Summary

Since 1994 the National Environmental Research Institute (NERI) has made the annual Danish air emission inventories within the frame of the European CORINAIR (CORe Inventory to the AIR) air emission inventory system. In this report the structure of CORINAIR is explained on a 1996 level with respect to pollutants comprised, the categorisation of emission sources in sectors and emission calculation principles.

International conventions to which Denmark submits emission data are also described together with the most important activity data used in the Danish emission inventory. The Danish 1996 emissions are described in sectors and compared with EU per capita levels and in addition the Danish national and international emissions are shown as time series from 1975 to 1996.

The CORINAIR emission inventory system

CORINAIR is the most extensive European air emission inventory programme with a defined emission calculation methodology and software for storing and further data processing. In CORINAIR a total number of 28 different emission species are estimated in 11 main sectors further divided in more detailed second and third levels. The emission sources are regarded as either area or large point sources according to specific CORINAIR definitions.

The CORINAIR calculation principle is to calculate the emissions as activities time emission factors. Activities are numbers referring to a specific process generating emissions, while an emission factor is the mass of emissions per unit activity. Information on activities to carry out the CORINAIR inventory is mainly obtained from official statistics. The most consistent emission factors are used and are either measured values or default factors proposed by the CORINAIR methodology.

For road traffic a special calculation model has been developed within the EU in compliance with the CORINAIR structure. The model calculates the emissions from operationally hot vehicles, the extra emissions during cold start and evaporative emissions. The calculations take into account the composition of the vehicle fleet, the annual mileage driven and the specific emission factors (emissions per driven kilometre) in urban, rural and highway traffic.

At NERI sub-models for estimating the emissions from air traffic and off road machinery have been developed according to the CORINAIR guidelines. In the air traffic model the domestic and international emissions are calculated for landing and take off (LTOs) and cruise. The LTO emissions are the number of LTOs per aircraft type times specific LTO emission factors, and the cruise emissions are calculated as the fuel used for cruise times fuel-related emission factors. To estimate the emissions from off road machinery the stock of different machine types, load factors, engine sizes, annual working hours and emission factors are combined.

Activity data

In Denmark the most important activities to make the CORINAIR emission inventory are fuel consumption, solvent use and livestock in the agricultural sector.

A major part of the Danish emission inventory relates to combustion processes. Activities are the total consumption of solid, liquid and gaseous fuels. Coal, coke, wood, straw and waste are the solid fuel types used in Denmark, with coal as the most frequently used fuel type at the large power plants. Liquid fuels such as motor gasoline and diesel oil are mainly used by the road traffic vehicles and other mobile sources, while orimulsion, LPG, gas oil and residual oil are mostly used to generate power and heat. Natural gas, refinery gas and biogas are used as gaseous fuels.

Solvents generate evaporative emissions with non negligible contributions to the total NMVOC emissions. Activities counted in the Danish inventory are paint application, chemical product manufacturing and processing (such as polystyrene foam processing) and other use of solvents and related activities (such as application of glues and adhesives).

The livestock and its manure is almost solely responsible for the Danish ammonia emissions and also contributes significantly to the total methane emissions load. The annual mean livestock number in different animal categories is used as activity data. To estimate the emissions the different mean livestock numbers are used together with emission factors (grams of emissions per animal per year). The activities are: cattle, pigs, poultry and other animals like horses or ovines.

Emissions

In the Danish 1996 CORINAIR inventory approximately 80, 60 and 45% of the total SO_2, CO_2 and NO_x emissions, respectively, are related to the combustion in energy and transformation industries. Approximately 30 and 15% of the NO_x and CO_2 emissions are emitted by road traffic, while 20% of the NO_x emissions originate from off road traffic and machinery. The road traffic sector has major CO and NMVOC emissions shares of 60 and 39%, respectively, of the total emissions load and emits 14% of the total CO_2 emissions.

For NMVOC the evaporative contribution from solvent use accounts for over 25% of the total emissions while 20% of the CO emissions are emitted from non-industrial combustion plants. Almost all the NH_3 emissions, half of the N_2O emissions and about 40% of the CH_4 emissions arise from activities in agriculture, forestry, land use and wood stock change. Around 45% of the CH_4 emissions and over 30% of the N_2O emissions are natural emissions.

Considering the international emissions, i.e. emissions from sea transportation or air traffic from Denmark with a foreign destination, the extra emissions of SO_2 and NO_x are in the order of 40% of the Danish totals in 1996. For SO_2 this is due to the residual fuel use (with a high sulphur content) in sea transportation and for NO_x the reason is a poor emission performance both for sea transportation and air traffic. The international CO_2 emissions are in the order of 10% of the national totals, while the emissions of NMVOC, CH_4, CO, N_2O and NH_3 are very small compared with the Danish totals.

For all the heavy metals except Cu and Ni the emissions from combustion in energy and transformation industries account for 50% or more of the national totals in 1996. Most of these emissions stem from public power plants. For Cd, As and Ni the industrial combustion accounts for 20-50% of the emission totals while road transport contribute with around 50 and almost 30% of the total Cu and Pb emissions, respectively.

The emission trend for SO_2, NO_x and CO_2 in the period 1975-1996 is dominated by the emissions from energy and transformation industries. For CO_2 the total emissions tend to increase with some fluctuations, whereas the SO_2 and NO_x emissions decrease during the period. The emission peaks in 1991 and 1992 are due to changes in the energy production rate. In general the power plants improve their SO_2 and NO_x emission factors during the period. After 1990 especially the road traffic emissions of NO_x, NMVOC, CO show a decline due to the introduction of catalyst cars. This also dominates the overall total emission picture for NMVOC and CO.

The latter emission species has a sudden drop from 1990 onwards in total emissions because of the total ban of on-field burning of straw. For NH_3 emission reduction measures taken tend to bring down the emissions from the agricultural sector, at least in the 1980s. The emissions of N_2O are almost constant during the period, while the N_2O emissions decrease slightly.

1 Introduction

Air emissions are formed in many ways and can be related both to human activities and natural processes. Examples of human activities which generate air emissions are: combustion processes in power plants and in transport vehicle engines, industrial production processes and activities in the agricultural and forestry sector. Emissions are also created from natural processes such as the evaporation from vegetation or anaerobic reactions in lake or wetland environments. To support regulative decisions it is necessary to make frequent air emission estimates and for assessment purposes these should be as consistent and reliable as possible.

Taking over the task from Risø National Laboratory the Danish national air emission inventories have been made since 1994 by the National Environmental Research Institute (NERI). The inventories are made on a yearly basis and are built up using the CORINAIR (CORe Inventory to the AIR) methodology and software developed by the European Environmental Agency (EEA). The Danish CORINAIR inventories are regarded as the official Danish inventories, giving input to different conventions established to reduce air emissions. At the same time the CORINAIR system serves as a general database for emission information and emissions calculations at different levels.

The aim of this report is to describe the structure of the CORINAIR emission inventory system on a 1996 level in terms of pollutants included and the grouping of the emission sources in two main types; large point sources and area sources. Furthermore the goal is to explain the overall emission calculation principle (emission factors times activity data) and to describe sub-models for calculating traffic emissions as a part of CORINAIR. The aim is also to describe the Danish 1996 air emissions in CORINAIR sectors (using the UNECE reporting guidelines) and the development of the Danish total emissions in the period 1975-1996.

Chapter 2 gives an administrative overview and describes the CORINAIR structure and emission calculation methodology. Also in chapter 2 sub-models for calculating traffic emissions are described. In chapter 3 a brief description is given of international conventions to reduce air emissions, to which CORINAIR submits Danish emission data. In chapter 4 data for activities i.e. the driving forces behind the formation of the emissions such as livestock, energy and solvent use are shown. In chapter 5 the emissions of sulphur dioxide (SO_2), nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOC), methane (CH_4), carbon monoxide (CO), carbon dioxide (CO_2), nitrous oxide (N_2O) and ammonia (NH_3) are shown for the year 1996 in details and as total emissions for the period 1975-1996. Heavy metal emissions of arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), mercury (Hg), nickel (Ni), lead (Pb), selenium (Se) and zinc (Zn) are also presented for the year 1996 by emissions from large point sources and area sources together with the split of all emissions.

It should be noted that this report only covers the atmospheric emissions leaving out the emissions to water and soil or as waste. The emissions are calculated as prescribed in the UNECE reporting guidelines using the CORINAIR 1994 version of the air emission inventory system. The emissions are not corrected for electricity trade or temperature variations during the year. The UNECE methodology excludes the international emissions from the national estimates. The international emissions are defined as the emissions originating from sea transport starting from Denmark with a foreign destination and the emissions from air traffic above 1000 m starting from Denmark and regardless of destination.

A special reporting procedure is made for CO_2 emissions from air traffic to harmonise the UNECE and IPCC guidelines. The CO_2 emissions from domestic traffic (i.e. origin and destination in the same country) are included, while the emissions from international traffic are left out of the total national emissions load. Even though distinctions are made between national and international emissions, the latter emission development will also be shown in this report for the years 1975 to 1996.

Emission inventories are frequently updated and adjusted, as more or better information becomes available. As a consequence, the numbers in the present report will not be fully in agreement with previously reported emission information by Fenhann and Kilde (1994) and Fenhann et al. (1997).

2 The CORINAIR emission inventory system

Starting out at a simple level the CORINAIR emission inventory system has step by step developed into being the most comprehensive European emission inventory system. The aim is to make CORINAIR universal and in this way be able to give answers to total emissions requests from all international conventions. This chapter provides an administrative overview of the CORINAIR emission inventory system, its methodology structure and the emission components included. The basis is the CORINAIR 1994 level of the emission inventory programme, which is used to create the Danish 1975-1996 air emission inventories presented in this report.

In this chapter external emission calculation models are furthermore described for road traffic and other mobile sources and machinery.

2.1 Administrative overview

The CORINAIR emission inventory system has been developed by the European Union. From start it was part of the EU (DG XI) Corine (COoRdination d'INformation Environmentale) programme set up by the Council of Ministers in 1985 (Decision 85/338/EEC). The first CORINAIR inventory covered the three pollutants: SO_2, NO_x and VOC (Volatile Organic Compounds) for the year 1985. The EU-12 countries at that time participated in this first pan European inventory. The second inventory (for the year 1990) was expanded to a number of 29 countries and the emission components SO_2, NO_x, NMVOC (Non Methane Volatile Organic Compounds), CH_4, CO, CO_2, N_2O and NH_3 (EEA 1995).

From 1994 the EEA has become in charge of the CORINAIR inventory programme and national estimates have been requested every year. At present, the inventory programme comprises the eight emission components mentioned above as well as nine trace metals and nine persistent organic pollutants (POP's). The trace metals are: As, Cd, Cr, Cu, Hg, Ni, Pb, Se and Zn. The POP's are: hexachlorocyclohexane (HCH), pentachlorophenol (PCP), hexachlorobenzene (HCB), tetrachloromethane (TCM), trichloroethylene (TRI), tetrachloroethylene (PER), trichlorobenzene (TCB), trichloroethene (TCE), dioxins, furanes and polycyclic aromatic hydrocarbons (PAH). The European inventories can be consulted on the EEA website (http://www.eea.eu.int/). The 1994, 1995 and 1996 CORINAIR inventories have been carried out by 19 countries: the EU-15, Estonia, Iceland, Liechtenstein, Norway and Switzerland. The 1997 inventory will be carried out by 35 countries: the EU-15, the Phare 13, Croatia, Cyprus, Iceland, Liechtenstein, Malta, Norway and Switzerland.

The European work with environmental data is organised by the EEA in several European Topic Centres (ETC's). Each ETC is responsible for gathering information at European level concerning specific environmental subjects or environmental compartments. For emissions to the atmosphere the

ETC/AE (European Topic Centre on Air Emissions) is lead by the Umweltbundesamt (UBA) in Germany, with partners from the UK (AEA Technology), The Netherlands (TNO), Austria (UBA), France (Citepa), Italy (ENEA) and Denmark (Risø National Laboratory).

The EEA has also made a network of National Focal Points (NFP's), one for each country. The NFP's are responsible for the country's overall organisation of environmental information. In Denmark the NFP is NERI (National Environmental Research Institute) in Silkeborg. For Denmark the NFP has organised the work in National Reference Centres (NRC's), one for each environmental subject or area. The Department of Policy Analysis at NERI is appointed to cover the Danish emissions to the atmosphere. In general the Danish NRC's cover the same environmental themes as the European ETC's. This means that the Danish CORINAIR inventories are submitted both to the ETC/AE and to the Danish NFP. The Danish air emission inventories can be found on http://www.dmu.dk and http://nfp-dk.eionet.eu.int.

Copies of the annual air emission inventories are also handed out to the Danish Environmental Protection Agency (Danish EPA) and the Danish Energy Agency (Danish EA). All international conventions, with Denmark as a party, are signed by the Danish government and the responsibility of the national air emission data is in the hands of the Danish EPA. In addition the Danish EA ensures consistency between their own data and the energy data behind the CORINAIR inventories.

2.2 The CORINAIR structure

Basically the emissions are calculated in the CORINAIR database as activities times emission factors. An activity can be explained as a number, describing a specific process that generates emissions. Examples of activities are: energy use by gasoline passenger cars, numbers of poultry or paint application. The emission factor is referred to the activity as grams of emission per activity unit.

The CORINAIR methodology describes the emission inventory process and the connected CORINAIR software is used both to store data for activities and emission factors and to make emission calculations at different levels (CORINAIR, 1996). To provide a solid basis for the emission estimates, data for activities and emission factors must be collected on a national scale. If Danish emission factors are missing from some sources, default emission factors are suggested by the methodology.

In CORINAIR the emissions can be calculated at different levels of aggregation, the so-called SNAP levels (Selected Nomenclature for Air Pollution, Chang and Fontelle, 1996). Furthermore all the emission sources are regarded as either point sources or area sources. The large point sources are defined from a list of specific conditions, leaving the remaining sources to be area sources.

2.2.1 Main categories in CORINAIR

The first CORINAIR SNAP level (SNAP level 1) consists of 11 main physical sectors. The main categories are divided into a second level (SNAP level 2) with a total number of around 50 categories. These are furthermore split into around 350 different categories on the third and most detailed level. SNAP level 3 can furthermore be disaggregated into "Annex rubrics", if data on activities and emission factors are available.

All activities are defined in SNAP codes (Selected Nomenclature for Air Pollution, Chang and Fontelle, 1996). The 11 main categories are shown in table 1 with their SNAP codes.

Table 1 The 11 main CORINAIR categories

SNAP code	Category description
1	Combustion in energy and transformation industries
2	Non-industrial combustion plants
3	Combustion in manufacturing industry
4	Production processes
5	Extraction and distribution of fossil fuels / geothermal energy
6	Solvent and other product use
7	Road transport
8	Other mobile sources and machinery
9	Waste treatment and disposal
10	Agriculture and forestry, land use and wood stock change
11	Nature

The first category mainly comprises the emissions from fuel combustion in large power plants generating power. The emissions from district heating plants related to fuel combustion are also comprised in this category (also using waste as a fuel) together with the emissions from refineries, gas works and oil and gas extraction. SNAP category 2 deals with the emissions from fuel combustion in non-industrial plants. These plants generates heat and power on smaller scales both for commercial, institutional and residential use and energy for use in agriculture, forestry and aquaculture. Category 3 covers all emissions from combustion in the industry (to generate production energy), while category 4 comprises the emissions directly related to the production process.

SNAP category 5 deals with all emissions (mainly evaporative emissions) from the extraction and distribution of fossil fuels and geothermal energy. The evaporative emissions originating from the use of solvents and other products are estimated in category 6. All transport emissions, i.e. the emissions from road traffic vehicles together with the emissions from trains, ships and air craft, are covered by SNAP category 7 and 8. The latter SNAP category also comprises the emissions from motorised equipment in industry, forestry, agriculture, household and gardening. Both SNAP groups only deals with the emissions from combustion engines. The emissions that arise from electric power generation for electric vehicles (cars or trains) or electric engines are accounted for at the power plant.

Emissions from waste treatment and disposal are estimated in SNAP category 9. In Denmark most of the waste is burned in district heating plants (SNAP category 2). The major part of the emissions from SNAP 9 stems from the treatment of waste water and dumps (evaporation) and off shore flaring.

Category 10 covers all emissions from agriculture and forestry, land use and wood stock change. In this category there are many different emission sources. Examples are: cultures (with or without fertilizers), livestock and its manure, and the biomass changes in different types of managed vegetation. The last category 11 comprises the emissions from all natural (non-managed) sources such as forest fires, volcano eruptions or evaporative emissions from vegetation.

All 11 SNAP groups are listed on SNAP level 3 in appendix 1. As an example the sector "Combustion in energy and transformation industries" (SNAP code 01) is shown at the second SNAP level in table 2 and the sub-sector "Public power" (SNAP code 0101) is disaggregated on the third SNAP code level in table 3.

Table 2 SNAP level 2 for Combustion in energy and transformation industries

SNAP code	Combustion in energy and transformation industries
01 01	Public power
01 02	District heating plants
01 03	Petroleum refining plants
01 04	Solid fuel transformation plants
01 05	Coal mining, oil / gas extraction, pipeline compressors

Table 3 SNAP level 3 for Public power

SNAP code	Public power
01 01 01	Combustion plants ≥ 300 MW (boilers)
01 01 02	Combustion plants ≥ 50 and < 300 MW (boilers)
01 01 03	Combustion plants < 50 MW (boilers)
01 01 04	Gas turbines
01 01 05	Stationary engines

No calculations have been made on "Annex rubric" level in any of the "Public power" sub-sectors. This very detailed emission level is mainly used in SNAP group 8 "Other mobile sources and machinery" to differentiate between aircraft types and equipment used in agriculture, forestry, industry, household and gardening.

2.2.2 Large point sources and area sources

The emission sources are divided into large point sources (LPS) and area sources in the CORINAIR methodology.

The LPSs have major contributions to the total air pollution for a large number of emission components. This is also true for Denmark, see chapter 5.11. In order to reduce these emissions Danish reduction plans have been decided as a part of international agreements, see chapter 3. For this use a detailed LPS registration must be carried out to make the LPS emissions calculations as precise as possible. The following LPS criteria in CORINAIR have been defined (Chang and Fontelle, 1996) based on the international agreements:

- Combustion plants with thermal capacities ≥50 MW
- Refineries
- Workshops included in integrated steel plants with production capacities $\geq 3 \cdot 10^6$ tonnes steel/year
- Sulphuric acid plants
- Nitric acid plants
- Paper pulp production plants with capacities ≥ 100.000 tonnes/year of paper pulp
- Painting car plants with capacities ≥ 100.000 passenger cars/year
- International airports with LTO cycle numbers ≥ 100.000/year
- Plants with stack tops ≥ 100 m
- Plants with annual emissions ≥ 1.000 tonnes/year of SO_2, NO_x, NMVOC or NH_3
- Plants of specific interest

Detailed LPS registrations and emission calculations are also made to support the work with emission dispersion models including atmospheric transport modelling and the transformation and deposition of chemical compounds. Finally the main European air polluters can be located, if the LPS's are registered.

2.3 Traffic emission sub models in CORINAIR

In CORINAIR the traffic emission calculations are carried out in two main categories: Road traffic (SNAP group 07) and Other sources and machinery (SNAP group 08). As an external part of CORINAIR a computer programme has been developed to calculate the road traffic emissions.

The remaining transport activity takes place in the off road traffic sector. This category comprises sea transport, fishery, air traffic, railways and military. Also other mobile sources and machinery such as machinery used in industry, forestry, agriculture and household and gardening are included in this sector. At present no special emission models are made in the framework of EEA to calculate the off road emissions. Instead calculation models have been developed at NERI especially to estimate these emissions.

2.3.1 Road traffic

The vehicles used in road traffic are: passenger cars, light duty vehicles, heavy duty vehicles and two wheelers. The vehicle types are shown in table 4 at SNAP level 2. A further division is made into urban, rural and highway driving at SNAP level 3, see appendix 1. For the period 1975-1989, the calculation of the emissions from road traffic is based on the statistical energy consumption from the Danish Energy Agency combined with aggregated emission factors.

Table 4 SNAP level 2 for road traffic

SNAP level 2	Road traffic
07 01	Passenger cars
07 02	Light duty vehicles < 3.5 tonnes
07 03	Heavy duty vehicles > 3.5 tonnes and buses
07 04	Mopeds and Motorcycles < 50 cm^3
07 05	Motorcycles > 50 cm^3
07 06	Gasoline evaporation from vehicles
07 07	Automobile tyre and brake wear

For the years 1990 onwards, the calculation of emissions from road traffic is more detailed, using the COPERT (Computer Programme to calculate the Emissions from Road Transport) model. The COPERT model has been developed and is currently being updated for the European Environmental Agency. The model is used by many countries, which ensures consistent and transparent calculation methods at European level. The COPERT calculation results are automatically exported to the CORINAIR database.

For 1990 - 1993 the COPERT 90 version of the model has been used to calculate the Danish road traffic emissions (CORINAIR, 1993). An updated version of the model, COPERT II (Ahlvik et al., 1997), has been used to calculate the 1994-1996 emissions. The COPERT model takes into account the composition of the vehicle fleet, the annual mileage driven and the specific emission factors per driven kilometre in urban, rural and highway traffic. Information on the vehicle fleet and the annual mileage is obtained from the Danish Road Directorate.

The number of passenger cars is split into categories taking into account the type of fuel used, the emission legislation level and the engine size. The number of light and heavy duty vehicles are split into categories characterised by the fuel type, the emission legislation level and the gross vehicle weight.

Subsequently the hot emissions are estimated by combining the yearly traffic of the sub-categories with the emission factors of urban, rural and highway driving. The estimations of the cold start emissions (of private cars and vans) are based on the cold/hot emission relation and every month's driving with a cold engine. The evaporative emissions; running loss, soak and diurnal loss are also estimated for the petrol vehicles (SNAP group 0706). The estimation is based on the total driving, the number of trips, the maximum and minimum day-temperature of the month and temperature dependent evaporation factors.

In order to assess the calculation procedure and the emission results the COPERT model creates a fuel balance. The fuel consumption is calculated and compared with the statistical fuel data from the Danish Energy Agency. A reasonable small difference between the statistical and calculated energy consumption is requested. To obtain this small difference the annual mileage is regulated in the different vehicle classes. The emissions are then repeatedly calculated following an iterative procedure.

2.3.2 Off road emission models

The off road sector is divided into several sub-sectors; sea transport, fishery, air traffic, railways, military, industry, forestry, agriculture and household and gardening. The emission calculations are very detailed for air traffic and the sectors: industry, forestry, agriculture and household and gardening. In these two cases models have been developed at NERI to calculate the emissions according to the CORINAIR guidelines.

Emission model for air traffic

Following the CORINAIR guidelines (CORINAIR, 1996) a Danish air traffic emission calculation model is developed at NERI. The basic model principle is to combine relevant air traffic statistics, energy use and emission factors. The CORINAIR methodology prescribes a differentiation between Landing and Take Off (LTO) and cruise for both national and international air transport on basis of the fuel bunkered in Danish airports. The CORINAIR categories are shown in table 5 on SNAP level 3. The Annex rubric level gives a further division of the air traffic emissions into different aircraft types.

The air traffic activity in Denmark takes place mainly at Copenhagen airport but also in a number of small provincial airports. The activity in Copenhagen airport exceeds 100.000 LTO's per year. According to the CORINAIR methodology it is therefore a large point source of air emissions. The provincial airports are treated as area sources.

Table 5 SNAP level 3 for air traffic

SNAP level 3	Air traffic
08 05 01	Domestic airport traffic (LTO cycles < 1000 m)
08 05 02	International airport traffic (LTO cycles < 1000 m)
08 05 03	Domestic cruise traffic (> 1000 m)
08 05 04	International cruise traffic (> 1000 m)

Air traffic statistics

Using the statistic sources Copenhagen Airport (1997) and Statistics Denmark (1997) the air traffic activity in Danish airports can be divided into the number of LTOs carried out by different aircraft. Due to a lack of statistics, it is assumed, that all domestic LTOs in Copenhagen airport and all large aircraft activity in the provincial airports are carried out by only one aircraft type (Fokker F50). Furthermore, it is assumed that all domestic traffic takes place between Copenhagen and the provincial airports.

Energy and emission factors

The duration of the different parts of a LTO cycle is defined by The International Civil Air Organisation (ICAO). The LTO cycle simulates the air traffic activity below 3000 ft during approach, landing, taxi traffic, take off and climb out. For engine certification purposes modal measurements are made for large aircraft during the test cycle. Emissions of CO, VOC, NO_x, and the fuel consumption are measured. From this overall emission and energy factors can be calculated.
For LTOs the emission and fuel consumption factors are taken from an environmental impact study in Copenhagen Airport (Copenhagen Airport, 1996). Especially for VOC the split in NMVOC and CH_4 is taken from CORINAIR (1996) together with the emission factors during the cruise phase.

Small aircraft do not have to meet any emission standards. Therefore no consistent emission factors are available for these air craft types. Instead emission factors for all pollutants are estimated by using the fuel related emission factors for non catalytic cars. The emission data comes from the COPERT model.

Energy use by LTO and cruise

An overall fuel allocation to the LTO and cruise activity has been made to calculate the emissions for both domestic and international traffic. The fuel allocation has been made separately for Copenhagen Airport and the provincial airports.
The energy use is calculated for both domestic and international LTO activity, by multiplying the fuel consumption factor for each aircraft type with the corresponding number of LTOs. The next step is to calculate the total energy use by domestic and international cruise. The cruise energy is the difference between the total fuel sold for aviation in Denmark and the total calculated fuel used for LTOs.

The cruise energy use is finally distributed to the various aircraft types in domestic and international cruise traffic. This is done by multiplying the total energy use for cruise with the fraction of the total number of LTOs for each aircraft type in domestic and international cruise, respectively.

Energy use and emissions in Copenhagen airport

According to the CORINAIR methodology, Copenhagen airport is considered as a large point source. The energy used in Copenhagen airport is divided into the domestic and international LTOs and the cruise activity. This is done for all of the various aircraft types as described in the previous paragraph. For small aircraft no relevant LTO fuel consumption factor is available and therefore the total energy use is allocated to the energy use under domestic and international LTOs.

In order to calculate the energy use and the emissions for domestic and international LTOs, the number of LTOs for each aircraft type is multiplied by the respective energy use/emission per LTO. The cruise emissions are estimated by combining the allocated cruise fuel consumption per aircraft type with the fuel related cruise emission factors.

Energy use and emissions in provincial airports

The provincial airports are regarded as area sources. The energy use is split into the domestic and international energy use by large aircraft (LTOs and cruise) and small aircraft (LTOs). The LTO energy use and emissions are calculated as the number of LTOs times the respective energy use or emission per LTO for each aircraft type. The cruise emissions are estimated by combining the allocated cruise fuel consumption per aircraft type with the fuel related cruise emission factors.

Emission model for inland waterways, industry, forestry, agriculture and household

The off road machinery used in the sectors inland waterways, industry, forestry, agriculture and household is very differentiated regarding engine sizes and combustion principles. Many small size two or four stroke gasoline vehicles and machines are present in the sector, but in terms of quantity diesel is most frequently used as a fuel. The CORINAIR SNAP categories are shown in table 6 on SNAP level 2. The many vehicle types and their different emissions are accounted for by using Annex rubrics.

Table 6 SNAP level 2 for other mobile sources and machinery

SNAP level 2	Other mobile sources and machinery
08 03	Inland waterways
08 06	Agriculture
08 07	Forestry
08 08	Industry
08 09	Household and gardening

The emissions are estimated following the guidelines in CORINAIR (1996). In order to calculate the total emissions, information regarding the stock of different machine types and their respective load factors, engine sizes, annual working hours and emission factors is combined.

The number of different types of machines, their load factors, engine sizes and annual working hours are taken from the Danish EPA (1992 and 1993). The emission factors are taken from Thomsen (1996) and CORINAIR (1996).

In the Danish EPA (1992 and 1993) the total fuel consumption of diesel oil, gasoline and LPG is also estimated. This fuel consumption is used to make an overall energy balance with the statistically sold energy within the off-road sector given by the Danish EA. An energy correction is made by regulating the annual working hours used for the vehicle stock in the calculations.

Other off road emission sources

The remaining transport emissions estimated in "Other mobile sources and machinery" stem from sea transport and fishery, railways and military. The CORINAIR SNAP categories are shown in table 7.

Table 7 SNAP codes for remaining off road categories

SNAP codes	Remaining off road categories
08 01	Military
08 02	Railways
08 04	Maritime activities
08 04 02	National sea traffic within the EMEP area
08 04 03	National fishing
08 04 04	International sea traffic (international bunkers)

Sea transport and fishery

According to the CORINAIR definitions the marine activity is determined by the fuel sold in the Danish ports. Furthermore the sea traffic is defined as either national or international depending on the destination of the vessels in question. In this context the transport is considered national, if the fuel is bunkered in a Danish port by a vessel going to another Danish port. If the fuel is bunkered in a Danish port by a vessel with a destination outside Denmark, the transport is defined as international.

The vessels used for sea transport and fishery are mainly equipped with medium speed engines using diesel oil with a moderate sulphur content or slow speed engines using residual oil with a relatively high content of sulphur. The emission factors used in the calculations are taken from CORINAIR (1996) and Lloyd's (1995).

Railways

To calculate the railway emissions, emission factors from the COPERT model are combined with the total diesel consumption given by the Danish EA. Fuel-related emission factors are used for heavy duty diesel vehicles at highway driving conditions.

Military

The emissions from the Danish military activity are calculated by multiplying the fuel consumption and fuel related emission factors. The fuel consumption is made up by the Danish Energy Agency and the emission factors used are aggregated from the COPERT model.

3 International conventions

Air pollution is not only a local environmental problem. The emissions are dispersed by the wind and in many cases travel over long distances, before they either deposit or take part in chemical reactions in the atmosphere forming harmful compounds. The air emissions have local, regional and global environmental impacts and the only way to address these is through international co-operation. Several international conventions have been established to reduce the emissions and the related environmental effects. Denmark submits emission data to the following conventions:

- The UNECE Convention on Long Range Transboundary Air Pollution (Geneva Convention)
- The Framework Convention on Climate Change (FCCC) under the Intergovernmental Panel on Climate Change (IPCC)
- The EU monitoring mechanism for CO_2 and other greenhouse gases
- The Oslo-Paris Convention (OSPARCOM)
- The Helsinki Convention (HELCOM).

UNECE Convention on Long Range Transboundary Air Pollution

The UNECE Convention on Long Range Transboundary Air Pollution (The Geneva Convention) was formulated in 1979. It is a framework convention and has expanded during the years to cover 7 protocols in all. The Geneva Convention comprises the international intentions to reduce the emissions of SO_2, NO_x, VOC and some heavy metals and POPs.

The Helsinki Protocol was signed in 1985 to reduce the emissions of SO_2 and the aim was an emission reduction of 30% in 1993 with 1980 as a baseline year. The protocol was signed by 21 countries and in a declaration to the protocol, Denmark declared a further 50% emission reduction in 1995 from a 1980 emission level. The emission reduction in both the protocol and in the declaration was fulfilled by Denmark.

The SO_2 emission reduction levels were further strengthened with the signing of the OSLO Protocol in 1994. The protocol was ratified by 18 countries in August 1998. According to the protocol Denmark is obliged to reduce the emissions with 80% in the year 2000 with 1980 as a baseline year.

In order to reduce the NO_x emissions, the Sofia Protocol was signed in 1988. At present the protocol has been ratified by 24 countries and the EU member states. Denmark has fulfilled the goal to stabilise the 1994 No_x emissions on a 1987 level. Furthermore Denmark has signed a protocol declaration, in which the 1998 emissions should be reduced with 30% compared with the 1986 emissions. Preparations for a new ECE nitrogen protocol covering acidification, eutrophication and the formation of ozone have been going on for several years.

The Geneva Protocol comprises the VOC emissions. The protocol was signed in 1991 by 21 countries and by 2 more countries in 1992. At present the protocol is ratified by 17 countries. In the protocol Denmark has agreed to reduce the 1999 VOC emissions with 30% compared with the 1985 level.

The Aarhus Protocol dealing with the emission reduction of POPs was signed in June 1998 by 34 countries. The protocol covers 16 POP species. For some POPs the production and use will be banned, while large restrictions will be put on the production and use of other POPs. Emission reductions referred to a baseline year will be laid on the POP components created during combustion or by industrial processes. In a declaration to the protocol restrictions are put to further 2 POPs by 18 countries and the EU.

Also the heavy metals Cd, Hg and Pb are covered by the Aarhus Protocol. The aim is to reduce the emissions from some industrial processes and combustion processes related to energy production, transport and waste incineration. The protocol establishes threshold values for stationary sources and formulates guidelines for the use of the best available technology and means to reduce the heavy metal content in some products. There is a specific demand in the protocol to phase out the use of lead as an additive to motor gasoline in the year 2010/11. In a declaration to the protocol, signed by 32 countries, the moment of a total phase out has been hastened to the year 2005.

The Aarhus Protocols are expected to be ratified by enough countries in the next 2 or 3 years to come into force.

UN Framework Convention on Climate Changes

The greenhouse gas emissions will be reduced in the UN Framework Convention on Climate Changes (UNFCCC) established in 1994. The Convention takes effect when it has been ratified by 55 countries. Among the ratifying countries shall be enough industrialised countries with total greenhouse gas emissions that sums up to be at least 55% of the emissions from all industrialised countries.
In a protocol to the convention (the Kyoto Protocol), the most important antropogenic greenhouse gases; CO_2, CH_4, HFC, PFC and SHF shall be reduced by the industrialised countries with 1990 as a baseline year. The emission reduction is 5,2% and should be counted as the average super national emission totals for the period 2008-2012 related to the CO_2 global warming potential index.

A declaration has been made to the Kyoto Protocol by the EU countries, aiming to reduce the 6 greenhouse gases with an average total of 8% in the period. The emission reduction share should be weighted between the countries, in order to account for overall socio-economic differences and sectoral varieties within the Union. As a result of this EU emission reduction distribution Denmark is obliged to reduce the average 2008-2010 national greenhouse gas emissions with 21% with 1990 as a baseline year.

To reach the desired national reductions multiple target reduction plans have been launched (NERI, 1998). In this way there is a reduction plan for the energy sector, Energy 21, and a reduction plan related to transport; Government's action plan for reducing CO_2 emissions from the transport sector. These two reduction plans mainly seek to reduce the CO_2 emissions. One of the aims of the New Action Plan for the Aquatic Environment is to reduce the use of nitrogen in the agricultural sector, which might result in smaller quantities of N_2O. Several forestry action strategies aims to increase the carbon uptake by raising new forest. The Action Plan for Waste and Recycling seeks to reduce the mass of organic waste and in this way lower the CH_4 emissions. At the same time an increased use of waste at power plants as prescribed in Energy 21 reduces the CO_2 emissions related to the fossil fuel use.

EU Monitoring Mechanism for CO2 and other Greenhouse Gases

The EU Monitoring Mechanism for CO_2 and other Greenhouse Gases was established as a council decision by the European Union (93/389/EEF). According to this directive the EU countries have to submit data on total national emissions of SO_2, NO_x, NMVOC (Non Methane Volatile Organic Compounds), CH_4, CO, CO_2, N_2O, HFC, PFC and SF_6. The emission estimates must be made in accordance with the IPCC guidelines.

OSPARCOM

The first conventions to protect the marine environment in the north-east Atlantic area including the North Sea and Kattegat were signed in 1972 (the Oslo convention) and in 1974 (the Paris convention) by the countries with coast lines that border the geographical area in question. In 1992 the Oslo and Paris conventions were integrated in a new OSPAR convention to come into force in 1998. The parties to the OSPAR conventions are the EU countries and Iceland, Norway and Switzerland. The three latter countries all have catchment areas to the marine area covered by OSPAR.
The goals for the OSPAR convention are twofold. One goal is to prevent marine pollution stemming from dumping and waste incineration at sea. Another aim is to protect the marine environment from the pollution created by off shore and land based activities. Furthermore the protection of marine ecosystems and biodiversity from the harmful effects of human activities is included in the convention.

To limit the emissions of hazardous substances, radioactive pollutants oil etc. recommendations and decisions have been made in the Paris convention and work is in progress to implement measures to bring down the anthropogenic nutrient load. In the Oslo convention waste incineration at sea was regulated and only accepted as an interim solution. Also a total ban on industrial waste dumping was carried out. In the same way the dumping of off shore installations and ships, including leaving behind installations and ships off shore, was regulated.

When the OSPAR convention was agreed in 1992 the dumping of radioactive pollutants was included and a total ban was agreed. In 1998 several decisions were made to improve the convention. A total ban of the dumping of condemned off shore installations which are no longer of use was agreed together with new sets of goals and strategies concerning hazardous substances and radioactive pollutants. Also a strategy to prevent and a common procedure to identify eutrophication was agreed. With respect to species and habitats a new annex to the OSPAR convention was agreed together with a strategy to protect and preserve these.

HELCOM

In 1974 a convention was signed in Helsinki to protect the marine environment in the Baltic region. The convention came into force in 1980 and aims to protect the Baltic Sea from pollution from all sources. This would be on shore air, soil and water polluters as well as off shore air and water polluters like ships, off shore installations and aircraft. Air emissions are part of the overall pollution impact. A revision of the Helsinki convention was signed by Estonia, Finland, Lithuania, Latvia, Poland, Russia, Sweden, Germany, Denmark and the remaining EU countries in 1992 but is yet not in force since Poland and Russia have not yet ratified.
The parties to HELCOM are currently developing and intensifying their co-operation. In this way there is a total ban on waste incineration and waste dumping at sea. The dumping of raised sea floor material is excluded from the latter restriction. To bring down the pollution from on shore sources like industry, agriculture and city sewage several recommendations have been agreed during the years.

In 1988 a ministerial declaration was agreed to reduce the emissions of some heavy metals, persistent organic pollutants and to bring down the anthropogenic nutrient load over a 10-year period. However, in 1998 it became clear that the goals were unachieved for several of the pollutants comprised in the declaration. In the same way weaknesses and gaps in the data behind were revealed. To address these problems a series of measures were taken and an objective and a strategy was agreed on how to reduce and phase out the most hazardous substances.

4 Activity data

In CORINAIR data for activities are used together with emission factors to calculate the emissions from all sources. The major activity behind the emissions from the SNAP categories 1, 2, 3, 7 and 8 is the fuel consumption. In these sectors emissions are formed during combustion processes that transform fuel into power, heat or propulsion. The SNAP category 4 activities are the number of units produced by the specific industry branches. In SNAP category 5 the activities are defined as the mass or volume of fossil fuel and geothermal energy during extraction and distribution, while the activities in SNAP categories 6 and 9 are the amounts of solvent and waste, respectively. In SNAP category 10 the cultivated areas and the number of animals are the activities, while the area of forests, wetlands etc. are examples of activities behind SNAP category 11.

In this chapter the important parts of the Danish activity data will be described in further details. Special attention will be given to describe the major statistics for fuel consumption, the use of solvents and the number of animals as these activities generate the dominant part of the total emissions. All the activities used in the inventories can be found on http://nfp-dk.eionet.eu.int./

4.1 Fuel consumption

To establish the basis for fuel consumption activity the national energy statistics from the Danish Energy Agency are used together with information on fuel consumption by large point sources. Data on this latter fuel consumption are mostly reported by the Danish EA, while in some cases the data are submitted by the large point sources themselves. The fuel consumed by area sources is calculated by subtracting the fuel consumption by large point sources from the national energy statistics.

Figure 1 shows the Danish consumption of fossil fuels in a time series from 1975 to 1996. The fuel consumption is summarised in three categories; solid, liquid and gaseous fuel consumption. The solid fuels are coal and coke together with wood, straw and waste, with coal as the most dominant energy source at the large power plants. In 1996 Denmark exported a large amount electricity, which resulted in an increase in the coal consumption. The liquid fuels include fuel oil, orimulsion, gasoline, diesel, gas oil and LPG. The gaseous fuels are natural gas, biogas and refinery gas.

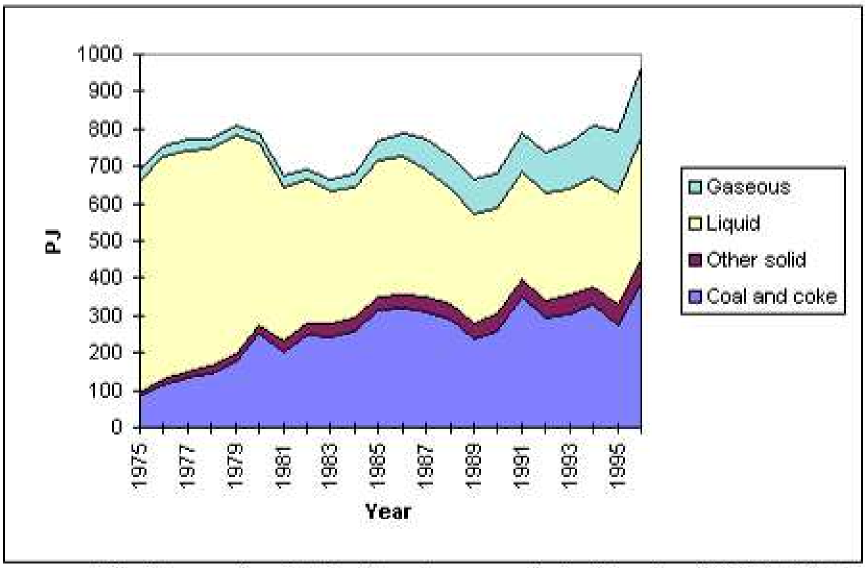


Figure 1 Danish use of solid, liquid and gaseous fuels (from the CORINAIR database)

The road traffic and other mobile sector stand for a major part of the Danish liquid fuel consumption, especially when motor gasoline and diesel oil are concerned. The liquid fuels: orimulsion, LPG, gas oil and residual oil are mainly used to generate power and heat for different purposes. The annual Danish total liquid fuel statistics from 1975 to 1996 are shown in figure 2. The fuel used for international transportation by ships and air craft is not included in the statistics, while the fuel statistics for road transport are based on consumption of gasoline and diesel in Denmark.

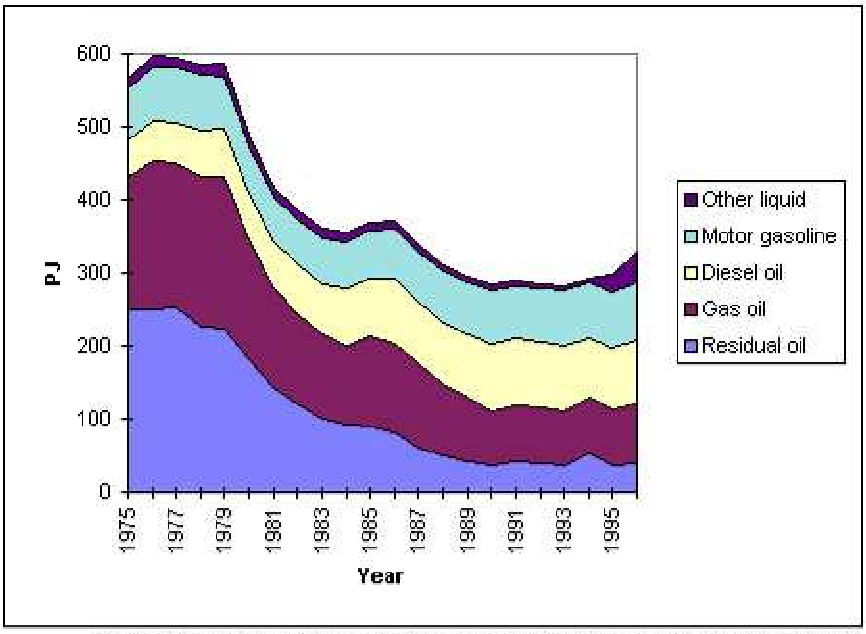


Figure 2 Time series of liquid fuels used in Denmark (from the CORINAIR database)

The Danish 1975-1996 gaseous fuel consumption statistics are shown in figure 3. The use of biogas and refinery gas is almost constant during the period. There has been a remarkable increase in the natural gas use since the mid 1980s. By that time natural gas was given a target role in the national energy supply system for power and heat generation.

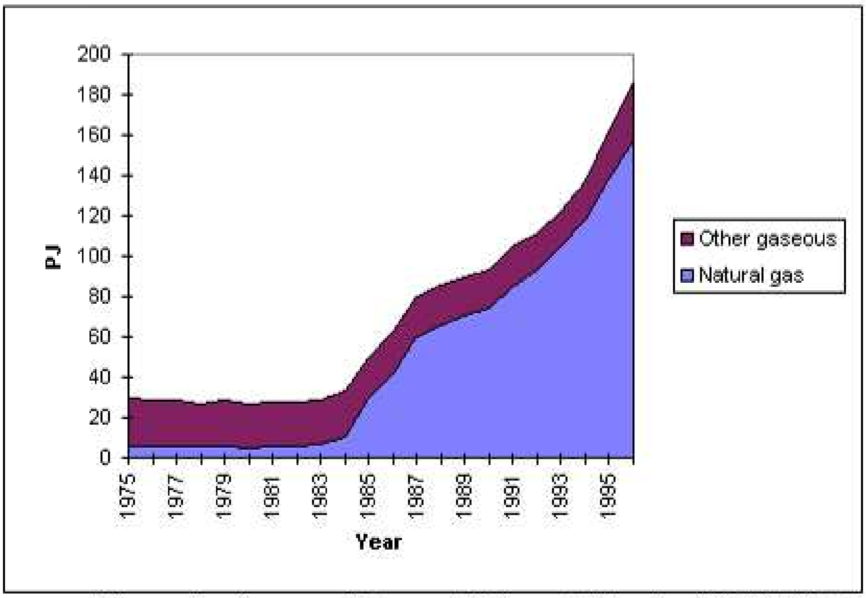


Figure 3 Time series of gaseous fuels used in Denmark (from the CORINAIR database)

4.2 Solvent use

Evaporative emissions from solvent use have large contributions to the national NMVOC totals. In order to estimate these emissions properly, it is important to gather statistics on solvent use. The amount of solvent used is reported to the Danish EPA by the Danish companies. The information is given as a part of an agreement between the Danish Industry and the Danish Environmental Protection Agency. The aim of the solvent use reduction plan is to reduce the emissions by 40% in year 2000 based on the 1988 emissions (NERI, 1998). The reporting is not annual and linear interpolation is used between the reporting years.

It is important to notice that not all the use of solvents are included in this agreement. Consequently not all emissions from solvents are included in the Danish CORINAIR inventories and efforts are still to be made in the future inventory work to improve the emission estimates.

In the Danish inventory emission estimates for solvent use are made for paint application (SNAP category 0601) in the sectors: construction and buildings, domestic use, boat building and wood. Chemical product manufacturing and processing includes: polyester processing, polyurethane processing, polystyrene foam processing, paint manufacturing, glues manufacturing and other product manufacturing and processing (SNAP category 0603).

The use of solvents in “Other use of solvents and related activities” (SNAP category 0604) takes places in the sectors: printing industry, fat, edible and non edible oil extraction, application of glues and adhesives, underseal treatment and conservation of vehicles, domestic solvent use and other uses.

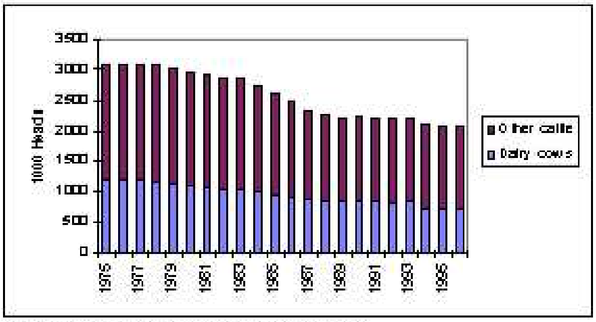
4.3 Livestock

The livestock and its manure is almost solely responsible for the Danish ammonia emissions and also contributes significantly to the total methane emissions load. The annual mean livestock number in different animal categories is used as activity data. To estimate the emissions the different mean livestock numbers are used together with emission factors (gram of emissions per animal per year).

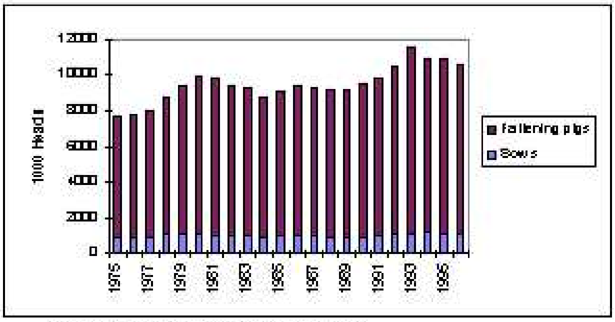
Not only the livestock numbers are important for the ammonia emission calculations. The handling (storage and spreading) of the manure as well as the construction of the farms will also have an impact on the final emission result.

The livestock numbers are difficult to estimate, since they vary during the year. The official statistics cover considerable livestock changes in the agricultural sector: animals are slaughtered and new are raised during the year and a certain animal import/export takes place. To ensure consistency and comparable estimates also published data on livestock is used from Statistics Denmark (1997).

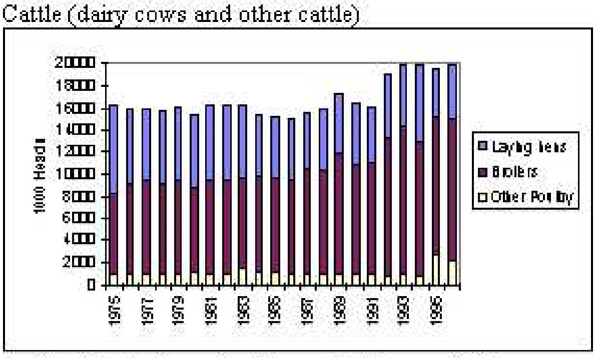
The livestock numbers are shown in figure 5 in four different main categories. In the inventories the main categories are split further into individual animal species.



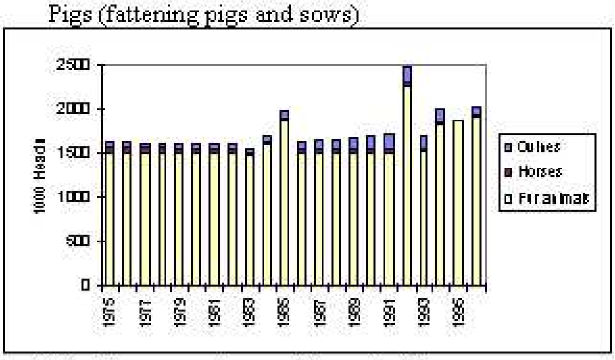
Cattle (dairy cows and other cattle)



Pigs (fattening pigs and sows)



Poultry (laying hens, broilers and other poultry)



Other (horses, ovines and fur animals)

Figure 5 Time series 1975-96 of the number of livestock in Denmark used in the inventories

In figure 5 the number of Danish livestock is shown in time series from 1975 to 1996 in four figures: cattle, pigs, hens and other livestock. The number of cattle (dairy cows and other cattle) has decreased during the period, whereas the number of pigs (fattening pigs and sows) has increased slightly, as has the number of poultry's (laying hens, broilers and other poultry). Other livestock, which includes horses, ovines and fur animals is at about the same level through the period.

5 Emissions

This chapter presents the Danish CORINAIR emission estimates as prescribed by the UNECE emissions reporting guidelines. The emissions of SO_2, NO_x, NMVOC, CH_4, CO, CO_2, N_2O and NH_3 are shown in figures on main contributing SNAP categories for 1996 and as national totals in the period 1975 to 1996. The latter emission results are listed in appendix 3. Time series of emissions excluded from the national totals, i.e. the international maritime and air traffic emissions, are also shown.

The national 1996 emission totals are also compared with the other EU-15 countries on a per capita level in this chapter. In addition the heavy metal emissions As, Cd, Cr, Cu, Hg, Ni, Pb, Se and Zn and their sources are shown in details for the years 1994 to 1996. The total 1996 emissions of all species are categorised as large point source and area source emissions.

5.1 Sulphur dioxide (SO_2)

The most important source of sulphur emissions in the Danish emission inventory is combustion processes.

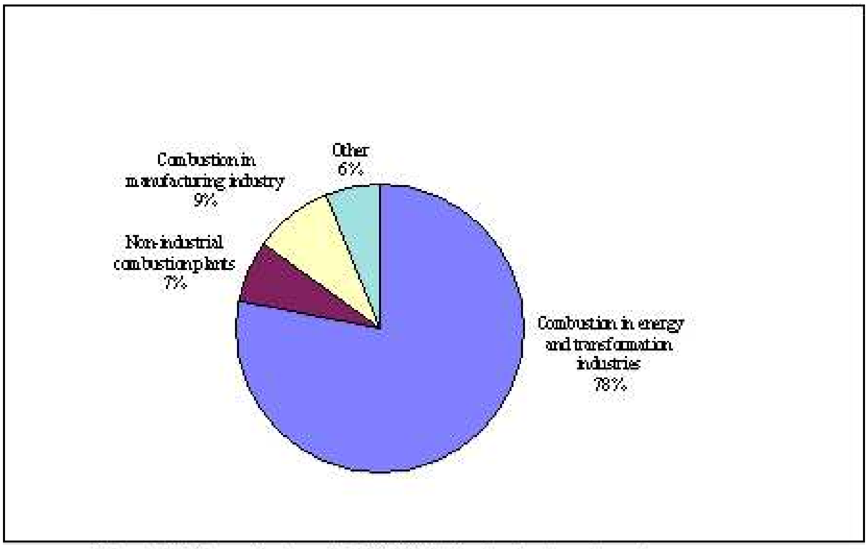


Figure 6 Danish SO_2 emissions in 1996 distributed into categories

Figure 6 shows the total 1996 SO_2 emissions (186.7 kilotons) by main source categories. The combustion of fuel in the energy and transformation industries (mainly power plants and district heating) contributes with 78% of the total Danish SO_2 emissions. This percentage figure is followed by a 9% emission share of the manufacturing industry and a 7% share of the non-industrial combustion plants.

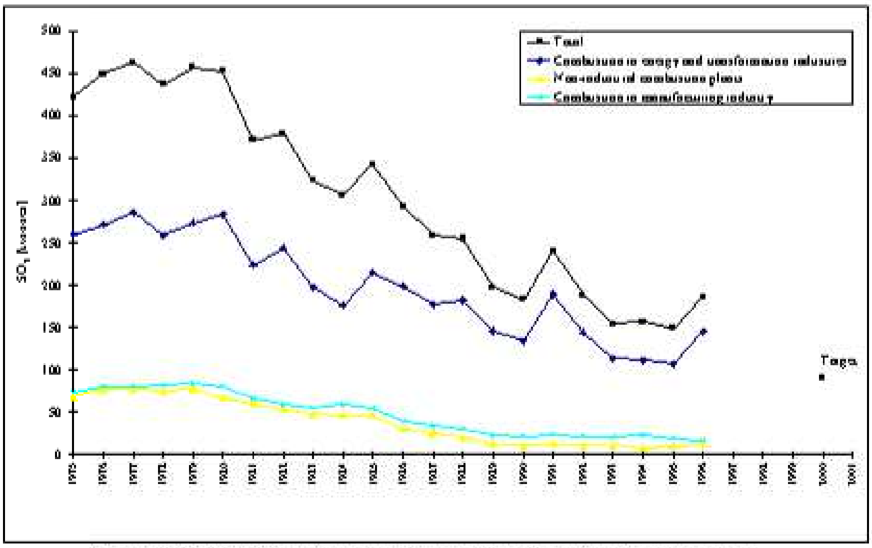


Figure 7 Danish 1975-1996 emissions of SO_2 in totals and main categories

The total Danish SO_2 emissions are shown for the years 1975 - 1996 in figure 7 together with the emissions from the main contributing sector: combustion in energy and transformation industries. In general there is a total emission decline determined by the emissions decrease in the sectors combustion in the energy and transformation industries and by transportation (not viewed). The emission peaks in 1991 and 1996 are due to higher energy production (and hence higher fuel consumption) in these years. The UNECE convention emission reduction target is also shown in figure 7. In the convention Denmark has agreed to reduce the SO_2 emissions with 80% in the year 2000, with 1980 as a baseline year.

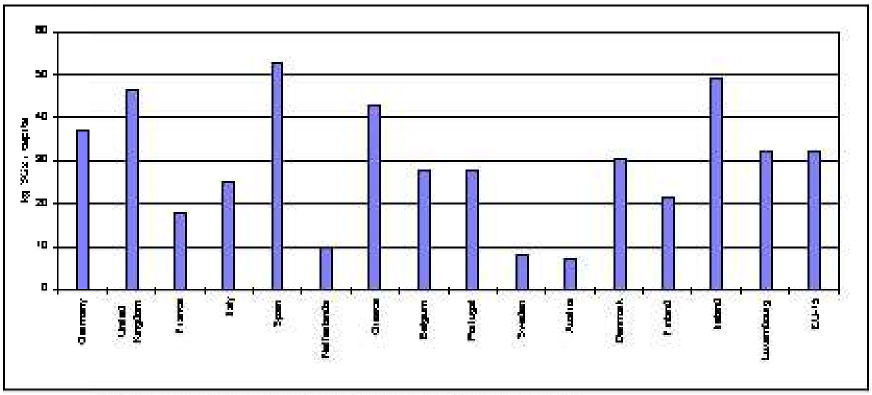


Figure 8 European SO_2 emissions in 1994 (kg SO_2/capita)

The 1994 SO_2 emissions are shown per capita for the EU-15 countries in figure 8 (Ritter, 1997). To be able to compare the emissions between countries the main category "Nature" is excluded from the emission totals. The Danish emissions are around 30 kg SO_2/capita/year and slightly lower than the EU-15 average of about 32 kg SO_2/capita/year. Denmark generates most of its power using either coal or fuel oil, see figure 30. This is why the Danish per capita emission is higher than countries, whose energy supply systems to a large extend are based on for example hydropower and nuclear power.

5.2 Nitrogen oxides (NO_x)

As for sulphur fuel combustion is the most important source of NO_x emissions in Denmark.

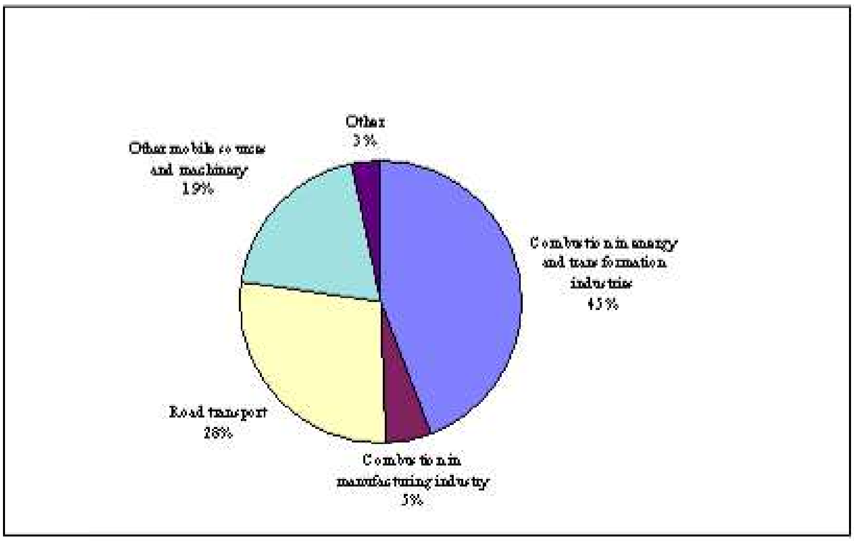


Figure 9 Danish NO_x emissions in 1996 distributed into categories

The distribution of the Danish 1996 NO_x emissions (287.7 kilotons) are viewed by source categories in figure 9. The energy and transformation industries account for 45% of the Danish emissions, while road transport and other mobile sources and machinery have individual NO_x shares of 28% and 19% respectively, and 47% in total.

The total Danish 1972-1996 NO_x emissions are shown in figure 10 with main emission contributors. The relatively large fluctuations in 1991 and 1996 are caused by the high electricity export in these years.

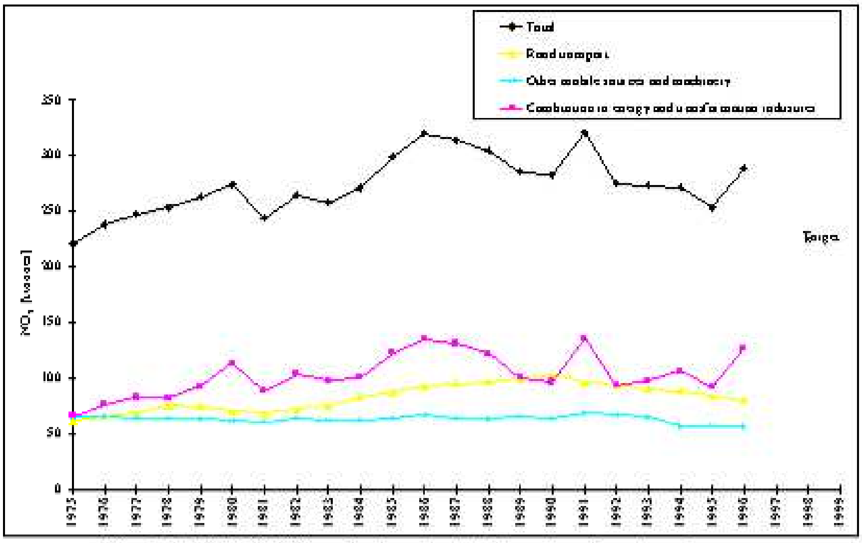


Figure 10 Danish 1975-96 NO_x emissions in totals and main categories

The road traffic emissions show a decline after 1990, as a result of the introduction of catalyst cars. The NO_x emission reduction target for the UNECE convention is also shown in the figure.

The EU-15 per capita NO_2 emissions are shown in figure 11 for the year 1994 (Ritter, 1997). The main category "Nature" is excluded from the emission totals for comparative reasons. The Danish emissions, which is around 55 kg NO_x per capita, are above the European mean of about 35 kg NO_x per capita. This is caused by the high emission contribution from energy production.

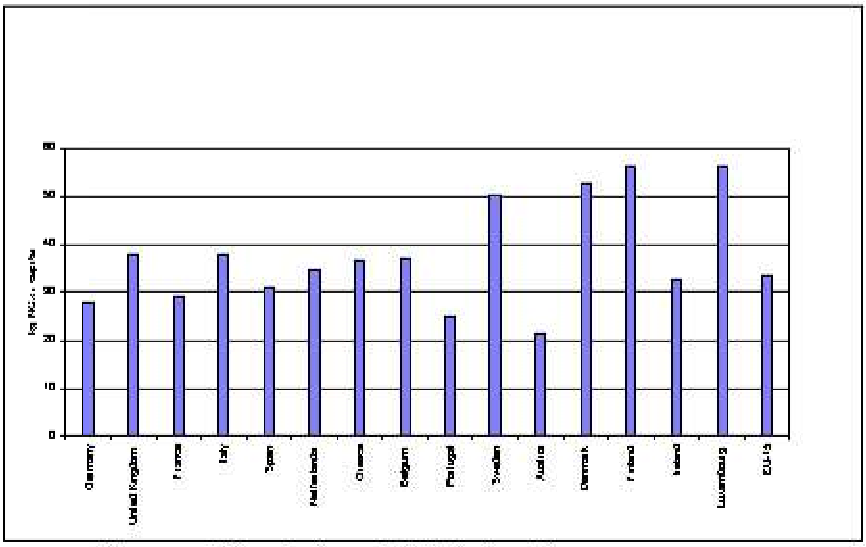


Figure 11 European NO_x emissions in 1994 (kg/capita)

5.3 Non-Methane Organic Compounds (NMVOC)

The Danish 1996 NMVOC emissions (155.5 kilotons) are shown in figure 12. With a 39% share of the total emissions road traffic is still a main contributing sector, even though the emissions have declined since the introduction of catalyst cars in 1990. The category solvent use contributes with 26% of the total NMVOC emissions in 1996. The inventory for this category is still incomplete in some sub-categories, and it is likely that the inventory comprises only a part of the total emissions. Furthermore the activity data behind the emissions from some sub sectors, e.g. households, are difficult to obtain and the emissions are often based on rough estimates.

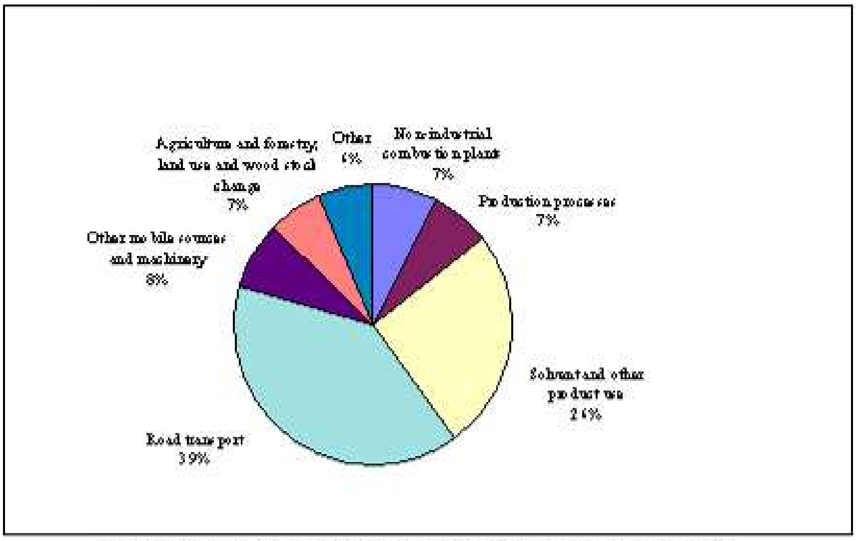


Figure 12 Danish NMVOC emissions in 1996 distributed into categories

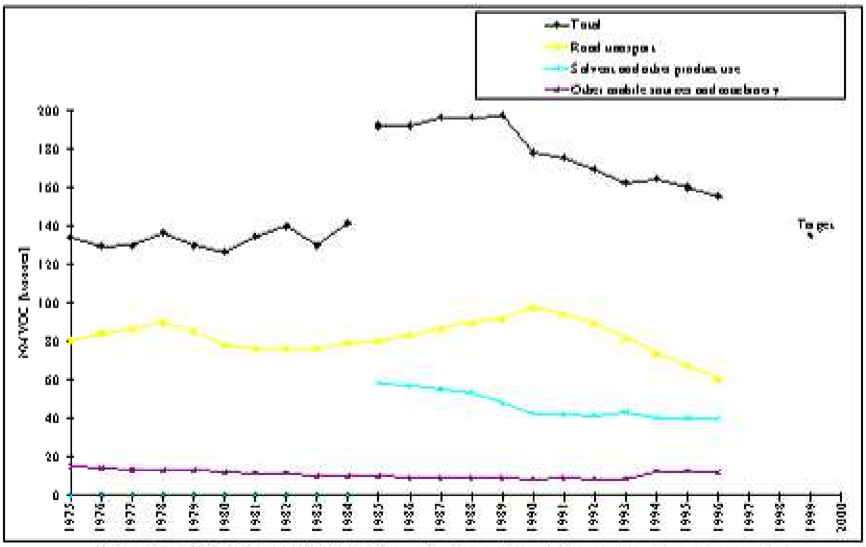


Figure 13 Danish 1975-1996 NMVOC emissions in totals and main categories

Figure 13 shows the Danish NMVOC emission in the time series 1975-1996. From 1984 to 1985 the emissions go up abruptly. The sudden emission increase occurs because from this year the emissions from solvent use are included in the inventories. The emission decline from 1989 to 1990 in the category "Agriculture and forestry, land use change and wood stock change" is due to the almost total national ban on on-field burning of straw. The decline from 1990 onwards is due to the introduction of catalyst cars and the effect of the emission reduction agreement between the Danish Industry and the Environmental Protection Agency (NERI, 1998). The target for the NMVOC emission reductions within the UNECE convention is also shown in figure 13.

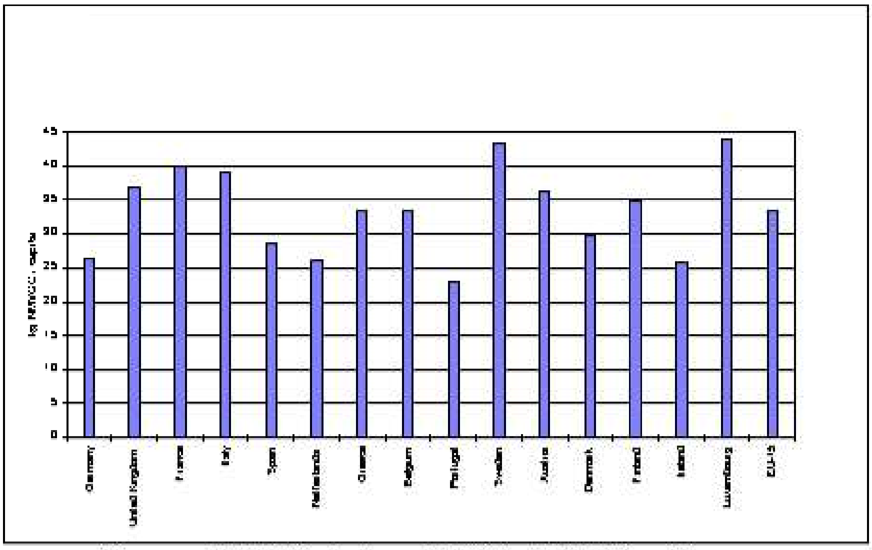


Figure 14 European NMVOC emissions in 1994 (kg NMVOC/capita)

Figure 14 shows the NMVOC per capita emissions in 1994 for the EU-15 countries (Ritter, 1997). To ensure inter country comparison (Ritter, 1997) the main groups "Agriculture and Forestry, Land use and Wood stock change" and "Nature" has been excluded in the figure.

Denmark has an approximate emission of 30 kg NMVOC per person, which is below the European Union mean emission of 36 kg NMVOC per person. Some countries like Sweden and Luxembourg have high emissions per capita. A reason for this could be the uncertainties in the emission inventory for solvent use. As regards the uncertainties, caution should be taken when comparing different countries emission estimates.

5.4 Methane (CH_4)

Figure 15 shows the Danish 1996 CH_4 emissions (779.4 kilotons) distributed into main categories. For CH_4 the main categories "Nature" and "Agriculture and Forestry, Land use and Wood stock change" each contributes with 45% and 42% to the national totals. The emissions from waste water treatment and the remaining emissions each have a 10% and 3% share of the national totals.

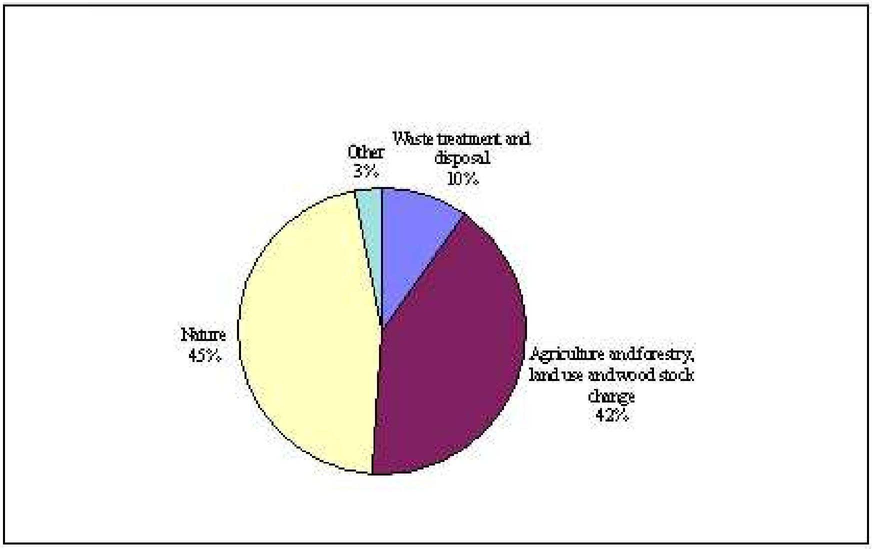


Figure 15 Danish CH_4 emissions in 1996 distributed into categories

The Danish CH_4 emissions are shown for the period 1975-1996 with the main contributing categories in figure 16. It is seen that the emissions are almost constant in the period. The major emissions from the "Nature" category are; the emissions from anaerobic bacterial processes in wetlands and waters and the emissions from near surface deposits, containing natural gas. In the "Agriculture and Forestry, Land use and Wood stock change" category it is the enteric fermentation in the ruminants, which causes the majority of CH_4 emissions.

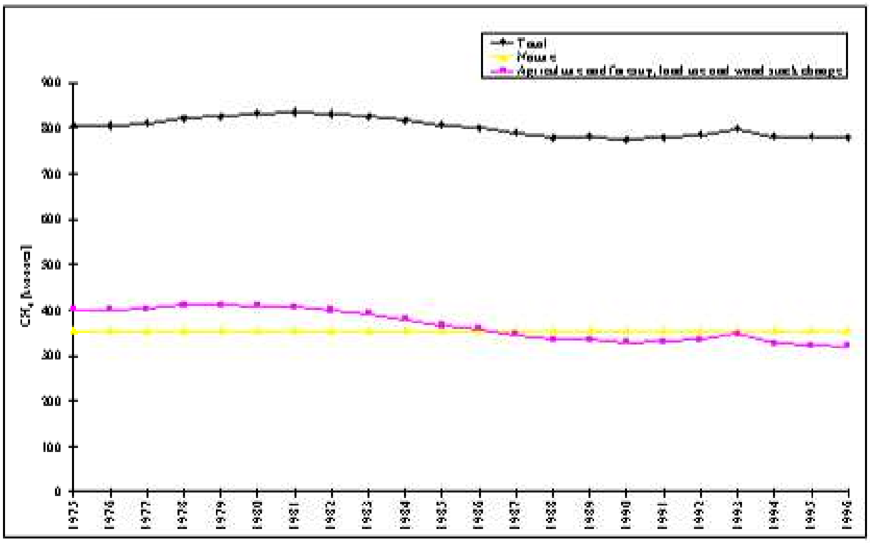


Figure 16 Danish 1975-1996 CH_4 emissions in totals and main categories

In Figure 17 the European 1994 CH_4 per capita emissions are shown (Ritter, 1997). The main group "Nature" has been excluded in order to make consistent comparisons between countries. The EU-15 mean emission is approximately 60 kg CH_4 per person and lower than the Danish emissions of around 80 kg per person. The relatively high Danish emissions stem from a large number of farm animals including ruminants. This is also the reason for the very high Irish emissions.

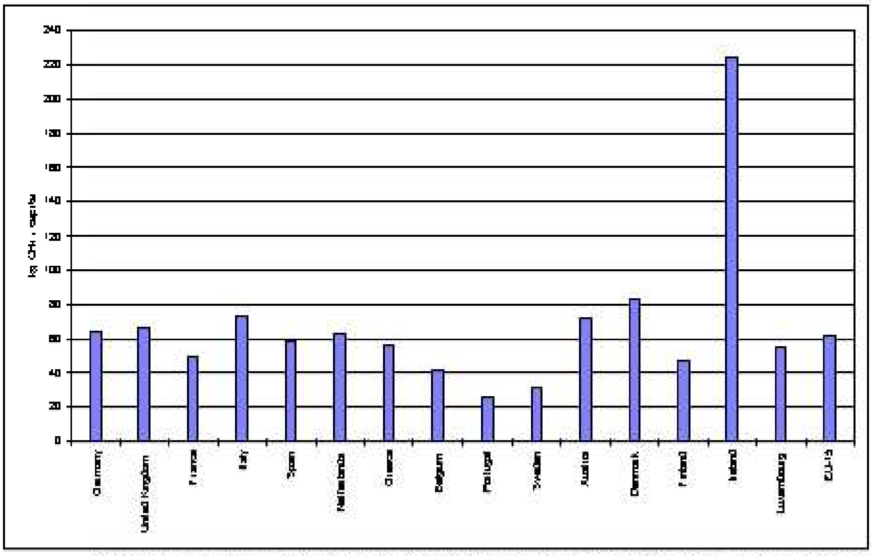


Figure 17 European CH_4 emissions in 1994 (kg CH_4/capita) with main sector nature excluded

5.5 Carbon monoxide (CO)

The Danish 1996 CO emissions (597.5 kilotons) are shown by main source categories in figure 18. Even though catalyst cars were introduced in 1990, road transport is still the main contributor to the CO emissions, with a 60% share of the national totals. The other mobile sources and machinery's accounts for 10%, giving a total emission share of 70% for the transport sector. The non-industrial combustion plants, mainly residential heating facilities, contribute with another 20% of the total emissions.

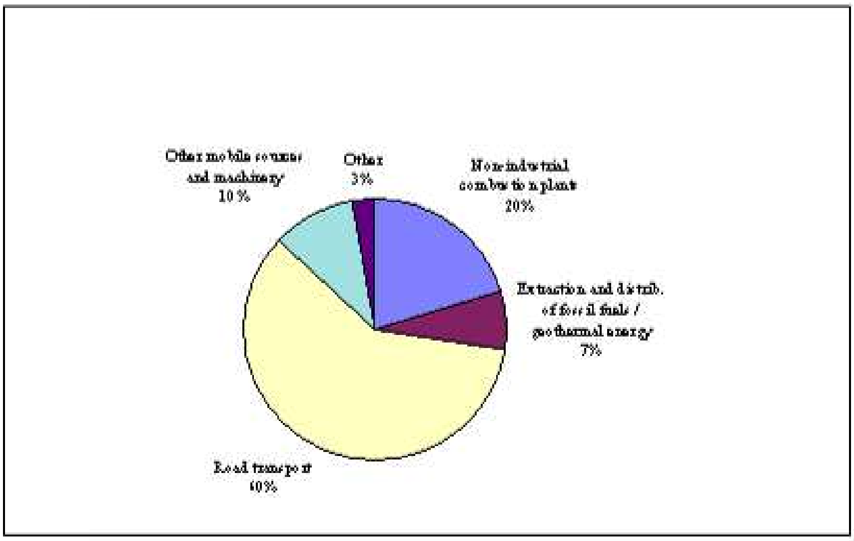


Figure 18 Danish CO emissions 1996 distributed into categories

The total Danish 1975-1996 CO emissions are shown in figure 19 together with the emissions from the main contributing categories. The almost complete ban on the burning of on-field straw causes a significant decline in the emissions from 1989 to 1990. The CO emission decline from 1990 onwards is mainly due to the introduction of catalysts on cars.

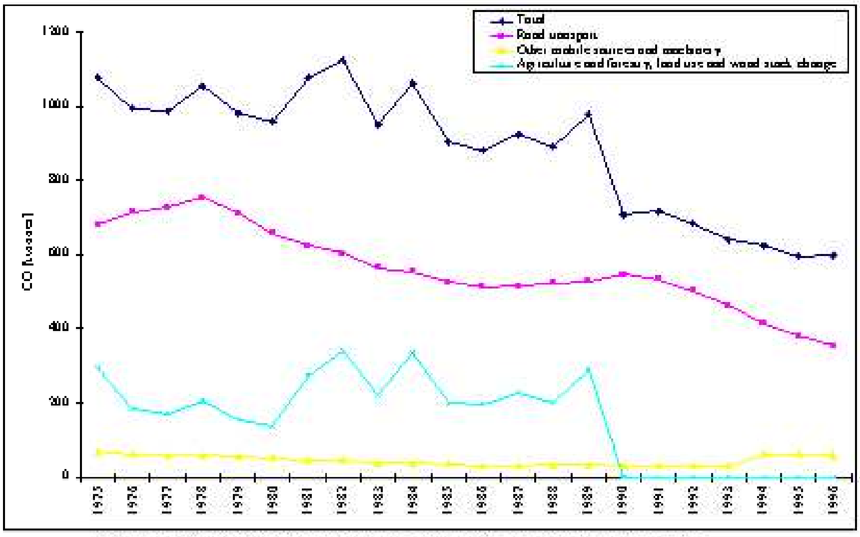


Figure 19 Danish 1975-96 CO emissions in totals and main categories

The 1994 European per capita CO emissions are shown in figure 20 (Ritter, 1997). To be able to compare the emissions between countries the main category "Nature" is excluded from the totals. With an emission of almost 140 kg CO per capita Denmark is just above the European mean of around 120 kg per capita. The high emissions per capita in Luxembourg arise from the industrial steel production.

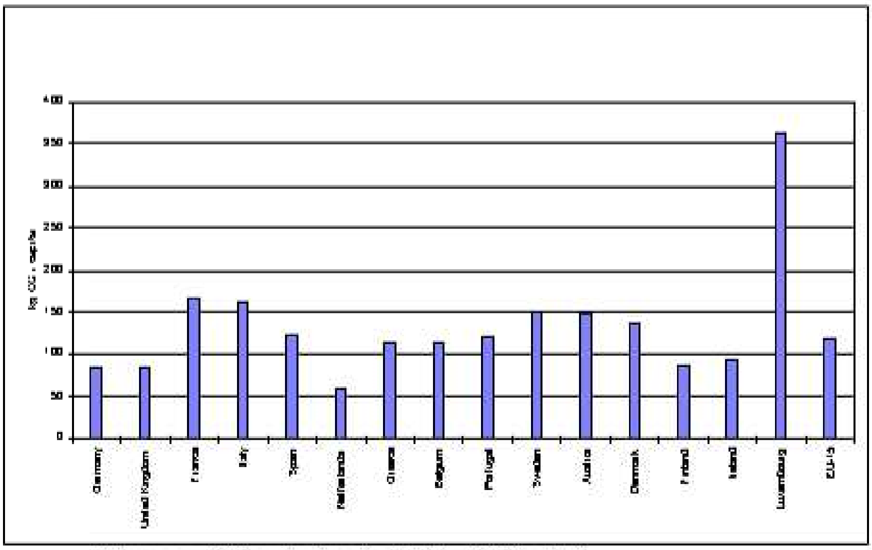


Figure 20 European CO emissions in 1994 (kg CO/capita)

5.6 Carbon dioxide (CO_2)

The inventory of CO_2 is made by assuming that all combustion processes are complete and consequently convert all the fuel-related carbon into CO_2. In almost any case this is not true and the not fully transformed carbon will be emitted as CO, CH_4 or NMVOC. In turn these emission components transform into CO_2 in the atmosphere.

Emissions from biomass fuels; straw, wood, biogas and municipal waste are not included in the CO_2 emission inventory. Also excluded are the CO_2 emissions from nature and the agricultural sector except from agricultural soils if available. These exclusions prevent double counting of carbon given the fact that biomass is circulated in the biosphere. The waste treatment and disposal sector includes the CO_2 emissions from oil and gas flaring and more general CO_2 contributions from non-biological wastes while the CO_2 emissions from solvent use relates to CO_2 from NMVOC.

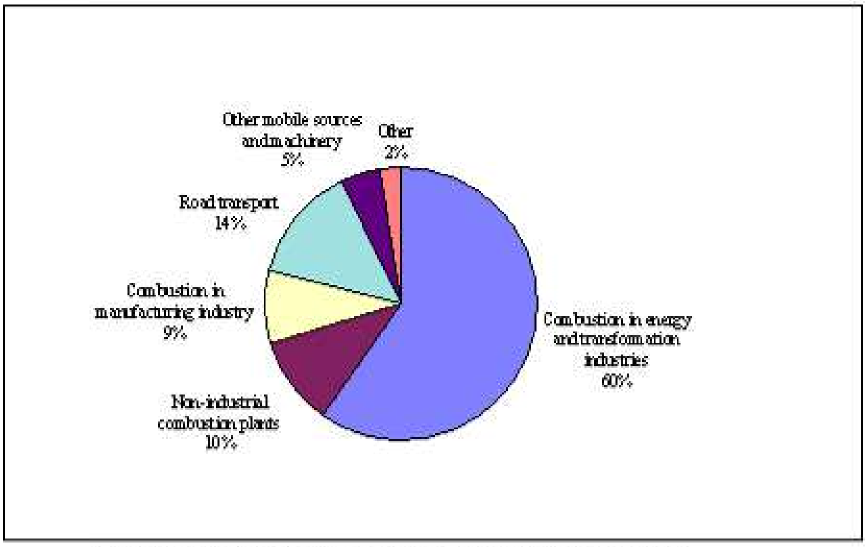


Figure 21 Danish CO_2 emissions in 1996 distributed into categories

Figure 21 shows the Danish 1996 CO_2 emissions per main category. The "Combustion in energy and transformation industries" sector is responsible for 60% of the total emissions, while road transport contributes with 14%.

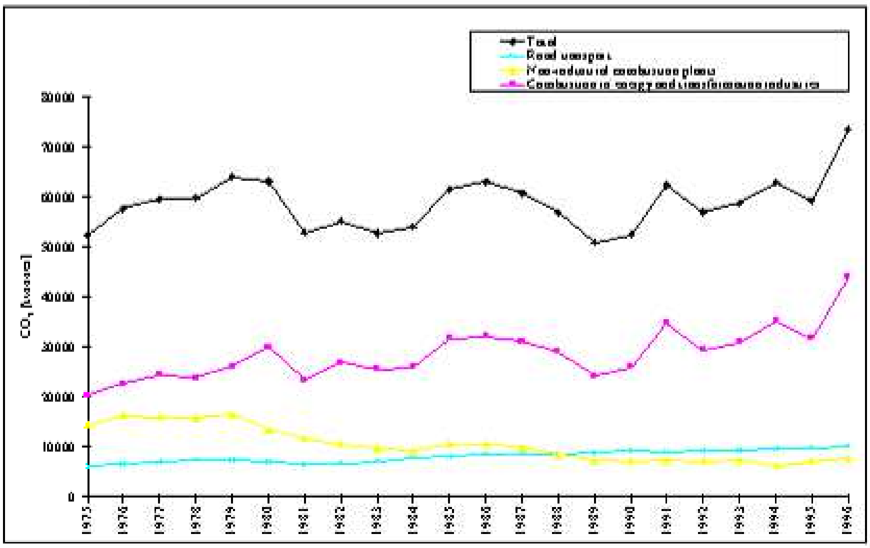


Figure 22 Danish 1975-96 CO_2 emissions in totals and in main categories

The total Danish 1975-1996 CO_2 emissions are shown in figure 22, as well as the time series emissions from the main contributing categories. The high 1996 emissions come from this year's large production and exportation of electricity. To a large extend the Danish total emission level is governed by the emissions from "Combustion in energy and transformation industries". However there is a constant increase in the road traffic emission starting already in the beginning of the 1980s. No CO_2 emission reduction target is plotted in figure 22, since the CO_2 emissions are only a part of the total greenhouse gas budget with reduction levels according to the Kyoto protocol, see chapter 3.

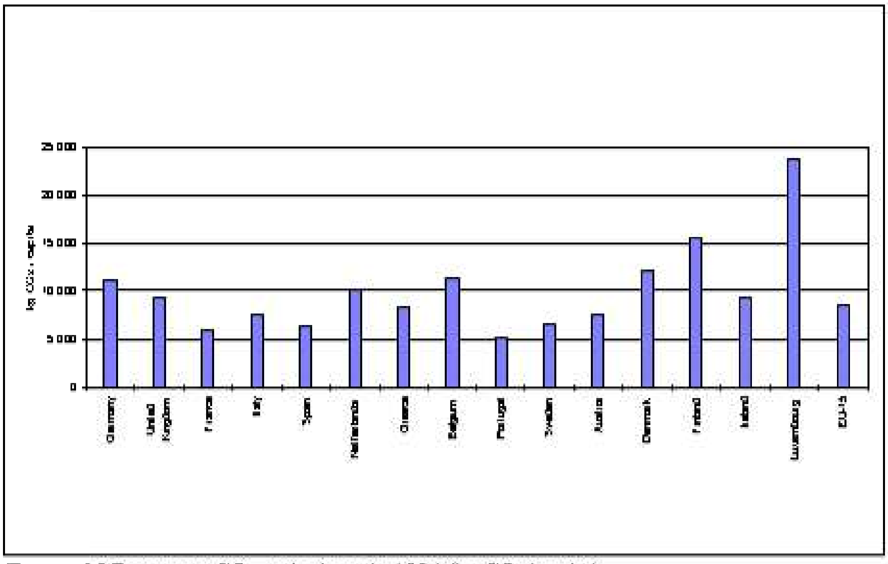


Figure 23 European CO_2 emissions in 1994 (kg CO_2/capita)

The EU-15 CO_2 emissions per capita are shown in figure 23 (Ritter, 1997).The emissions from agriculture and forestry as well as nature are excluded from the totals. The Danish per capita emissions are higher than the EU-15 average CO_2 per capita. This is due to the dominant role of fossil fuels in the power and heat generation system.

5.7 Nitrous oxide (N_2O)

Large quantities of N_2O are created in bacterial processes. Some N_2O is also formed during combustion, but the emission impact from this process is smaller than the impact from the naturally formed N_2O. In Denmark the sector "Agriculture and forestry, land use and wood stock change" contributes with 51% of the total emissions in 1996, while "Nature" has a 32% share of the total emissions. The remaining 17% are formed in different combustion processes. The emission distribution is shown in figure 24.

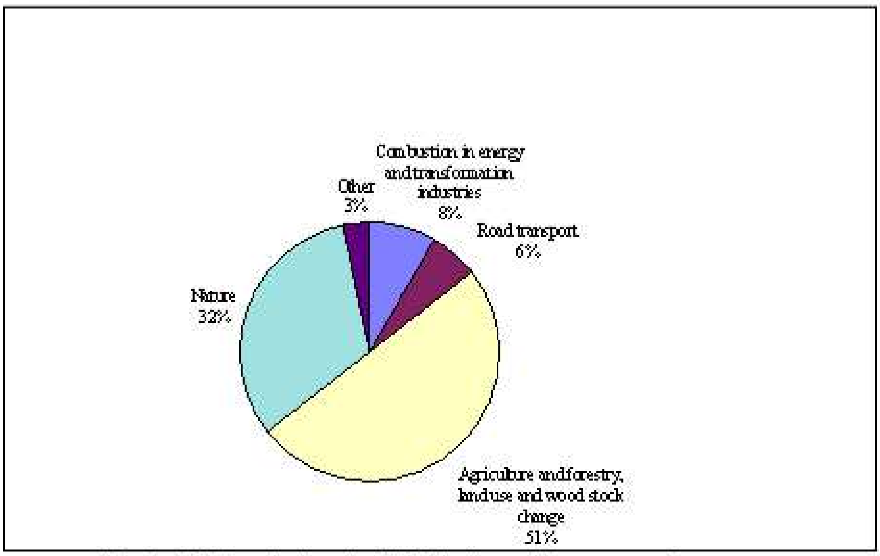


Figure 24 Danish N_2O emissions in 1996 distributed into categories

The Danish N_2O emission inventory does not yet follow the revised set of guidelines developed in the framework of IPCC. An update of the Danish inventory will be carried out according to these procedures, but still awaits the update of the CORINAIR software and methodology from the European Environment Agency. The revised N_2O inventory method is expected to estimate emissions on a 3-4 times higher level for agriculture compared with the inventory method used until now.

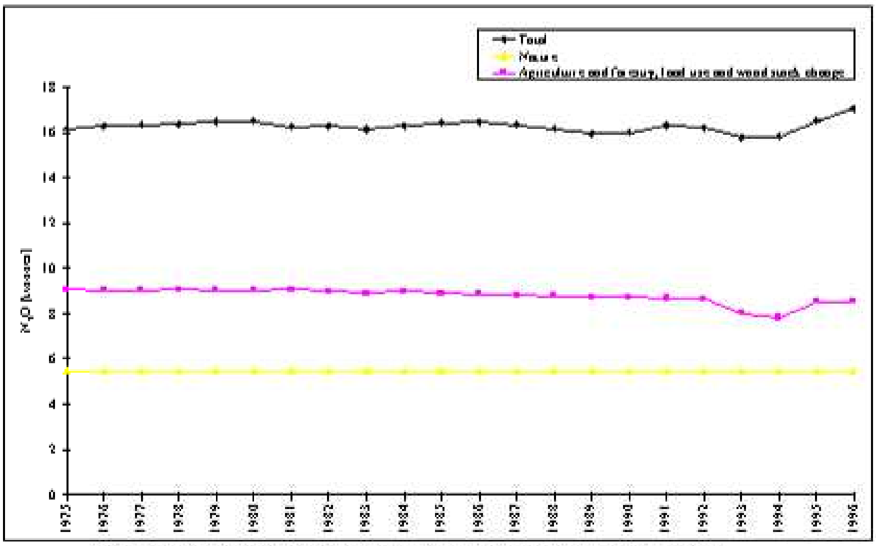


Figure 25 Danish 1975-96 N_2O emissions in totals and main categories

In Figure 25 the Danish N_2O emissions are shown from 1975 to 1996 in main source categories. Most of the emissions are created by natural processes. In the sector "Agriculture and forestry, land use and wood stock change" it is the use of fertiliser, which causes the emissions. A small amount of the applied fertiliser is transformed to N_2O by bacteria. From "nature" it is mainly drainage waters, open sea and underdrained and brackish marshes which are the emission sources.

The 1994 N_2O per capita emissions from the EU-15 countries are shown in figure 26 (Ritter , 1997). The emissions from "nature" are not included in the figure. A large nitrogen input to fertilizers and the production of manure from cattle and sheep give high Irish per capita emissions.

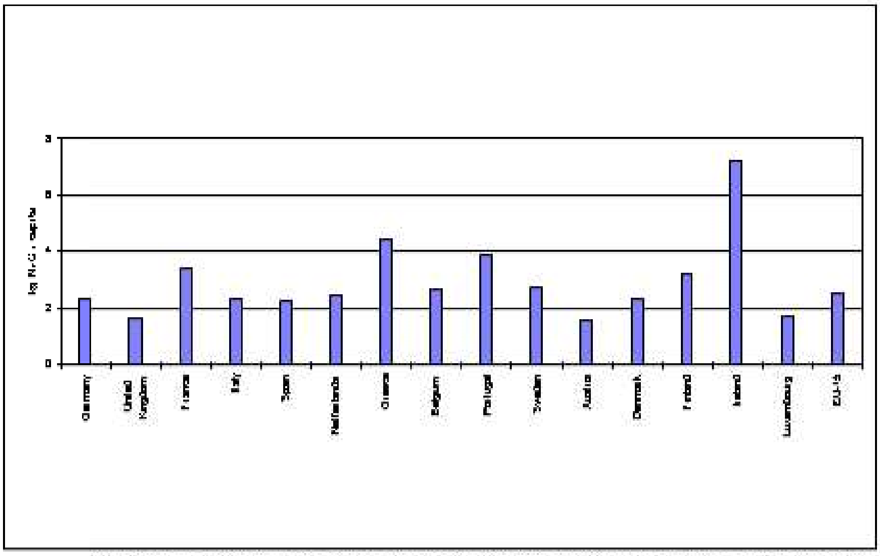


Figure 26 European N_2O emissions 1994 (kg N_2O/capita) with main sector nature excluded

5.8 Ammonia (NH_3)

In Denmark manure is almost the only source of NH_3 emissions to the atmosphere. Some ammonia is also formed in combustion processes, but only in negligible quantities.

The inventory of NH_3 has recently been updated. The 1995 and 1996 estimates are based on a model developed at NERI, where the influence of different stables, storage and spreading methods is taken into account. The model is currently being developed and changes will influence the emission results.

For the years 1975-1994 the NH_3 estimates are based on the emission calculations for 1995. This is done by adjusting every year's emissions factors in the entire time period.

The aims for several ammonia emission reduction plans have been included in the emission factor adjustments. A target reduction plan from 1986 (NERI, 1998) made clear that all manure spread on fields should be ploughed down within 24 hours after spreading, wherever possible. The reduction plan was further strengthened in 1987 (NERI, 1998), where it was placed on the farmers to plough down the manure within 12 hours after spreading.

In the adjustments it is furthermore assumed that nothing is cultivated on one third of the crop area by the time of spreading. In this situation it is possible to plough down the manure immediately after it has been spread. The effect is a 80% reduction in the emission factors for spreading process (CORINAIR, 1996).

Also a reduction of the emissions from storage tanks is assumed (CORINAIR, 1996). The reduction is made according to the Action Plan on the Aquatic Environment from 1987 stating that all storage tanks should be equipped with surface cover from the year 1987 (Andersen et al., 1999).

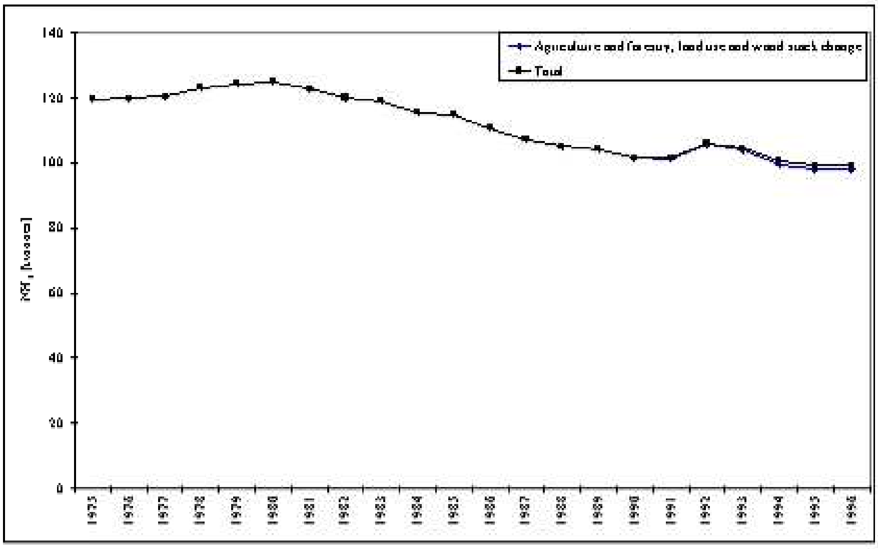


Figure 27 Danish 1975-96 NH_3 emissions in totals and main categories

The Danish NH_3 emissions and the main contributing categories are shown in figure 27 for the period 1975-1996. The total emissions almost solely stem from "Agriculture and Forestry, Land use and Wood stock change", with animal manure as a main contributor. The adjustment of the emission factors and subsequent lower emission estimates represents an improvement of the NH_3 inventory. However, the emission decrease in the period would tend to be stronger, if more effort was made to calculate more precisely the previous year's emission factors.

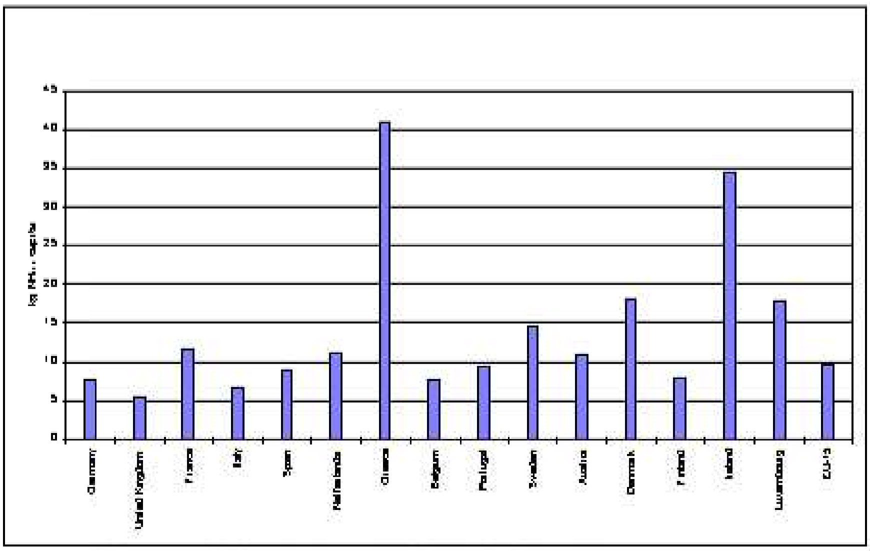


Figure 28 European NH_3 emissions in 1994 (kg NH_3/capita)

The EU-15 1994 NH_3 emissions are shown in figure 28 (Ritter, 1997). The Danish emissions are almost 18 kg NH_3 per capita, which is above the EU-15 average of almost 10 kg NH_3 per capita. Irish emissions are very high and this is due to the large population of cattle and sheep, which produce large quantities of manure. Since this report was prepared the high per capita emission in Greece have been adjusted to a smaller number as part of an inventory revision.

5.9 Heavy metals

At present Denmark has the obligation to report emission inventories for As, Cd, Cr, Cu, Hg, Ni, Pb and Zn according to the Oslo-Paris/Helsingfors conventions and As, Cd, Cr, Cu, Hg, Ni, Pb, Se and Zn according to the European Topic Centre for Air Emissions. Furthermore a protocol under the UNECE convention covering the heavy metals, Cd, Hg and Pb has been signed.

Table 9 International bodies to which Denmark has to report emission data on heavy metals

Heavy metal	OSPARCOM	HELCOM	EEA	UNECE (to be established)
As	X	X	X	
Cd	X	X	X	X
Cr	X	X	X	
Cu	X	X	X	
Hg	X	X	X	X
Ni	X	X	X	
Pb	X	X	X	X
Se			X	
Zn	X	X	X	

The inventory of heavy metals is calculated from activities and emission factors. The quality of the emission factors and the corresponding emissions varies from sector to sector. To a large extend the Danish inventory is based on emission factors from various European sources (e.g., CORINAIR (1996), Berdowski et al. (1995), Most and Veldt (1992)) though also Danish emission factors are used. Table 10 summarises the origin of the emission factors used for calculating the emissions of heavy metals for the most important sectors.

Table 10 Origin of the emission factors used in the Danish heavy metal inventory

SNAP code	Category	Danish sources	European sources
1	Public power plants > 300 MW	X	
	Public power plants > 50 MW	X	X
	District heating plants	X	X
	Refineries		X
2	Non-industrial combustion		X
3	Combustion in manufacturing industry	(X)	X
4	Production processes	X	
7	Road transport		X
8	Other mobile sources		X

Table 11 Total Danish 1996 heavy metal emissions in kg (-: not estimated)

SNAP code	Category	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
01	Combustion in energy and transformation industries	638	511	2350	2941	1930	8767	11259	2751	21407
02	Non-industrial combustion plants	145	262	223	444	287	3123	1497	8	3749
03	Combustion in manufac-turing industry	329	242	615	322	145	11949	652	23	1159
04	Production processes	-	42	7	-	147	294	728	-	5782
05	Extraction and distrib. of fossil fuels	-	-	-	-	-	-	-	-	-
06	Solvent and other product use	-	-	-	-	-	-	-	-	-
07	Road transport	159	32	159	5420	159	223	5445	32	3189
08	Other mobile sources and machinery	71	12	57	1253	54	1091	488	93	928
09	Waste treatment and dis-posal	-	-	-	-	-	-	-	-	-
10	Agriculture and forestry	-	-	-	-	-	-	-	-	-
11	Nature	-	-	-	-	-	-	-	-	-
	Total	1342	1101	3411	10380	2722	25447	20069	2907	36214

Table 11 shows the Danish 1996 total emissions distributed in main categories. The percentage share per category is shown in figure 29. For all the metals except Cu and Ni the emissions for sector 1, "Combustion in energy and transformation industries", account for 50% or more of the national totals.

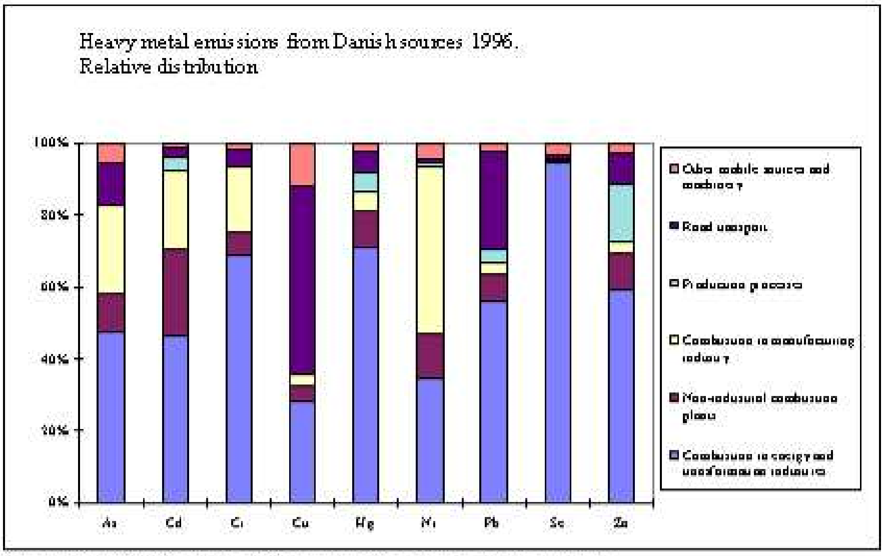


Figure 29 Distribution of heavy metals on the main sectors

The distribution of heavy metals from SNAP category 1 "Combustion in energy and transformation industries" into the three sub-sectors, "Public power", "District heating" and "Refinery", shows that 49-68 % of the emissions stem from public power plants. For public power plants with a thermal capacity larger than 300 MW, detailed heavy metal inventories are made for 1995 and 1996. The emission factors and the total emissions are listed in table 12 for the heavy metals which are going to be covered by the UNECE Convention.

Table 12 Emission of heavy metals from public power plants > 300 MW

Year	Cd	Hg	Pb
1995 (kg/year)	32	399	1391
1996 (kg/year)	51	590	1814
1995 (kg/PJ)	0.123	1.53	5.35
1996 (kg/PJ)	0.139	1.60	4.94

For all three metals there is a significant increase in the emissions, even though the emission factors are almost constant. The increase in the emissions from 1995 to 1996 is due to a large increase in the energy production. Figure 30 shows that coal is used as main fuel in public power plants larger than 300 MW. The large coal consumption in 1996 covers the extra fuel needed for this year's increased energy production.

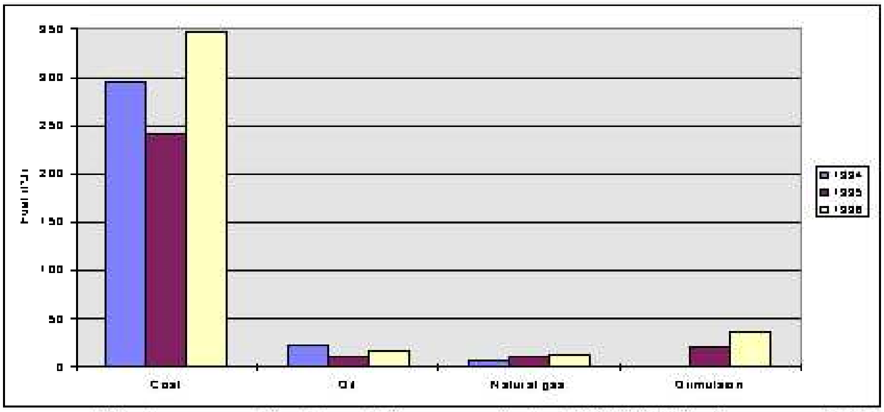


Figure 30 Fuel consumption by public power plants > 300 MW in the years 1994-1995.

Table 11 also shows that heavy metal emissions from industrial production are significant. These emissions come from combustion (SNAP category 3) or production processes (SNAP category 4). The combustion processes contribute with most of the emissions.

The primary fuel used in industrial combustion is oil, and in opposite to the coal-fired large power plants, gas cleaning devices are only seldomly installed. As a consequence the emissions of heavy metals contribute with a relatively high fraction of the total emissions, in cases where the oil heavy metal content is high compared to coal. This is true for Cd, As and Ni, where the industrial combustion accounts for 20-50% of the total emissions.

The road transport (SNAP category 7) contributes to the Cu and Pb emissions with 52 % and 27 %, respectively. All of the road traffic emission factors, except Pb where the Danish fuel content is used, are European default values from the COPERT model, see paragraph 2.3.1. In general a large part of the emission factors behind the Danish heavy metal inventory is based on

European values. To make the Danish inventory more reliable, improved emission factors are going to be worked out based on Danish production processes and combustion plants.

5.10 Large point and area source emissions

In the Danish 1996 inventory 44 large point sources have been registered. They are distributed as shown in table 13. The 44 LPS are furthermore listed in appendix 2.

Table 13 Number and category of large point sources registered in the Danish CORINAIR '96 inventory

Category	Number
Public power/district heating (> 300 MW)	14
Public power/district heating (50-300 MW)	17
Public power/district heating (< 50 MW)	1
Industry	8
Refineries	3
Airports	1

Public power or district heating plants with a thermal capacity greater than 50 MW used only as reserve plants are not included in the list, since the actual activities are very low. However, the list still needs to be completed for future inventory years. This implies the adding of some district heating and industrial plants that fulfil the large point source definitions in paragraph 2.2.2.

Table 14 shows the types of data that can be registered in the CORINAIR database with respect to large point sources (LPS). For most of the large point sources included in the Danish CORINAIR inventory these data are obtained.

Table 14 Type of LPS data registered in the CORINAIR database

Point source level	Registered data
LPS	Location, nominal capacity, starting year, number of parts (e.g. boilers for power plants, number of stacks)
Parts	Nominal and actual activity, gas cleaning device, fuel consumption, fuel types, emissions or emission factors
Stacks	Height, temperature of the exhaust gases, (area of the stack, flow rate of the exhaust gases).

For most of the LPS in the Danish CORINAIR database the above information is registered.

The emission distribution between area sources and LPS are listed in table 15 and the emission distribution percentages are shown in the figures 31 and 32.

Table 15 Distribution of the Danish 1996 emissions between area and point sources

Pollutant	Area source emission	Point source emission	Total emission	Unit
SO_2	41733	143927	185660	Mg
No_x	167416	120264	287680	Mg
NMVOC	129207	7150	136357	Mg
CH_4	778149	1220	779369	Mg
CO	590111	7408	59519	Mg
CO_2	28619	44997	73616	Gg
N_2O	15720	1324	17044	Mg
NH_3	99267	0	99267	Mg
As	736	579	1315	kg
Cd	863	242	1105	kg
Cr	1389	2078	3467	kg
Cu	8834	1672	10506	kg
Hg	1359	1336	2695	kg
Ni	16606	9905	26511	kg
Pb	15620	4615	20235	kg
Se	168	3424	3592	kg
Zn	19685	16526	36211	kg

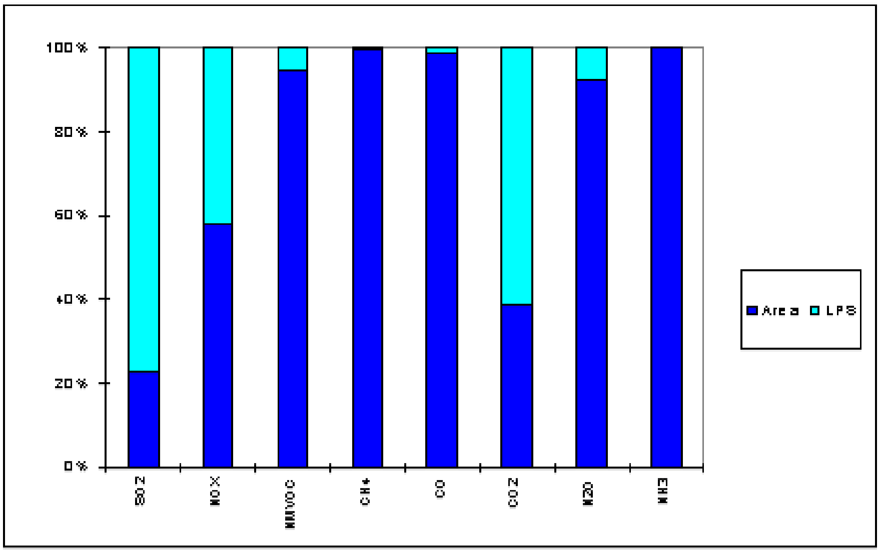


Figure 31 Relative 1996 emissions from Danish area and point sources

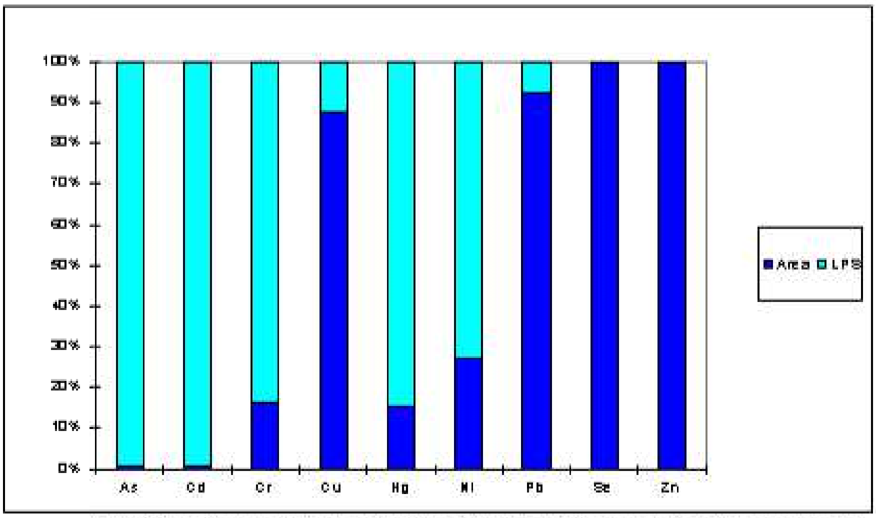


Figure 32 Relative heavy metals emissions from Danish area and point sources in 1996

The large point sources contribute with 78 %, 42 % and 61 % of the total SO_2, NO_x and CO_2 emissions, respectively. Also for the heavy metals, As, Cd, Hg and Ni, there are major contributions from large point sources (figure 32). The major part of the emissions of these pollutants are due to combustion in energy and transformation industries (SNAP category 1).

Most of the SO_2, NO_x and CO_2 emissions from SNAP category 1 come from public power plants with a thermal capacity larger than 300 MW.

Table 16 Relative emissions from public power plants > 300 MW

% of point source emissions			% of total emissions		
SO_2	NO_x	CO_2	SO_2	NO_x	CO_2
93	91	84	72	38	51

Table 16 shows that 14 public power plants contribute with 72, 38 and 51% of the total 1996 SO_2, NO_x and CO_2 emissions, respectively. The total shares would have been more modest if the power generation peak had been lower in 1996 The distribution of the energy consumption on fuels for public power plants larger than 300 MW is given in figure 30 for the years 1994, 1995 and 1996. From that figure it is seen that coal is the most used fuel and that the coal consumption has increased with more than 40% from 1995 to 1996.

5.11 International emissions

The emissions of SO_2, NO_x and CO_2 related to international sea transportation and air traffic are shown in the figures 33, 34 and 35, respectively. Since the international emissions of NMVOC, CH_4, CO, N_2O and NH_3 are very small compared to domestic totals they will not be viewed in this report.

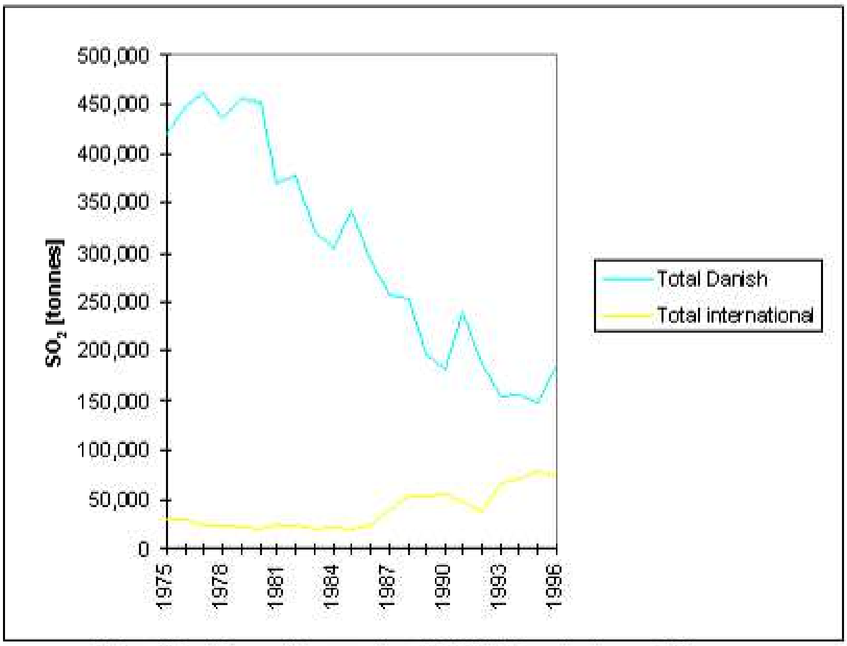


Figure 33 Total Danish and international 1975-1996 emissions of SO_2

The Danish SO_2 emissions decline from 1975 to 1996 is due to measures taken to reduce the emissions from the energy and transformation industries and a lowering of the sulphur content in the fuels used for national transportation. No special attempts have been made to bring down the international SO_2 emissions from marine activities, where especially the residual oil used has a high sulphur content. As a result the international SO_2 emissions show an increase from the mid 1980s and onwards. The emission increase is governed by the increase in fuel use and the high sulphur content. It appears that the international totals are almost half of the Danish national totals even though the international fuel use is lower than 10 % compared with the total national energy consumption.

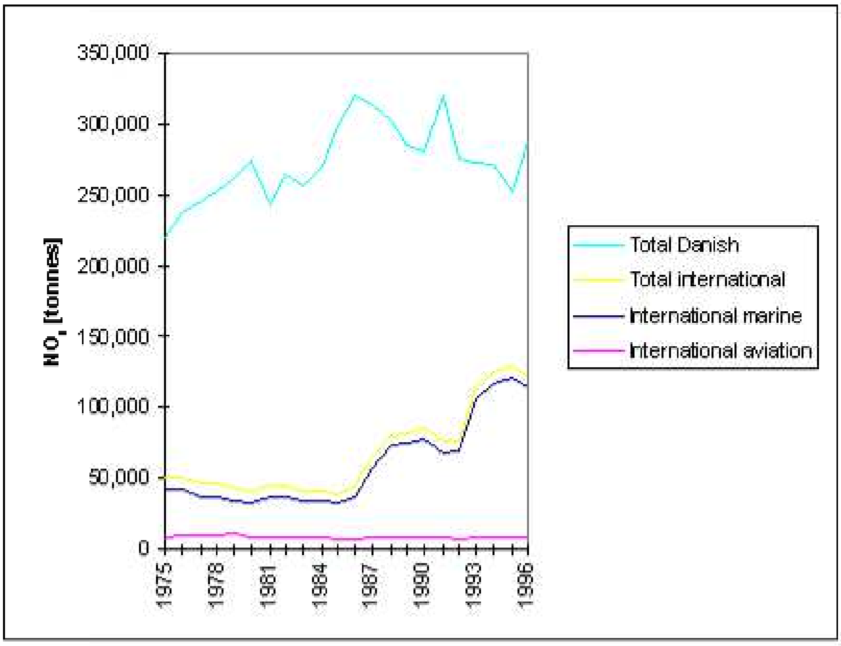


Figure 34 Total Danish and international 1975-1996 emissions of NO_x

The development in the international NO_x emissions is almost similar to what is seen for SO_2. No major improvements have been achieved in reducing NO_x and hence the emissions are ruled by the development in fuel use during the period. Most of the international emissions originate from ships using residual fuel but also vehicles using marine diesel for propulsion and to a smaller extent international air traffic have significant contributions.

Energy and transformation industries and national transportation have the largest contributions to the Danish totals but in these two sectors steps have been taken during the period to bring down the emissions. This in combination with an increase in fuel use in general since the mid 1980s and a low NO_x emission performance by international transportation brings Danish and international emissions on comparable levels in the late part of the 1975-1996 time period.

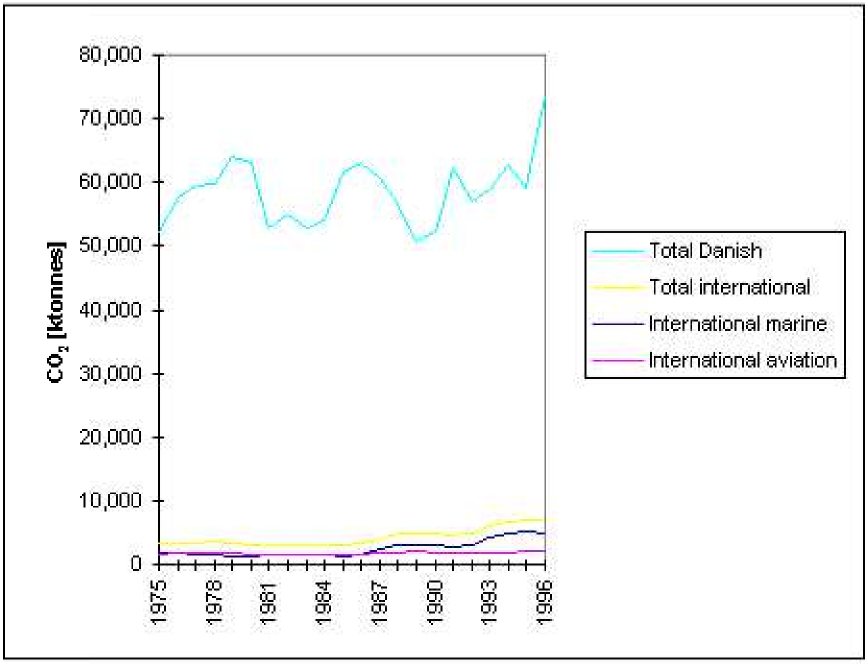


Figure 35 Total Danish and international 1975-1996 emissions of CO_2

In terms of CO_2 the international emissions are modest compared with the total Danish budget. The CO_2 emissions related to the use of residual oil are slightly higher than the emissions from ships using marine diesel and the emissions from air traffic, which are at the same level.

6 References

Ahlvik, P., Eggleston, S., Gorißen, N., Hassel, D., Hickman, A.-J., Joumard, R., Ntziachristos, L., Rijkeboer, R., Samaras, Z. and Zierock, K.-H. (1997): COPERT II Computer Programme to Calculate Emissions from Road Transport - Methodology and Emission Factors - Technical Report No. 6. European Environment Agency, Copenhagen.

Andersen, J. M., Hutchings, j., Kristensen, V. F., Sommer, S. G. (1999): Emission af ammoniak fra landbruget - status og kilder, DJF report (under publication).

Bang, J. R. (1996): Utslipp av NMVOC for fritidsbåter og bensindrevne motorredskaper. Transportteknologi, Teknologisk Institutt, Oslo.

Berdowski, J.J.M. , Veldt, C., Baas, J., Bloos, J.P.J. and Klein, A.E. (1995): Technical paper to the OPSPARCOM-HELCOM-UNECE Emission Inventory of Heavy Metals and Persistent Organic Pollutants. Report TNO-MEP-R 95/247. TNO Institute of Environmental Sciences, Energy Research and Process Innovation, Delft, The Netherlands.

Chang, J.-P. and Fontelle, J.-P. (1996): Corinair air emission system version 1.0. Instructions for use. Report, European Environmental Agency, Copenhagen, Denmark.

Copenhagen Airport (1996): VVM Fagprojekt - Luftforurening, Copenhagen Airport, Copenhagen (in Danish).

Copenhagen Airport (1997): Traffic Statistics 1996, Copenhagen Airport, Copenhagen (in Danish).

CORINAIR (1993): CORINAIR working group on emission factors for calculating 1990 emissions from road traffic: Volume 1: Methodology and emission factors, ISBN 92-826-5771-X, Commission of the European Communities, Brussels.

CORINAIR (1996): Atmospheric Emission Inventory Guidebook, First Edition. Vol. 1 and 2. European Environment Agency, Copenhagen Denmark.

Dansk Teknologisk Institut (1992): Emission fra Landbrugsmaskiner og Entreprenørmateriel, udført for Miljøstyrelsen af Miljøsamarbejdet i Århus (in Danish).

Dansk Teknologisk Institut (1993): Emission fra Motordrevne Arbejdsredskaber og -maskiner, udført for Miljøstyrelsen af Abrahamsen & Nielsen A/S (in Danish).

EEA (1995): CORINAIR 90 - Summary Report 1. European Environmental Agency EEA/053/95. Copenhagen, Denmark.

Fenhann, J. and Kilde, N. (1994): Inventory of Emissions to the Air from Danish Sources 1972-1994. Risø National Laboratory, Roskilde, Denmark.

Fenhann, J., Kilde, N.A., Runge, E., Winther, M., & Illerup, J.B. (1997): Inventory of Emissions to the Air from Danish Sources 1992-1995. Samfund og miljø - Emission Inventories. National Environmental Research Institute, Roskilde, Denmark 130 pp.- Research Notes from NERI No 68.

Lloyd's (1995): Marine Exhaust Emissions Programme. Engineering Services Group, Croydon, UK.

Most, P.F.J van der and Veldt C. (1992): Emission Factors Manual. PARCOM-ATMOS. Emission factors for air pollutants 1992. Report TNO-92-235. Delft, The Netherlands.

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

Ritter, M. (1997): CORINAIR 94. Summary Report. Final version. Report to the European Environmental Agency from the European Topic Centre on Air Emissions, Copenhagen, Denmark.

Statistics Denmark (1997): Statistical Yearbook 1997, Statistics Denmark, Copenhagen (in Danish).

Appendix 1

01	COMBUSTION IN ENERGY AND TRANSFORMATION INDUSTRIES	ACIDIFYERS, OZONE PRECURSORS AND GREENHOUSE GASES								HEAVY METALS									PERSISTANT ORGANIC POLLUTANTS			
		SO_x	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn	TRI	PER	DIOX	PAH
01 01	**Public power**																					
01 01 01	Combustion plants >= 300 MW (boilers)	**M**	**M**	x	x	x	**M**	**X**	(x)	x	x	x	x	x	x	x	x	x	-	-	(x)	x
01 01 02	Combustion plants >= 50 and < 300 MW (boilers)	**X**	x	(x)	(x)	(x)	**X**	x	(x)	x	x	x	x	x	x	x	x	x	-	-	(x)	x
01 01 03	Combustion plants < 50 MW (boilers)	x	x	(x)	(x)	(x)	x	x	(x)	x	x	x	x	x	x	x	x	x	-	-	(x)	x
01 01 04	Gas turbines	(x)	x	(x)	(x)	(x)	x	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	-	-	-	(x)
01 01 05	Stationary engines	x	x	(x)	(x)	(x)	(x)	(x)	(x)	x	x	x	x	x	x	x	x	x	-	-	-	x
01 02	**District heating plants**																					
01 02 01	Combustion plants >= 300 MW (boilers)	x	x	(x)	(x)	(x)	x	x	(x)	x	x	x	x	x	x	x	x	x	-	-	(x)	x
01 02 02	Combustion plants >= 50 and < 300 MW (boilers)	**X**	x	(x)	(x)	(x)	x	x	(x)	x	x	x	x	x	x	x	x	x	-	-	(x)	x
01 02 03	Combustion plants < 50 MW (boilers)	**X**	x	(x)	(x)	x	x	x	(x)	x	x	x	x	x	x	x	x	x	-	-	(x)	x
01 02 04	Gas turbines	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	-	-	-	(x)
01 02 05	Stationary engines	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	x	x	x	x	x	x	x	x	x	-	-	-	x
01 03	**Petroleum refining plants**																					
01 03 01	Combustion plants >= 300 MW (boilers)	x	x	(x)	(x)	(x)	x	x	(x)	x	x	x	x	x	x	x	x	x	-	-	(x)	x
01 03 02	Combustion plants >= 50 and < 300 MW (boilers)	x	x	(x)	(x)	(x)	x	x	(x)	x	x	x	x	x	x	x	x	x	-	-	(x)	x
01 03 03	Combustion plants < 50 MW (boilers)	x	x	(x)	(x)	(x)	x	x	(x)	x	x	x	x	x	x	x	x	x	-	-	(x)	x
01 03 04	Gas turbines	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	-	-	-	(x)
01 03 05	Stationary engines	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	x	x	x	x	x	x	x	x	x	-	-	-	x
01 03 06	Process furnaces	**X**	x	x	x	x	**X**	x	(x)	x	x	x	x	x	x	x	x	x	-	-	-	x
01 04	**Solid fuel transformation plants**																					
01 04 01	Combustion plants >= 300 MW (boilers)	x	x	(x)	(x)	(x)	x	x	(x)	x	x	x	x	x	x	x	x	x	-	-	(x)	x
01 04 02	Combustion plants >= 50 and < 300 MW (boilers)	x	x	(x)	(x)	(x)	x	x	(x)	x	x	x	x	x	x	x	x	x	-	-	(x)	x
01 04 03	Combustion plants < 50 MW (boilers)	x	x	(x)	(x)	(x)	x	x	(x)	x	x	x	x	x	x	x	x	x	-	-	(x)	x
01 04 04	Gas turbines	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	-	-	-	(x)
01 04 05	Stationary engines	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	x	x	x	x	x	x	x	x	x	-	-	-	x
01 04 06	Coke oven furnaces	x	x	x	x	x	**X**	x	(x)	x	x	x	x	x	x	x	x	x	-	-	-	x
01 04 07	Other (coal gasification, liquefaction, ...)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	x	x	x	x	x	x	x	x	x	-	-	-	x
01 05	**Coal mining, oil / gas extraction, pipeline compressors**																					
01 05 01	Combustion plants >= 300 MW (boilers)	x	x	(x)	(x)	(x)	x	x	(x)	x	x	x	x	x	x	x	x	x	-	-	(x)	x
01 05 02	Combustion plants >= 50 and < 300 MW (boilers)	x	x	(x)	(x)	(x)	x	x	(x)	x	x	x	x	x	x	x	x	x	-	-	(x)	x
01 05 03	Combustion plants < 50 MW (boilers)	x	x	(x)	(x)	(x)	x	x	(x)	x	x	x	x	x	x	x	x	x	-	-	(x)	x
01 05 04	Gas turbines	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	-	-	-	(x)

01 05 05 Stationary engines	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	x	x	x	x	x	x	x	x	x	-	-	-	x
01 05 06 Pipeline compressors	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	-	-	-	(x)

M: > 10 % , **X**: > 1 % , x : > 0.1 % , (x) : < 0.1 % , - : generally not relevant
TRI: trichloroethylene, PER: tetrachloroethylene, DIOX: dioxins, PAH: Polyaromatic hydrocarbons

02	NON-INDUSTRIAL COMBUSTION PLANTS	ACIDIFYERS, OZONE PRECURSORS AND GREENHOUSE GASES								HEAVY METALS									PERSISTANT ORGANIC POLLUTANTS			
		SO_x	No_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn	TRI	PER	DIOX	PAH
02 01	**Commercial and institutional plants**																					
02 01 01	Combustion plants >= 300 MW (boilers)	x	x	x	(x)	x	x	x	(x)	x	x	x	x	x	x	x	x	x	-	-	(x)	x
02 01 02	Combustion plants >= 50 and < 300 MW (boilers)	x	x	x	(x)	x	x	x	(x)	x	x	x	x	x	x	x	x	x	-	-	(x)	x
02 01 03	Combustion plants < 50 MW (boilers)	x	x	x	(x)	x	x	x	(x)	x	x	x	x	x	x	x	x	x	-	-	(x)	x
02 01 04	Stationary gas turbines	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	-	-	-	(x)
02 01 05	Stationary engines	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	x	x	x	x	x	x	x	x	x	-	-	-	x
02 01 06	Other stationary equipment's	x	x	x	(x)	x	x	x	(x)	x	x	x	x	x	x	x	x	x	-	-	(x)	x
02 02	**Residential plants**																					
02 02 01	Combustion plants >= 50 MW (boilers)	x	x	x	(x)	(x)	x	x	(x)	x	x	x	x	x	x	x	x	x	-	-	x	x
02 02 02	Combustion plants < 50 MW (boilers)	**M**	**X**	**X**	**X**	**M**	**M**	**X**	(x)	x	x	x	x	x	x	x	x	x	-	-	x	x
02 02 03	Gas turbines	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	-	-	-	(x)
02 02 04	Stationary engines	x	(x)	(x)	(x)	(x)	(x)	(x)	(x)	x	x	x	x	x	x	x	x	x	-	-	-	x
02 02 05	Other equipment (stoves, fireplaces, cooking,...)	x	x	x	x	x	x	x	(x)	x	x	x	x	x	x	x	x	x	-	-	x	x
02 03	**Plants in agriculture, forestry and aquacul-ture**																					
02 03 01	Combustion plants >= 50 MW (boilers)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	x	x	x	x	x	x	x	x	x	-	-	(x)	x
02 03 02	Combustion plants < 50 MW (boilers)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	x	x	x	x	x	x	x	x	x	-	-	(x)	x
02 03 03	Stationary gas turbines	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	-	-	-	(x)
02 03 04	Stationary engines	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	x	x	x	x	x	x	x	x	x	-	-	-	x
02 03 05	Other stationary equipment	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	x	x	x	x	x	x	x	x	x	-	-	(x)	x

M: > 10 % , **X**: > 1 % , x : > 0.1 % , (x) : < 0.1 % , - : generally not relevant

03	COMBUSTION IN MANUFACTURING INDUSTRY	ACIDIFYERS, OZONE PRECURSORS AND GREENHOUSE GASES								HEAVY METALS									PERSISTANT ORGANIC POLLUTANTS			
		Ox	Ox	NMVOC	CH_4	CO	CO_2	N_2O	NH_3	As	Cd	Kr	Cu	Hg	Ni	PBX	Se	Zen	TRI	PER	DIOX	PAH
03 01	**Comb. in boilers, gas turbines and stationary engines**																					
03 01	Combustion plants >= 300 MW (boilers)	X	X	(x)	(x)	x	X	x	(x)	x	x	x	x	x	x	x	x	x	-	-	(x)	x
03 01 02	Combustion plants >= 50 and < 300 MW (boilers)	X	X	(x)	(x)	x	X	x	(x)	x	x	x	x	x	x	x	x	x	-	-	(x)	x
03 01 03	Combustion plants < 50 MW (boilers)	X	X	x	x	x	X	X	(x)	x	x	x	x	x	x	x	x	x	-	-	(x)	x
03 01 04	Gas turbines	(x)	x	(x)	(x)	(x)	x	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	-	-	-	(x)
03 01 05	Stationary engines	x	x	(x)	(x)	(x)	x	(x)	(x)	x	x	x	x	x	x	x	x	x	-	-	-	x
03 01 06	Other stationary equipment	x	x	x	x	x	x	x	(x)	x	x	x	x	x	x	x	x	x	-	-	(x)	x
03 02	**Process furnaces without contact**																					
03 02 03	Blast furnace cowpers	x	x	(x)	(x)	x	X	x	-	x	x	x	x	x	x	x	x	x	-	-	-	x
03 02 04	Plaster furnaces	x	x	x	(x)	x	x	x	-	x	x	x	x	x	x	x	x	x	-	-	-	x
03 02 05	Other furnaces	(x)	(x)	(x)	-	(x)	(x)	x	-	x	x	x	x	x	x	x	x	x	-	-	(x)	x
03 03	**Processes with contact**																					
03 03 01	Sinter plants	X	X	x	x	X	x	(x)	(x)	x	x	x	x	(x)	x	x	(x)	x	-	-	x	x
03 03 02	Reheating furnaces steel and iron	x	x	(x)	(x)	x	x	x	-	x	x	x	x	(x)	x	x	(x)	x	-	-	(x)	x
03 03 03	Gray iron foundries	(x)	(x)	(x)	(x)	X	x	(x)	-	x	x	x	-	-	x	x	-	x	-	-	(x)	x
03 03 04	Primary lead production	x	(x)	(x)	-	(x)	(x)	-	-	x	x	-	x	(x)	-	x	-	x	-	-	-	(x)
03 03 05	Primary zinc production	x	(x)	(x)	-	(x)	(x)	-	-	x	x	-	x	(x)	-	x	-	x	-	-	-	(x)
03 03 06	Primary copper production	x	(x)	(x)	-	x	(x)	-	-	x	x	-	x	(x)	-	x	-	x	-	-	(x)	-
03 03 07	Secondary lead production	(x)	(x)	(x)	-	(x)	(x)	-	-	x	x	-	-	-	-	x	-	x	-	-	-	(x)
03 03 08	Secondary zinc production	(x)	(x)	(x)	-	(x)	(x)	-	-	x	x	-	-	x	-	x	-	x	-	-	-	-
03 03 09	Secondary copper production	(x)	(x)	(x)	-	(x)	(x)	-	-	x	(x)	-	x	-	-	(x)	-	(x)	-	-	(x)	-
03 03 10	Secondary aluminium production	(x)	(x)	(x)	-	(x)	(x)	-	-	-	x	-	-	-	-	-	-	-	-	-	(x)	x
03 03 11	Cement (f)	x	X	(x)	(x)	x	X	x	-	x	x	x	x	x	x	x	x	x	-	-	(x)	x
03 03 12	Lime (incl.. iron and steel and paper pulp industry)	x	x	(x)	-	x	x	-	-	x	x	x	-	x	x	x	x	x	-	-	(x)	x
03 03 13	Asphalt concrete plants	x	(x)	(x)	-	(x)	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x
03 03 14	Flat glass	x	x	(x)	-	(x)	x	-	-	x	x	x	x	x	x	x	x	x	-	-	-	-
03 03 15	Container glass (f)	x	x	(x)	-	(x)	x	-	-	x	x	x	x	x	x	x	x	x	-	-	-	-
03 03 16	Glass wool (except binding) (f)	(x)	(x)	(x)	-	(x)	(x)	-	-	x	x	x	x	x	x	x	x	x	-	-	-	-
03 03 17	Other glass (f)	(x)	x	(x)	-	(x)	(x)	-	-	x	x	x	x	x	x	x	x	x	-	-	-	-
03 03 18	Mineral wool (except binding)	(x)	(x)	(x)	-	(x)	(x)	-	-	x	x	x	x	x	x	x	x	x	-	-	-	-
03 03 19	Bricks and tiles	x	x	(x)	-	x	x	x	-	x	x	x	x	x	x	x	x	x	-	-	-	-
03 03 20	Fine ceramic materials	x	x	(x)	-	x	x	x	-	(x)	(x)	-	-	-	-	(x)	(x)	-	-	-	-	-
03 03 21	Paper-mill industry (drying processes)	x	(x)	(x)	(x)	(x)	x	x	-	-	-	-	-	-	-	-	-	-	-	-	(x)	-
03 03 22	Aluminium production	(x)	(x)	(x)	-	(x)	(x)	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
03 03 23	Magnesium production (dolomite treatment)	(x)	-	-	-	(x)	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	(x)	-
03 03 24	Nickel production (thermal process)	(x)	(x)	(x)	-	(x)	(x)	(x)	-	-	-	-	-	-	x	-	-	-	-	-	(x)	-
03 03 25	Enamel production	(x)	(x)	(x)	-	(x)	(x)	(x)	-	x	x	-	-	-	-	x	-	x	-	-	-	-
03 03 26	Other	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	-	(x)	(x)	(x)

M: > 10 % , **X**: > 1 % , x : > 0.1 % , (x) : < 0.1 % , - : generally not relevant

04	PRODUCTION PROCESSES	ACIDIFYERS, OZONE PRECURSORS AND GREENHOUSE GASES								HEAVY METALS									PERSISTANT ORGANIC POLLUTANTS			
		SO_x	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn	TRI	PER	DIOX	PAH
04 01	**Processes in petroleum industries**																					
04 01 01	Petroleum products processing	x	x	x	(x)	(x)	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-	x
04 01 02	Fluid catalytic cracking - CO boiler	x	x	(x)	-	(x)	x	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	(x)
04 01 03	Sulphur recovery plants	x	-	(x)	-	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(x)
04 01 04	Storage and handling of petroleum prod.. in refinery	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(x)
04 01 05	Other	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)
04 02	**Processes in iron and steel industries and collier-ies**																					
04 02 01	Coke oven (door leakage and extinction)	-	-	x	x	(x)	(x)	-	(x)	x	x	x	x	x	x	x	-	x	-	-	-	x
04 02 02	Blast furnace charging	-	-	(x)	-	x	x	-	-	x	x	x	x	-	x	x	-	x	-	-	-	x
04 02 03	Pig iron tapping	(x)	-	-	(x)	(x)	-	-	-	-	x	-	-	-	-	-	-	-	-	-	(x)	x
04 02 04	Solid smokeless fuel	-	-	(x)	(x)	-	-	-	-	x	x	-	-	x	-	x	-	x	-	-	-	x
04 02 05	Open hearth furnace steel plant	(x)	x	(x)	(x)	(x)	(x)	(x)	-	x	x	x	x	x	x	x	x	x	-	-	(x)	x
04 02 06	Basic oxygen furnace steel plant	x	(x)	(x)	(x)	X	(x)	(x)	-	x	x	x	x	x	x	x	x	x	-	-	(x)	x
04 02 07	Electric furnace steel plant	(x)	x	(x)	(x)	x	(x)	(x)	-	x	x	x	x	x	x	x	x	x	-	-	(x)	x
04 02 08	Rolling mills	-	-	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x
04 02 09	Sinter plant (except combustion 03.03.01)	(x)	(x)	(x)	(x)	(x)	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	(x)	x
04 02 10	Other	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)
04 03	**Processes in non-ferrous metal industries**																					
04 03 01	Aluminium production (electrolysis)	x	(x)	(x)	-	x	x	(x)	(x)	-	x	-	-	-	x	-	-	x	-	-	(x)	x
04 03 02	Ferro alloys	x	(x)	(x)	(x)	x	x	-	-	-	-	x	-	-	x	-	-	-	-	-	(x)	x
04 03 03	Silicium production	-	-	-	-	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(x)
04 03 04	Magnesium production (except 03.03.23)	x	-	-	-	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-	(x)	-
04 03 05	Nickel production (except 03.03.24)	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-		-	-
04 03 06	Allied metal manufacturing	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-
04 03 07	Galvanising	-	-	-	-	-	-	-	-	-	x	-	-	-	-	x	-	x	-	-	-	-
04 03 08	Electroplating	-	-	-	-	-	-	-	-	-	-	x	-	-	x	-	-	-	-	-	-	-
04 03 09	Other	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)
04 04	**Processes in inorganic chemical industries**																					
04 04 01	Sulphuric acid	x	-	-	-	-	-	-	-	(x)	(x)	-	-	(x)	-	(x)	-	(x)	-	-	-	-
04 04 02	Nitric acid	-	x	x	-	-	-	X	x	-	-	-	-	-	-	-	-	-	-	-	-	-
04 04 03	Ammonia	-	x	x	(x)	-	x	X	x	-	-	-	-	-	-	-	-	-	-	-	-	-
04 04 04	Ammonium sulphate	(x)	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-
04 04 05	Ammonium nitrate	-	(x)	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-
04 04 06	Ammonium phosphate	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-
04 04 07	NPK fertilisers	x	x	x	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
04 04 08	Urea	-	-	-	-	(x)	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-
04 04 09	Carbon black	(x)	-	x	x	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x
04 04 10	Titanium dioxide	x	x	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04 04 11	Graphite	-	-	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x

04 04 12	Calcium carbide production	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04 04 13	Chlorine production	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	(x)	-
04 04 14	Phosphate fertilizers	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-
04 04 15	Storage and handling of inorganic chemical prod.	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(x)	(x)	(x)	-
04 04 16	Other	-	-	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04 05	**Proc. in organic chemical industry (bulk production)**																					
04 05 01	Ethylene	-	-	x	(x)	(x)	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04 05 02	Propylene	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04 05 03	1,2 dichloroethane (except 04.05.05)	-	-	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04 05 04	Vinyl chloride (except 04.05.05)	-	-	(x)	-	(x)	-	-	-	-	-	-	-	-	-	-	-	-	x	x	-	-
04 05 05	1,2 dichloroethane + vinyl chloride (balanced process)	-	-	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04 05 06	Polyethylene Low Density	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04 05 07	Polyethylene High Density	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04 05 08	Polyvinyl chloride	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04 05 09	Polypropylene	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04 05 10	Styrene	-	-	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04 05 11	Polystyrene	-	-	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04 05 12	Styrene butadiene	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04 05 13	Styrene-butadiene latex	-	-	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04 05 14	Styrene-butadiene rubber (SBR)	-	-	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04 05 15	Acrylonitrile Butadiene Styrene (ABS) resins	-	-	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04 05 16	Ethylene oxide	-	-	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04 05 17	Formaldehyde	-	-	x	-	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04 05 18	Ethylbenzene	-	-	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04 05 19	Phtalic anhydride	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04 05 20	Acrylonitrile	-	-	(x)	-	-	-	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04 05 21	Adipic acid	-	(x)	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04 05 22	Storage and handling of organic chemical products (o)	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04 05 23	Glyoxylic acid	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04 05 24	Halogenated hydrocarbons production	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	(x)	-
04 05 25	Pesticide production	-	-	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(x)	-
04 05 26	Production of persistent organic compounds	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	(x)	(x)	x
04 05 27	Other (phytosanitary,...)	-	-	(x)	-	-	-	-	-	-	-	-	-	(x)	-	-	-	-	-	x	-	-
04 06	**Processes in wood, paper pulp, food, drink and other industries**																					
04 06 01	Chipboard	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04 06 02	Paper pulp (kraft process)	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(x)	-
04 06 03	Paper pulp (acid sulphite process)	x	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(x)	-
04 06 04	Paper pulp (Neutral Sulphite Semi-chemical process)	x	-	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(x)	-
04 06 05	Bread	-	-	x	-	-	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04 06 06	Wine	-	-	(x)	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04 06 07	Beer	-	-	x	-	-	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04 06 08	Spirits	-	-	x	-	-	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

04 06 10 Roof covering with asphalt materials	(x)	-	x	-	(x)	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x
04 06 11 Road paving with asphalt	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04 06 12 Cement (decarbonizing)	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04 06 13 Glass (decarbonizing)	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04 06 14 Lime (decarbonizing)	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

04 06 15	Batteries manufacturing	-	-	-	-	-	-	-	-	-	x	-	-	x	x	x	-	x	-	-	-	-
04 06 16	Extraction of mineral ores	-	-	-	-	-	-	-	-	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	-	-	-	-
04 06 17	Other (including amiante production)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	-
04 07	**Cooling plants**	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-

M: > 10 % , **X**: > 1 % , x : > 0.1 % , (x) : < 0.1 % , - : generally not relevant

05	EXCTRACTION AND DISTRIBUTION OF FOSSIL FUELS AND GEOTHERMAL ENERGY	ACIDIFYERS, OZONE PRECURSORS AND GREENHOUSE GASES								HEAVY METALS									PERSISTANT ORGANIC POLLUTANTS			
		SO_x	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3	As	Cd	Cr	Cu	Hg	Ni	Se	Zn	TRI	PER	DIOX	PAH
05 01	**Extraction and 1st treatment of solid fossil fuels**																				
05 01 01	Open cast mining	-	-	-	**X**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
05 01 02	Underground mining	-	-	-	**M**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
05 01 03	Storage of solid fuel	-	-	-	**X**	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
05 02	**Extraction, 1st treatment and loading of liquid fossil fuels**																				
05 02 01	Land-based activities	(x)	-	(x)	(x)	(x)	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
05 02 02	Off-shore activities	(x)	-	**X**	x	(x)	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
05 03	**Extraction, 1st treatment and loading of gaseous fossil fuels**																				
05 03 01	Land-based desulfuration	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
05 03 02	Land-based activities (other than desulfuration)	(x)	-	x	x	(x)	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
05 03 03	Off-shore activities	(x)	-	(x)	x	(x)	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
05 04	Liquid fuel distribution (except gasoline distribution)																				
05 04 01	Marine terminals (tankers, handling and storage)	-	-	x	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
05 04 02	Other handling and storage (including pipeline)	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
05 05	**Gasoline distribution**																				
05 05 01	Refinery dispatch station	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
05 05 02	Transport and depots (except 05.05.03)	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
05 05 03	Service stations (including refuelling of cars)	-	-	**X**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
05 06	**Gas distribution networks**																				
05 06 01	Pipelines	-	-	(x)	x	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
05 06 03	Distribution networks	-	-	x	**X**	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
05 07	Geothermal energy extraction	(x)	-	-	-	-	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-

M: > 10 % , **X**: > 1 % , x : > 0.1 % , (x) : < 0.1 % , - : generally not relevant

06	SOLVENT AND OTHER PRODUCT USE	ACIDIFYERS, OZONE PRECURSORS AND GREENHOUSE GASES								HEAVY METALS									PERSISTANT ORGANIC POLLUTANTS			
		SO_x	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn	TRI	PER	DIOX	PAH
06 01	**Paint application**																					
06 01 01	Paint application : manufacture of automobiles	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	-	-
06 01 02	Paint application : car repairing	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	-	-
06 01 03	Paint application : construction and buildings (except item 06.01.07)	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	-	-
06 01 04	Paint application : domestic use (except 06.01.07)	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	-	-
06 01 05	Paint application : coil coating	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	-	-
06 01 06	Paint application : boat building	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	-	-
06 01 07	Paint application : wood	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	-	-
06 01 08	Other industrial paint application	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	-	-
06 01 09	Other non industrial paint application	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	-	-
																-						
06 02	**Degreasing, dry cleaning and electronics**															-						
06 02 01	Metal degreasing	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	(x)	-
06 02 02	Dry cleaning	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	(x)	-
06 02 03	Electronic components manufacturing	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	-	-
06 02 04	Other industrial cleaning	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	-	-
																-						
06 03	**Chemical products manufacturing or processing**															-						
06 03 01	Polyester processing	-	-	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
06 03 02	Polyvinyl chloride processing	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
06 03 03	Polyurethane processing	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
06 03 04	Polystyrene foam processing	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
06 03 05	Rubber processing	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x
06 03 06	Pharmaceutical products manufacturing	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
06 03 07	Paints manufacturing	-	-	x	-	-	-	-	-	-	x	x	-	-	-	x	-	x	x	-	-	-
06 03 08	Inks manufacturing	-	-	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-
06 03 09	Glues manufacturing	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-
06 03 10	Asphalt blowing	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x
06 03 11	Adhesive, magnetic tapes, films and photographs manufacturing	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(x)	-	-	-
06 03 12	Textile finishing	-	-	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-
06 03 13	Leather tanning	-	-	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
06 03 14	Other	-	-	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(x)	(x)	-	-
0604	**Other use of solvents and related activities**																					
060401	Glass wool enduction			x																		
060402	Mineral wool enduction			(x)																		
060403	Printing industry			x																(x)		
060404	Fat, edible and non edible oil extraction			x																x	x	
060405	Application of glues and adhesives			x																		
060406	Preservation of wood			x																		

060407	Underseal treatment and conservation of vehicles	x

060408	Domestic solvent use (other than paint application)	x		(x)	
060409	Vehicles dewaxing	x			
060410	Pharmaceutical products manufacturing	x			
060411	Domestic use of pharmaceutical products	x			
060412	Other (Preservation of seeds,....)	x		(x)	(x)
0605	**Use of N2O**				
060501	Use of N2O for anaesthesia		x		
060502	Other use of N2O		x		

M: > 10 % , **X**: > 1 % , x : > 0.1 % , (x) : < 0.1 % , - : generally not relevant

07	ROAD TRANSPORT	ACIDIFYERS, OZONE PRECURSORS AND GREENHOUSE GASES								HEAVY METALS									PERSISTANT ORGANIC POLLUTANTS			
		SO_x	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn	TRI	PER	DIOX	PAH
07 01	**Passenger cars**																					
07 01 01	Highway driving	x	**X**	**X**	(x)	**X**	**X**	x	x	-	x	x	x	-	x	x	x	x	-	-	(x)	x
07 01 02	Rural driving	x	**X**	**X**	x	**M**	**X**	x	x	-	x	x	x	-	x	x	x	x	-	-	(x)	x
07 01 03	Urban driving	x	**X**	**X**	x	**M**	**X**	x	x	-	x	x	x	-	x	x	x	x	-	-	(x)	x
07 02	**Light duty vehicles < 3.5 t**																					
07 02 01	Highway driving	(x)	x	x	(x)	x	x	x	(x)	-	x	x	x	-	x	x	x	x	-	-	(x)	x
07 02 02	Rural driving	x	**X**	x	(x)	**X**	x	x	(x)	-	x	x	x	-	x	x	x	x	-	-	(x)	x
07 02 03	Urban driving	x	**X**	**X**	(x)	**X**	x	x	(x)	-	x	x	x	-	x	x	x	x	-	-	(x)	x
07 03	**Heavy duty vehicles > 3.5 t and buses**																					
07 03 01	Highway driving	x	**X**	x	(x)	x	**X**	x	(x)	-	x	x	x	-	x	x	x	x	-	-	(x)	x
07 03 02	Rural driving	x	**X**	**X**	(x)	**X**	**X**	x	(x)	-	x	x	x	-	x	x	x	x	-	-	(x)	x
07 03 03	Urban driving	x	**X**	**X**	(x)	**X**	**X**	x	(x)	-	x	x	x	-	x	x	x	x	-	-	(x)	x
07 04	**Mopeds and Motorcycles < 50 cm3**	(x)	(x)	**X**	(x)	x	x	(x)	(x)	-	x	x	x	-	x	x	x	x	-	-	(x)	x
07 05	**Motorcycles > 50 cm3**																					
07 05 01	Highway driving	(x)	(x)	x	(x)	x	(x)	(x)	(x)	-	x	x	x	-	x	x	x	x	-	-	(x)	x
07 05 02	Rural driving	(x)	(x)	x	(x)	x	x	(x)	(x)	-	x	x	x	-	x	x	x	x	-	-	(x)	x
07 05 03	Urban driving	(x)	(x)	x	(x)	x	x	(x)	(x)	-	x	x	x	-	x	x	x	x	-	-	(x)	x
07 06	**Gasoline evaporation from vehicles**	-	-	**X**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07 07	**Automobile tyre and brake wear**	-	-	-	-	-	-	-	-	-	x	x	x	-	x	-	-	x	-	-	-	-

M: > 10 % , **X**: > 1 % , x : > 0.1 % , (x) : < 0.1 % , - : generally not relevant

08	OTHER MOBILE SOURCES AND MACHINERY	ACIDIFYERS, OZONE PRECURSORS AND GREENHOUSE GASES								HEAVY METALS									PERSISTANT ORGANIC POLLUTANTS			
		SO_x	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn	TRI	PER	DIOX	PAH
08 01	**Military**	(x)	x	x	(x)	x	x	(x)	-	-	x	x	x	-	x	x	x	x	-	-	(x)	x
08 02	**Railways**																				(x)	x
08 02 01	Shunting locs	(x)	x	(x)	(x)	(x)	x	(x)	-	-	x	x	x	-	x	x	x	x	-	-	(x)	x
08 02 02	Rail-cars	(x)	x	(x)	(x)	(x)	x	(x)	-	-	x	x	x	-	x	x	x	x	-	-	(x)	x
08 02 03	Locomotives	(x)	x	(x)	(x)	(x)	x	(x)	-	-	x	x	x	-	x	x	x	x	-	-	(x)	x
08 03	**Inland waterways**																				(x)	x
08 03 01	Sailing boats with auxiliary engines	(x)	x	(x)	(x)	(x)	(x)	(x)	-	-	x	x	x	-	x	x	x	x	-	-	(x)	x
08 03 02	Motorboats / work boats	(x)	x	(x)	(x)	(x)	(x)	(x)	-	-	x	x	x	-	x	x	x	x	-	-	(x)	x
08 03 03	Personal water craft	(x)	x	(x)	(x)	(x)	(x)	(x)	-	-	x	x	x	-	x	x	x	x	-	-	(x)	x
08 03 04	Inland goods carrying vessels	(x)	x	(x)	(x)	(x)	(x)	(x)	-	-	x	x	x	-	x	x	x	x	-	-	(x)	x
08 04	**Maritime activities**																					
08 04 02	National sea traffic within EMEP area	x	X	x	(x)	x	x	x	-	-	x	x	x	-	x	x	x	x	-	-	(x)	x
08 04 03	National fishing	x	x	(x)	(x)	(x)	x	(x)	-	-	x	x	x	-	x	x	x	x	-	-	(x)	x
08 04 04	International sea traffic (international bunkers)	x	x	x	x	x	x	x	-	-	x	x	x	-	x	x	x	x	-	-	(x)	x
08 05	**Air traffic**																				(x)	x
08 05 01	Domestic airport traffic (LTO cycles - < 1000 m)	(x)	x	x	(x)	x	x	(x)	(x)	-	x	x	x	-	x	x	x	x	-	-	(x)	x
08 05 02	International airport traffic (LTO cycles - <1000 m)	(x)	x	x	(x)	x	x	(x)	(x)	-	x	x	x	-	x	x	x	x	-	-	(x)	x
08 05 03	Domestic cruise traffic (>1000 m)	x	x	x	x	x	x	x	x	-	x	x	x	-	x	x	x	x	-	-	(x)	x
08 05 04	International cruise traffic (>1000 m)	x	x	x	x	x	x	x	x	-	x	x	x	-	x	x	x	x	-	-	(x)	x
08 06	**Agriculture**	x	X	X	(x)	X	X	x	-	-	x	x	x	-	x	x	x	x	-	-	(x)	x
08 07	**Forestry**	(x)	x	x	(x)	(x)	(x)	(x)	-	-	x	x	x	-	x	x	x	x	-	-	(x)	x
08 08	**Industry**	x	X	x	(x)	x	x	x	-	-	x	x	x	-	x	x	x	x	-	-	(x)	x
08 09	**Household and gardening**	(x)	x	x	(x)	x	(x)	(x)	-	-	x	x	x	-	x	x	x	x	-	-	(x)	x
08 10	**Other off-road**	x	x	x	x	x	x	x	-	-	x	x	x	-	x	x	x	x	-	-	(x)	(x)

M: > 10 % , X: > 1 % , x : > 0.1 % , (x) : < 0.1 % , - : generally not relevant

09	WASTE TREATMENT AND DISPOSAL	ACIDIFYERS, OZONE PRECURSORS AND GREENHOUSE GASES								HEAVY METALS									PERSISTANT ORGANIC POLLUTANTS			
		SO_x	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn	TRI	PER	DIOX	PAH
09 02	**Waste incineration**																					
09 02 01	Incineration of domestic or municipal wastes	x	x	(x)	(x)	x	x	(x)	-	x	x	x	x	x	x	x	x	x	x	-	(x)	x
09 02 02	Incineration of industrial wastes (except flaring)	x	(x)	(x)	(x)	(x)	(x)	(x)	-	x	x	x	x	x	x	x	x	x	x	-	(x)	x
09 02 03	Flaring in oil refinery	x	x	(x)	(x)	(x)	(x)	(x)	-	-	-	-	-	-	-	-	-	-	-	-	(x)	x
09 02 04	Flaring in chemical industries	(x)	(x)	(x)	(x)	(x)	(x)	(x)	-	-	-	-	-	-	-	-	-	-	-	-	(x)	x
09 02 05	Incineration of sludge from waste water treatment	(x)	(x)	(x)	(x)	(x)	(x)	(x)	-	x	x	x	x	x	x	x	-	x	-	x	(x)	x
09 02 06	Flaring in gas and oil extraction	(x)	(x)	(x)	(x)	(x)	(x)	(x)	-	-	-	-	-	-	-	-	-	-	-	-	(x)	x
09 02 07	Incineration of hospital wastes	(x)	(x)	(x)	(x)	(x)	(x)	(x)	-	x	x	x	x	x	x	x	-	x	x	x	(x)	x
09 02 08	Incineration of waste oil	(x)	(x)	(x)	(x)	(x)	(x)	(x)	-	x	x	x	x	x	x	x	-	x	x	x	(x)	x
09 07	**Open burning of agricultural wastes (except 10.03)**	(x)	x	**X**	x	**X**	x	x	(x)	-	-	-	-	-	-	-	-	-	-	-	-	x
09 09	**Cremation**																					
09 09 01	Incineration of corpses	x	x	x	x	x	x	x	-	-	-	-	-	x	-	-	-	-	-	-	-	x
09 09 02	Incineration of carcasses	x	x	x	x	x	x	x	-	-	-	-	-	x	-	-	-	-	-	-	-	x
09 10	**Other waste treatment**																					
09 10 01	Waste water treatment in industry	-	-	x	x	-	(x)	x	x	-	-	-	-	-	-	-	-	-	x	-	(x)	-
09 10 02	Waste water treatment in residential/commercial sect.	-	-	x	x	-	x	x	x	-	-	-	-	-	-	-	-	-	x	-	(x)	-
09 10 03	Sludge spreading	-	-	x	x	-	-	(x)	x	-	-	-	-	-	-	-	-	-	-	-	(x)	-
09 10 04	Land filling	-	x	x	**M**	x	x	-	**X**	-	-	-	-	-	-	-	-	-	x	-	(x)	(x)
09 10 05	Compost production from waste	-	-	(x)	x	-	x	-	(x)	-	-	-	-	-	-	-	-	-	x	-	(x)	-
09 10 06	Biogas production	-	-	(x)	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(x)
09 10 07	Latrines	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-
09 10 08	Refuse Derived Fuel production	(x)	(x)	(x)	(x)	(x)	(x)	(x)	-	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	-	-	-	(x)

M: > 10 % , **X**: > 1 % , x : > 0.1 % , (x) : < 0.1 % , - : generally not relevant

10	AGRICULTURE AND FORESTRY, LAND USE AND WOOD STOCK CHANGE	ACIDIFYERS, OZONE PRECURSORS AND GREENHOUSE GASES								HEAVY METALS									PERSISTANT ORGANIC POLLUTANTS			
		SO_x	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn	TRI	PER	DIOX	PAH
10 01	**Cultures with fertilizers (except animal manure)**																					
10 01 01	Permanent crops	-	-	x	**X**	-	-	**X**	**X**	-	-	-	-	-	-	-	-	-	-	-	-	-
10 01 02	Arable land crops	-	-	x	x	-	-	**M**	**M**	-	-	-	-	-	-	-	-	-	-	-	-	-
10 01 03	Rice field	-	-	(x)	x	-	-	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-
10 01 04	Market gardening	-	-	(x)	x	-	-	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-
10 01 05	Grassland	-	-	x	x	-	-	**X**	**X**	-	-	-	-	-	-	-	-	-	-	-	-	-
10 01 06	Fallow	-	-	-	(x)	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 02	**Cultures without fertilizers**																					
10 02 01	Permanent crops	-	-	x	(x)	-	-	x	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-
10 02 02	Arable land crops	-	-	(x)	(x)	-	-	x	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-
10 02 03	Rice field	-	-	(x)	x	-	-	x	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-
10 02 04	Market gardening	-	-	(x)	(x)	-	-	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-
10 02 05	Grassland	-	-	x	(x)	-	-	**X**	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-
10 02 06	Fallow	-	-	-	(x)	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 03	**On-field burning of stubble, straw,...**	-	x	x	x	x	x	-	(x)	-	-	-	-	-	-	-	-	-	-	-	-	x
10 04	**Enteric fermentation**																					
10 04 01	Dairy cows	-	-	-	**X**	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-
10 04 02	Other cattle	-	-	-	**X**	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-
10 04 03	Ovines	-	-	-	**X**	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-
10 04 04	Fattening pigs	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 04 05	Horses	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 04 06	Mules and asses	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 04 07	Goats	-	-	-	x	-	-	-	(x)	-	-	-	-	-	-	-	-	-	-	-	-	-
10 04 08	Laying hens	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 04 09	Broilers	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 04 10	Other poultry (ducks, geese, etc.)	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 04 11	Fur animals	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 04 12	Sows	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 04 13	Camels	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 04 14	Buffalo	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 04 15	Other	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 05	**Manure management**																					
10 05 01	Dairy cows	-	-	x	**X**	-	-	x	**M**	-	-	-	-	-	-	-	-	-	-	-	-	-
10 05 02	Other cattle	-	-	x	**X**	-	-	x	**M**	-	-	-	-	-	-	-	-	-	-	-	-	-
10 05 03	Fattening pigs	-	-	**X**	**X**	-	-	x	**M**	-	-	-	-	-	-	-	-	-	-	-	-	-
10 05 04	Sows	-	-	x	x	-	-	(x)	**X**	-	-	-	-	-	-	-	-	-	-	-	-	-
10 05 05	Ovines	-	-	x	x	-	-	x	**X**	-	-	-	-	-	-	-	-	-	-	-	-	-
10 05 06	Horses	-	-	x	x	-	-	-	**X**	-	-	-	-	-	-	-	-	-	-	-	-	-

10 05 07	Laying hens	-	-	x	x	-	-	-	**X**	-	-	-	-	-	-	-	-	-	-	-	-	-
10 05 08	Broilers	-	-	x	x	-	-	-	**X**	-	-	-	-	-	-	-	-	-	-	-	-	-

10 05 09	Other poultry (ducks, geese, etc.)	-	-	x	x	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-
10 05 10	Fur animals	-	-	x	x	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-
10 05 11	Goats	-	-	x	x	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-
10 05 12	Mules and asses	-	-	x	x	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-
10 05 13	Camels	-	-	x	x	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-
10 05 14	Buffalo	-	-	x	x	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-
10 05 15	Other	-	-	x	x	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-
10 06	**Use of pesticides**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(x)	-
10 07	**Managed deciduous forests**																					
10 07 01	High isoprene emitters	-	-	**X**	x	-	-	**X**	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 07 02	Low isoprene emitters	-	-	x	(x)	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 07 03	Non isoprene emitters	-	-	**X**	x	-	-	**X**	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 08	**Managed coniferous forests**	-	-	**M**	x	-	-	**X**	x	-	-	-	-	-	-	-	-	-	-	-	-	-
10 11	**LUWC-Wood biomass stock change /annual growth**																					
10 11 01	Tropical forests/Plantations	-	-	-	-	-	u	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 11 02	Tropical forests/Other managed forests	-	-	-	-	-	u	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 11 03	Tropical forests/Other	-	-	-	-	-	u	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 11 04	Temperate forests/Plantations	-	-	-	-	-	u	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 11 05	Temperate forests/Commercial	-	-	-	-	-	u	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 11 06	Temperate forests/Other	-	-	-	-	-	u	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 11 07	Boreal forests	-	-	-	-	-	u	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 11 08	Other ecosystem types	-	-	-	-	-	u	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 11 09	Non-forest trees	-	-	-	-	-	u	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 12	**LUWC-Wood Biomass stock change /annual harvest**																					
10 12 01	Biomass in commercial harvest	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 12 02	Traditional fuel wood consumed	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 12 03	Other wood use	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 13	**LUWC-Conversion /Burning aboveground biomass**																					
10 13 01	Tropical forests on site	-	x	x	x	x	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 13 02	Tropical forests off site	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 13 03	Temperate forests on site	-	x	x	x	x	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 13 04	Temperate forests off site	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 13 05	Boreal forests on site	-	x	x	x	x	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 13 06	Boreal forests off site	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 13 07	Grassland on site	-	x	x	x	x	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 13 08	Grassland off site	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 13 09	Other on site	-	x	x	x	x	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 13 10	Other off site	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 14	**LUWC-Conversion /Aboveground biomass decay**																					

10 14 01	Tropical forests	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 14 02	Temperate forests	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 14 03	Boreal forests	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 14 04	Grassland	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 14 05	Other	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 15	**LUWC-Conversion /Soil carbon release**																					
10 15 01	Tropical forests	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 15 02	Temperate forests	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 15 03	Boreal forests	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 15 04	Grassland	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 15 05	Other	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 16	**LUWC-Managed land abandonment < 20 years / Aboveground biomass carbon uptake**																					
10 16 01	Tropical forests	-	-	-	-	-	u	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 16 02	Temperate forests	-	-	-	-	-	u	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 16 03	Boreal forests	-	-	-	-	-	u	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 16 04	Grassland	-	-	-	-	-	u	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 16 05	Other	-	-	-	-	-	u	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 17	**LUWC-Managed land abandonment < 20years / Soil carbon uptake**																					
10 17 01	Tropical forests	-	-	-	-	-	u	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 17 02	Temperate forests	-	-	-	-	-	u	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 17 03	Boreal forests	-	-	-	-	-	u	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 17 04	Grassland	-	-	-	-	-	u	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 17 05	Other	-	-	-	-	-	u	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 18	**LUWC-Managed land abandonment >20years / Aboveground biomass carbon uptake**																					
10 18 01	Tropical forests	-	-	-	-	-	u	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 18 02	Temperate forests	-	-	-	-	-	u	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 18 03	Boreal forests	-	-	-	-	-	u	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 18 04	Grassland	-	-	-	-	-	u	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 18 05	Other	-	-	-	-	-	u	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 19	**LUWC-Managed land abandonment > 20years / Soil carbon uptake**																					
10 19 01	Tropical forests	-	-	-	-	-	u	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 19 02	Temperate forests	-	-	-	-	-	u	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 19 03	Boreal forests	-	-	-	-	-	u	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 19 04	Grassland	-	-	-	-	-	u	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 19 05	Other	-	-	-	-	-	u	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

M: > 10 % , **X**: > 1 % , x : > 0.1 % , (x) : < 0.1 % , - : generally not relevant

11	NATURE	ACIDIFYERS, OZONE PRECURSORS AND GREENHOUSE GASES								HEAVY METALS									PERSISTANT ORGANIC POLLUTANTS			
		SO_x	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn	TRI	PER	DIOX	PAH
11 01	**Non-managed deciduous forests**																					
11 01 01	High isoprene emitters	-	-	**X**	x	-	-	**X**	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11 01 02	Low isoprene emitters	-	-	x	(x)	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11 01 03	Non isoprene emitters	-	-	**X**	x	-	-	**X**	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11 02	**Non-managed coniferous forests**	-	-	**M**	x	-	-	**X**	x	-	-	-	-	-	-	-	-	-	-	-	-	-
11 03	**Forest fires**	(x)	x	x	x	**X**	-	-	(x)	-	-	-	-	-	-	-	-	-	-	-	x	x
11 04	**Natural grassland**	-	-	x	x	-	-	**X**	x	-	-	-	-	-	-	-	-	-	-	-	-	-
11 05	**Wetlands (marshes swamps)**																					
11 05 01	Underdrained and brackish marshes	-	-	-	**X**	-	-	x	(x)	-	-	-	-	-	-	-	-	-	-	-	-	x
11 05 02	Drained marshes	-	-	-	x	-	-	x	(x)	-	-	-	-	-	-	-	-	-	-	-	-	x
11 05 03	Raised bogs	-	-	-	x	-	-	x	(x)	-	-	-	-	-	-	-	-	-	-	-	-	x
11 06	**Waters**																					
11 06 01	Lakes	-	-	-	**M**	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11 06 02	Shallow saltwater	-	-	-	x	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11 06 03	Ground waters	-	-	-	x	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11 06 04	Drainage waters	-	-	-	x	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11 06 05	Rivers	-	-	-	x	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11 06 06	Ditches and canals	-	-	-	x	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11 06 07	Open sea (> 6m)	-	-	-	x	-	-	**X**	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11 07	**Animals**																					
11 07 01	Termites	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11 07 02	Mammals	-	-	-	x	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-
11 08	**Volcanoes**	**X**	x	x	x	x	x	-		(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	(x)	-	-	-	x
11 09	**Near-surface deposits**	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

M: > 10 % , **X**: > 1 % , x : > 0.1 % , (x) : < 0.1 % , - : generally not relevant

Appendix 2

LPS	Name	Longitude	Latitude	Thermal capacity [MW]
1	Amagervaerket	12.63 - E	55.69 - N	968
2	Svanemoellevaerket	12.59 - E	55.71 - N	634
3	H.C.Oerstedsvaerket	12.56 - E	55.66 - N	1166
4	Kyndbyvaerket	11.88 - E	55.81 - N	2136
5	Masnedoevaerket	11.89 - E	55.00 - N	205
6	Q8 Raffinaderi	11.25 - E	55.21 - N	0
7	Stigsnaesvaerket	11.25 - E	55.21 - N	746
8	Asnaesvaerket	11.09 - E	55.66 - N	2658
9	Statoil Raffinaderi	11.10 - E	55.66 - N	10
10	Avedoerevaerket	12.48 - E	55.60 - N	615
11	Fynsvaerket	10.41 - E	55.43 - N	1588
12	Studstrupvaerket	10.35 - E	56.25 - N	2693
14	Vendsysselvaerket	9.98 - E	57.09 - N	1080
15	Aalborgvaerket	9.93 - E	57.05 - N	690
16	Kemira Danmark	9.76 - E	55.56 - N	0
17	Shell Raffinaderi	9.75 - E	55.59 - N	10
18	Skaerbaekvaerket	9.62 - E	55.51 - N	916
19	Enstedvaerket	9.44 - E	55.02 - N	1124
20	Esbjergvaerket	8.45 - E	55.46 - N	1779
21	Kastrup Lufthavn	12.66 - E	55.62 - N	0
22	Oestkraft	14.70 - E	55.09 - N	226
23	Danisco Ingredients	-	-	60
24	Dansk Naturgas Behandlingsanlaeg	-	-	-1
25	Horsens Kraftvarmevaerk	9.86 - E	55.85 - N	93
26	Herningvaerket	-	-	300
27	Vestforbraendingen	12.42 - E	55.71 - N	88
28	Amagerforbraendingen	12.62 - E	55.68 - N	87
29	Randersvaerket	10.05 - E	56.46 - N	178
30	Grenaavaerket	10.91 - E	56.42 - N	88
31	Hilleroedvaerket	-	-	150
32	Helsingoervaerket	-	-	125
33	Staalvalsevaerket	12.02 - E	55.96 - N	60
34	Stora Dalum	-	-	90
35	Assens Sukkerfabrik	-	-	98
36	Kolding Kraftvarmevaerk	9.47 - E	55.49 - N	50
37	Maabjergvaerket	8.62 - E	56.37 - N	90
38	Soenderborg Kraftvarmevaerk	-	-	130
39	Kara Affaldsforbraendingsanlaeg	12.12 - E	55.64 - N	50
40	Viborg Kraftvarmevaerk	-	-	148
41	Skive Fjernvarmeanlaeg	9.03 - E	56.56 - N	83
42	Nordforbraendingen	12.49 - E	55.90 - N	26
43	Goerlev Sukkerfabrik	-	-	73
44	Frederiksberg Varmevaerk	12.52 - E	55.68 - N	240
45	Aalborg Portland	9.98 - E	57.06 - N	0
46	Aarhus Nord	-	-	59
47	Reno Nord	-	-	52
48	Silkeborg Kraftvarmevaerk	-	-	216