloaded in electronic format (pdf) without charge. Some of the Danish reports include an English summary.

Nr./No. 2011

817 Improving the Greenlandic Greenhouse Gas Inventory.
By Nielsen, O.-K., Baunbæk, L., Gyldenkærne, S., Bruun, H.G., Lyck, E., Thomsen, M., Mikkelsen, M.H., Albrektsen, R., Hoffmann, L., Fauser, P., Winther, M., Nielsen, M., Plejdrup, M.S., Hjelgaard, K. 46 pp.

815 Danmarks biodiversitet 2010 – status, udvikling og trusler.
Af Ejrnæs, R., Wiberg-Larsen, P., Holm, T.E., Josefson, A., Strandberg, B., Nygaard, B., Andersen, L.W., Winding, A., Termansen, M., Hansen, M.D.D., Søndergaard, M., Hansen, A.S., Lundsteen, S., Baattrup-Pedersen, A., Kristensen, E., Krogh, P.H., Simonsen, V., Hasler, B. & Levin, G. 152 s. (også tilgængelig i trykt udgave, DKK 150)

814 Bynaturen i hverdagslivet.
Af Petersen, L.K. & Nielsen, S.S. 80 s.

813 Environmental monitoring at the Seqi olivine mine 2010.
By Søndergaard, J. & Asmund. G. 36 pp.

2010

812 Environmental monitoring at the cryolite mine in Ivittuut, South Greenland, in 2010.
By Johansen, P., Asmund, G., Rigét, F. & Schledermann, H. 34 pp.

811 Environmental monitoring at the Nalunaq Gold Mine, South Greenland, 2010.
By Glahder, C.M., Søndergaard, J., Asmund, G. & Rigét, F. 32 pp.

810 Danish emission inventories for agriculture. Inventories 1985 - 2009.
By Mikkelsen, M.H. Albrektsen, R. & Gyldenkærne, S. 136 pp.

809 Review, improvement and harmonisation of the Nordic particulate matter air emission inventories.
By Nielsen, O.-K., Illerup, J.B., Kindbom, K., Saarinen, K., Aasestad, K., Hallsdottir, B., Winther, M., Sjodin, Å., Makela, K. & Mikkola-Pusa, J. 77 pp.

808 Temporal and spatial variations in the long-term fluctuations of wildlife populations in Greenland.
By Moshøj, C.M., Forchhammer, M. & Aastrup, P. 36 pp.

807 Evaluation of local contamination sources from the former mining operation in Maarmorilik.
By Johansen, P., Asmund, G., Schiedek, D. & Schledermann, H. 44 pp.

806 Vandmiljø og Natur 2009. NOVANA. Tilstand og udvikling – faglig sammenfatning.
Af Nordemann Jensen, P., Boutrup, S., Bijl, L. van der, Svendsen, L.M., Grant, R., Wiberg-Larsen, P., Bjerring, R., Ellermann, T., Petersen, D.L.J., Hjorth, M., Søgaard, B., Thorling, L. & Dahlgren. K. 108 s.

805 Arter 2009. NOVANA.
Af Søgaard, B., Pihl, S., Wind, P., Clausen, P., Andersen, P.N., Bregnballe, T. & Wiberg-Larsen, P. 114 s.

804 Vandløb 2009. NOVANA.
Af Wiberg-Larsen, P., Windolf, J., Baattrup-Pedersen, A.., Bøgestrand, J., Ovesen, N.B., Larsen, S.E., Thodsen, H., Sode, A., Kristensen, E. & Kjeldgaard, A. 98 s.

803 Søer 2009. NOVANA.
Af Bjerring, R. Johansson, L.S., Lauridsen, T.L., Søndergaard, M., Landkildehus, F., Sortkjær, L. & Wiindolf, J. 96 s.

802 Landovervågningsoplande 2009. NOVANA.
Af Grant, R., Blicher-Mathiesen, G., Jensen, P.G., Hansen, B. & Thorling, L. 124 s.

801 Atmosfærisk deposition 2009. NOVANA.
Af Ellermann, T., Andersen, H.V., Bossi, R., Christensen, J., Løfstrøm, P., Monies, C., Grundahl, L. & Geels, C. 95 s.

800 Marine områder 2009. NOVANA. Tilstand og udvikling i miljø- og naturkvaliteten.
Af Petersen, D.L.J. & Hjorth, M. (red.) 127 s.

799 The Danish Air Quality Monitoring Programme. Annual Summary for 2009.
By Ellermann, T., Nordstrøm, C., Brandt, J., Christensen, J., Ketzel, M. & Jensen, S.S. 61 pp.

798 Økologisk risikovurdering af genmodificerede planter i 2009. Rapport over behandlede forsøgsudsætninger og markedsføringssager.
Af Kjellsson, G., Damgaard, C., Strandberg, M., Sørensen, J.G. & Krogh, P.H. 46 s.

DENMARK'S NATIONAL INVENTORY REPORT 2011

Emission Inventories 1990-2009
– Submitted under the United Nations Framework Convention on Climate Change and the Kyoto Protocol

This report is Denmark's National Inventory Report 2011. The report contains information on Denmark's emission inventories for all years' from 1990 to 2009 for CO_2, CH_4, N_2O, HFCs, PFCs and SF_6, NOx, CO, NMVOC, SO_2.

ISBN: 978-87-7073-234-5
ISSN: 1600-0048