ANNUAL DANISH ATMOSPHERIC EMISSIONS INVENTORY

Jytte Boll Illerup
Johnny M. Andersen
Morten Winther
Erik Lyck
Henrik Gundorph Bruun

Department of Policy Analysis

National Environmental Research Institute
Ministry of Environment and Energy
Denmark

February 2001

Introduction

The National Environmental Research Institute (NERI) carries out the Danish atmospheric emissions inventory and reports to EU and international conventions such as the UNECE Convention on Long Range Transboundary Air Pollution (CLRTAP) and the UN Framework Convention on Climate Change (UNFCCC) under the Intergovernmental Panel on Climate Change (IPCC). The two international conventions deal with regional and global air pollution effects and this survey covers the pollutants reported to these conventions. The greenhouse gas emissions are also reported to EU because EU - as well as the nations - is a party to the Climate Convention.

Reported pollutants and deadlines for reporting 1999-emission data:

	Deadline for reporting	Pollutants
UNECE-convention	December 31 2000	SO_2, NO_x, CO_2, CO, NMVOC, CH_4, NH_3, As, Cd, Cr, Cu, Hg, Ni, Pb, Se, Zn, Dioxins, PAH
EU	December 31 2000	CO_2, CH_4, N_2O, SO_2, NO_x, CO, NMVOC HFCs, PFCs, SF_6
UNFCCC	April 15 2001	CO_2, CH_4, N_2O, SO_2, NO_x, CO, NMVOC HFCs, PFCs, SF_6

SO_2 (sulphur dioxide), NO_x (nitrogen oxides), CO_2 (carbon dioxide), CO (carbon monoxide), NMVOC (none-methane volatile organic compounds), CH_4 (methane), N_2O (nitrous oxide), NH_3 (ammonia), As (asenic), Cd (cadmium), Cr (chromium), Cu (copper), Hg (mercury), Ni (nickel), Pb (lead), Se (selenium), Zn (zinc), Dioxins, PAH (polycyclic aromatic hydrocarbons), HFCs (hydrofluorocarbons), PFCs (perfluorocarbons), SF_6 (sulphurhexafluoride).

The official Danish reports to UNECE (1999), EU (1999) and UNFCCC (1998) are available at NERI's homepage

www.dmu.dk

The UNFCCC report for 1999 will be available at the homepage in April 2001.

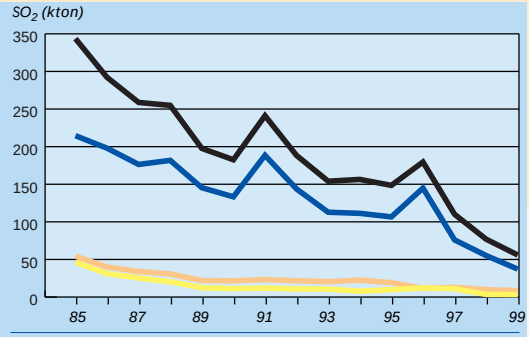
Since the 1998-inventory (Illerup et al., 2000 a) the emission data from some of the pollutants has changed due to recalculation of the emissions from various sectors primarily agriculture, road transport and other mobile sources.

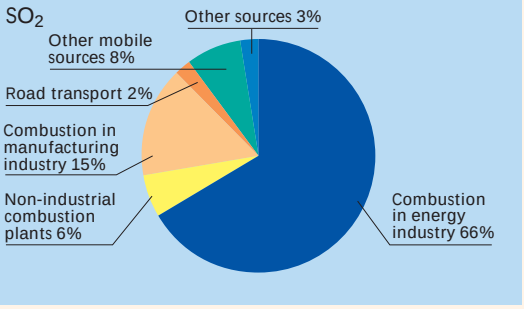
Pollutants

The distribution of emissions on main sectors based on the emissions reported to UNECE for 1999:

	SO_2 ton	NO_x ton	NMVOC ton	CH_4 ton	CO ton	CO_2 kton	N_2O ton	NH_3 ton
Combustion in energy and transformation industry	37145	55964	1699	17682	13325	28237	928	0
Non-industrial combustion plants	3293	6694	7904	9101	130801	5873	184	0
Combustion in manufacturing industry	8536	15169	683	1318	6075	5293	151	0
Production processes	1359	451	5071	45	0	1402	0	0
Extraction and distribution of fossil fuels and geotermel energy	0	0	5539	13404	23799	0	0	0
Solvent and other product use	0	0	38535	0	0	120	0	0
Road transport	1267	69258	46071	3073	269391	11358	1434	2049
Other mobile sources and machinery	4264	57837	20004	560	94826	3836	918	7
Waste treatment and disposal	50	4798	1349	55341	3099	900	16	0
Agriculture	0	0	1191	168314	0	0	19735	93930
Other sources and sinks	0	0	14095	354238	0	-976	7700	0
Total	55912	210171	142143	623076	541316	56042	31066	95986

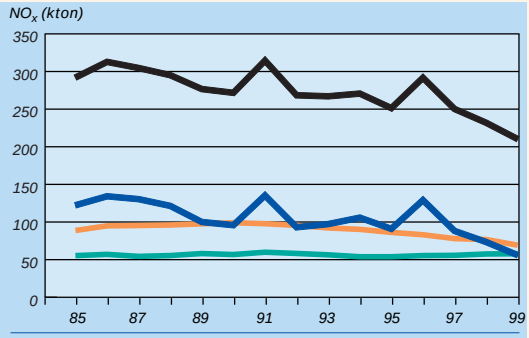
Time series and distribution of emissions on main sectors for 1999 are shown for SO_2, NO_x, CO_2, CO, NMVOC, CH_4, N_2O and NH_3.

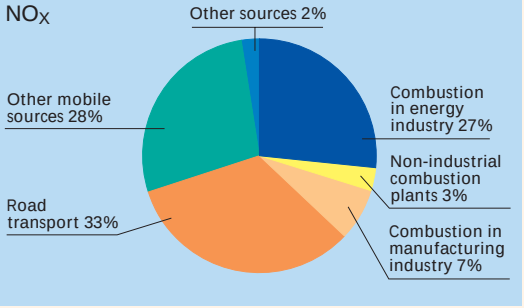




SO_2

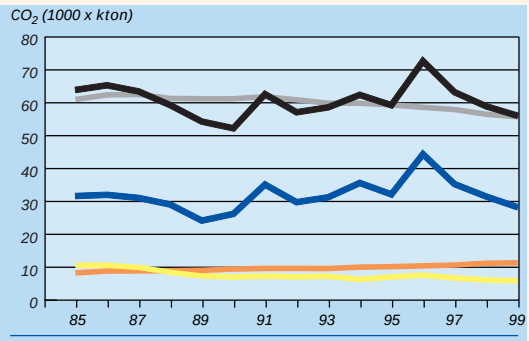
From 1998 to 1999 the SO_2 emission has decreased as much as 27%. This is mainly due to decreased consumption of coal while the use of natural gas and renewable energy has increased. The decrease is also due to continuous installation of desulphurization plants. But similarly to previous years the main part of the SO_2 emission originates from combustion of fossil fuels – mainly coal and oil – on public power plants and district heating plants. The relatively large fluctuations in the emissions are due to cross-country electricity trade. Thus the high emissions in 1991 and 1996 reflect a large electricity export.

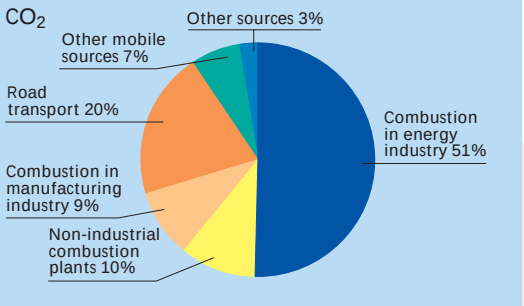




NO_x ($NO + NO_2$)

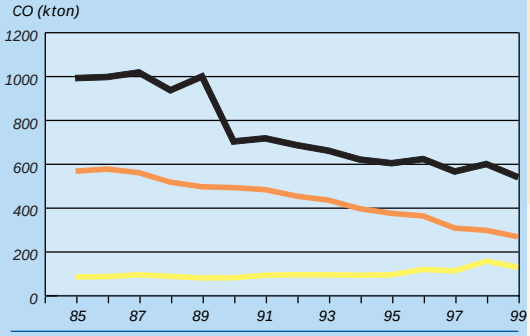
As for the SO_2 emission the NO_x emission has decreased significantly from 1998 to 1999. This is due to reduced emissions from power plants as well as from road transport. Less export of electricity is together with reduced use of coal the reason for a reduction of 24% from the power plants. The drop in the emissions from road transport is caused by increasing use of catalyst converters and other techniques reducing the NO_x emissions. The emissions from road transport have decreased with about 10% despite the fact that the energy consumption has increased.

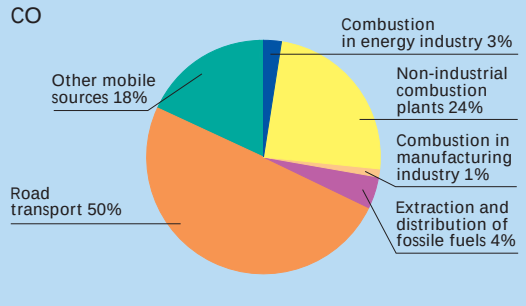




CO_2

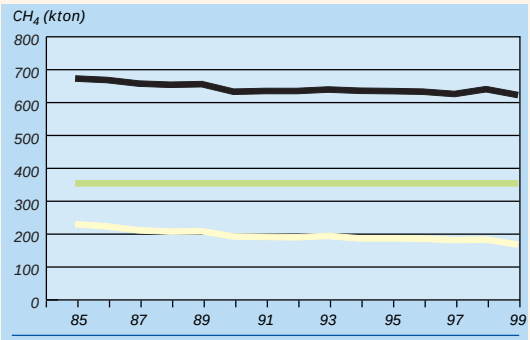
The actual CO_2 emission decreased 5% from 1998 to 1999. This was mainly due to less export of electricity and higher outdoor temperature in 1999 compared to 1998. But also the change of fuel from coal to natural gas and renewable energy has contributed to the lower emission. As a result of the lower consumption of coal in resent years the main part of the CO_2 emission comes from oil combustion.

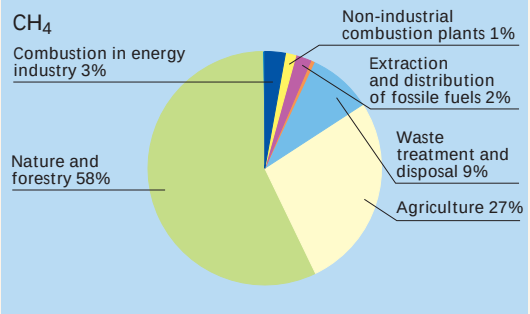




CO

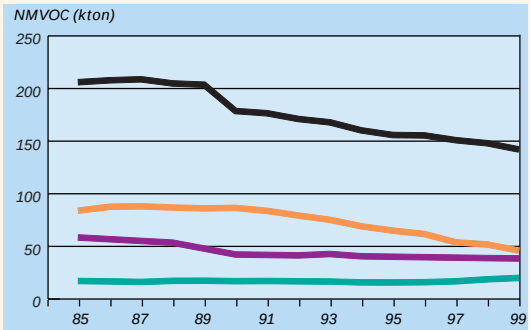
Road transport still has the dominant share of the total CO emission budget, but as seen for the NO_x emission there has been a significant decrease from 1998 to 1999. This is due to increasing use of catalyst converters. Also other mobile sources and non-industrial combustion plants contribute significantly to the total emission of this pollutant.

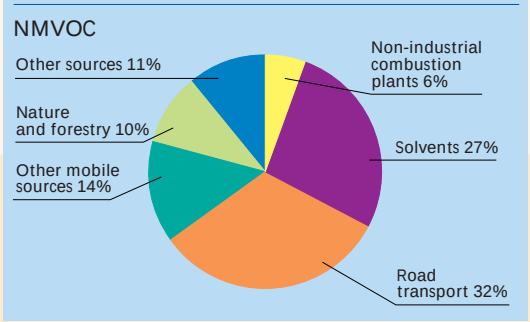




CH_4

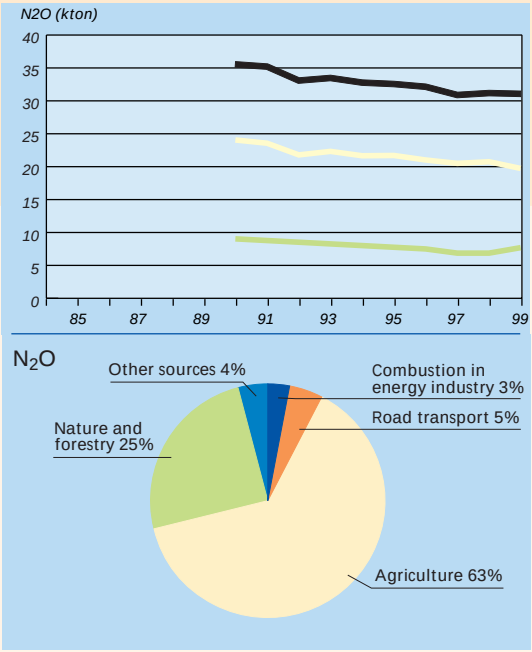
There are two large sources to CH_4 emissions: nature and agriculture. Natural sources contribute with more than half of the emissions and originate mainly from anaerobic processes in wetlands. The emission from agriculture derives from enteric fermentation and management of animal manure. From 1998 to 1999 the number of livestock has decreased resulting in a slight decrease in the emission.





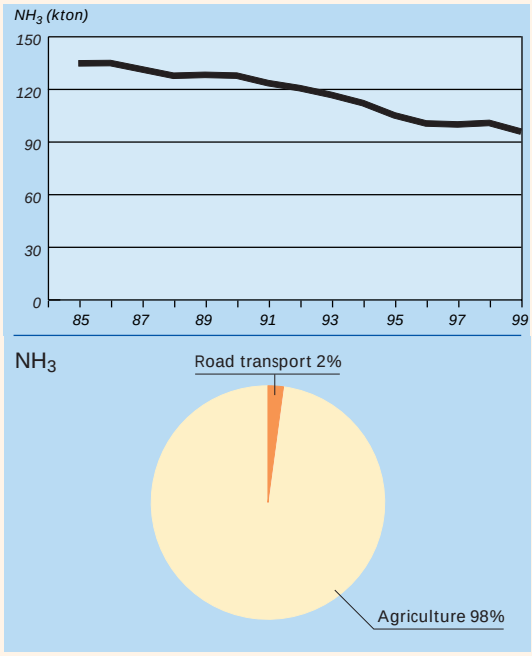
NMVOC

The sources to emissions of NMVOC can be divided into two main types: Incomplete combustion and evaporation. The main sources to NMVOC emissions from incomplete combustion processes are road vehicles and other mobile sources such as sea vessels and off-road machinery. The emissions from road transportation vehicles have decreased with about 5% from 1998 to 1999 while the emissions from other mobile sources has increased with about 7% in the same period. The anthropogenic evaporative emissions mainly come from use of solvents in industries and households.



N_2O

Agriculture is the most important N_2O emission source. N_2O is emitted from agricultural crops and formed in soil from nitrogen in manure and fertilisers. Substantial emissions also come from drainage water and coastal waters where nitrogen is converted to N_2O through bacterial processes. However, the nitrogen in these processes originates mainly from the agricultural use of manure and fertilisers.

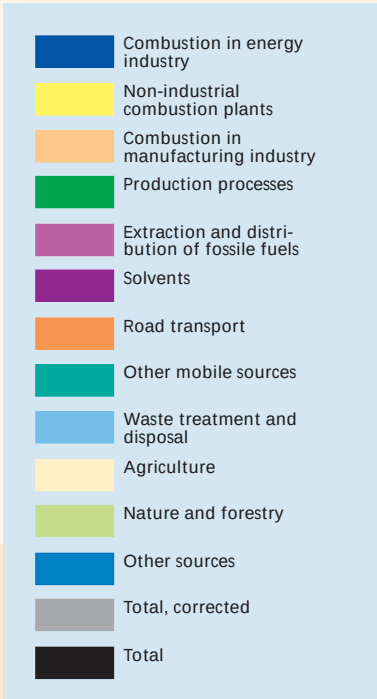


NH_3

Almost all atmospheric emissions of NH_3 result from agricultural activities. Only a minor part originates from road transport. This part is however increasing due to increasing use of catalyst cars. The main part of the emission from agriculture comes from manure (75%). Other contributions come from use of chemical fertilisers (7%), crops (15%) and ammonia used for straw treatment (2%).

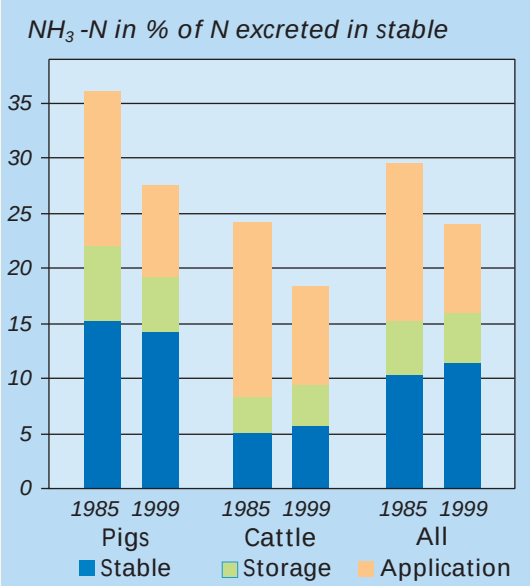
Heavy metals, dioxins and PAHs

The emissions of heavy metals, dioxins and PAHs can be seen at NERI's homepage. The dioxin emissions for 1999 are revised according to a new report from the Danish Environmental Protection Agency (Environmental Project No. 570, 2000).



The ammonia emissions from agricultural activities

The ammonia emission has decreased from 128 kton to 94 kton from 1985 to 1999. The reduction is primarily connected with manure management in spite of increasing animal production in the same period. The main reason for the drop in the emission is due to improved food utilisation resulting in less nitrogen excreted per unit produced. The basis for ammonia emission is then reduced.



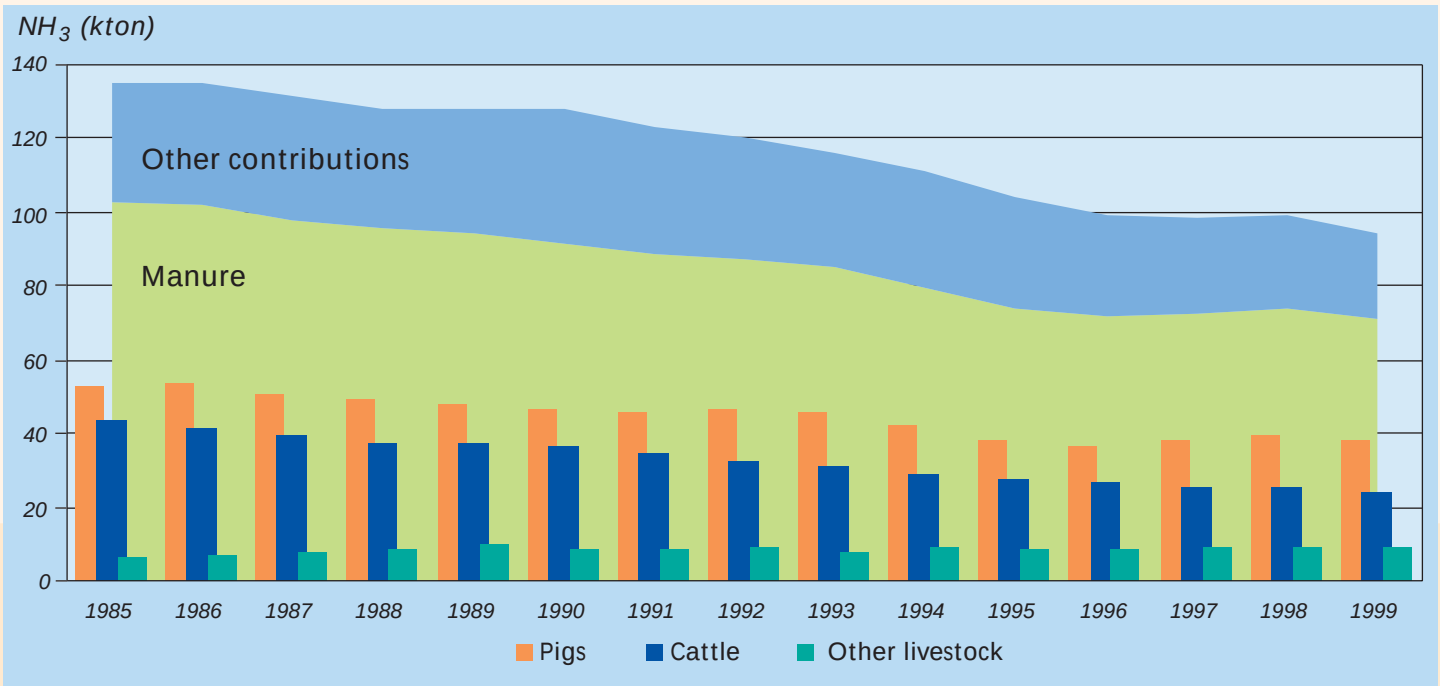
Ammonia emissions from livestock in stable.

At the same time the stable types for cattle and pigs have changed from traditional stables with solid and liquid fraction manure to a slurry system. Furthermore the capacity of storage facilities for manure has increased in the same period. As a consequence an increasing part of the manure has been spread in early spring resulting in less emission.

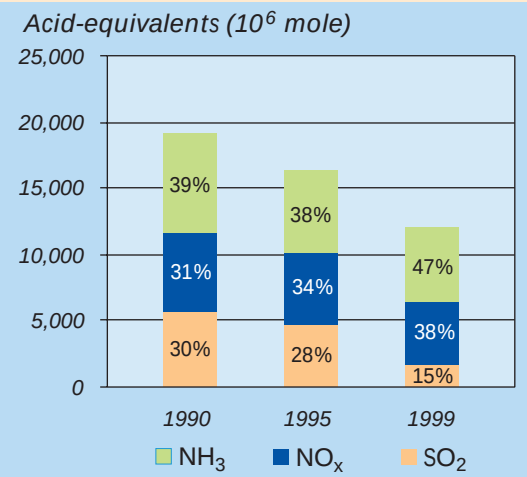
The increasing amount of slurry has made it more attractive to develop new application methods. During the 90's an increasing part of the slurry has been spread with trail hoses instead of broad-spread with the traditional slurry broad-spreader. It mainly means less emission from slurry spread during the summertime. Since the middle of the 90's the use of deep injection has been introduced as well, however, to a more limited extent. The last mentioned method reduces the emission to a few percent of the total nitrogen in spread animal manure.

The emissions from the other sources – use of fertilisers and ammonia to straw treatment – have decreased too. Finally, the agricultural area is reduced, and an area of 200.000 ha has been set aside, meaning a further reduction in the ammonia emission from crops.

Ammonia emissions from agriculture.

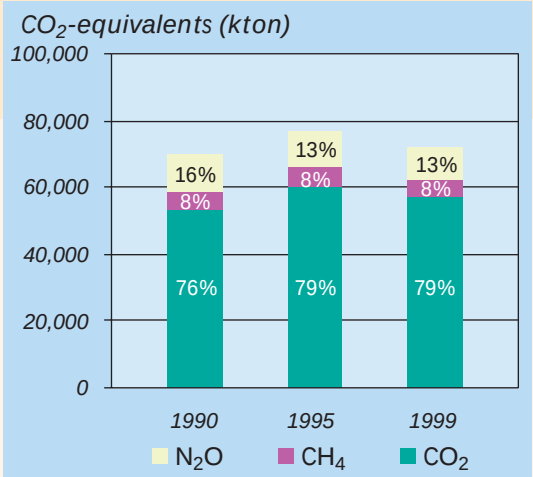


Acidifying gases



Emission of Danish acidifying gases in terms of acid equivalents. The most important acidification factor in Denmark is ammonia nitrogen. The emissions for all the acidifying gases have decreased since 1990, especially the emission of SO_2 has decreased markedly.

Greenhouse gases



Danish greenhouse gas emissions apportioned by type of total anthropogenic emissions in CO_2-equivalents. CO_2 is the most important greenhouse gas followed by N_2O and CH_4. The share from HFCs, PFCs and SF_6 is less than 1%. In contrary to the acidifying gases the reduction has been much less pronounced.

Progress towards targets

The reduction of the emission of pollutants according to existing protocols.

	Pollutants	Base year	Target year	Reduction Target (%)	Reduction in 1999 (%)	Projected reduction in target year (Fenhann, 1999)
UNECE-CLRTAP sulphur protocol	SO_2	1980	2000	80	88	-
UNECE-CLRTAP NO_x protocol	NO_x	1987	1994	0	11 (1994) 31	-
UNECE-CLRTAP VOC protocol	VOC	1985	1999	30	35	-
UNFCCC Kyoto-protocol[1)]	CO_2, N_2O, CH_4, HFC's, PFC's SF_6	1990: CO_2, N_2O, CH_4 1995: HFC's, PFC's, SF_6	2008-2012	21[2)]	5	17

[1)] *EU Burden Sharing Agreement to achieve the EU 8% reduction target under the Kyoto-protocol (not yet ratified).*
[2)] *Based on CO_2 emissions adjusted for import of electricity in 1990.*

The target in the VOC-protocol is a reduction of 30% of the anthropogenic emissions from 1985 to 1999. This target is fulfilled by a reduction of 35%.

In the sulphur protocol under the UNECE-CLRTAP Denmark is obliged to reduce the SO_2 emission by 80% from 1980 to 2000. This target is likely to be met since the reduction was 88% in 1999. The general target in the NO_x protocol is a stabilisation of the NO_x emission at 1987 level in 1994. In this period Denmark achieved a reduction of 11% and in 1999 the reduction was 31%.

If the target in the Kyoto protocol is to be achieved, new actions in order to reduce the greenhouse gas emissions in Denmark are needed.

Literature

Andersen, J.M., Poulsen, H.D., Børsting, C.F., Rom, H.B., Sommer, S.G. og Hutchings, N.J. (2000). Ammoniakemissionen fra landbruget siden midten af 80'erne. Samfund og Miljø. Danmarks Miljøundersøgelser. Arbejdsrapport fra DMU nr. XXX (in prep.) (In Danish).

Andersen, J. M., Sommer, S. G., Hutchings, N. J., Kristensen, V. F. og Poulsen, H. D. (1999): Emission af ammoniak fra landbruget - status og kilder. Rapport fra Danmarks JordbrugsForskning og Danmarks Miljøundersøgelser, 71 pp (In Danish).

Environmental Project No. 570 (2000): Substance Flow Analysis for Dioxins in Denmark. The Danish Environmental Protection Agency, Denmark, 103 pp.

Fenhann, J. (1999): Projections of Emissions of Greenhouse Gases, Ozone Precursors and Sulphur Dioxide from Danish Sources until 2012. Report from the Danish Energy Agency.

Holten-Andersen, J., Christensen, N., Kristiansen, L. W., Kristensen, P and Emborg, L. (Eds.) (1998): The State of the Environment in Denmark, 1997. National Environmental Research Institute, Denmark. Technical Report No. 243, 288 pp.

Houghton, J. T., Meira Filho, L. G., Lim, B., Tréanton, K., Mamaty, I., Bonduki, Y. Griggs, D. J. and Callander, B. A. (Eds) (1997): Greenhouse Gas Inventory Reporting Instructions. Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Vol 1, 2 and 3. The Intergovernmental Panel on Climate Change (IPCC), IPCC WGI Technical Support Unit, United Kingdom.

Illerup, J.B., Geertinger, A., Hoffmann, L. og Christiansen, K., (1999 a): Emissionsfaktorer for tungmetaller 1990 - 1996. Danmarks Miljøundersøgelser. Faglig rapport fra DMU nr. 301, 66 pp (In Danish).

Illerup, J. B., Lyck, E., Winther, M., and Rasmussen, E. (2000 a): Denmark's National Inventory Report – Sub-mitted under the United Nations Framework Convention on Climate Change. Samfund og Miljø – Emission Inventories. Research Notes from National Environmental Research Institute, Denmark no. 127, 326 pp.

Illerup, J. B., Winther, M., Lyck, E. and Bruun, H. G. (2000 b): Annual Danish Atmospheric Emissions Inventory 1998. National Environmental Research Institute, Department of Policy Analysis, September, 8 pp

Illerup, J. B., Winther, M., Lyck, E. og Fenger, J. (1999 b): Hvor kommer luftforureningen fra? - fakta om kilder, stoffer og udvikling. Temarapport fra DMU nr. 29. Danmarks Miljøundersøgelser, Roskilde, 32 pp (In Danish).

Richardson, S. (Ed) (1999): Atmospheric Emission Inventory Guidebook, Joint EMEP/CORINAIR, Second Edition. Vol. 1, 2 and 3. European Environment Agency, Copenhagen, Denmark.

Winther, M. (2001): 1998 Fuel Use and Emissions for Danish IFR Flights. Environmental Project No. xxx. The Danish Environmental Protection Agency, Denmark . Prepared by the National Environmental Research Institute, Denmark, 100 pp.

Winther M., Illerup, J. B., Fenhann, J. and Kilde, N. A. (1999): The Danish CORINAIR Inventories. Timeseries 1975-1996 of Emissions to the Atmosphere. The National Environmental Research Institute, Roskilde, Denmark. Technical Report no. 287, 83 pp.

Contacts

Senior Scientist Jytte Boll Illerup, Senior Scientist Erik Lyck, Scientist Morten Winther, Computer Professional Henrik Gundorph Bruun, Senior Scientist Johnny M. Andersen.

National Environmental Research Institute, Department of Policy Analysis, Frederiksborgvej 399
P.O. Box 358, DK-4000 Roskilde, Denmark, Telehone +45 46 30 12 00, E-mail jbi@dmu.dk

The emission data used for presentation in this survey can be found at the internet address: http://www.dmu.dk

Publisher: *National Environmental Research Institute*
Frederiksborgvej 399, P.O. Box 358, DK-4000 Roskilde
Tel. +45 4630 1200, Fax +45 4630 1114
e-mail: dmu@dmu.dk
Layout and production: *NERI/Graphic Section, Roskilde*
Photos: *BIOFOTO/Lars Gejl og CDanmark*

Printing: *Scanprint as. Certified according to ISO 9002, ISO 14001 and the Nordic Eco-labelling scheme. EMAS (Environmental management) registered.*
Paper: *100% Danish recycled paper, Cyclus Offset. Organic solvent-free vegetable printing dyes.*
Number printed: *500*

NORDISK MILJØMÆRKNING
541 055