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 (3(106 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, NOx, 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 CH4 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 Nox 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 CO_2 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 NOx shares of 28% and 19% respectively, and 47% in total.
The total Danish 1972-1996 NOx 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 NOx 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 NOx emission reduction target for the UNECE convention is also shown in the figure.
The EU-15 per capita NO2 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 NOx per capita, are above the European mean of about 35 kg NOx per capita. This is caused by the high emission contribution from energy production.

Figure 11 European NOx 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
Public power plants > 50 MW
District heating plants
Refineries
X
X
X

X
X
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 manufacturing 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 disposal
-
-
-
-
-
-
-
-
-
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
Nox	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 SO2,

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 NOx 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.

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Appendix 1

01

COMBUSTION IN ENERGY AND
TRANSFORMATION INDUSTRIES

ACIDIFYERS, OZONE PRECURSORS
AND GREENHOUSE GASES
HEAVY METALS
PERSISTANT ORGANIC POLLUTANTS

SOx
NOx
NMVOC
CH4
CO
CO2
N2O
NH3
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)
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(x)
(x)
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(x)
(x)
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(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
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-
(x)
x
01 03 04
Gas turbines
(x)
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(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)
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(x)
(x)
(x)
(x)
(x)
(x)
(x)
(x)
(x)
(x)
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-
-
(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)
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(x)
(x)
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(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

SOx
Nox
NMVOC
CH4
CO
CO2
N2O
NH3
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 aquaculture

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
CH4
CO
CO2
N2O
NH3
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)
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(x)
x
03 01 03
Combustion plants < 50 MW (boilers)
X
X
x
x
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X
X
(x)
x
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x
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x
x
x
x
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(x)
x
03 01 04
Gas turbines
(x)
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(x)
(x)
(x)
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(x)

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(x)
03 01 05
Stationary engines
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(x)
(x)
(x)
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(x)
(x)
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x
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x
03 01 06
Other stationary equipment
x
x
x
x
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x
x
(x)
x
x
x
x
x
x
x

x
x
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(x)
x

03 02
Process furnaces without contact

03 02 03
Blast furnace cowpers

x
x
(x)
(x)
x
X
x
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x
x
x
x
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x
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03 02 04
Plaster furnaces
x
x
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(x)
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03 02 05
Other furnaces
(x)
(x)
(x)
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(x)
(x)
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(x)
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03 03
Processes with contact

03 03 01
Sinter plants
X
X
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X
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(x)
(x)
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(x)
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(x)
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03 03 02
Reheating furnaces steel and iron
x
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(x)
(x)
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x
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(x)
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(x)
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(x)
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03 03 03
Gray iron foundries
(x)

(x)
(x)
(x)
X
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(x)
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(x)
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03 03 04
Primary lead production
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(x)
(x)
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(x)
(x)
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(x)
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(x)
03 03 05
Primary zinc production
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(x)
(x)
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(x)
(x)
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(x)
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(x)
03 03 06
Primary copper production
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(x)
(x)
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(x)
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(x)
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03 03 07
Secondary lead production
(x)
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(x)
03 03 08
Secondary zinc production
(x)
(x)
(x)
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(x)
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03 03 09
Secondary copper production
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(x)
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03 03 10
Secondary aluminium production
(x)
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(x)
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03 03 11
Cement (f)
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X
(x)
(x)
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X
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(x)
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03 03 12
Lime (incl.. iron and steel and paper pulp industry)
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(x)
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(x)
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03 03 13
Asphalt concrete plants
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(x)
(x)
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(x)
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03 03 14
Flat glass
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(x)
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(x)
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03 03 15
Container glass (f)
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(x)
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(x)
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03 03 16
Glass wool (except binding) (f)
(x)
(x)
(x)
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(x)
(x)
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03 03 17
Other glass (f)
(x)
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(x)

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(x)
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03 03 18
Mineral wool (except binding)
(x)
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(x)
(x)
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03 03 19
Bricks and tiles
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(x)
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03 03 20
Fine ceramic materials
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(x)
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(x)
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03 03 21
Paper-mill industry (drying processes)
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03 03 22
Aluminium production
(x)
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03 03 23
Magnesium production (dolomite treatment)
(x)
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(x)
(x)
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03 03 24
Nickel production (thermal process)
(x)
(x)
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03 03 25
Enamel production
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03 03 26
Other
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(x)
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(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

SOx
NOx
NMVOC
CH4
CO
CO2
N2O
NH3
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
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(x)
(x)
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04 01 02
Fluid catalytic cracking - CO boiler
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(x)
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04 01 03
Sulphur recovery plants
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(x)
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04 01 04
Storage and handling of petroleum prod.. in refinery
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04 01 05
Other
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04 02
Processes in iron and steel industries and collieries

04 02 01
Coke oven (door leakage and extinction)
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(x)
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(x)
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04 02 02
Blast furnace charging
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(x)
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04 02 03
Pig iron tapping
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04 02 04
Solid smokeless fuel
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04 02 05
Open hearth furnace steel plant
(x)
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(x)
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(x)
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04 02 06
Basic oxygen furnace steel plant
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(x)
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(x)
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04 02 07
Electric furnace steel plant
(x)
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04 02 08
Rolling mills
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04 02 09
Sinter plant (except combustion 03.03.01)
(x)
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04 02 10
Other
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04 03
Processes in non-ferrous metal industries

04 03 01
Aluminium production (electrolysis)
x
(x)
(x)
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(x)
(x)
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(x)
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04 03 02
Ferro alloys
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(x)
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04 03 03
Silicium production
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(x)
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(x)
04 03 04
Magnesium production (except 03.03.23)
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(x)
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04 03 05
Nickel production (except 03.03.24)
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04 03 06
Allied metal manufacturing
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04 03 07
Galvanising
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04 03 08
Electroplating
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04 03 09
Other
(x)
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04 04
Processes in inorganic chemical industries

04 04 01
Sulphuric acid
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(x)
(x)
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(x)
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(x)
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(x)
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04 04 02
Nitric acid
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04 04 03
Ammonia
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x
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(x)
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X
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04 04 04
Ammonium sulphate
(x)
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04 04 05
Ammonium nitrate
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(x)
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04 04 06
Ammonium phosphate
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04 04 07

NPK fertilisers
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04 04 08
Urea
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(x)
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04 04 09
Carbon black
(x)
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(x)
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04 04 10
Titanium dioxide
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(x)
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04 04 11
Graphite
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(x)
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04 04 12
Calcium carbide production
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04 04 13
Chlorine production
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(x)
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04 04 14
Phosphate fertilizers
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04 04 15
Storage and handling of inorganic chemical prod.
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(x)
(x)
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04 04 16
Other
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(x)
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04 05
Proc. in organic chemical industry (bulk production)

04 05 01
Ethylene
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x
(x)
(x)
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x
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04 05 02
Propylene
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04 05 03
1,2 dichloroethane (except 04.05.05)
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(x)
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04 05 04
Vinyl chloride (except 04.05.05)
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(x)
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(x)
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04 05 05
1,2 dichloroethane + vinyl chloride (balanced process)
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(x)
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04 05 06
Polyethylene Low Density
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04 05 07
Polyethylene High Density
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04 05 08
Polyvinyl chloride
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04 05 09

Polypropylene
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04 05 10
Styrene
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04 05 11
Polystyrene
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04 05 12
Styrene butadiene
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04 05 13
Styrene-butadiene latex
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(x)
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04 05 14
Styrene-butadiene rubber (SBR)
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(x)
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04 05 15
Acrylonitrile Butadiene Styrene (ABS) resins
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(x)
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04 05 16
Ethylene oxide

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04 05 17
Formaldehyde
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04 05 18
Ethylbenzene
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(x)
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04 05 19
Phtalic anhydride
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04 05 20
Acrylonitrile
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(x)
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(x)
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04 05 21
Adipic acid
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(x)
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04 05 22
Storage and handling of organic chemical products (o)
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04 05 23
Glyoxylic acid
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04 05 24
Halogenated hydrocarbons production
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x
x
(x)
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04 05 25
Pesticide production
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(x)
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(x)
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04 05 26
Production of persistent organic compounds
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x
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x
(x)
(x)
x
04 05 27
Other (phytosanitary,...)
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(x)
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(x)
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x
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04 06
Processes in wood, paper pulp, food, drink and other industries

04 06 01
Chipboard
-

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x
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04 06 02
Paper pulp (kraft process)
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x
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(x)
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04 06 03
Paper pulp (acid sulphite process)
x
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x
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(x)
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04 06 04
Paper pulp (Neutral Sulphite Semi-chemical process)
x
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(x)
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(x)
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04 06 05
Bread
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x
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(x)
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04 06 06
Wine
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(x)
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x
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04 06 07
Beer
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x
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(x)
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04 06 08
Spirits
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x
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(x)
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-
-
04 06 10
Roof covering with asphalt materials
(x)
-
x
-
(x)
(x)
-
-
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x
04 06 11
Road paving with asphalt
-
-
x
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04 06 12

Cement (decarbonizing)

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X

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04 06 13

Glass (decarbonizing)

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x

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04 06 14
Lime (decarbonizing)
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x
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04 06 15

Batteries manufacturing

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x

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x

x

x

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x

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04 06 16
Extraction of mineral ores
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(x)
(x)
(x)
(x)
(x)
(x)
(x)

(x)
(x)
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04 06 17
Other (including amiante production)
(x)
(x)
(x)
(x)
(x)
(x)
(x)
(x)
(x)
(x)
(x)
(x)
(x)
(x)
(x)
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(x)
(x)
(x)
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04 07
Cooling plants

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x
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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

SOx
NOx
NMVOC
CH4
CO
CO2
N2O
NH3
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
-
-

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05 01 02
Underground mining
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-
-
M
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05 01 03
Storage of solid fuel
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X
(x)
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05 02
Extraction, 1st treatment and loading of liquid fossil fuels

05 02 01
Land-based activities
(x)
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(x)
(x)

(x)
(x)
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05 02 02
Off-shore activities
(x)
-
X
x
(x)
x
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05 03
Extraction, 1st treatment and loading of gaseous fossil fuels

05 03 01
Land-based desulfuration
x
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05 03 02
Land-based activities (other than desulfuration)
(x)
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x
x
(x)
x
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05 03 03
Off-shore activities
(x)
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(x)
x
(x)
(x)
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05 04
Liquid fuel distribution (except gasoline distribution)

05 04 01
Marine terminals (tankers, handling and storage)
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x
(x)
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05 04 02
Other handling and storage (including pipeline)

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x
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05 05
Gasoline distribution

05 05 01
Refinery dispatch station
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x
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05 05 02
Transport and depots (except 05.05.03)
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x
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05 05 03
Service stations (including refuelling of cars)
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X
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05 06
Gas distribution networks

05 06 01
Pipelines
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(x)
x
(x)
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05 06 03
Distribution networks
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x
X
(x)
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05 07
Geothermal energy extraction
(x)
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(x)
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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

SOx
NOx
NMVOC
CH4
CO
CO2
N2O
NH3
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
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x
x
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06 01 02
Paint application : car repairing
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x
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x
x
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06 01 03
Paint application : construction and buildings (except item 06.01.07)
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X
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x
x
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06 01 04
Paint application : domestic use (except 06.01.07)
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x
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x
x
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06 01 05
Paint application : coil coating
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x
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x
x
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06 01 06
Paint application : boat building
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x
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x
x
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06 01 07
Paint application : wood
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x
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x
x
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06 01 08
Other industrial paint application
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x
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x
x
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06 01 09
Other non industrial paint application
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x
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x
x
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06 02
Degreasing, dry cleaning and electronics

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06 02 01
Metal degreasing
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X
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x
x
(x)
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06 02 02
Dry cleaning
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x
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x
x
(x)
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06 02 03
Electronic components manufacturing
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x

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06 02 04
Other industrial cleaning
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x
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x
x
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06 03
Chemical products manufacturing or processing

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06 03 01
Polyester processing
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(x)
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06 03 02
Polyvinyl chloride processing
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06 03 03
Polyurethane processing
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06 03 04
Polystyrene foam processing
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06 03 05
Rubber processing
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06 03 06
Pharmaceutical products manufacturing
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x
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06 03 07
Paints manufacturing
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x
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x
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06 03 08
Inks manufacturing
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(x)
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x
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06 03 09
Glues manufacturing
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x
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x
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06 03 10
Asphalt blowing
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x
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x
06 03 11
Adhesive, magnetic tapes, films and photographs manufacturing
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x
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(x)
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06 03 12
Textile finishing
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(x)
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x
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06 03 13
Leather tanning
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(x)
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06 03 14
Other
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(x)
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(x)
(x)
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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

SOx
NOx
NMVOC
CH4
CO
CO2
N2O
NH3
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
-
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(x)
x

07 06
Gasoline evaporation from vehicles
-
-
X
-
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07 07
Automobile tyre and brake wear
-
-
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x
x
x
-
x
-
-

x
-
-
-
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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

SOx
NOx
NMVOC
CH4
CO
CO2
N2O
NH3
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
Locotives
(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
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x
x
x
x
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(x)
x
08 03 04
Inland goods carrying vessels
(x)
x
(x)
(x)
(x)
(x)

(x)
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x
x
x
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x
x
x
x
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(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)
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x
x
x
-
x
x
x
x
-
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(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
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x
x

x
x
-
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(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
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(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)
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-
x
x
x
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x
x
x
x
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(x)
x

08 08
Industry
x
X
x
(x)
x
x
x
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x
x
x
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x
x
x
x
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(x)
x

08 09
Household and gardening
(x)

x
x
(x)
x
(x)
(x)
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x
x
x
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x
x
x
x
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(x)
x

08 10
Other off-road
x
x
x
x
x
x
x
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x
x
x
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x
x
x
x
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(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

SOx
NOx
NMVOC
CH4
CO

CO2
N2O
NH3
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
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(x)
x
09 02 03
Flaring in oil refinery
x
x
(x)
(x)
(x)
(x)
(x)
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(x)
x

09 02 04
Flaring in chemical industries
(x)
(x)
(x)
(x)
(x)
(x)
(x)
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(x)
x
09 02 05
Incineration of sludge from waste water treatment
(x)
(x)
(x)
(x)
(x)
(x)
(x)
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x
x
x
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x
x
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x
(x)
x
09 02 06
Flaring in gas and oil extraction
(x)
(x)
(x)
(x)
(x)
(x)

(x)
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(x)
x
09 02 07
Incineration of hospital wastes
(x)
(x)
(x)
(x)
(x)
(x)
(x)
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x
x
x
x
x
x
x
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x
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(x)
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09 02 08
Incineration of waste oil
(x)
(x)
(x)
(x)
(x)
(x)
(x)
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x
x
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x
x

x
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(x)
x

09 07
Open burning of agricultural wastes (except 10.03)
(x)
x
X
x
X
x
x
(x)
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x

09 09
Cremation

09 09 01
Incineration of corpses
x
x
x
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x
09 09 02
Incineration of carcasses
x
x
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x

09 10
Other waste treatment

09 10 01
Waste water treatment in industry
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x
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(x)
x
x
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(x)
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09 10 02
Waste water treatment in residential/commercial sect.

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(x)
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09 10 03
Sludge spreading
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(x)
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(x)
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09 10 04
Land filling
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x
x
M
x
x
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X

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x
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(x)
(x)
09 10 05
Compost production from waste
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(x)
x
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x
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(x)
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x
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(x)
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09 10 06
Biogas production
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(x)
x
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(x)
09 10 07
Latrines
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x
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09 10 08
Refuse Derived Fuel production
(x)
(x)
(x)
(x)
(x)
(x)
(x)
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(x)
(x)
(x)
(x)
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(x)
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(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

SOx
NOx
NMVOC
CH4
CO
CO2
N2O
NH3
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
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10 01 02
Arable land crops
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x

x
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M
M
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10 01 03
Rice field
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(x)
x
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x
x
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10 01 04
Market gardening
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(x)
x
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x
x
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10 01 05
Grassland
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x
x
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X
X
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10 01 06
Fallow
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(x)
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x
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10 02
Cultures without fertilizers

10 02 01
Permanent crops
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(x)

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(x)
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10 02 02
Arable land crops
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(x)
(x)
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(x)
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10 02 03
Rice field
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(x)
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(x)
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10 02 04
Market gardening
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(x)
(x)
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10 02 05
Grassland
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(x)
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X
(x)
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10 02 06
Fallow
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(x)
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10 03
On-field burning of stubble, straw,...
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x
x
x
x

x
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(x)
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x

10 04
Enteric fermentation

10 04 01
Dairy cows
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X
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x
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10 04 02
Other cattle
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X
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x
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10 04 03
Ovines
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X
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x
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10 04 04
Fattening pigs
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10 04 05
Horses
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10 04 06
Mules and asses
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10 04 07
Goats
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x
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(x)
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10 04 08
Laying hens
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x
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10 04 09
Broilers
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x
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10 04 10

Other poultry (ducks, geese, etc.)
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10 04 11
Fur animals
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10 04 12
Sows
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x
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10 04 13
Camels
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x
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10 04 14
Buffalo
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x
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10 04 15
Other
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x
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10 05
Manure management

10 05 01
Dairy cows
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x
X
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x
M
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10 05 02
Other cattle
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x
X
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x
M

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10 05 03
Fattening pigs
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X
X
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x
M
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10 05 04
Sows
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x
x
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(x)
X
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10 05 05
Ovines
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x
x
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X
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10 05 06
Horses
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x
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X
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10 05 07
Laying hens
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x
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X
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10 05 08
Broilers
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x
x
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X
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10 05 09
Other poultry (ducks, geese, etc.)
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x
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10 05 10
Fur animals
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10 05 11
Goats
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10 05 12
Mules and asses
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x
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10 05 13
Camels
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x
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10 05 14
Buffalo
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x
x
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x
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10 05 15
Other
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x
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10 06
Use of pesticides
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(x)
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10 07
Managed deciduous forests

10 07 01
High isoprene emitters
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X
x
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X
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10 07 02

Low isoprene emitters
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x
(x)
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10 07 03
Non isoprene emitters
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X
x
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X
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10 08
Managed coniferous forests
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M
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10 11
LUWC-Wood biomass stock change /annual growth

10 11 01
Tropical forests/Plantations
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10 11 02
Tropical forests/Other managed forests

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10 11 03
Tropical forests/Other
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10 11 04
Temperate forests/Plantations
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10 11 05
Temperate forests/Commercial
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10 11 06
Temperate forests/Other
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10 11 07
Boreal forests
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10 11 08
Other ecosystem types
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10 11 09
Non-forest trees
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10 12
LUWC-Wood Biomass stock change /annual harvest

10 12 01
Biomass in commercial harvest
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x
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10 12 02
Traditional fuel wood consumed
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x
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10 12 03
Other wood use
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x
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10 13
LUWC-Conversion /Burning aboveground biomass

10 13 01
Tropical forests on site
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x
x
x
x
x
x
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10 13 02
Tropical forests off site
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x
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10 13 03
Temperate forests on site
-
x
x
x
x
x
x
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10 13 04
Temperate forests off site
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x
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10 13 05
Boreal forests on site
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x
x
x
x
x
x
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10 13 06
Boreal forests off site
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x
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10 13 07
Grassland on site
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x
x

x
x
x
x
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10 13 08
Grassland off site
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x
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10 13 09
Other on site
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x
x
x
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10 13 10
Other off site
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10 14
LUWC-Conversion /Aboveground biomass decay

10 14 01
Tropical forests
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x
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10 14 02
Temperate forests
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10 14 03
Boreal forests
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10 14 04
Grassland
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10 14 05
Other
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x
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10 15
LUWC-Conversion /Soil carbon release

10 15 01
Tropical forests
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10 15 02
Temperate forests
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10 15 03
Boreal forests
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10 15 05
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10 16
LUWC-Managed land abandonment < 20 years /

Aboveground biomass carbon uptake

10 16 01
Tropical forests
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10 16 02
Temperate forests
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10 16 03
Boreal forests
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10 16 04
Grassland
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10 16 05
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Soil carbon uptake

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10 17
LUWC-Managed land abandonment < 20years /

Soil carbon uptake

10 17 01
Tropical forests
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10 17 02
Temperate forests
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10 17 03
Boreal forests
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10 17 04
Grassland
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10 17 05
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10 18
LUWC-Managed land abandonment >20years /

Aboveground biomass carbon uptake

10 18 01
Tropical forests
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10 18 02
Temperate forests
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10 18 03
Boreal forests
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10 18 04
Grassland
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10 18 05
Other
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10 19
LUWC-Managed land abandonment > 20years /

Soil carbon uptake

10 19 01
Tropical forests
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10 19 02
Temperate forests
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10 19 03

Boreal forests
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10 19 04
Grassland
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10 19 05
Other
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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

SOx
NOx
NMVOC
CH4

CO
CO2
N2O
NH3
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
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-
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11 01 02
Low isoprene emitters
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x
(x)
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x
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11 01 03
Non isoprene emitters
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X
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X
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11 02
Non-managed coniferous forests
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X
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11 03
Forest fires
(x)
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X
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(x)
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x
x

11 04
Natural grassland
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x
x
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X
x
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11 05
Wetlands (marshes swamps)

11 05 01
Underdrained and brackish marshes
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X
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x
(x)
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x
11 05 02
Drained marshes
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(x)
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x
11 05 03
Raised bogs
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(x)
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11 06
Waters

11 06 01
Lakes
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M
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11 06 02

Shallow saltwater
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11 06 03
Ground waters
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11 06 04
Drainage waters
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11 06 05
Rivers
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x
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x
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11 06 06
Ditches and canals
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x
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x
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11 06 07
Open sea (> 6m)
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x
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X
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11 07
Animals

11 07 01
Termites
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x
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11 07 02
Mammals
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x
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x

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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
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-
-
-
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

Appendix 3

Summary table of annual national emissions 1975

SNAP code
Category
SO2
NOX
NMVOC
CH4
CO
CO2

N2O
NH3

[tonnes]
[tonnes]
[tonnes]
[tonnes]
[tonnes]
[ktonnes]
[tonnes]
[tonnes]
1
Combustion in energy and transformation industries
259252
65026
756
729
4346
20393
589
0
2
Non-industrial combustion plants
68183
12955
1983
2154
21726
14449
390
0
3
Combustion in manufacturing industry
73687
14018
1590
516
8861
7162
203
0
4
Production processes
0
0
0
0
0
0
0
0
5
Extraction and distrib. of fossil fuels / geothermal energy

0
0
3314
8451
0
0
0
0
6
Solvent and other product use
0
0
0
0
0
0
0
0
7
Road transport
3777
61022
80593
1450
679862
6135
209
0
8
Other mobile sources and machinery
15564
64283
14769
823
68392
4020
183
1
9
Waste treatment and disposal
0
769
218
34650
499
142
3
0
10
Agriculture and forestry, land use and wood stock change
734
1469
30744
401730

293770
0
9082
119561
11
Nature
0
0
0
354238
0
0
5475
0

Total
421197
219542
133967
804741
1077456
52301
16134
119562

Summary table of annual national emissions 1976

SNAP code
Category
SO2
NOX
NMVOC
CH4
CO
CO2
N2O
NH3

[tonnes]
[tonnes]
[tonnes]
[tonnes]

[tonnes]
[ktonnes]
[tonnes]
[tonnes]
1
Combustion in energy and transformation industries
271102
75368
782
752
4605
22662
669
0
2
Non-industrial combustion plants
76401
14480
1963
2250
20617
16279
439
0
3
Combustion in manufacturing industry
80674
15253
1537
570
8552
7835
222
0
4
Production processes
0
0
0
0
0
0
0
0
5
Extraction and distrib. of fossil fuels / geothermal energy
0
0
3314
8451
0
0
0
0

6
Solvent and other product use
0
0
0
0
0
0
0
0
7
Road transport
4629
65408
84677
1518
713702
6594
231
0
8
Other mobile sources and machinery
15954
65172
13750
711
61578
4104
186
1
9
Waste treatment and disposal
0
877
248
37115
569
162
3
0
10
Agriculture and forestry, land use and wood stock change
460
920
23324
400512
184005
0
9049
119911
11
Nature
0
0

0
354238
0
0
5475
0

Total
449220
237478
129595
806117
993628
57636
16274
119912

Summary table of annual national emissions 1977

SNAP code
Category
SO2
NOX
NMVOC
CH4
CO
CO2
N2O
NH3

[tonnes]
[tonnes]
[tonnes]
[tonnes]
[tonnes]
[ktonnes]
[tonnes]
[tonnes]
1
Combustion in energy and transformation industries
285610
82048
818
788
4818

24382
721
0
2
Non-industrial combustion plants
76587
14309
1841
2141
16130
15867
428
0
3
Combustion in manufacturing industry
79807
15582
1464
618
8164
8030
230
0
4
Production processes
0
0
0
0
0
0
0
0
5
Extraction and distrib. of fossil fuels / geothermal energy
0
0
3314
8451
0
0
0
0
6
Solvent and other product use
0
0
0
0
0
0
0
0
7

Road transport
5011
68007
86410
1561
726532
6837
240
0
8
Other mobile sources and machinery
15188
63564
13205
686
58586
4014
179
1
9
Waste treatment and disposal
0
2059
583
40259
1337
380
7
0
10
Agriculture and forestry, land use and wood stock change
424
848
22353
401965
169650
0
9045
120495
11
Nature
0
0
0
354238
0
0
5475
0

Total
462627
246417
129988

810707
985217
59510
16325
120496

Summary table of annual national emissions 1978

SNAP code
Category
SO2
NOX
NMVOC
CH4
CO
CO2
N2O
NH3

[tonnes]
[tonnes]
[tonnes]
[tonnes]
[tonnes]
[ktonnes]
[tonnes]
[tonnes]
1
Combustion in energy and transformation industries
258337
81427
762
732
4590
23711
712
0
2
Non-industrial combustion plants
74599
14107
2528

2609
25029
15838
432
0
3
Combustion in manufacturing industry
80856
16185
1501
653
8371
8381
241
0
4
Production processes
0
0
0
0
0
0
0
0
5
Extraction and distrib. Of fossil fuels / geothermal energy
0
0
3314
8451
0
0
0
0
6
Solvent and other product use
0
0
0
0
0
0
0
0
7
Road transport
6657
74896
89923
1638
751923
7521
269

0
8
Other mobile sources and machinery
15240
63329
13067
662
57748
4002
179
1
9
Waste treatment and disposal
0
1882
533
42799
1222
348
6
0
10
Agriculture and forestry, land use and wood stock change
513
1025
24745
410454
205030
0
9055
123052
11
Nature
0
0
0
354238
0
0
5475
0

Total
436202
252851
136373
822236
1053913
59801
16369
123053

Summary table of annual national emissions 1979

SNAP code
Category
SO2
NOX
NMVOC
CH4
CO
CO2
N2O
NH3

[tonnes]
[tonnes]
[tonnes]
[tonnes]
[tonnes]
[ktonnes]
[tonnes]
[tonnes]
1
Combustion in energy and transformation industries
273520
91891
803
769
4946
26116
793
0
2
Non-industrial combustion plants
77387
14841
4076
3679
45371
16468
457
0
3
Combustion in manufacturing industry
83903
16435
1366
665

7620
8514
244
0
4
Production processes
0
0
0
0
0
967
0
0
5
Extraction and distrib. Of fossil fuels / geothermal energy
0
0
3314
8451
0
0
0
0
6
Solvent and other product use
0
0
0
0
0
0
0
0
7
Road transport
7264
73784
85349
1564
710975
7404
268
0
8
Other mobile sources and machinery
14603
62651
12832
648
55984
4103
178
1

9
Waste treatment and disposal
0
1920
544
45552
1247
355
6
0
10
Agriculture and forestry, land use and wood stock change
387
774
21353
410397
154860
0
9040
124339
11
Nature
0
0
0
354238
0
0
5475
0

Total
457064
262296
129637
825963
981003
63927
16461
124340

Summary table of annual national emissions 1980

SNAP code
Category
SO2
NOX
NMVOC
CH4
CO
CO2
N2O
NH3

[tonnes]
[tonnes]
[tonnes]
[tonnes]
[tonnes]
[ktonnes]
[tonnes]
[tonnes]
1
Combustion in energy and transformation industries
283492
112593
795
759
5157
29981
935
0
2
Non-industrial combustion plants
66733
13057
6330
4979
67176
13355
388
0
3
Combustion in manufacturing industry
80168
15342
1095
603
6156
7968
228
0
4
Production processes
0
0

0
0
0
879
0
0
5
Extraction and distrib. of fossil fuels / geothermal energy
0
0
7491
13896
33932
0
0
0
6
Solvent and other product use
0
0
0
0
0
0
0
0
7
Road transport
6976
69605
78668
1477
656468
6963
253
0
8
Other mobile sources and machinery
14432
61044
11799
567
49859
3803
171
1
9
Waste treatment and disposal
0
876
248
47830
569
162

3
0
10
Agriculture and forestry, land use and wood stock change
343
685
20147
408521
137025
0
9035
124777
11
Nature
0
0
0
354238
0
0
5475
0

Total
452144
273202
126573
832870
956342
63111
16488
124778

Summary table of annual national emissions 1981

SNAP code
Category
SO2
NOX
NMVOC
CH4
CO
CO2
N2O
NH3

[tonnes]
[tonnes]
[tonnes]
[tonnes]
[tonnes]
[ktonnes]
[tonnes]
[tonnes]
1
Combustion in energy and transformation industries
223651
87707
680
648
4505
23452
743
0
2
Non-industrial combustion plants
60362
12081
8155
6086
85366
11635
354
0
3
Combustion in manufacturing industry
65292
12598
923
499
5218
6481
189
0
4
Production processes
0
0
0
0
0
751
0
0
5
Extraction and distrib. of fossil fuels / geothermal energy
0
0
7239

13842
36329
0
0
0
6
Solvent and other product use
0
0
0
0
0
0
0
0
7
Road transport
6544
68062
76410
1438
623348
6590
239
0
8
Other mobile sources and machinery
13859
60098
11404
539
46934
3758
166
1
9
Waste treatment and disposal
0
1261
357
50946
819
233
4
0
10
Agriculture and forestry, land use and wood stock change
682
1363
29299
407227
272600
0
9063

122877
11
Nature
0
0
0
354238
0
0
5475
0

Total
370390
243170
134467
835463
1075119
52900
16233
122878

Summary table of annual national emissions 1982

SNAP code
Category
SO2
NOX
NMVOC
CH4
CO
CO2
N2O
NH3

[tonnes]
[tonnes]
[tonnes]
[tonnes]
[tonnes]
[ktonnes]
[tonnes]
[tonnes]

1
Combustion in energy and transformation industries
243436
103409
733
703
4935
26857
858
0
2
Non-industrial combustion plants
52803
10985
8864
6501
92696
10516
329
0
3
Combustion in manufacturing industry
58361
11542
739
461
4388
5902
175
0
4
Production processes
0
0
0
0
0
792
0
0
5
Extraction and distrib. of fossil fuels / geothermal energy
0
0
7165
13578
32245
0
0
0
6
Solvent and other product use
0
0

0
0
0
0
0
0
7
Road transport
7269
71586
76620
1447
601404
6793
249
0
8
Other mobile sources and machinery
16003
63553
11539
547
47047
3957
177
1
9
Waste treatment and disposal
0
1291
365
53956
838
238
4
0
10
Agriculture and forestry, land use and wood stock change
848
1696
33772
399780
339155
0
8991
120011
11
Nature
0
0
0
354238
0
0

5475
0

Total
378720
264062
139797
831211
1122708
55055
16258
120012

Summary table of annual national emissions 1983

SNAP code
Category
SO2
NOX
NMVOC
CH4
CO
CO2
N2O
NH3

[tonnes]
[tonnes]
[tonnes]
[tonnes]
[tonnes]
[ktonnes]
[tonnes]
[tonnes]
1
Combustion in energy and transformation industries
196892
97285
745
712
5153
25496
825
0
2

Non-industrial combustion plants
47175
10153
8982
6538
90180
9669
307
0
3
Combustion in manufacturing industry
55589
11026
821
423
4879
5583
167
0
4
Production processes
0
0
0
0
0
816
0
0
5
Extraction and distrib. of fossil fuels / geothermal energy
0
0
7248
13041
28393
0
0
0
6
Solvent and other product use
0
0
0
0
0
0
0
0
7
Road transport
8040
74780
76266

1428
564946
7127
263
0
8
Other mobile sources and machinery
14670
61508
10019
422
38199
3814
170
1
9
Waste treatment and disposal
0
1188
336
56972
772
220
4
0
10
Agriculture and forestry, land use and wood stock change
545
1090
25576
392691
218080
0
8913
118973
11
Nature
0
0
0
354238
0
0
5475
0

Total
322911
257030
129993
826465
950602
52725
16124

118974

Summary table of annual national emissions 1984

SNAP code
Category
SO2
NOX
NMVOC
CH4
CO
CO2
N2O
NH3

[tonnes]
[tonnes]
[tonnes]
[tonnes]
[tonnes]
[ktonnes]
[tonnes]
[tonnes]
1
Combustion in energy and transformation industries
175694
99755
825
791
5795
25884
842
0
2
Non-industrial combustion plants
46210
10145
9091
6569
87475
9192
295
0

3
Combustion in manufacturing industry
58371
12102
899
506
5349
6119
185
0
4
Production processes
0
0
0
0
0
935
0
0
5
Extraction and distrib. of fossil fuels / geothermal energy
0
0
7389
13394
32790
0
0
0
6
Solvent and other product use
0
0
0
0
0
0
0
0
7
Road transport
9890
82997
79288
1474
553378
7826
294
0
8
Other mobile sources and machinery
14477
62122

10114
423
38916
3757
170
1
9
Waste treatment and disposal
0
1490
422
60274
967
275
5
0
10
Agriculture and forestry, land use and wood stock change
839
1678
33516
380364
335675
0
8992
115418
11
Nature
0
0
0
354238
0
0
5475
0

Total
305481
270289
141544
818033

53988
16258
115419

Summary table of annual national emissions 1985

SNAP code
Category
SO2
NOX
NMVOC
CH4
CO
CO2
N2O
NH3

[tonnes]
[tonnes]
[tonnes]
[tonnes]
[tonnes]
[ktonnes]
[tonnes]
[tonnes]
1
Combustion in energy and transformation industries
214568
122264
1031
1000
7217
31658
1021
0
2
Non-industrial combustion plants
46442
10896
9023
6618
86445
10590
331
0
3
Combustion in manufacturing industry
54369
12029
930
514
5497
6106
184
0
4

Production processes
0
0
0
0
0
894
0
0
5
Extraction and distrib. Of fossil fuels / geothermal energy
0
0
7490
14419
42499
0
0
0
6
Solvent and other product use
0
0
58469
0
0
105
0
0
7
Road transport
10304
86660
80641
1482
525251
8059
303
0
8
Other mobile sources and machinery
16405
63857
9790
384
36953
3739
175
1
9
Waste treatment and disposal
0
1699
481

63184
1103
314
6
0
10
Agriculture and forestry, land use and wood stock change
496
992
24212
365646
198360
0
8904
114949
11
Nature
0
0
0
354238
0
0
5475
0

Total
342584
298397
192067
807485
903325
61465
16399
114950

Summary table of annual national emissions 1986

SNAP code
Category
SO2
NOX
NMVOC

CH4
CO
CO2
N2O
NH3

[tonnes]
[tonnes]
[tonnes]
[tonnes]
[tonnes]
[ktonnes]
[tonnes]
[tonnes]
1
Combustion in energy and transformation industries
197942
134188
1128
1077
7596
32012
1037
0
2
Non-industrial combustion plants
30949
10963
9150
6702
87946
10579
332
0
3
Combustion in manufacturing industry
39907
12737
1058
544
6263
6428
192
0
4
Production processes
0
0
0
0
0
0
1027
0

0
5
Extraction and distrib. of fossil fuels / geothermal energy
0
0
7300
13588
40781
0
0
0
6
Solvent and other product use
0
0
56828
0
0
100
0
0
7
Road transport
7113
92277
83272
1518
510913
8659
328
0
8
Other mobile sources and machinery
15471
66016
8763
297
30460
3783
181
1
9
Waste treatment and disposal
0
1996
565
65718
1296
369
6
0
10
Agriculture and forestry, land use and wood stock change
489

978
24009
357582
195605
0
8870
110625
11
Nature
0
0
0
354238
0
0
5475
0

Total
291871
319155
192073
801264
880860
62957
16421
110626

Summary table of annual national emissions 1987

SNAP code
Category
SO2
NOX
NMVOC
CH4
CO
CO2
N2O
NH3

[tonnes]
[tonnes]
[tonnes]
[tonnes]

[tonnes]
[ktonnes]
[tonnes]
[tonnes]
1
Combustion in energy and transformation industries
176351
130388
1140
1093
7646
31075
1011
0
2
Non-industrial combustion plants
25341
9920
9620
6975
96034
9967
312
0
3
Combustion in manufacturing industry
33989
12025
1260
566
7161
5988
179
0
4
Production processes
0
0
0
0
0
983
0
0
5
Extraction and distrib. of fossil fuels / geothermal energy
0
0
7284
12608
40377
0
0
0

6
Solvent and other product use
0
0
55187
0
0
96
0
0
7
Road transport
7085
94422
86721
1566
513451
8640
327
0
8
Other mobile sources and machinery
15164
63270
8729
333
31067
3719
175
1
9
Waste treatment and disposal
0
1459
413
67420
948
270
5
0
10
Agriculture and forestry, land use and wood stock change
568
1135
26122
344882
227070
0
8830
107189
11
Nature
0
0

0
354238
0
0
5475
0

Total
258498
312619
196476
789681
923754
60738
16314
107190

Summary table of annual national emissions 1988

SNAP code
Category
SO2
NOX
NMVOC
CH4
CO
CO2
N2O
NH3

[tonnes]
[tonnes]
[tonnes]
[tonnes]
[tonnes]
[ktonnes]
[tonnes]
[tonnes]
1
Combustion in energy and transformation industries
181741
121432

1138
1092
7648
29072
951
0
2
Non-industrial combustion plants
20340
8490
9214
6619
89200
8472
270
0
3
Combustion in manufacturing industry
30713
11167
1094
559
6037
5556
166
0
4
Production processes
0
0
0
0
0
1003
0
0
5
Extraction and distrib. of fossil fuels / geothermal energy
0
0
7317
11669
30988
0
0
0
6
Solvent and other product use
0
0
53546
0
0
91

0
0
7
Road transport
7072
96705
90094
1625
521735
8704
329
0
8
Other mobile sources and machinery
14065
62964
9092
336
33201
3590
172
1
9
Waste treatment and disposal
0
1523
431
69070
989
281
5
0
10
Agriculture and forestry, land use and wood stock change
503
1006
24373
335186
201115
0
8768
105146
11
Nature
0
0
0
354238
0
0
5475
0

Total

254434
303287
196299
780394
890913
56769
16136
105147

Summary table of annual national emissions 1989

SNAP code
Category
SO2
NOX
NMVOC
CH4
CO
CO2
N2O
NH3

[tonnes]
[tonnes]
[tonnes]
[tonnes]
[tonnes]
[ktonnes]
[tonnes]
[tonnes]
1
Combustion in energy and transformation industries
145416
100024
1092
1028
7373
24174
806
0
2
Non-industrial combustion plants
12447
7432
8721

6219
81639
7333
236
0
3
Combustion in manufacturing industry
22008
10654
845
556
4508
5352
159
0
4
Production processes
0
0
0
0
0
1152
0
0
5
Extraction and distrib. Of fossil fuels / geothermal energy
0
0
7203
11810
35585
0
0
0
6
Solvent and other product use
0
0
47922
0
0
83
0
0
7
Road transport
4995
98715
91963
1658
526428
8822
335

0
8
Other mobile sources and machinery
11845
65266
9029
334
32846
3666
180
1
9
Waste treatment and disposal
0
1341
380
70253
871
248
4
0
10
Agriculture and forestry, land use and wood stock change
724
1448
30351
334951
289565
0
8749
104215
11
Nature
0
0
0
354238
0
0
5475
0

Total
197435
284880
197506
781047
978815
50830
15944
104216

Summary table of annual national emissions 1990

SNAP code	Category	SO_2	NO_X	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
		[tonnes]	[tonnes]	[tonnes]	[tonnes]	[tonnes]	[ktonnes]	[tonnes]	[tonnes]
1	Combustion in energy and transformation industries	133318	95801	1161	1074	8000	25849	867	0
2	Non-industrial combustion plants	11227	7210	8756	6221	82445	7042	227	0
3	Combustion in manufacturing industry	21496							

10703
909
568
4795
5337
159
0
4
Production processes
327
806
0
0
0
1006
0
0
5
Extraction and distrib. Of fossil fuels / geothermal energy
0
0
7535
11747
33254
0
0
0
6
Solvent and other product use
0
0
42298
0
0
75
0
0
7
Road transport
5345
102192
97812
1819
546023
9241
355
132
8
Other mobile sources and machinery
10581
63984
8497
314
30016

3573
176
1
9
Waste treatment and disposal
0
1299
368
71184
844
240
4
0
10
Agriculture and forestry, land use and wood stock change
0
0
10779
328553
0
0
8712
101379
11
Nature
0
0
0
354238
0
0
5475
0

Total
182294
281995
178115
775718
705377
52363
15975
101512

Summary table of annual national emissions 1991

SNAP code
Category
SO2
NOX
NMVOC
CH4
CO
CO2
N2O
NH3

[tonnes]
[tonnes]
[tonnes]
[tonnes]
[tonnes]
[ktonnes]
[tonnes]
[tonnes]
1
Combustion in energy and transformation industries
188450
135290
1392
1286
9393
34766
1150
0
2
Non-industrial combustion plants
11870
7627
9481
6708
94100
7290
234
0
3
Combustion in manufacturing industry
23246
11343
908
596
4796
5669
168
0
4
Production processes
0
0

0
0
0
1178
0
0
5
Extraction and distrib. of fossil fuels / geothermal energy
0
0
6943
12326
42374
0
0
0
6
Solvent and other product use
0
0
41871
0
0
73
0
0
7
Road transport
5052
95439
94278
1759
533236
9014
401
229
8
Other mobile sources and machinery
11892
67648
8789
320
31091
3852
189
1
9
Waste treatment and disposal
0
2677
758
72565
1738
495

9
0
10
Agriculture and forestry, land use and wood stock change
0
0
10763
330368
0
0
8666
101313
11
Nature
0
0
0
354238
0
0
5475
0

Total
240510
320024
175183
780166
716728
62337
16292
101543

Summary table of annual national emissions 1992

SNAP code
Category
SO2
NOX
NMVOC
CH4
CO
CO2

N2O
NH3

[tonnes]
[tonnes]
[tonnes]
[tonnes]
[tonnes]
[ktonnes]
[tonnes]
[tonnes]
1
Combustion in energy and transformation industries
143689
93011
1358
1241
9022
29392
994
0
2
Non-industrial combustion plants
10797
7325
9620
6792
96263
7092
228
0
3
Combustion in manufacturing industry
21683
11511
892
587
4646
5775
166
0
4
Production processes
0
0
0
0
0
1300
0
0
5
Extraction and distrib. of fossil fuels / geothermal energy

0
0
6221
12393
40867
0
0
0
6
Solvent and other product use
0
0
41442
0
0
71
0
0
7
Road transport
3310
93819
89493
1741
500774
9155
502
415
8
Other mobile sources and machinery
8310
66144
8594
309
30123
3673
182
1
9
Waste treatment and disposal
0
2765
783
72988
1795
511
9
0
10
Agriculture and forestry, land use and wood stock change
0
0
10750
334570

0
0
8634
105514
11
Nature
0
0
0
354238
0
0
5475
0

Total
187789
274575
169153
784859
683490
56969
16190
105930

Summary table of annual national emissions 1993

SNAP code
Category
SO2
NOX
NMVOC
CH4
CO
CO2
N2O
NH3

[tonnes]
[tonnes]
[tonnes]
[tonnes]
[tonnes]
[ktonnes]
[tonnes]

[tonnes]
1
Combustion in energy and transformation industries
112769
97246
1376
1256
8914
30864
1044
0
2
Non-industrial combustion plants
10587
7456
9379
6628
96026
7248
228
0
3
Combustion in manufacturing industry
20395
11428
895
607
4639
5731
165
0
4
Production processes
0
0
0
0
0
1311
0
0
5
Extraction and distrib. Of fossil fuels / geothermal energy
0
0
6387
13187
35050
0
0
0
6
Solvent and other product use
0

0
42761
0
0
69
0
0
7
Road transport
1544
89472
81731
1661
462603
9323
647
687
8
Other mobile sources and machinery
8293
64712
8460
303
29228
3738
178
1
9
Waste treatment and disposal
0
2408
682
72920
1564
445
8
0
10
Agriculture and forestry, land use and wood stock change
0
0
10637
348252
0
0
8019
103818
11
Nature
0
0
0
354238
0

0
5475
0

Total
153588
272722
162308
799052
638024
58729
15764
104506

Summary table of annual national emissions 1994

SNAP code
Category
SO2
NOX
NMVOC
CH4
CO
CO2
N2O
NH3

[tonnes]
[tonnes]
[tonnes]
[tonnes]
[tonnes]
[ktonnes]
[tonnes]
[tonnes]
1
Combustion in energy and transformation industries
111319
105791
1500
1389
9204

35220
1164
0
2
Non-industrial combustion plants
7834
5838
8226
5819
94141
6285
193
0
3
Combustion in manufacturing industry
22516
11789
771
666
4429
5857
173
0
4
Production processes
4481
600
8969
1385
0
1659
0
26
5
Extraction and distrib. of fossil fuels / geothermal energy
0
0
6664
15664
39697
0
0
0
6
Solvent and other product use
0
0
40589
0
0
68
0
0
7

Road transport
1640
87835
74085
1576
412995
9648
816
993
8
Other mobile sources and machinery
8035
56016
12452
684
61593
3602
160
6
9
Waste treatment and disposal
520
2561
684
74977
1530
441
8
0
10
Agriculture and forestry, land use and wood stock change
0
0
10609
325803
0
0
7822
99575
11
Nature
0
0
0
354238
0
0
5475
0

Total
156345
270430
164549

782201
623589
62780
15811
100600

Summary table of annual national emissions 1995

SNAP code
Category
SO2
NOX
NMVOC
CH4
CO
CO2
N2O
NH3

[tonnes]
[tonnes]
[tonnes]
[tonnes]
[tonnes]
[ktonnes]
[tonnes]
[tonnes]
1
Combustion in energy and transformation industries
106621
91445
1626
1561
9253
31690
1051
0
2
Non-industrial combustion plants
9783
7283
9850
6919
95930
7039

218
0
3
Combustion in manufacturing industry
19077
10608
631
552
3241
5426
154
0
4
Production processes
3237
600
10124
1407
0
1311
0
0
5
Extraction and distrib. of fossil fuels / geothermal energy
0
0
6875
16353
43867
0
0
0
6
Solvent and other product use
0
0
40153
0
0
66
0
0
7
Road transport
1672
83763
67584
1490
379858
9731
921
1186
8
Other mobile sources and machinery

8077
56795
12515
681
61798
3591
163
5
9
Waste treatment and disposal
203
1837
521
74536
1196
334
6
26
10
Agriculture and forestry, land use and wood stock change
0
0
10275
323318
0
0
8516
97982
11
Nature
0
0
0
354238
0
0
5475
0

Total
148670
252331
160154
781055
595143
59188
16504
99199

Summary table of annual national emissions 1996

SNAP code
Category
SO2
NOX
NMVOC
CH4
CO
CO2
N2O
NH3

[tonnes]
[tonnes]
[tonnes]
[tonnes]
[tonnes]
[ktonnes]
[tonnes]
[tonnes]
1
Combustion in energy and transformation industries
144869
126612
1818
1596
10742
43990
1431
0
2
Non-industrial combustion plants
12523
7808
11513
7481
120368
7620
236
0
3
Combustion in manufacturing industry
16703
15626
1030
640

6328
6461
183
0
4
Production processes
2691
504
10884
202
0
1388
0
0
5
Extraction and distrib. of fossil fuels / geothermal energy
0
0
6875
16353
43867
0
0
0
6
Solvent and other product use
0
0
39724
0
0
64
0
0
7
Road transport
1776
79334
60925
2795
354846
10142
1008
1277
8
Other mobile sources and machinery
6823
55843
11924
675
60120
3573
168
6

9
Waste treatment and disposal
274
1954
543
74208
1250
378
7
0
10
Agriculture and forestry, land use and wood stock change
0
0
10256
321182
0
0
8537
97984
11
Nature
0
0
0
354238
0
0
5475
0

Total
185659
287681
155492
779370
597521
73616
17045
99267

80

5