National Environmental Research Institute
Ministry of the Environment · Denmark

Emission Inventories

Denmark's National Inventory Report

Submitted under the United Nations Framework Convention on Climate Change, 1990-2002

Research Notes from NERI No. 196

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2004

Jytte Boll Illerup
Erik Lyck
Malene Nielsen
Morten Winther
Mette Hjort Mikkelsen
Leif Hoffmann
Peter Borgen Sørensen
Patrik Fauser
National Environmental Research Institute

Lars Vesterdal
Danish Centre for Forest, Landscape and Planning

Data sheet

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Authors:	Jytte Boll Illerup[1], Erik Lyck[1], Malene Nielsen[1], Morten Winther[1], Mette Hjort Mikkelsen[1], Leif Hoffmann[1], Peter Borgen Sørensen[1], Lars Vesterdal[2], Patrik Fauser[1]. [1)] Department of Policy Analysis, National Environmental Research Institute. [2)] Danish Centre for Forest, Landscape and Planning.
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Abstract:	This report is Denmark's National Inventory Report reported to the Conference of the Parties under the United Nations Framework Convention on Climate Change (UNFCCC) due by 15 April 2004. The report contains information on Denmark's inventories for all years' from 1990 to 2002 for CO_2, CH_4, N_2O, HFCs, PFCs and SF_6, CO, NMVOC, SO_2.
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Ministry of the Environment
Frontlinien
Rentemestervej 8
DK-2400 København NV
Tel: +45 70 12 02 11
Frontlinien@frontlinien.dk

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1 Introduction

1.1 Background information on greenhouse gas inventories and climate change

Annual report
This report is Denmark's National Inventory Report (NIR) due by 15 April 2004 to the United Nations Framework Convention on Climate Change (UNFCCC) and the European Union's Greenhouse Gas Monitoring Mechanism. The report contains information on Denmark's inventories for all years from 1990 to 2002. The structure of the report is in accordance with the UNFCCC Guidelines on reporting and review (UNFCCC, 2002). The report includes detailed and complete information on the inventories for all years from the base year to the year of the current annual inventory submission, in order to ensure the transparency of the inventory.

The annual emission inventory for Denmark from 1990 to 2002 are reported in the Common Reporting Format (CRF) as requested in the reporting guidelines. The CRF-spreadsheets contain data on emissions, activity data and implied emission factors for each year. Emission trends are given for each greenhouse gas and for the total greenhouse gas emissions in CO_2 equivalents. The complete sets of CRF-files are available in Annex 9.

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

According to the instrument of ratification the Danish government has ratified the UNFCCC on behalf of Denmark, Greenland and the Faroe Islands. Annex 6.1 contains total emissions for Denmark, Greenland and the Faroe Islands for 1990 to 2002. However, it has not been possible to present a complete inventory in CRF. In Annex 6.2 information on the Greenland and the Faroe Islands inventories are given. Apart from Annexes 6.1 and 6.2 the information in this report only relates to Denmark.

The NIR and the CRF tables are available to the public on the homepage of the Danish National Environmental Research Institute (NERI) (http://www.dmu.dk/1_Viden/2_Miljoe-tilstand/3_luft/4_adaei/default_en.asp).

Greenhouse gasses
The greenhouse gasses reported under the Climate Convention are:

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

The main greenhouse gas responsible for the anthropogenic influence on the heat balance is CO_2. The atmospheric concentration of CO_2 has increased from 280 to 370 ppm (about 30%) since the pre-industrial era in the nineteenth century. The main cause is the use of fossil fuels, but changing land use, including forest clearance, has also been a significant factor. The concentrations of the greenhouse gasses methane

and N_2O, which are highly linked to agricultural production, have increased by 150% and 16%, respectively. Changes in the concentrations of greenhouse gasses are not simply related to these effects on the heat balance, however. The various gasses absorb radiation at different wavelengths and with different efficiency. Moreover, the concentrations of some gasses are so high that the radiation at some wavelengths is already nearly fully absorbed. An increasing concentration will therefore have a limited effect. This must be considered in assessing the effects of changes in the concentrations of various gasses. Further, the lifetime of the gasses in the atmosphere needs to be taken into account – the longer they remain in the atmosphere, the greater their overall effects. The global warming potential of various gasses has been defined as the warming effect of a given weight of a specific substance relative to CO_2. The purpose of this is to be able to compare and integrate the effects of individual substances on the global climate. The typical lifetimes are 100, 10 and 300 years for CO_2, CH_4 and N_2O, respectively, and the time perspective clearly plays a decisive role. The lifetime chosen is typically 100 years. Then the effect of the various greenhouse gasses can be converted into the equivalent quantity of CO_2, i.e. the quantity of CO_2 giving the same effect in absorbing solar radiation. According to the IPCC, the most recent global warming potential values for a 100-year time horizon are:

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

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

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

Under the Burden Sharing Agreement Denmark must reduce emissions by an average 21% in the period 2008-2012 compared to the 1990 emission level.

In accordance with the Kyoto-Protocol Denmark's base year emissions include the emissions of CO_2, CH_4 and N_2O in 1990 in CO_2-equivalents and the emissions of HFCs, PFCs and SF_6 in 1995 in CO_2-equvivalents. Furthermore, the removals by sinks are included in the net emissions. Removals by sinks only include sequestration due

to afforestation since 1990. When reporting to the Climate Convention the net CO_2 removals by forests existing in 1990 are included in the calculation also.

The role of the European Union
The European Union (EU) is a Party to the UNFCCC and the Kyoto Protocol. Therefore EU has to submit similar data sets and reports for the collective 15 EU Member States. The EU imposes some additional guidelines to EU Member States through the EU Greenhouse Gas Monitoring Mechanism to guarantee that the EU meets its reporting commitments.

1.2 A description of the institutional arrangement for inventory preparation

NERI under the Danish Ministry of Environment is responsible for the annual preparation and submission to the UNFCCC (and the EU) of the National Inventory Report and the GHG inventories in the Common Reporting Format in accordance with the UNFCCC Guidelines. NERI participates in meetings in the Conference of Parties (COP) to the UNFCCC and its subsidiary bodies, where the reporting rules, are negotiated and settled. Furthermore NERI participates in the EU Monitoring Mechanism on greenhouse gases, where the guidelines and methodologies on inventories to be prepared by the EU member states are regulated.

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

Danish Energy Authority, The Ministry of Economic and Business Affairs: Annual energy statistics in a format suitable for the emission inventory work and fuel use data for the large combustion plants.

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

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

Danish Institute of Agricultural Sciences, The Ministry of Food, Agriculture and Fisheries: Data on use of mineral fertiliser, feeding stuff consumption and nitrogen turnover in animals.

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

Danish Centre for Forest, Landscape and Planning, The Royal Veterinary and Agricultural University. Background data for Forestry and CO_2 uptake by forest.

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

Danish Railways, The Ministry of Transport. Fuel related emission factors for diesel locomotives.

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

Until now the providing of data has been on a voluntary basis but more formal agreements are now being worked out.

1.3 Brief description of the process of inventory preparation

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

Figure 1.1 shows a schematic overview of the process of inventory preparation. Level 3 illustrates the level where the central data bases are placed and level 4 illustrates the process where the reporting schemes are generated to UNFCCC and EU (the CRF format (Common Reporting Format)) and to United Nations Economic Commission for Europe/ Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (UNECE/EMEP) (the NFR format (Nomenclature For Reporting)). For data handling the software tool is CollectER (Pulles et al., 1999a), for the CRF reporting the software tool is ReportER (Pulles et al., 1999b) and CRF correction templates have been developed by NERI. Data files and program files used in the inventory preparation process is listed in Table 1.2.

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

Level	Name	Application	Path	Type	Input sources	Remarks
5	NFR-tables (UNECE/EMEP)	External report	I:\ROSPROJ\LUFT_EMI\2002_unece	MS Excel	NFR_Report_Automatisk.xls	NFR-format
5	CFR-tables (UNFCCC and EU)	External report	I:\ROSPROJ\LUFT_EMI\2002_EU	MS Excel	ReportER CRF-skabeloner CRF-Retteskabelon	CRF-format
4	CRF-Retteskabelon (correction templates)	Help tool	I:\ROSPROJ\LUFT_EMI\2002_EU\2002_EU_15March2004	MS Excel	manual input	Notations keys, etc.
4	CollectER	Management tool	I:\ROSPROJ\LUFT_EMI\programmer\CollectER\programfiler	(exe + mdb)	manual input	Version: 1.3 3 from Spirit
4	ReportER	Reporting tool	I:\ROSPROJ\LUFT_EMI\programmer\ReportER\programfiler	(exe + mdb)	CollectER databases ReportER database	Version: 3.1 Beta dbversion:4 from Spirit
3	dk1972.mdb..dkxxxx.mdb	Datastore	I:\ROSPROJ\LUFT_EMI\Collect	MS Access	CollectER MS Access	CollectER data-bases
4	NFR-skabelon	Presentation template	I:\ROSPROJ\LUFT_EMI\Collect\v4\NFRsheets_original_koder.xls	MS Excel	none	
4	DMURep.mdb	Help tool	I:\ROSPROJ\LUFT_EMI\DMURep	MS Access	dk1972.mdb..dkxxxx.mdb ReportER database manual input	
4	NFR_Report_Automatisk.xls	Help tool, Report compiler	I:\ROSPROJ\LUFT_EMI\DMURep\Excel skabeloner	MS Excel	DMURep(_ny).mdb;qXLS_NFR_Report NFR-skabelon	
5	EMEP_NFR.xlt	Internal Time-series report	I:\ROSPROJ\LUFT_EMI\DMURep\Excel skabeloner	MS Excel	DMURep.mdb	

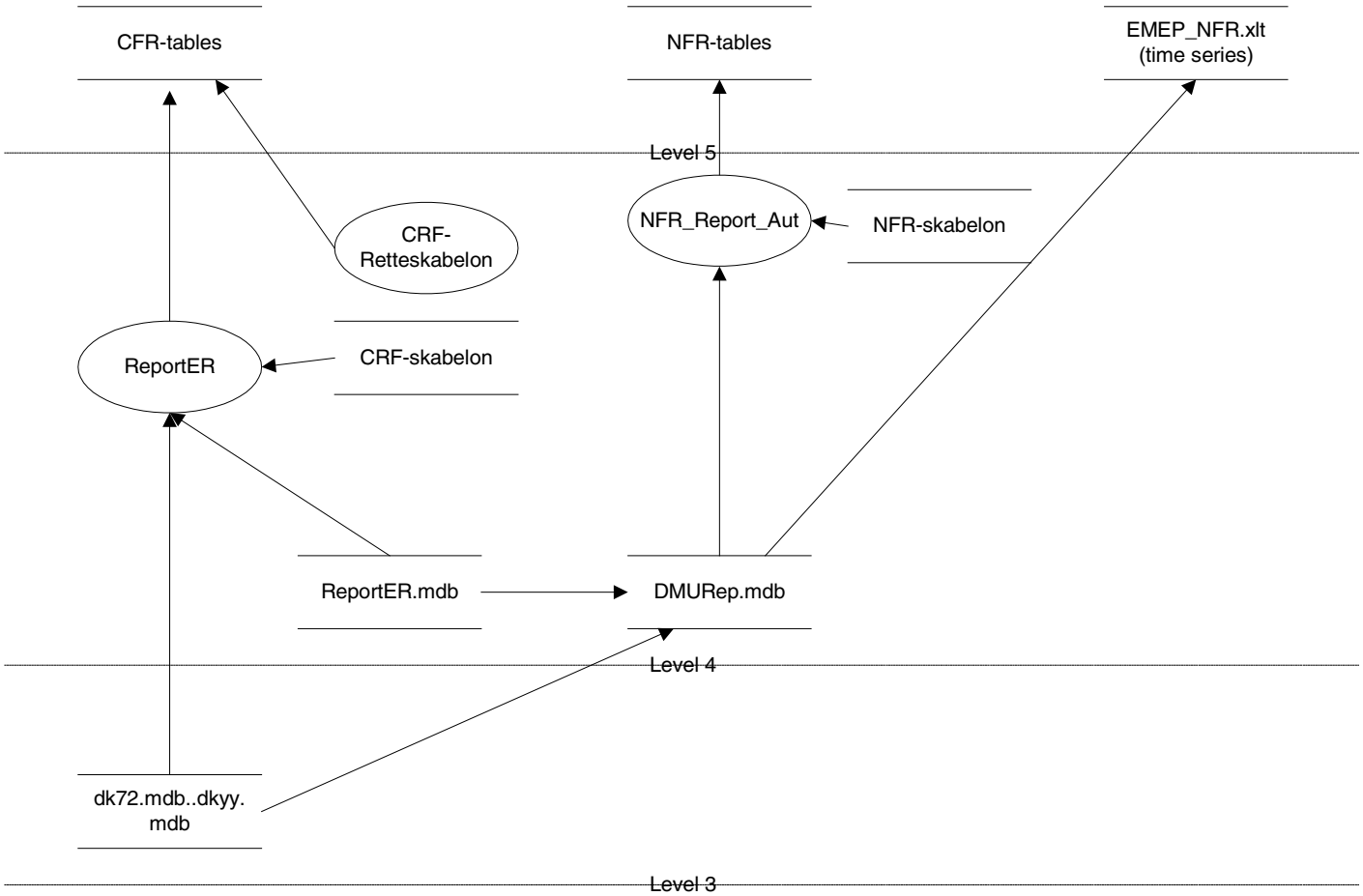


Figure 1.1. Schematic diagram of the process of inventory preparation.

1.4 Brief description of methodologies and data sources used

Denmark's air emission inventories are based on the Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (Houghton et al., 1997), the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (Penman et al., 2000) and the CORINAIR methodology. CORINAIR (COoRdination of Information on AIR emissions) is a European air emission inventory programme for national sector-wise emission estimations harmonised with the IPCC guidelines. To ensure estimates as timely, consistent, transparent, accurate and comparable as possible, the inventory programme has developed calculation methodologies for most sub-sectors and software for storing and further data processing (Richardson, S. (Ed), 1999).

A thorough description of the CORINAIR inventory programme used for Danish emission estimations is given in Illerup et al. (2000). The CORINAIR calculation principle is to calculate the emissions as activities multiplied by emission factors. Activities are numbers referring to a specific process generating emissions, while an emission factor is the mass of emissions per unit activity. Information on activities to carry out the CORINAIR inventory is mainly based on official statistics. The most consistent emission factors have been used, either as national values or default factors proposed by the CORINAIR methodology. The documentation on the CORINAIR methodology can be obtained from the "Joint EMEP/CORINAIR Atmospheric Emission Inventory Guidebook, Second edition (Richardson, S. (Ed), 1999). The documentation on the COPERT III is given in Ntziachristos et al. (2000).

A list of all sub-sectors on the most detailed level is given in Illerup et al., 2000. Incorporated in the CORINAIR software is a feature to serve the specific UNFCCC and UNECE convention needs for emission reporting. The translation between CORINAIR and IPCC codes for sector classifications are listed in Illerup et al, 2000.

1.4.1 The specific methodologies regarding Stationary Combustion Plants

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

The Danish emission inventory for stationary combustion plants is based on the CORINAIR system described in the Emission Inventory Guidebook 3rd edition. The inventory is based on activity rates from the Danish energy statistics and on emission factors for different fuels, plants and sectors.

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

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

Some of the large plants like e.g. power plants and municipal waste incineration plants are registered individually as large point sources and emission data from the actual plants are used. This enables use of plant specific emission factors that refers to emission measurements stated in annual environmental reports etc. At present the emission factors for CO_2, CH_4 and N_2O are however not plant specific whereas emission factors of SO_2 and NO_X often are.

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

In addition to the detailed emission calculation in the national approach, CO_2 emission from fuel combustion is aggregated using the reference approach. In 2002 the CO_2 emission inventory based on the reference approach and the national approach respectively differs 0,05%.

Improved emission factors for cogeneration plants <25MW_e and CO_2 emission from incineration of the plastic part of municipal waste are implemented this year.

Please refer to Chapter 3 and Annex 3A for further information about emission inventories for stationary combustion plants.

The specific methodologies regarding Fugitive Emissions from Fuels

Fugitive emissions from solid fuels (CRF Table 1.B.1.c)

Storage and handling of coal:
Coal mining is not occurring in Denmark, but power plants use a considerable amount of coal. CH_4 emission from storage and handling of coal is included in the Danish inventory. The CH_4 emission inventory is based on Tier 1 in 'IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual'. The CH_4 emission occurring in Denmark is assumed to be half the post-mining emission.

Fugitive emissions from natural gas (CRF Table 1.B.2.b)

Natural gas transmission and distribution:
Inventories of CH_4 emission from gas transmission and distribution is based on annual environmental reports from the Danish gas transmission company, DONG and on a Danish inventory for the years 1999-2002 reported by the Danish gas sector (transmission and distribution companies).

Off-shore activities:
Rough estimates for the emission of CH_4 from extraction of oil and gas are made for the years 1994 to 2002. A project is going on to make consistence inventories from 1990.

Fugitive emissions from oil (CRF Table 1.B.2. a)

Oil Refineries – Petroleum products processing:
The VOC emissions from petroleum refinery processes cover non-combustion emissions from feed stock handling/storage, petroleum products processing, product storage/handling and flaring. SO_2 is also emitted from the non-combustion processes and includes emissions from products processing and sulphur recovery plants. The emission calculations are based on information from the Danish refineries and the Energy statistic.

Please refer to Chapter 3 and Annex 3A for further information about fugitive emissions from fuels.

1.4.2 The specific methodologies regarding Transport

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

The European COPERT III emission model is used to calculate the Danish annual emissions for road traffic. In COPERT III the emissions are calculated for operationally hot engines, during cold start and fuel evaporation. The model also includes the emission effect of catalyst wear. Input data for vehicle stock and mileage is obtained from the Danish Road Directorate, and is grouped according to average fuel consumption and emission behaviour. For each group the emissions are estimated by combining vehicle and annual mileage numbers with hot emission factors, cold:hot ratios and evaporation factors (Tier 2 approach).

For air traffic the 2001 and 2002 estimates are made on a city-pair level, using flight data from the Danish Civil Aviation Agency (CAA-DK) and LTO and distance related emission factors from the CORINAIR guidelines (Tier 2 approach). For previous years the background data consist of LTO/aircraft type statistics from Copenhagen Airport and total LTO numbers from CAA-DK. With appropriate assumptions a consistent time-series of emissions is produced back to 1990, which also includes the findings from a Danish city-pair emission inventory in 1998.

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

The most thorough recalculations have changed the estimates for the navigation and agriculture/forestry/fisheries sectors. In general terms the new estimates rely on a revised fuel allocation for small boats, non-road working machinery and equipment used in the two sectors. For railways updated emission factors for diesel are used based on real emission measurements carried out by the Danish Railways.

For transport the CO_2 emissions are determined with the lowest uncertainty, while the levels of the CH_4 and N_2O estimates are significantly more uncertain. The overall uncertainty in 2002 for CO_2, CH_4 and N_2O are around 4, 32 and 56 %, while the 1990-2002 emission trend uncertainties for the same three components are 4, 4 and 193 %, respectively.

Please refer to Chapter 3 and Annex 3B for further information about emission from transport.

1.4.3 The specific methodologies regarding Industrial Processes

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

Mineral Products: Cement. CRF Table 2(I).A-G Sectoral Background Data for Industrial processes. A.1.
There is only one producer of cement in Denmark, Aalborg Portland ltd. The activity data for the production of cement and the emission factor are obtained from the company as accounted for and published in the "Green National Accounts" (In Danish: "Grønne regnskaber") which the compocorporation works out according to obligations in Danish law. These accounts are subject to audit. The emission factor is produced as a result of weighting of emission factors resulting from the production of low alkali cement, rapid cement, basis cement, and white cement.

Mineral Products: Lime and bricks. CRF Table 2(I).A-G Sectoral Background Data for Industrial processes. A.2.
The reference for the activity data for production of lime and bricks are the production statistics for manufacturing industries published by Statistics Denmark. The productions of lime and yellow bricks imply CO_2 emissions. For the calculation of these emissions and the emission factors used please refer to Annex 3.C.

Mineral products: Glass and glass wool. CRF Table 2(I).A-G Sectoral Background Data for Industrial processes. A.7.
The reference for activity data for production of glass and glass wool are obtained from the producers published in their environmental reports. Emission factors are based on stoichiometric relations between raw materials and CO_2 emission.

Chemical Industry. Nitric Acid production: CRF Table 2(I).A-G Sectoral Background Data for Industrial processes. B.2.
There is one producer. The data so far in the inventory relies on information from the producer. The producer only reports NO_x emissions associated with the production. The producer reports these emissions as measured emissions. Information on N_2O emission has been obtained by contact to the producer.

Chemical Industry. Catalysts/fertilisers: CRF Table 2(I).A-G Sectoral Background Data for Industrial processes. B.5 Others.
There is one producer. The data in the inventory relies on information published by the producer in environmental reports.

Metal production. Steelwork: CRF Table 2(I).A-G Sectoral Background Data for Industrial processes. C.1.
There is one producer. The activity data as well as data on consumption of raw materials (coke) has been published by the producer in environmental reports. Emission factors are based on stoichiometric relations between raw materials and CO_2 emission.

F-gases (HFCs, PFCs and SF_6): CRF Sectoral Report for Industrial Processes Table2(I) and 2(II) and Sectoral Background Data for Industrial Processes Tables 2(II).F
The inventory on the F-gases: HFCs, PFCs and SF_6 is based on work carried out by the Danish Consultant Company "Planmiljø". Their yearly report (Danish Environmental Protection Agency, 2004a) is available in English as documentation of inventory data up to year 2002. The methodology and the model were in 2002 revised to better reflect the Tier 2 methodology of the IPCC guidelines. This revision was firstly implemented for the 2001 inventory. The inventories in this submission reflect the new methods implemented for the whole time-series 1990-2002. For the full information on data, methodology etc., reference is made to the report, The Danish environmental Agency, 2004a.

Please refer to Chapter 4 and Annex 3.C for further information about industrial processes.

1.4.4 The specific methodologies regarding Solvents

CRF Table 3.A-D. Sectorial background data for solvents and other product use

The emission inventory for 'Solvents' is based on reports from the Danish Industry on emissions from various industrial sectors. 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 and no activity data has been available. A work is going on to improve the emission estimates.

Please refer to Chapter 5 for further information about emission inventories for solvents.

1.4.5 The specific methodologies regarding Agriculture

CRF Table 4.A-F. Sectorial background data for agriculture

The emission from the agricultural sector is mainly related to the livestock production. The emission is given in CRF: *Table 4 Sectoral Report for Agriculture and Table 4.A, 4.B(a), 4.B(b) and 4.D Sectoral Background Data for Agriculture.*

The calculation of emission from the agricultural sector is based on methods described in the IPCC Guideline (IPCC, 1996) and the Good Practice Guidance (IPCC, 2000). Activity data for livestock is one year average from Agriculture Statistics published in Statistics Denmark (2003). Data concerning the landuse and crop yield is as well from the Agricultural Statistic.

The Implied Emission factors for Enteric Fermentation and Manure Management for CH_4 are based on a Tier 2 approach for all animal categories. Background information as e.g. daily feed intake and excretion on a detailed animal categorisation level are based on data from the Danish Institute of Agricultural Science. For Dairy Cattle and Manure Management the emission factor is higher than the IPCC default for cool -Western Europe and for Other Cattle lower. The reasons is that in Denmark the type of feed and excretion, and animal waste management systems, deviates from Western Europe. Further, the counting of subgroups in Other Cattle in the Danish activity data reported here includes several categories, which might have been omitted referring to IPCC guidelines.

Emission of N_2O is closely related to the nitrogen balance. Thus, quite a lot of the activity data is related to the Danish calculations for ammonia emission. In Denmark a model based system is applied for calculation of the emission of ammonia (Hutchings et al., 2001) and the data is primarily based on information from Statistics Denmark, The Danish Institute of Agricultural Science and The Danish Agricultural Advisory Centre. The emission of CO_2 from Agricultural Soils is not yet estimated.

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

The uncertainties for assessment of emissions from Enteric Fermentation, Manure Management and Agricultural Soil have been estimated. The most significant uncertainties are related to the N_2O emission.

A more detail description of the methodology for the agriculture sector is given in Chapter 6 and Annex 3D.

1.4.6 The specific methodologies regarding Forestry

CRF Table 5 Sectoral Report for Land-Use Change and Forestry and Table 5.A Sectoral Background Data for Land-Use Change and Forestry.

This submission of inventories 1990-2002 represents slightly revised data on removals by sinks compared to the submission in 2003 for the period 1990-2001. The main revision is that net annual increment in Danish forests is now estimated using annually specific amounts of harvested wood instead of a ten-year average as used in previous submissions. This revision has only led to slight changes in the reported CO_2 uptake during 1990-2001 for Danish forests planted before 1990. The only exception is the year 2000, which has a low CO_2 uptake due to a severe storm in December 1999. This storm resulted in much larger fellings being recorded in the year 2000. These changes were done to improve the transparency and consistency in the methods.

There has only been a very minor adjustment of Forest sinks due to afforestation since 1990. This is due to an adjustment of afforested areas in the period 1999-2001.

More detailed information on the revisions and further information on the Forestry Census, the calculation methodology, the removal of sinks data and their background data for the new estimates can be found in Chapter 6. In response to the latest evaluation report of the NIR, the chapter has been updated with more information on estimation of net annual uptake of CO_2 in forests planted before 1990 based on the Danish Forestry Census. Comments on uncertainty have also been added together with other relevant information.

1.4.7 The specific methodologies regarding Waste

CRF Table 6 Sectoral Report for Waste Table 6.A Sectoral Background Data for Waste
The data used for the amounts of Municipal Solid Waste deposited at Solid Waste Disposal Sites is according to official registration performed by the Danish Environmental Protection Agency. The data are registered in the ISAG database, the latest yearly report Environmental Protection Agency, 2004b, see the reference list for the link to the report). CH_4 emissions from Solid Waste Disposal Sites are based on a model suited to the Danish conditions. The model is based on the IPCC Tier 2 approach using a First Order Decay approach. The model is unchanged for the whole time-series. The model is described in Chapter 8. All waste incinerated are used for energy and heat production. This production is included in energy statistics, hence emissions are included in *CRF Table 1A.1a Public Electricity and Heat Production*. The Danish wastewater handling systems treat the wastewater aerobically. They are therefor considered to produce CH_4 emissions of only minor and negligible importance. These CH_4 emissions and possibly N_2O emission are planned considered for the next submissions.

Please refer to Chapter 8 and Annex 3E for further information about emission inventories for waste.

1.5 Brief description of key source categories

A key source analysis for year 2002 has been carried out in accordance with the Good Practice Guidance (Penman et al, 2000). The analysis as regards the basic source categorisation has been kept unchanged since the analyses for the submissions in 2002 and 2003. The source categorisation used results for in total 63 sources, of which 15 are identified as key sources due to both level and trend key source analysis. The Energy Sector contributes with 8 key sources of which CO_2 from Coal is the highest contributing category with 24.4% of the National total. The category CO_2 emissions from Mobile Combustion, Road Transportation is the second most important contributing with 16.6% and CO_2 from Natural gas is the third largest contributor with 16.6%. In the Agricultural Sector, there are four trend and level key sources, of which three are among the seventh highest contributing sources to the National total. These three sources are direct N_2O emissions from Agricultural Soils, indirect N_2O emissions from Nitrogen used in Agriculture and CH_4 from Enteric Fermentation, contributing by 4.3, 4.1 and 4.1% respectively to the National total in 2002. The fourth Agricultural key source is N_2O from Manure Management contributing with 0.9%. Finally, the Industrial Sector contributes with three level and trend key sources, which are CO_2 from Cement production (contributes with 2.1%), N_2O from Nitric Acid Production (1,1%) and emissions from substitutes for ODS, F-gases (1.0%). The categorisation used, results etc. are included in Annex 1.

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

1.6.1 Introduction

This document outlines a first draft for implementing a Quality Control (QC) and Quality Assurance (QA) plan for greenhouse gas emission inventories performed by the Danish National Environmental Research Institute. The plan is in accordance with the guidelines provided by the UNFCCC and the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC).

In the preparation of Denmark's annual emission inventory several quality control (QC) procedures are carried out already and the QA/QC plan will in the future improve this activity. The Danish Tier 1 QC includes:

- Check of time-series of the CRF and SNAP source categories as they are found in the CORINAIR databases. Considerable trends and changes are checked and explained.
- Comparison to inventory of the previous year on the level of the categories of the CRF as well as on SNAP source categories. Any major changes are checked and verified.
- Total emissions when aggregated to CRF source categories are compared to totals based on SNAP source categories (control of data transfer).
- A manual log table have been introduced in the emission databases to collect information about recalculations

A part from the UNFCCC's In-Depth-Reviews, Quality Assurance (QA) with independent review of the inventories has not yet been carried out. A strategy for implementing a formal QA/QC plan is given below.

1.6.2 Objectives

The main objective is to implement a plan that comprises a frame for documenting and reporting emissions in way that emphasises transparency, consistency, comparability, completeness and accuracy. To fulfil these high criteria a data structure is proposed that describes the pathway from collection of raw data to data compilation, modelling and final reporting. In a first approach a general structure is proposed, but realising the differences in availability and quality in data from the different sectors, the structure is designed to exhibit flexibility towards varying forms of input data.

1.6.3 Definitions

The UNFCCC Guidelines prescribe the source categories, calculation methodologies and the contents and the format for the inventory report. For the definition of the source categories and calculation methodologies the UNFCCC Guidelines generally refer to the IPCC Guidelines for Greenhouse Gas Inventories and the IPCC Good Practice Guidance reports.

The IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse provides assistance in producing inventories that are accurate and in which uncertainties are reduced as much as possible. The IPCC report addresses the Energy, Industrial Processes, Agriculture and Waste sectors, with respect to

- Choice of estimation methods suited to national circumstances

- Advice on the most suitable emission factors and other data necessary for inventory calculations
- Quality assurance and quality control procedures to enable cross-checks during inventory compilation
- Information to be documented, archived and reported to facilitate review of emission estimates
- Uncertainties at the source category level

The IPCC uses the concept of a tiered approach, i.e. a stepwise approach where complexity, advancement and comprehensiveness increase from Tier 1 to Tier 2 to Tier 3 and so on. Generally, more detailed and advanced methods are recommended in order to give guidance to countries which have more detailed datasets and more capacity, as well as to countries with less data and manpower available. The tiered approach helps focussing on areas of the inventories that are relatively weak instead of investing effort on irrelevant subjects. Furthermore the IPCC Guidelines recommends using higher Tier methods for key sources in particular.

The plan comprises emission inventories for the six main greenhouse gases:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulphur hexafluoride (SF6)

In addition to these so-called direct greenhouse gases there are other gases which contribute to heating the atmosphere. Some of these are the indirect greenhouse gases, such as CO, NO_x and NMVOC. These are precursors of tropospheric ozone, which is a greenhouse gas. Furthermore SO_2 leads to aerosol formation with a cooling effect.

Quality Control (QC) is a system of routine technical activities, to measure and control the quality of the inventory as it is being developed. The QC system is designed to:

1. Provide routine and consistent checks to ensure data integrity, correctness and completeness;
2. identify and address errors and omissions
3. Document and archive inventory material and record all QC activities.

Quality Assurance (QA) activities include a planned system of review procedures conducted by personnel not directly involved in the inventory compilation/development process.

A key option for quality is robustness in relation to possible change in conditions. This includes critical external data sources and change in the inventory staff.

1.6.4 Practical considerations in developing a QA/QC system

The QA/QC system will include the following factors:

1. Resources allocated to QC for different source categories and the compilation
2. Time allocated to conduct the checks and reviews of emissions estimates
3. Availability and access to information on activity data and emission factors, including data quality

4. Procedures to ensure confidentiality of inventory and source category information, when required
5. Requirements for archiving information
6. Frequency of QA/QC checks on different parts of the inventory
7. The level QC appropriate for each source category
8. Whether increased effort on QC will result in improved emission estimates and reduced uncertainties
9. Whether sufficient expertise is available to conduct the checks and reviews

A good data structure will balance the limited resources for the inventory development process with the resources applied for QC/QA to enable continuos improvement of the inventory.

1.6.5 Elements of a QA/QC system

- An inventory agency responsible for co-ordinating QA/QC activities
- A QA/QC plan
- General QC procedures (Tier 1)
- Source category-specific QC procedures (Tier 2)
- QA review procedure
- Reporting, documentation, and archiving procedures

The Tier2 QC includes the procedures in Tier 1 plus additional source category-specific activities.

1.6.6 Strategy

As a first stage in the QA/QC strategy Critical Control Points (CCP) will be defined. A CCP is an element necessary to be taken into account in order to secure the quality. The second stage is then to set up ways to apply the CCPs. The third stage is to set up measures, which can quantify how well the means fulfils the needs of the CCP. The two first stages are needed for Quality assurance, while the third stage is needed for Quality Control.

The following CCPs are defined to the QA/QC strategy:

1. ***Transparency*** Transparency plays a key role in relation to both data presentation, handling and calculations. It is also important to have a high degree of transparency in order to obtain robustness in relation the change in staff.
2. ***Consistency*** The basic dataset should be consistent and comprise the same elements from year to year. Deviations from the standard should be noted and explanation of changes in data treatment should be clearly stated. The used methodologies should be consistent from year to year, and if deviations occur they should be clearly stated.
3. ***Accuracy*** The realism of an emission estimate is important to quantify as a key quality parameter. Accordingly the QC/QA also includes assessment of uncertainty.

The following two general means are identified:

1. ***Data structure*** The basic data structure needs to support the QC/QA in order to facilitate a cost-effective procedure. The flow of data has to take place in a transparent way by making the transformation of data detectable. It needs to be easy to find the original data background for any calculation and to trace the sequence of calculations from the raw data to the final emission

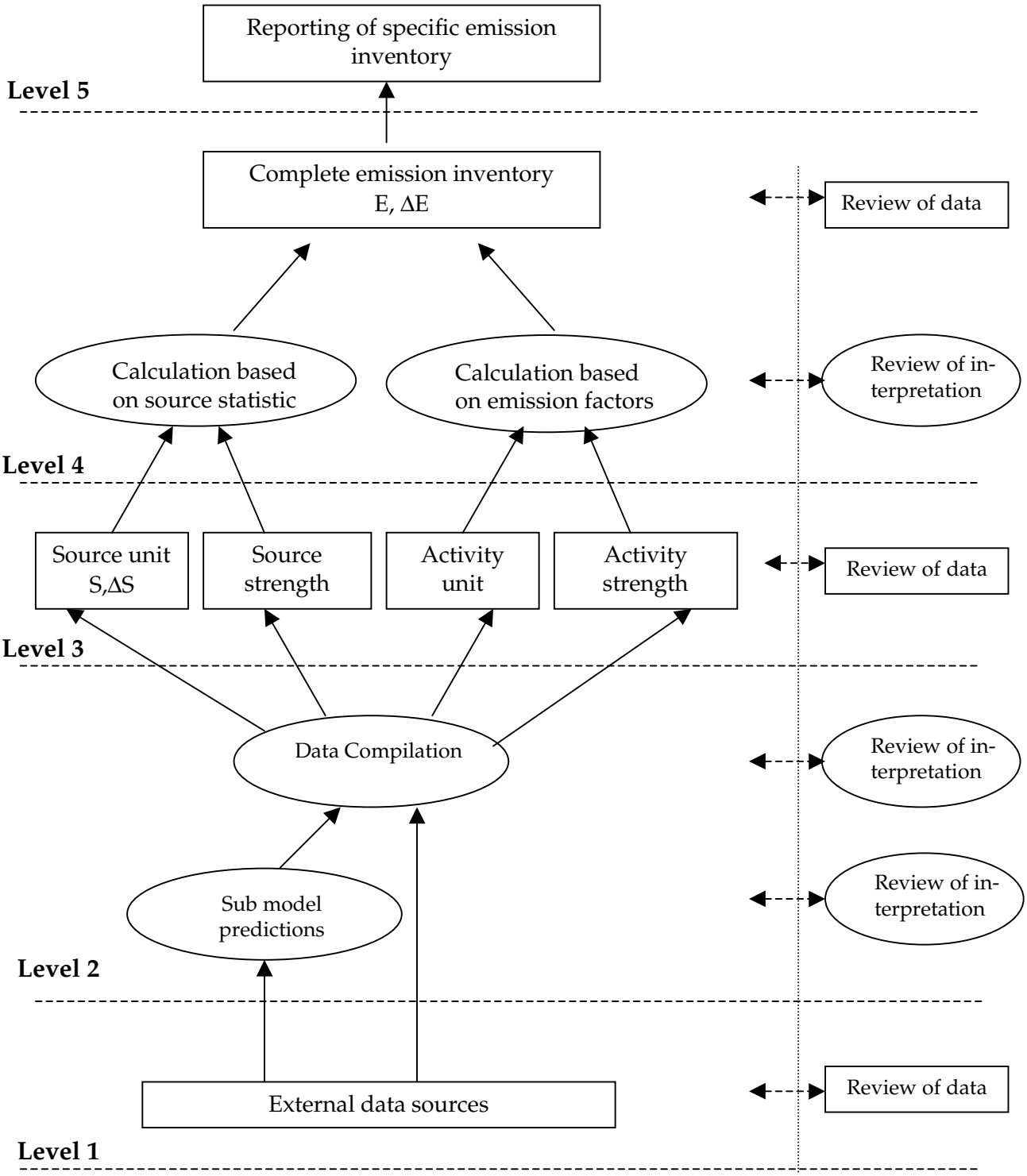
result. Computer programming for automated calculations and checking will enhance the accuracy and minimise the number of miscalculations and flaws in input value settings. Especially manual typing of numbers needs to be minimised. This assumes however, that the quality of the programming has been verified to ensure the correctness of the automated calculations. Automated value control is also one of the important tools to secure accuracy. Realistic uncertainty estimates is necessary for securing accuracy, but they can be difficult to produce, due to an important degree of uncertainty related to the uncertainty estimates itself. It is therefore important to include the uncertainty calculation procedures into the data structure as much as possible. The QC/QA procedures can easily become troublesome and subject for frustration if not highly supported by a simple and transparent data structure.

2. ***Manual for praxis*** The used methodologies needs to be well documented in a manual lining up all the assumptions behind the chosen methodologies and key references. This also includes a detailed description of the calculation procedures. In this way transparency is improved by documentation of the calculation procedures and by a data structure, where the background for the value setting is easy to trace. The assumptions and methodologies must be clearly described to facilitate replication, documentation and review.

The first priority in the strategy is to evaluate and modify the data structure and afterwards consider the manual for praxis.

1.6.7 Data structure supporting QC/QA

A data structure which can support the demands coming from the QC/QC activity is outlined in the following diagram, where 5 different levels are defined, having increasing data aggregation from level 1 toward level 5.


Reporting of specific emission inventory
Level 5
Complete emission inventory E, ΔE
Review of data
Calculation based on source statistic
Calculation based on emission factors
Review of in-terpretation
Level 4
Source unit S,ΔS
Source strength
Activity unit
Activity strength
Review of data
Level 3
Data Compilation
Review of in-terpretation
Sub model predictions
Review of in-terpretation
Level 2
External data sources
Review of data
Level 1

Level 1

Collection of external data sources from different sectors and statistical surveys typically reported on a yearly basis. Level 1 data consist of raw data, having identical format as the data received and gathered from external sources. Level 1 data acts as a base set, on which al subsequent calculations are based. If alterations in calculation procedures are made they is based the same data set. When new data are introduced they can be implemented in accordance with the QA/QC structure of the inventory. The review of data consists of evaluating the most updated data bases and continuously personal contact to key persons in other institutions. The methodological development in scientific world can inspire the expert to consider new/other external data sources as input, so the review of the data is thus important. Level 1 data acts as verification of the inventory, which means that questions regarding the output of the emission inventory can be assessed by tracing back to the base set. Evaluation of external data quality has to be a part of the level 1 work including valid agreements with external data sources about data quality and delivery.

Level 2

Preparation of input data for the emission inventory based on the external data sources. Some external data may be useful more directly as input while others needs to be interpreted using more or less complicated models. This interpretation is developed as a continuous process in line with the development in the scientific world, so the review of the interpretation is an integrated part of the data interpretation. The data compilation creates a data set designed for the emission inventory. Both the parameters values (S, S_S, A, A_S) and the related uncertainties (ΔS, ΔS_S, ΔA, ΔA_S) are created based on the data compilation. The data preparation in level 2 typically comprises most of the assumptions, simplifications and choices in the overall data treatment procedure. These need therefore to be clearly stated and transparently linked to the raw data in level 1. Activities in level 2 often require the highest workload.

Level 3

Level 3 represents data that have been prepared and compiled in a form that is directly applicable for calculation of emissions. The compiled data is structured in a database for internal use, where the structure and design allows for automatic assessment of the emission inventory calculation program including related uncertainty calculations. The database allows an easy reporting for documentation of the reasoning behind the value setting and estimation of data uncertainty. This induces a need for the database to communicate key information from the data compilation, more than just to value setting and including reference to the external data sources. Level 3 is the link between more or less raw data and data that is ready for reporting. The data is compiled in a way that elucidates the different approaches in emission assessment; 1) Emissions that are estimated as the product of activity statistics and emission factors, and 2) emissions directly found from measurements or by expert judgement. The value setting has to be compared with other emission inventories in other countries in order to review the data compilation step in level 2.

Level 4

The emission inventory calculations result in the emission value (E) and the related uncertainty (ΔE) as illustrated in Figure 1.2. Level 4 data comprises all emissions from all sectors and activities. The methodology of calculating is reviewed based on the scientific literature and international standards.

Level 5

Dependent on the specific emission inventory that is performed, relevant data are extracted from level 4 and reported in the appropriate format. The informational content of the emissions is limited compared to the large data material that has been used to derive the emissions. If there are

any assumptions in the previous levels (typically level 2) that are fundamental for assessing the emission inventory, these need to be stated in level 5.

The existing data structure is related to the general structure (cf. Chapter 1.3) as described in Chapter 1.6.8.

1.6.8 QC/QA as lined out in IPCC and in relation to the suggested data structure

In the following the general procedure suggested by IPCC is lined out and related to the data structure lined out in Chapter 1.6.7 above. The first two columns in the table are similar to Table 8.1 in IPCC, 2000. The last two columns are related to the data structure described in Chapter 1.6.7. The column heading "Manual" denotes an activity where the inventory personal needs to take action. This action can either be a part of a yearly activity or verification of calculation routines. In case of verification activity "(verification)" is written explicitly. Verification is a check of a calculation routine and thus not a control of a specific result. The benefit of a verification is that once the routine is controlled the following calculations needs not to be controlled and the quality of the calculation will in this way be imbedded in the procedure and thus not demand a continuously effort from the personal. The last column heading is "Automated" and denotes check routines, which is programmed into the calculations. Such routines will support the QC in an effective way when they are possible.

QC Activity	Procedures	Manual	Automated
Check that assumptions and criteria for the selection of activity data and emission factors are documented	Cross-check description of activity data and emission factors with information on source categories and ensure that these are properly recorded and archived	level 3	
Check for transcription errors in data input and references	Confirm that bibliographical data references are properly cited in the internal documentation	level 1	
	Cross-check a sample of input data from each source category (either measurements or parameters used in calculations) for transcription errors.	level 2 (verification)	
Check that emission are calculated correctly	Reproduce a representative sample of emissions calculations	level 2-4 (verification)	
	Selectively mimic complex model calculations with abbreviated calculations to judge relative accuracy	level 2 (verification)	
Check that parameter and emission units are correctly recorded and that appropriate conversion factors are used	Check that units are properly labelled an calculation sheets	level 2-3 (verification)	
	Check that units are correctly carried though from beginning to end of calculations	level 2-4 (verification)	
	Check that conversion factors are correct	level 3	
	Check that temporal and spatial adjustment factors are used correctly	level 3	
Check the integrity of database files	Confirm that the appropriate data processing steps are correctly represented in the database		level 2, 4
	Confirm that data relationships are correctly represented in the database		level 2, 4
	Ensure that data fields are properly labelled and have the correct design specifications		level 2, 4

	Ensure that adequate documentation of database and model structure and operation are archived	level 2-4 (writing manuals)	
Check for consistency in data between source categories	Identify parameters (e.g. activity data, constants) that are common to multiple source categories and confirm that there is consistency in the values used for these parameters in the emission calculations	level 2-4 (verification)	
Check that the movement of inventory data among processing steps is correct	Check that emission data are correctly aggregated from lower reporting levels to higher reporting levels when preparing summaries	level 2, 4 (verification)	
	Check that emission data are correctly transcribed between different intermediate products	level 2, 4 (verification)	
Check that uncertainties in emission and removals are estimated or calculated correctly	Check that qualifications of individuals providing expert judgement for uncertainty estimates are appropriate	level 1, 2	
	Check that qualifications, assumptions and expert judgements are recorded	level 1,2	
	Check that calculated uncertainties are complete and calculated correctly	level 1,2 and level 4 (verification)	
	If necessary, duplicate error calculations or a small sample of the probability distributions used by Monte Carlo analyses		level 4
Undertake review of internal documentation	Check that there is detailed internal documentation to support the estimates and enable duplication of the emission and uncertainty estimates	level 3 (verification)	
	Check that inventory data, supporting data, and inventory records are archived and stored to facilitate detailed review	level 3 (verification) level 1	
	Check integrity of any data archiving arrangements of outside organisations involved in inventory preparation	level 1	
Check methodological and data changes resulting in recalculations	Check for temporal consistency in time-series input data for each source category		level 4
	Check for consistency in algorithm/method used for calculations throughout the time-series	level 4 (verification)	
Undertake completeness checks	Confirm that estimates are reported for all source categories and for all years from the appropriate base year to the period of the current inventory		level 4
	Check that known data gaps that result in incomplete source category emissions estimates are documented	level 1	
Compare estimates to previous estimates	For each source category, current inventory estimates should be compared to previous estimates. If there are significant changes or departures from excepted trends, recheck estimates and explain any differences		level 4

1.6.9 Work plan for the development of a QC/QA procedure

The following activities will be undertaken in the work of setting up QA/QC procedures:

Review of existing data structure

A detailed construction of the existing data structure in order to get a complete overview of all aspects from the raw data to the final emission estimate. There will be more or less separate struc-

tures for separate categories in the inventory, but for all of them a structure needs to be made including the interaction between different categories.

Review of existing methods
A complete overview of all the applied methods has to be made in a schematic and transparent way. In this way the challenges associated with the writing of understandable manuals will be elucidated.

Review of the uncertainty calculations
A complete overview of the actual uncertainty calculations as they are performed in order to identify possible gaps to be covered to obtain a fulfilment of good praxis in the performance and procedure for uncertainty analysis.

Modifying data structure
The data structure has to be reconsidered in relation to possible modification, which support the QC/QA procedure.

Filling up methodological gabs
Especially the demand of a transparent and valid uncertainty analysis may identify gaps in the methodology that needs to be filled out. A change in data structure may also induce a demand of minor changes in the methodology.

Writing manuals
The methods applied for the inventory has to be explained in manuals in order to secure transparency and robustness for change in personal.

Setting up control measures
Measures has to be made, which can quantify how well the Critical Control Points are taken into account in the inventory. These measures are essential in relation to the communication with external reviewers. Furthermore, CCP's function as guidelines for the ongoing work of improving the inventory.

Two source categories will be processed using the activity plan above during 2004. These two categories are selected in relation to both high importance and difference in type. It is important that the composition of data and procedures are distinct between the two selected source categories because this will facilitate a fast development of a QA/QC system, which can handle all classes of sources. In this way the selected source categories will act as training set for a general QA/QC procedure development. The selected categories are:

- Agriculture
- Public electricity and heat production

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

The uncertainty estimates are based on the Tier 1 methodology in IPCC Good Practice Guidance (GPG) (IPCC 2000). Uncertainty estimates for stationary combustion plants, mobile combustion, agriculture and fugitive emissions from fuels are included this year. The aim is to include an increasing part of the emission sources during the next years. The sources included in the uncertainty estimate cover 93% of the total Danish greenhouse gas emission (given in CO_2 equivalents).

The uncertainties of the activity rates and emission factors are shown in Table 1.2.

The estimated uncertainties for total GHG and for CO_2, CH_4 and N_2O are shown in Table 1.3. The total Danish GHG emission is estimated with an uncertainty of ±46% and the trend of GHG emission since 1990 have been estimated to be -1,4%[1] ± 19%-age points. The GHG uncertainty estimates do not take into account the uncertainty of the GWP factors.

The uncertainty on N_2O from agricultural soils is the predominant source of uncertainty for the Danish GHG inventory.

The uncertainty of the GHG emission from combustion (sector 1A) is 8% and the trend uncertainty is 1,8%.

[1] Including only emission sources for which the uncertainty have been estimated

Table 1.2 Uncertainty rates for each emission source

IPCC Source category	Gas	Base year emission (1990)	Year t emission	Activity data uncertainty	Emission factor uncertainty
		Gg CO2 eq	Gg CO2 eq	%	%
Stationary Combustion, Coal	CO2	24209	16708	1	5
Stationary Combustion, Petroleum coke	CO2	410	762	3	5
Stationary Combustion, Plastic waste	CO2	369	599	5	5
Stationary Combustion, Residual oil	CO2	2505	1923	2	2
Stationary Combustion, Gas oil	CO2	4564	2920	4	5
Stationary Combustion, Kerosene	CO2	366	18	4	5
Stationary Combustion, Orimulsion	CO2	0	1908	1	2
Stationary Combustion, Natural gas	CO2	4330	11090	3	1
Stationary Combustion, LPG	CO2	194	104	4	5
Stationary Combustion, Refinery gas	CO2	806	842	3	5
Stationary combustion plants, gas engines	CH4	2	400	2,2	40
Stationary combustion plants, other	CH4	117	133	2,2	100
Stationary combustion plants	N2O	397	383	2,2	1000
Transport, Civil aviation, Aviation Gasoline	CO2	8	7	2	5
Transport, Civil aviation, Jet Kerosene	CO2	208	139	2	5
Transport, Road transport, Gasoline	CO2	4914	6021	2	5
Transport, Road transport, Diesel Oil	CO2	4436	5369	2	5
Transport, Railways, Diesel Oil	CO2	297	210	2	5
Transport, Navigation, Residual Oil	CO2	278	161	2	5
Transport, Navigation, Gas/Diesel Oil	CO2	246	320	2	5
Transport, Agriculture, Diesel Oil	CO2	1280	1184	20	5
Transport, Agriculture, Gasoline	CO2	38	36	20	5
Transport, Forestry, Diesel Oil	CO2	0	0	20	5
Transport, Forestry, Gasoline	CO2	4	4	20	5
Transport, Industry, Diesel Oil	CO2	687	635	20	5
Transport, Industry, Gasoline	CO2	10	10	20	5
Transport, Industry, LPG	CO2	81	97	20	5
Transport, Household and gardening, Gasoline	CO2	87	82	20	5
Transport, Civil aviation, Aviation Gasoline	CH4	0	0	2	100
Transport, Civil aviation, Jet Kerosene	CH4	0	0	2	100
Transport, Road transport, Gasoline	CH4	48	56	2	40
Transport, Road transport, Diesel Oil	CH4	7	7	2	40
Transport, Railways, Diesel Oil	CH4	0	0	2	100
Transport, Navigation, Residual Oil	CH4	0	0	2	100
Transport, Navigation, Gas/Diesel Oil	CH4	0	0	2	100
Transport, Agriculture, Diesel Oil	CH4	2	1	20	100
Transport, Agriculture, Gasoline	CH4	1	1	20	100
Transport, Forestry, Diesel Oil	CH4	0	0	20	100
Transport, Forestry, Gasoline	CH4	0	0	20	100
Transport, Industry, Diesel Oil	CH4	1	1	20	100
Transport, Industry, Gasoline	CH4	0	0	20	100
Transport, Industry, LPG	CH4	2	2	20	100
Transport, Household and gardening, Gasoline	CH4	3	3	20	100
Transport, Civil aviation, Aviation Gasoline	N2O	0	0	2	1000
Transport, Civil aviation, Jet Kerosene	N2O	3	2	2	1000
Transport, Road transport, Gasoline	N2O	47	276	2	50
Transport, Road transport, Diesel Oil	N2O	84	118	2	50
Transport, Railways, Diesel Oil	N2O	3	2	2	1000
Transport, Navigation, Residual Oil	N2O	5	3	2	1000
Transport, Navigation, Gas/Diesel Oil	N2O	5	6	2	1000
Transport, Agriculture, Diesel Oil	N2O	17	15	20	1000
Transport, Agriculture, Gasoline	N2O	0	0	20	1000
Transport, Forestry, Diesel Oil	N2O	0	0	20	1000
Transport, Forestry, Gasoline	N2O	0	0	20	1000
Transport, Industry, Diesel Oil	N2O	9	8	20	1000
Transport, Industry, Gasoline	N2O	0	0	20	1000
Transport, Industry, LPG	N2O	1	1	20	1000
Transport, Household and gardening, Gasoline	N2O	1	1	20	1000
Energy, fugitive emissions, oil and natural gas	CO2	240	535	15	5
Energy, fugitive emissions, solid fuels	CH4	72	62	2	200
Energy, fugitive emissions, oil and natural gas	CH4	21	70	15	50
Energy, fugitive emissions, oil and natural gas	N2O	1	3	15	50
Agriculture, enteric fermentation	CH4	3100	2798	2	20
Agriculture, manure management	CH4	742	966	10	30
Agriculture, manure management	N2O	686	605	10	500
Agriculture, Agricultural soils	N2O	8297	5765	20	500

Table 1.3 Uncertainty

1)	Uncertainty [%]	Trend [%]	Uncertainty in trend [%-age points]
CO_2	2,0	+2,2	±1,7
CH_4	15	+9,3	±6,3
N_2O	407	-25	±32
GHG	46	-1,4	±19

1. The uncertainty estimates includes stationary combustion plants, mobile combustion, agriculture and fugitive emissions from fuels

1.8 General assessment of the completeness

The Danish greenhouse gas emission inventory due 15 April 2004 includes all sources identified by the Revised IPPC Guidelines except the following (cf. CRF table A5.1):

- Waste: Wastewater handling systems are considered to produce only minor emissions of CO_2, CH_4 and N_2O but it will be investigated further.
- Industrial processes: CO_2 emission from sugar production and production of expanded clay will be included in the next submission. Also CO_2 emissions from use of coke in iron foundries will be included in the next submission.
- Agriculture: The methane conversion factor for poultry and fur farming is not estimated. There is no default value recommended in IPCC (table A-4 in GPG). The CH_4 emissions from manure storage in the field and from cultivation of organogenic soil are not estimated.

In response to review of previous submissions the use of notation key in the Danish CRF-tables is improved and extended.

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2 Trends in Greenhouse Gas Emissions

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

The greenhouse gas emissions are estimated according to the IPCC guidelines and are aggregated in seven main sectors. The greenhouse gases include CO_2, CH_4, N_2O, HFCs, PFCs and SF_6. Figure 1.1 shows the estimated total greenhouse gas emissions with CO_2 removal by forestry in CO_2 equivalents from 1990 to 2002. The emissions are not corrected for electricity trade or temperature variations. CO_2 is the most important greenhouse gas followed by N_2O and CH_4 in relative importance. The contribution to national totals from HFCs, PFCs and SF_6 is about 1%. Stationary combustion plants, transport and agriculture are the largest sources. The removal by forestry is about 5% of the total emissions in CO_2 equivalents. The national total greenhouse gas emissions in CO_2 equivalents are almost equal in 1990 and in 2002.

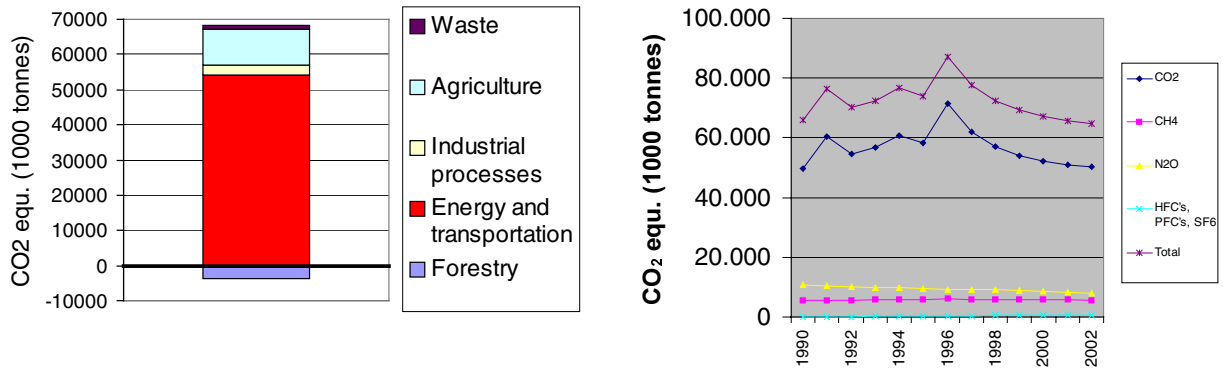

Figure 2.1 Greenhouse gas emissions in CO_2 equivalents without Land Use Change and Forestry (LUCF). Time-series for 1990 to 2002 and distribution on main sectors for 2002.

2.2 Description and interpretation of emission trends by gas

Carbon dioxide

The largest source to the emission of CO_2 is the energy sector, which includes combustion of fossil fuels like oil, coal and natural gas. Public power and district heating plants contribute with about half of the emissions. About 23% come from the transport sector. The CO_2 emission decreased by about 1% from 2001 to 2002. The reason for the small decrease is mainly due to higher outdoor temperature in 2002 compared with 2001. If the CO_2 emission is adjusted for climatic variations and electricity trade with other countries the CO_2 emission has decreased by 13% since 1990. The decrease in CO_2 emissions is observed despite an almost constant gross energy consumption and an increase in the gross national product of 29%. This is due to change of fuel from coal to natural gas and renewable energy. As a result of the lower consumption of coal in the recent years the main part of the CO_2 emission comes from oil combustion. In 2002 the actual CO_2 emission was almost the same as the emission in 1990.

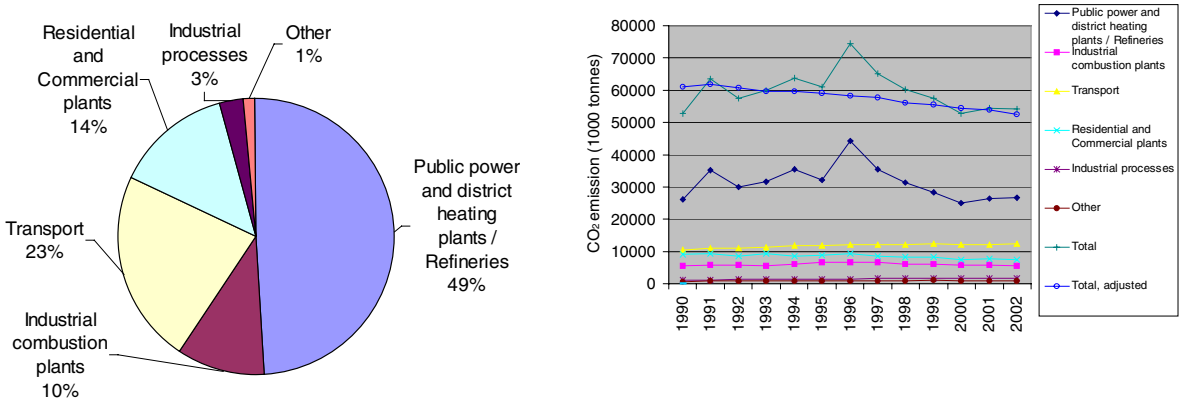

Figure 2.2. CO_2 emissions. Time-series for 1990 to 2002 and distribution on main sectors for 2002.

Nitrous oxide

Agriculture is the most important N_2O emission source (cf. Figure 2.3). N_2O is emitted as a result of microbial processes in the soil. Substantial emissions also come from drainage water and coastal waters where nitrogen is converted to N_2O through bacterial processes. However, the nitrogen converted in these processes originates mainly from the agricultural use of manure and fertilisers. The main reason for the drop in the emissions of about 30% from 1990 to 2002 is due to demands according to legislation to an improved utilisation of nitrogen in manure. The legislation has resulted in less nitrogen excreted per unit produced and a considerably reduction in the use of fertilisers. The basis for N_2O emission is then reduced. About 10% come from combustion of fossil fuels and transport accounts for about 5%. The N_2O emission from transport has increased in the nineties because of increasing use of catalyst cars. Emissions of N_2O from Nitric Acid production amounts to about 10% of the total N_2O emission.

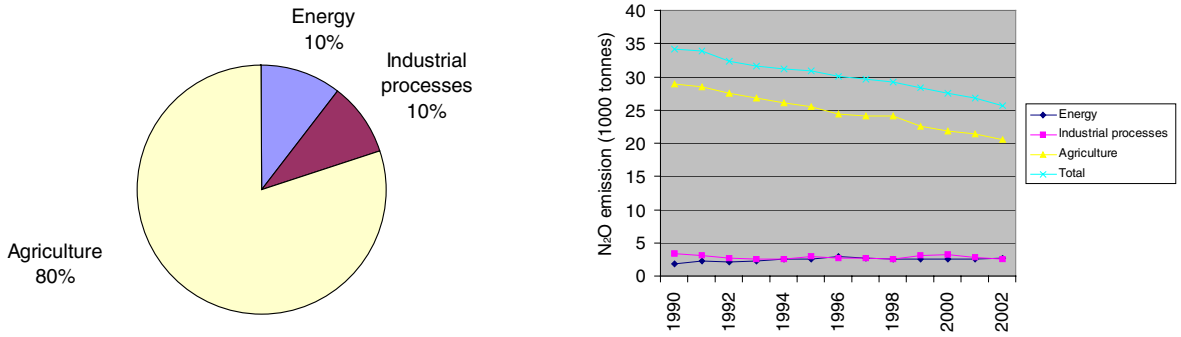

Figure 2.3. N_2O emissions. Right: Time-series for 1990 to 2002. Left: distribution on the three main sectors in 2002.

Methane

The largest sources to anthropogenic CH_4 emissions are: Agriculture activities, managed waste disposal on land, public power and district heating plants. The emission from agriculture derives from enteric fermentation and management of animal manure. The increasing CH_4 emissions from public power and district heating plants are due to increasing use of gas engines in the decentralised cogeneration plants sector. About 3% of the natural gas in the gas engines are not combusted. From 1990 the emissions of CH_4 from enteric fermentation has decreased because of decreasing numbers of cattle. However the emission from manure management have increased due to change in stable systems towards an increase in slurry based stable systems. Altogether the emission of

CH_4 for the agriculture sector has been almost constant from 1990 to 2002. The emission of CH_4 from waste disposal is decreasing slightly due to increasing use of waste for incineration.

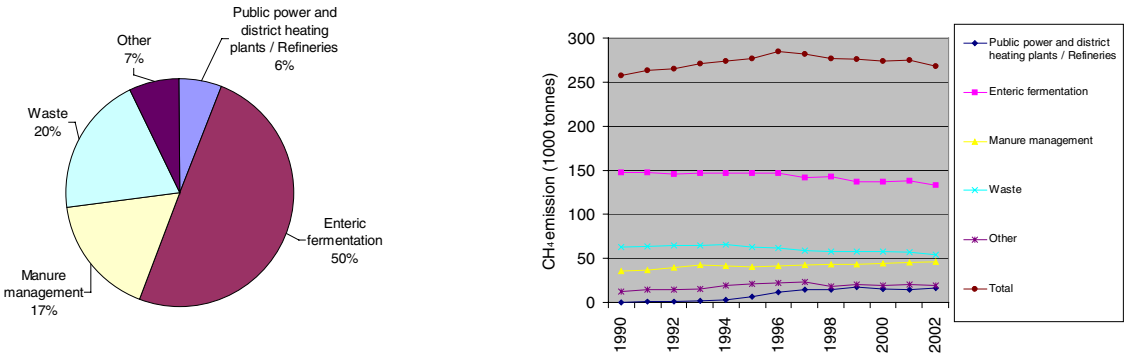

Figure 2.4. CH_4 emissions. Right: Time-series for 1990 to 2002. Left: distribution on main sectors for 2002.

HFCs, PFCs and SF6

This part of the Danish inventory only has data on all substances back to 1995. Since then and until 2000 there has been a continuous and substantial increase in the contribution from the sum of F-gases, calculated as the sum of emissions in CO_2-equivalents in Figure 2.5. The increase is occurring simultaneously with an increase in emissions of HFCs. For the time-series 2000-2002 the increase has been markedly stagnant. (The falling tendency 2000-2001 reported in the NIR 2003 has disappeared due to recalculations). The reasons for these trends are several. SF_6 contributed considerably in the first part of the trend, in 1993 by 52%. Environmental awareness and facing regulation of this gas in Danish law has decreased its industrial use and its contribution in 2002 is around 3%. The use of HFCs, and especially HFC-134a as a main contributor to the HFCs, has increased several folds and the model for the emissions responds with increasing emissions. So HFCs has become a very dominating F-gas from 48% in 1993 to 94% in 2002. HFC-134a is mainly used as a refrigerant. However, the tendency is that the use of HFC-134a as a refrigerant as well as the use of other HFCs as refrigerant, is stagnant or falling. This is due to Danish law, which in 2007 forbids new HFC based refrigerant stationary systems. Counter to this trend is the increasing use of air conditioning in mobile systems.

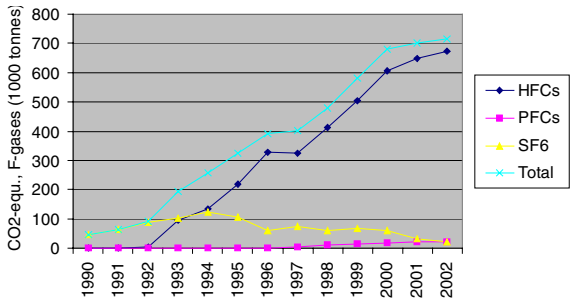

Figure 2.5. F-gas emissions. Time-series for 1990 to 2002.

2.3 Description and interpretation of emission trends by source

Energy
The emission of CO_2 from public power and district heating plants has increased by 1% from 1990 to 2002. The relatively large fluctuation in the emission is due to cross-country electricity trade. Thus the high emissions in 1991 and 1996 reflect a large electricity export and the low emission in 1990 is due to a large import of electricity. The increasing emission of CH_4 is due to increasing use of gas engines in the decentralised cogeneration plants. The CO_2 emission from the transport sector has increased by 18% since 1990 mainly due to increasing road traffic.

More details for the energy sector are given in Chapter 3.

Agriculture
The agricultural sector contributes with 15% of the total greenhouse gas emission in CO_2- equivalents and is one of the most important sectors regarding the emissions of N_2O and CH_4 and in 2002 the contributions to the total emissions were 80% and 67 % respectively. The N_2O emission has decreased by 29% from 1990 to 2002, while the CH_4 emission has been almost constant.

More details about the agriculture sector are given in chapter 6.

Industrial processes
The emissions from industrial process – i.e. emissions from processes other than fuel combustion amount to 4% of the total emissions in CO_2- equivalents. The main sources are cement production, nitric acid production, refrigeration, foam blowing and calcination of limestone. The CO_2 emission from cement production – which is the largest source contributing with 2,1% of the national totals – increased with 65% from 1990 to 2002. The second largest source is N_2O from production of nitric acid. The N_2O emission from this production decreased with 26% from 1990 to 2002.
More details for the industrial processes are given in Chapter 4.

Waste
Waste disposal is the third largest source to CH_4 emission. The emission has decreased by 14% from 1990 to 2002 where the contribution was 20% of the total CH_4 emission. The decrease is due to increasing use of waste for power and heat production. Since all incinerated waste is used for power and heat production, the emissions are included in the 1A1a IPCC category. More details for the waste sector are given in Chapter 8.

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

NO_X
The three largest sources, which are almost equal in size – are combustion in energy industries (mainly public power and district heating plants), road transport and other mobile sources. The transport sector is the sector contributing most to the emission of NO_X and in 2002 40% of the Danish emissions of NO_X stem from road transport, national navigation, railways and civil aviation. Also emissions from national fishing and off-road vehicles contribute significantly to the NO_X emission. For non-industrial combustion plants the main sources are combustion of gas oil, natural gas and wood in residential plants. The emissions from public power plants and district heating plants have decreased by 57% from 1985 to 2002. In the same period the total emission has decreased by 35%. The reduction is due to increasing use of catalyst cars and installation of low-NO_X-burners and de-nitrifying units on power and district heating plants.

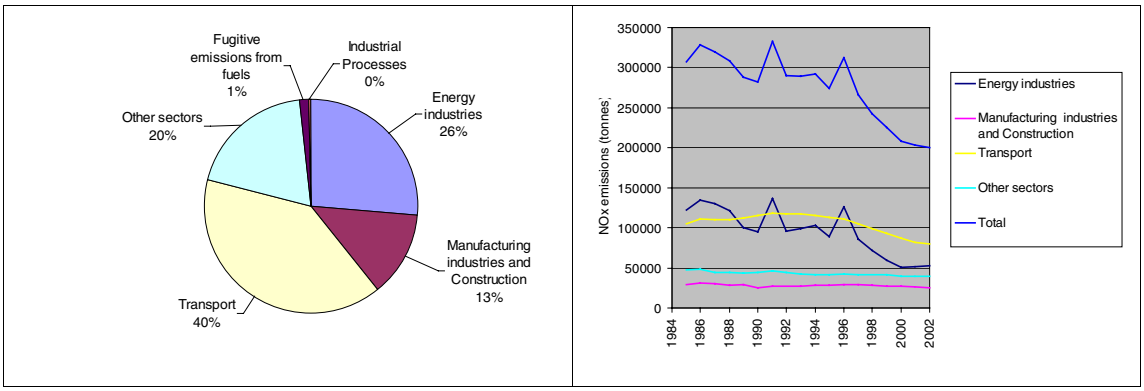

Figure 2.6. NO_4 emissions. Time-series for 1990 to 2002 and distribution on main sectors for 2002.

CO

Even though catalyst cars were introduced in 1990, road transport still has the dominant share of the total CO emission. Also other mobile sources and non-industrial combustion plants contribute significantly to the total emission of this pollutant. The drop in the emissions seen in 1990 was a consequence of a law forbidding burning of agricultural waste on fields. The emission decreased by 23 % from 1990 to 2002 mainly because of decreasing emission from road transportation.

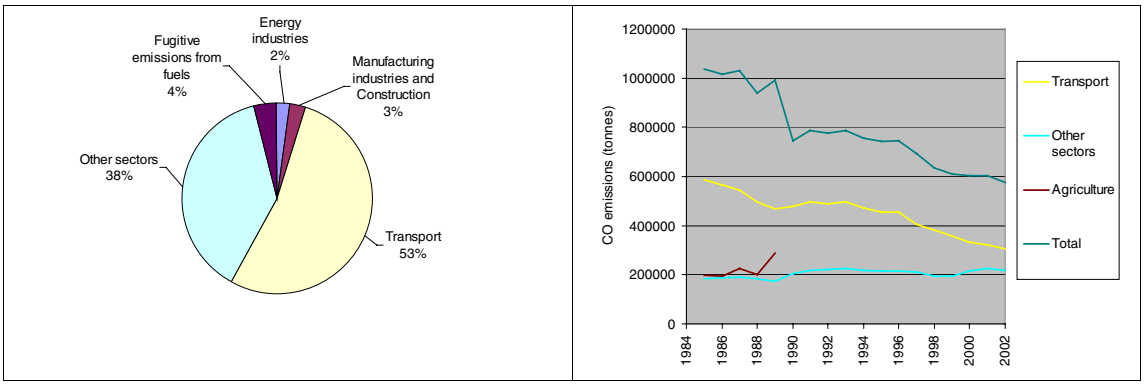

Figure 2.7. CO emissions. Time-series for 1990 to 2002 and distribution on main sectors for 2002.

NMVOC

The emissions of NMVOC originate from many different sources and can be divided into two main groups: Incomplete combustion and evaporation. The main sources to NMVOC emissions from incomplete combustion processes are road vehicles and other mobile sources such as national navigation vessels and off-road machinery. Road transportation vehicles are still the main contributors even though the emissions have declined since the introduction of catalyst cars in 1990. The evaporative emissions mainly originate from use of solvents. The emissions from energy industries have increased during the nineties because of increasing use of stationary gas engines that have much higher emissions of NMVOC than conventional boilers. The total anthropogenic emissions have decreased by 36% from 1985 to 2002 mainly due to increasing use of catalyst cars and reduced emissions from use of solvents.

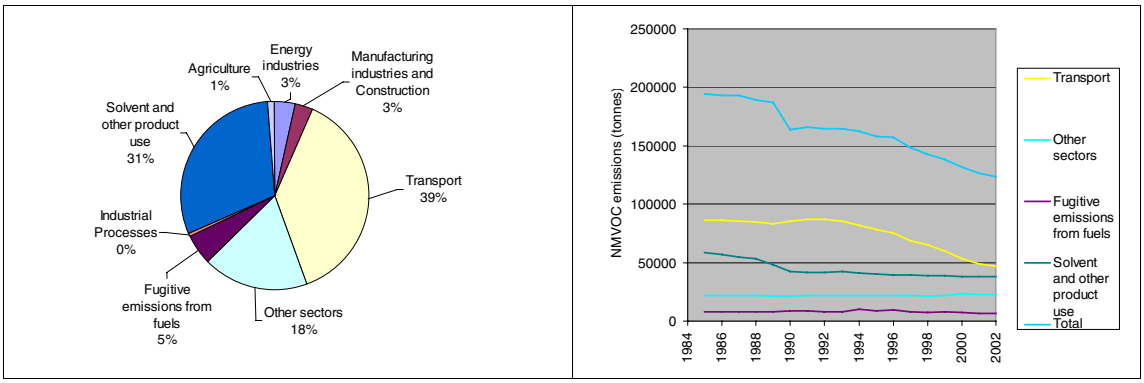

Figure 2.8. NMVOC emissions. Time-series for 1990 to 2002 and distribution on main sectors for 2002.

SO_2

The main part of the SO_2 emissions originate from combustion of fossil fuels, i.e. mainly coal and oil, on public power and district heating plants. From 1980 to 2002 the total emission has decreased by 94%. The large reduction is mainly due installation of desulphurization plants and use of fuels with lower content of sulphur in public power and district heating plants. Despite the large reduction of the SO_2 emissions these plants make up 43% of the total emission. Also emissions from industrial combustion plants, non-industrial combustion plants and other mobile sources are important. National sea traffic (navigation and fishing) contributes with about 11% of the total SO_2 emission. This is due to the use of residual oil with high content of sulphur.

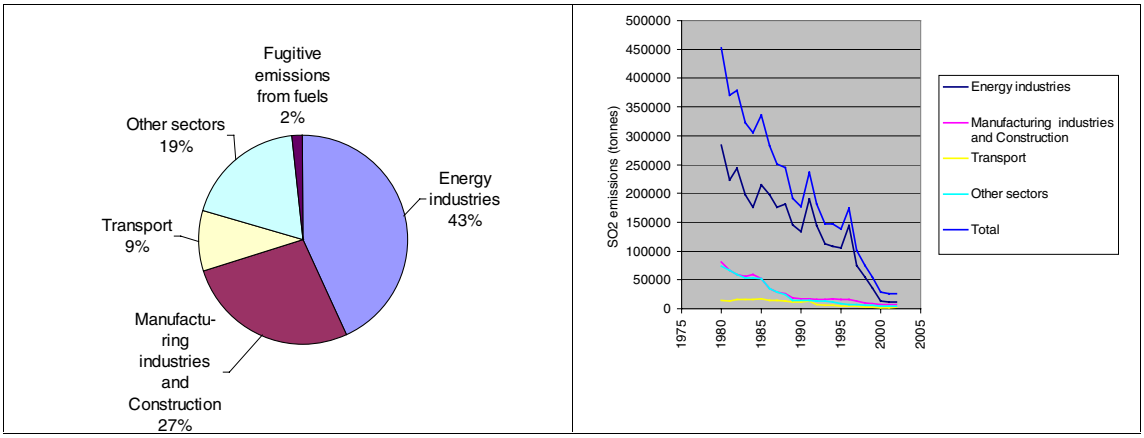

Figure 2.9. SO_2 emissions. Time-series for 1990 to 2002 and distribution on main sectors for 2002.

3 Energy (CRF sector 1)

3.1 Overview of the sector

The energy sector have been reported in four main chapters:

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

Emissions of SO_2, NO_X, NMVOC and CO from container glass production, that are reported in the CRF category 1A2f, is included in the NIR Chapter *4 Industry*. Greenhouse gases connected to fuel combustion in this sector are however included in Chapter 3.2 Stationary Combustion.

Table 3.1 shows detailed source categories for the energy sector and plant category in which the sector is discussed in this report.

Table 3.1 CRF energy sectors and relevant NIR chapters

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

Summary tables for the energy sector are shown below.

Table 3.2 CO_2 emission from the energy sector

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
	(Gg)												
1. Energy	**51.486**	**62.029**	**56.084**	**58.426**	**62.409**	**59.645**	**72.974**	**63.468**	**58.499**	**55.789**	**51.168**	**52.787**	**52.457**
A. Fuel Combustion (Sectoral Approach)	51.246	61.535	55.573	57.981	61.941	59.280	72.574	62.903	58.077	54.887	50.575	52.153	51.922
1. Energy Industries	26.177	35.123	30.096	31.643	35.353	32.058	44.376	35.395	31.471	28.206	25.070	26.377	26.548
2. Manufacturing Industries and Construction	5.383	5.801	5.645	5.575	6.161	6.464	6.650	6.550	5.952	5.981	5.740	5.760	5.557
3. Transport	10.415	10.914	11.045	11.236	11.684	11.823	12.029	12.160	12.191	12.253	12.120	12.149	12.300
4. Other Sectors	9.152	9.410	8.647	9.290	8.492	8.683	9.342	8.626	8.259	8.265	7.535	7.771	7.428
5. Other	119	287	141	237	252	252	176	171	204	182	111	97	89
B. Fugitive Emissions from Fuels	240	495	511	445	468	365	400	565	422	903	593	633	535
1. Solid Fuels	0	0	0	0	0	0	0	0	0	0	0	0	0
2. Oil and Natural Gas	240	495	511	445	468	365	400	565	422	903	593	633	535

Table 3.3 CH_4 emission from the energy sector

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
	(Gg)												
Total Emissions	**258,52**	**263,71**	**265,46**	**271,39**	**278,15**	**282,02**	**287,79**	**280,77**	**279,86**	**274,33**	**272,91**	**275,76**	**268,32**
1. Energy	**13,19**	**15,53**	**15,72**	**17,76**	**25,36**	**32,16**	**37,36**	**37,59**	**35,72**	**35,81**	**34,32**	**36,06**	**35,21**
A. Fuel Combustion (Sectoral Approach)	8,76	9,78	10,20	11,44	16,69	22,63	27,98	27,54	29,22	28,01	27,76	29,07	28,93
1. Energy Industries	1,06	1,43	1,68	2,45	6,27	11,39	14,94	14,36	16,93	15,51	14,94	16,18	16,18
2. Manufacturing Industries and Construction	0,79	0,83	0,82	0,85	0,95	1,09	1,65	1,64	1,22	1,51	1,66	1,73	1,78
3. Transport	2,69	2,97	3,11	3,38	3,55	3,71	3,98	3,82	3,66	3,58	3,43	3,39	3,15
4. Other Sectors	4,21	4,53	4,58	4,76	5,91	6,43	7,40	7,71	7,40	7,39	7,72	7,75	7,82
5. Other	0,01	0,02	0,01	0,01	0,01	0,02	0,01	0,01	0,01	0,01	0,01	0,01	0,00
B. Fugitive Emissions from Fuels	4,43	5,75	5,52	6,32	8,67	9,53	9,38	10,05	6,50	7,80	6,57	7,00	6,28
1. Solid Fuels	3,45	3,97	3,91	4,79	5,61	6,30	6,36	6,53	3,47	3,37	3,04	3,28	2,97
2. Oil and Natural Gas	0,98	1,78	1,61	1,52	3,06	3,23	3,02	3,52	3,03	4,43	3,53	3,72	3,31

Table 3.4 N_2O emission from the energy sector

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
	(Gg)												
Total Emissions	**34,24**	**33,85**	**32,40**	**31,68**	**31,25**	**30,90**	**30,04**	**29,64**	**29,27**	**28,30**	**27,57**	**26,85**	**25,73**
1. Energy	**1,90**	**2,29**	**2,17**	**2,29**	**2,51**	**2,49**	**2,96**	**2,76**	**2,62**	**2,61**	**2,52**	**2,62**	**2,68**
A. Fuel Combustion (Sectoral Approach)	1,90	2,29	2,16	2,28	2,50	2,48	2,95	2,75	2,61	2,60	2,51	2,61	2,67
1. Energy Industries	0,89	1,17	1,01	1,06	1,17	1,06	1,44	1,15	0,99	0,89	0,79	0,84	0,85
2. Manufacturing Industries and Construction	0,17	0,19	0,18	0,18	0,20	0,20	0,21	0,21	0,18	0,19	0,19	0,19	0,20
3. Transport	0,47	0,55	0,61	0,67	0,79	0,87	0,94	1,05	1,12	1,18	1,23	1,27	1,31
4. Other Sectors	0,36	0,37	0,35	0,36	0,33	0,33	0,35	0,33	0,32	0,32	0,31	0,31	0,30
5. Other	0,00	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,00	0,01	0,00
B. Fugitive Emissions from Fuels	0,00	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,02	0,01	0,01	0,01
1. Solid Fuels	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
2. Oil and Natural Gas	0,00	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,02	0,01	0,01	0,01

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

Fuel consumption and emissions from stationary combustion plants in CRF sector 1A1, 1A2 and 1A4 are all included in this chapter. Further details about the inventories for stationary combustion is enclosed in Annex 3A.

3.2.1 Source category description

Emission source categories, fuel consumption data and emission data are presented in this chapter.

3.2.1.1 Emission source categories

In the Danish emission database all activity rates and emissions are defined in SNAP sector categories (Selected Nomenclature for Air Pollution). The data from the Danish database are aggregated to the CRF sector codes based on a correspondence list between SNAP and CRF sectors. The correspondence list is enclosed in Annex 3A. Stationary combustion is defined as combustion activities in the SNAP sectors 01-03.

Stationary combustion plants are included in the emission source subcategories:

- *1A1 Energy, Fuel consumption, Energy Industries*
- *1A2 Energy, Fuel consumption, Manufacturing Industries and Construction*
- *1A4 Energy, Fuel consumption, Other Sectors*

The emission sources *1A2* and *1A4* however also include emission from transport subsectors. The emission source *1A2* includes emission from some off road machinery in the industry. The emis-

sion source *1A4* includes off road machinery in agriculture, forestry and household/gardening. Further emissions from national fishing are included in subsector *1A4*.

Emission and fuel consumption data shown in tables and figures in Chapter 3.2 only includes emissions originating from stationary combustion plants of a given CRF sector. The CRF sector codes have been applied unchanged, but some source category names have been changed to reflect the stationary combustion part of the source.

3.2.1.2 Fuel consumption

In 2002 the total fuel consumption for stationary combustion plants was 568 PJ of which 490 PJ was fossil fuels.

Fuel consumptions of the stationary combustion subsectors are shown in Figure 3.1 and Figure 3.2. The main part, i.e. 59%, of the fuels is combusted in the sector *Electricity and heat production.* Other sectors with high fuel consumption are *Residential* and *Industry*.

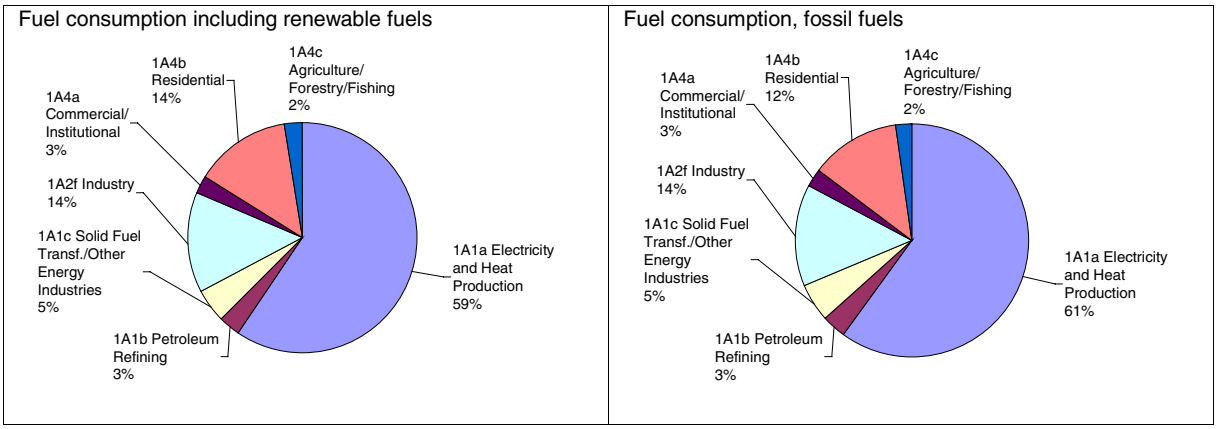

Figure 3.1 Fuel consumption rate of stationary combustion, 2002 (based on DEA 2003a)

Coal and natural gas are the most utilised fuels for stationary combustion plants. Coal is mainly used in power plants and natural gas is used in power plants and decentralised CHP plants as well as in industry, district heating and households.

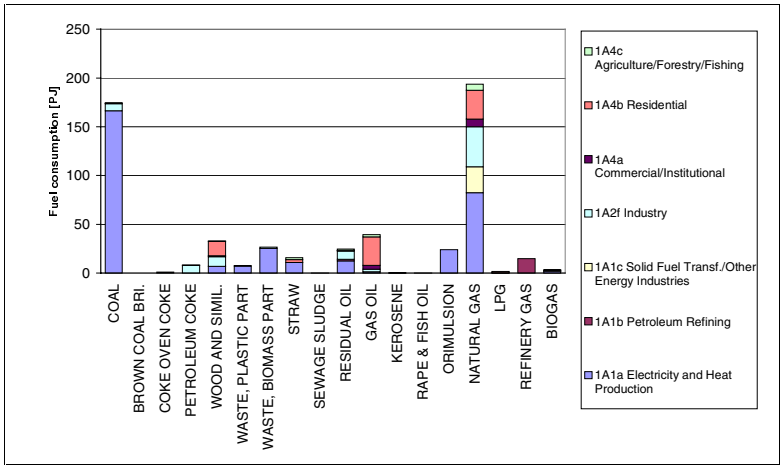

Figure 3.2 Fuel consumption of stationary combustion plants 2002 (based on DEA 2003a)

Fuel consumption time-series for stationary combustion plants are shown in Figure 3.3. The total fuel consumption has increased by 14% from 1990 to 2002, while the fossil fuel consumption has only increased by 8%. The consumption of natural gas and renewable fuels has increased since 1990 whereas coal consumption has decreased.

The fuel consumption rate fluctuates considerably mainly due to electricity import/export but also due to outdoor temperature variations. The fuel consumption fluctuation is further discussed in Chapter 3.2.1.3.

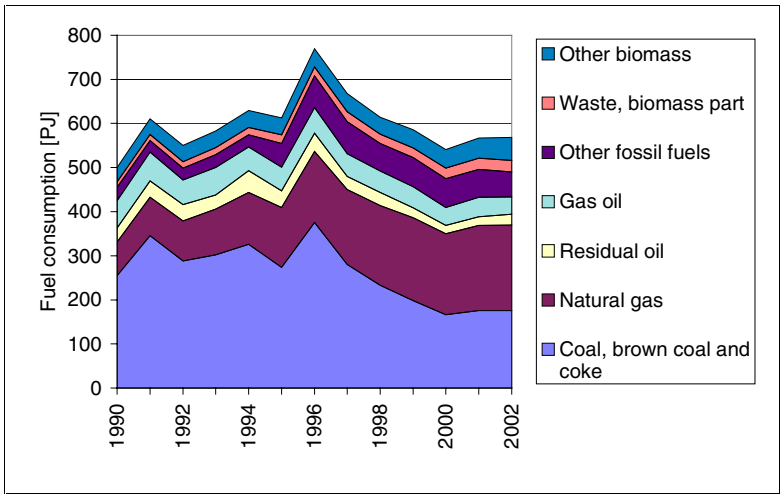

Figure 3.3 Fuel consumption time-series, stationary combustion (based on DEA 2003a)

3.2.1.3 Emissions

The GHG emissions from stationary combustion are shown in Table 3.5.

The CO_2 emission from stationary combustion plants accounts for 68% of the total Danish CO_2 emission (gross). CH_4 accounts for 9% of the total Danish CH_4 emission and N_2O for only 5% of the total Danish N_2O emission.

Table 3.5 Greenhouse gas emission for the year 2002

	CO_2	CH_4	N_2O
	Gg CO_2 equivalent		
1A1 Fuel consumption, Energy industries	26548	340	264
1A2 Fuel consumption, Manufacturing Industries and Construction[1)]	4815	34	53
1A4 Fuel consumption, Other sectors [1)]	5510	159	66
Total emission from stationary combustion plants	**36873**	**533**	**383**
Total Danish emission (gross)	54164	5635	7976
		%	
Emission share for stationary combustion	68	9	5

1) Only stationary combustion sources of the sector is included

CO_2 is the most important GHG pollutant accounting for 97,6% of the GHG emission (given in CO_2 equivalents).

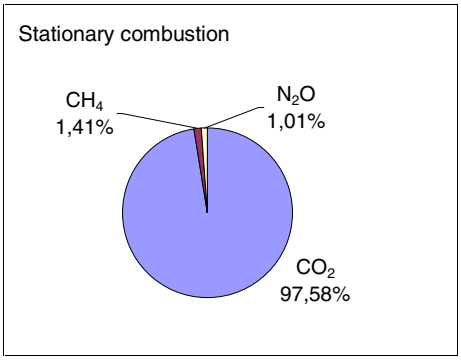

Figure 3.4 GHG emission (CO_2 equivalent) from stationary combustion plants

Figure 3.5 shows the time-series for GHG emission (given in CO_2 equivalents) from stationary combustion. It appears that the GHG emission development follows the CO_2 emission development very close. Both the CO_2 and the total GHG emission have decreased a little from 1990 to 2002, CO_2 by 2,3% and GHG by 1,3%. However fluctuations of the GHG emission level are considerable.

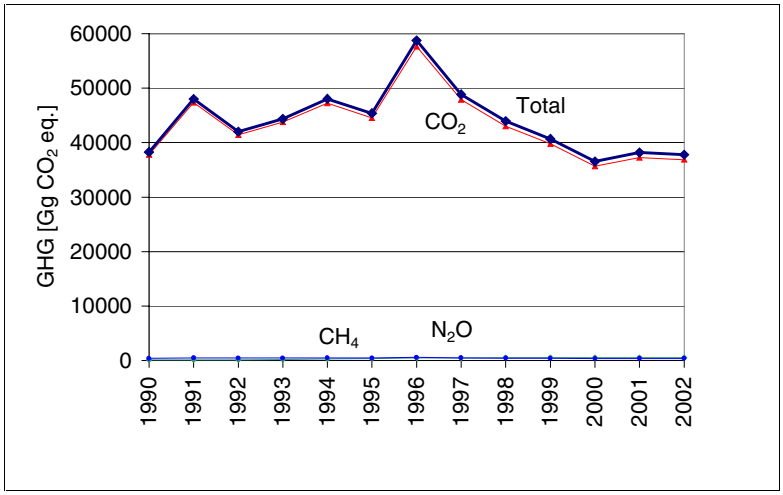

Figure 3.5 GHG emission time-series for stationary combustion

The fluctuations in the time-series are a result mainly of electricity import/export but also of outdoor temperature variations between years. These fluctuations are shown in Figure 3.6. In 1990 the Danish electricity import was large causing relatively low emissions, whereas the emissions are high in 1996 due to a large electricity export. In 2002 the net electricity export was 7453 TJ.

To be able to follow the national energy consumption and for statistical and reporting purposes the Danish Energy Authority produces a correction of the actual emissions without random variations in electricity imports/exports and in ambient temperature. This emission trend, which is smoothly decreasing, is also shown in Figure 3.6. The corrections are included here to explain the fluctuations in the emission time-series. The GHG emission corrected for electricity import/export and ambient temperature has decreased by 20% since 1990, the CO_2 emission by 21%.

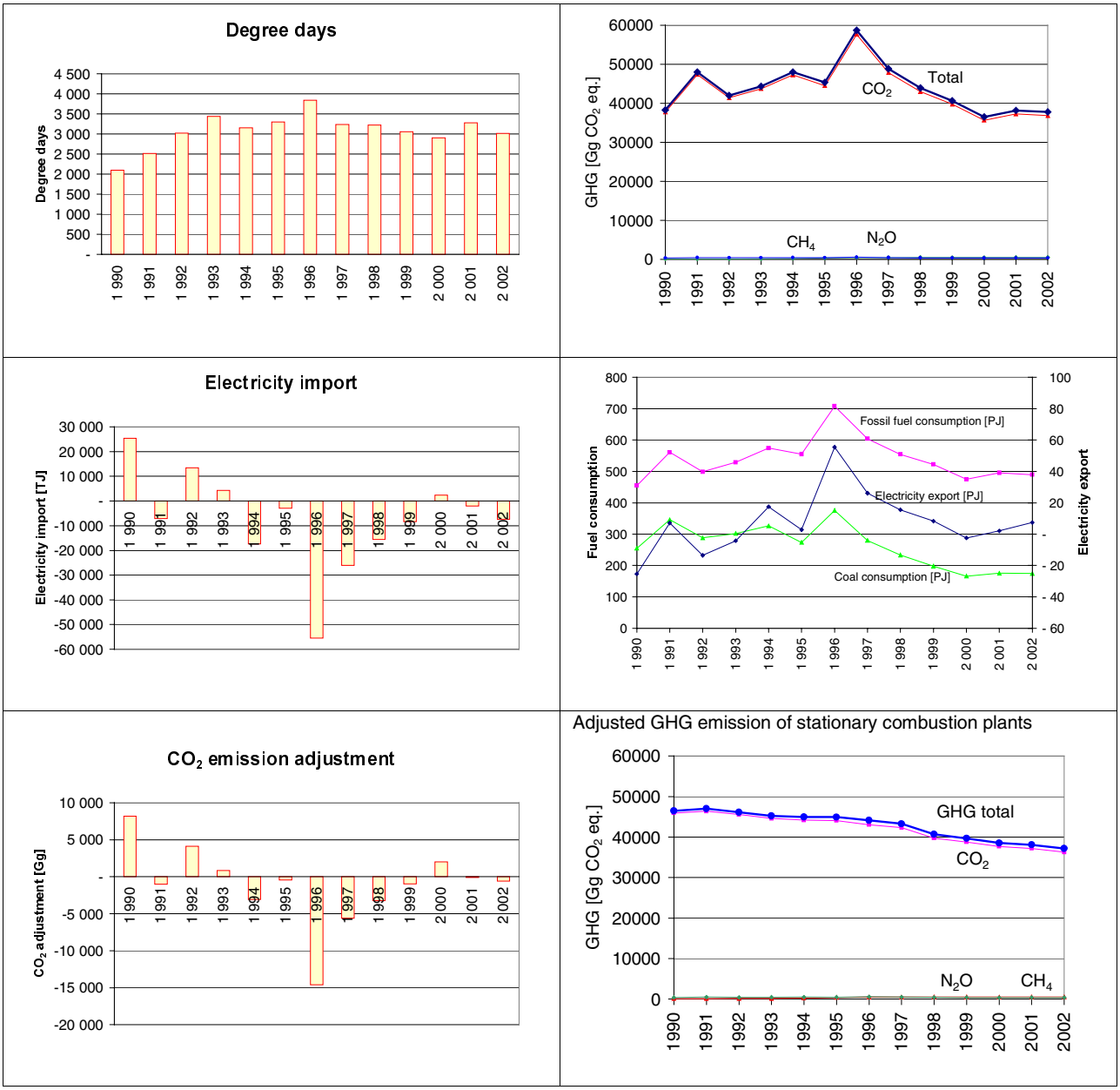

Figure 3.6 GHG emission time-series for stationary combustion and adjustment for electricity import/export and temperature variations (DEA 2003b)

3.2.1.3.1 CO_2

The CO_2 emission from stationary combustion plants is one of the most important GHG emission sources and accounts for 68% of the total Danish CO_2 emission. Table 3.6 shows the CO_2 emission inventory for stationary combustion plants for 2002. Figure 3.7 shows that *Electricity and heat production* accounts for 65% of the CO_2 emission from stationary combustion. This share is somewhat higher than the fossil fuel consumption share of this sector, which is 61% (Figure 3.1). Other large CO_2 emission sources are industrial plants and residential plants. These are the sectors that also account for a considerable share of the fuel consumption.

Table 3.6 CO_2 emission from stationary combustion plants 2002[1)]

CO_2	2002	
1A1a Electricity and heat production	24083	Gg
1A1b Petroleum refining	948	Gg
1A1c Solid fuel transf. and other energy industries	1517	Gg
1A2f Industry	4815	Gg
1A4a Commercial / Institutional	800	Gg
1A4b Residential	3979	Gg
1A4c Agriculture / Forestry / Fishing	731	Gg
Total	**36873**	**Gg**

1) Only emission from stationary combustion plants included

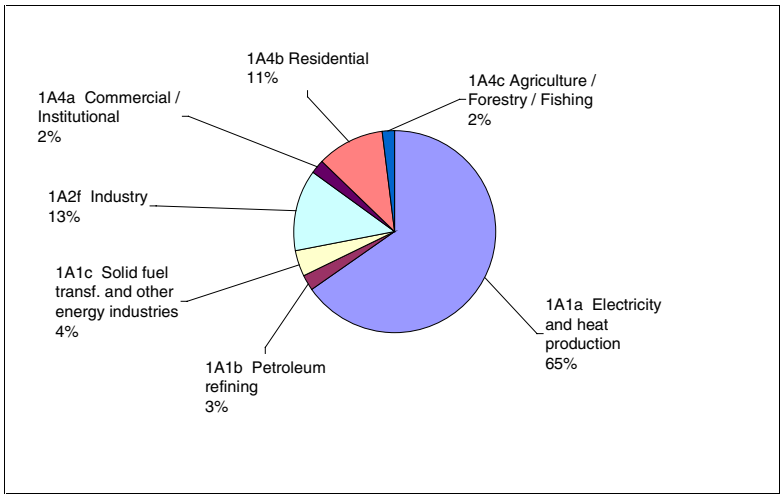

Figure 3.7 CO_2 emission sources, stationary combustion plants, 2002

The sector *Electricity and heat production* consists of the SNAP sectors: *Public power* and *District heating*. The CO_2 emissions from each of these subsectors are shown in Table 3.7. The most important subsector is centralised power plants.

Table 3.7 CO_2 emission from subsectors to *1A1a Electricity and heat production*

SNAP source	SNAP name	2002	
0101	Public power	0	Gg
010101	Combustion plants ≥ 300MW (boilers)	18823	Gg
010102	Combustion plants ≥ 50MW and < 300 MW (boilers)	971	Gg
010103	Combustion plants <50 MW (boilers)	172	Gg
010104	Gas turbines	2247	Gg
010105	Stationary engines	1608	Gg
0102	District heating plants	-	Gg
010201	Combustion plants ≥ 300MW (boilers)	-	Gg
010202	Combustion plants ≥ 50MW and < 300 MW (boilers)	39	Gg
010203	Combustion plants <50 MW (boilers)	223	Gg
010204	Gas turbines	-	Gg
010205	Stationary engines	0	Gg

CO_2 emission from combustion of biomass fuels is not included in the total CO_2 emission data because biomass fuels are considered CO_2-neutral. The CO_2 emission from biomass combustion is reported as a memo item in CRF. In 2002 the CO_2 emission from biomass combustion was 8454 Gg.

Time-series for CO_2 emission are shown in Figure 3.8. Despite an increase in fuel consumption of 14% since 1990 CO_2 emission from stationary combustion has decreased by 2,3% because of the change of fuel type used.

The fluctuations of CO_2 emission are discussed in Chapter 3.2.1.3.

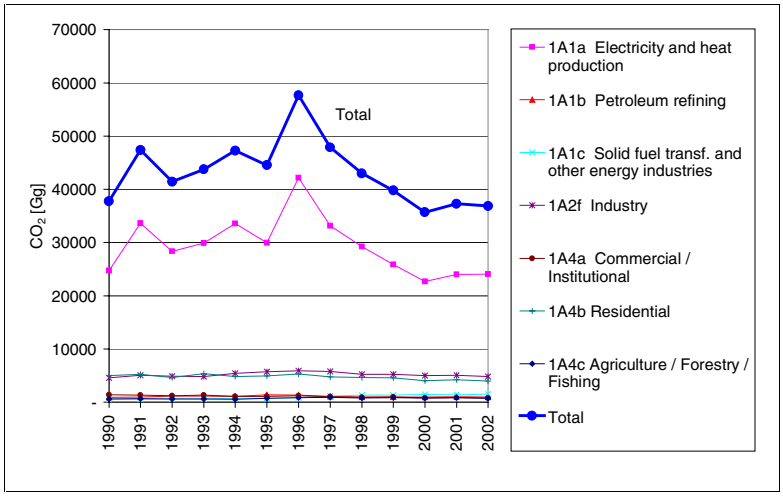

Figure 3.8 CO_2 emission time-series for stationary combustion plants

3.2.1.3.2 CH_4

The CH_4 emission from stationary combustion plants accounts for 9% of the total Danish CH_4 emission. Table 3.8 shows the CH_4 emission inventory for stationary combustion plants in 2002. Figure 3.9 shows that *Electricity and heat production* accounts for 63% of the CH_4 emission from stationary combustion and this is close to the fuel consumption share.

Table 3.8 CH_4 emission from stationary combustion plants 2002 [1)]

CH_4	2002	
1A1a Electricity and heat production	16005	Mg
1A1b Petroleum refining	2	Mg
1A1c Solid fuel transf. and other energy industries	177	Mg
1A2f Industry	1635	Mg
1A4a Commercial / Institutional	974	Mg
1A4b Residential	4479	Mg
1A4c Agriculture / Forestry / Fishing	2112	Mg
Total	25384	Mg

1) Only emission from stationary combustion plants included

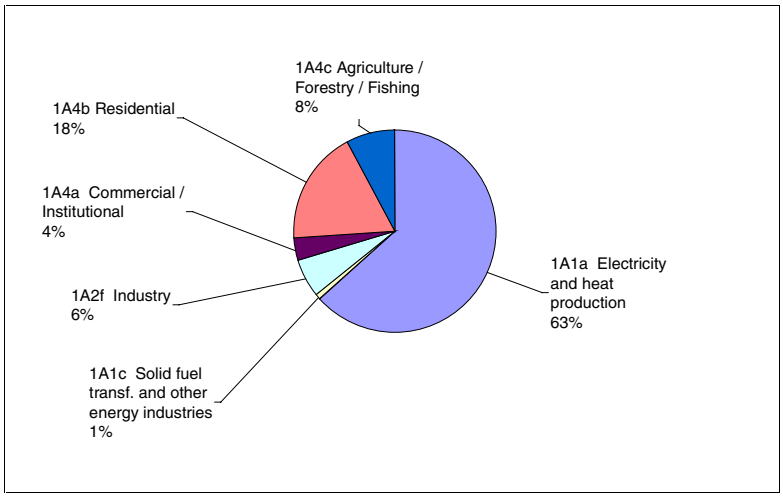

Figure 3.9 CH_4 emission sources, stationary combustion plants, 2002

The CH_4 emission factor for reciprocating lean-burn gas engines is much higher than for other combustion plants due to the continuous ignition/burn out of the gas (see Chapter 3.2.2.4.2). A considerable number of lean-burn gas engines are in operation in Denmark and these plants accounts for 75% of the CH_4 emission from stationary combustion plants (Figure 3.10). The engines are installed in CHP plants and the fuel used is either natural gas or biogas.

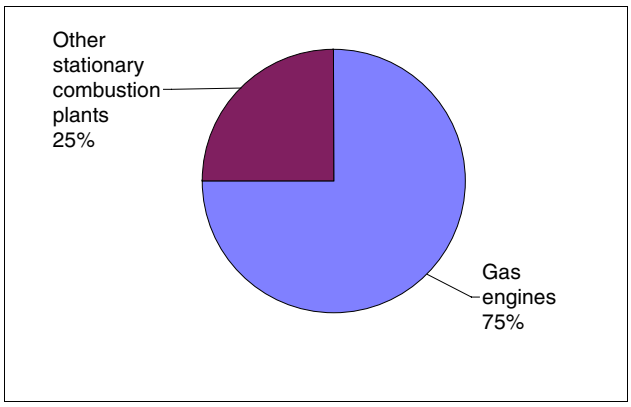

Figure 3.10 Gas engine CH_4 emission share, 2002

The CH_4 emission from stationary combustion increased by a factor 4,5 since 1990 (Figure 3.11). This is a result of the considerable number of lean-burn gas engines that was installed in decentralised CHP plants in Denmark in this period. This increase is also the reason for the increasing IEF (implied emission factor) for gaseous fuels and biomass in CRF sector *1A1*, *1A2* and *1A4*. Figure 3.12 shows time-series for the fuel consumption rate in gas engines and the corresponding increase of CH_4 emission.

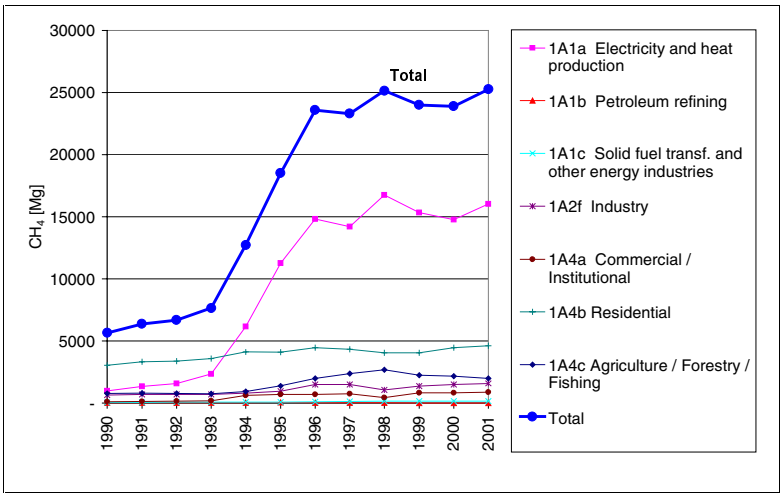

Figure 3.11 CH_4 emission time-series for stationary combustion plants

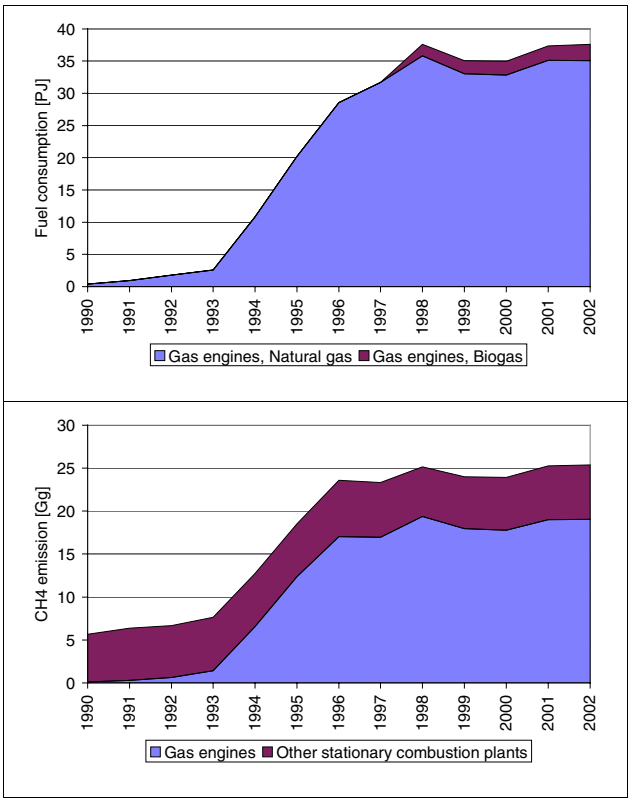

Figure 3.12 Fuel consumption and CH_4 emission from gas engines, time-series

3.2.1.3.3 N_2O

The N_2O emission from stationary combustion plants accounts for 5% of the total Danish N_2O emission. Table 3.9 shows the N_2O emission inventory for stationary combustion plants in 2002. Figure 3.13 shows that *Electricity and heat production* accounts for 64% of the N_2O emission from stationary combustion. This is only a little higher than the fuel consumption share.

Table 3.9 N_2O emission from stationary combustion plants 2002 [1)]

N_2O	2002	
1A1a Electricity and heat production	793	Mg
1A1b Petroleum refining	32	Mg
1A1c Solid fuel transf. and other energy industries	27	Mg
1A2f Industry	170	Mg
1A4a Commercial / Institutional	23	Mg
1A4b Residential	163	Mg
1A4c Agriculture / Forestry / Fishing	26	Mg
Total	1234	Mg

1) Only emission from stationary combustion plants included

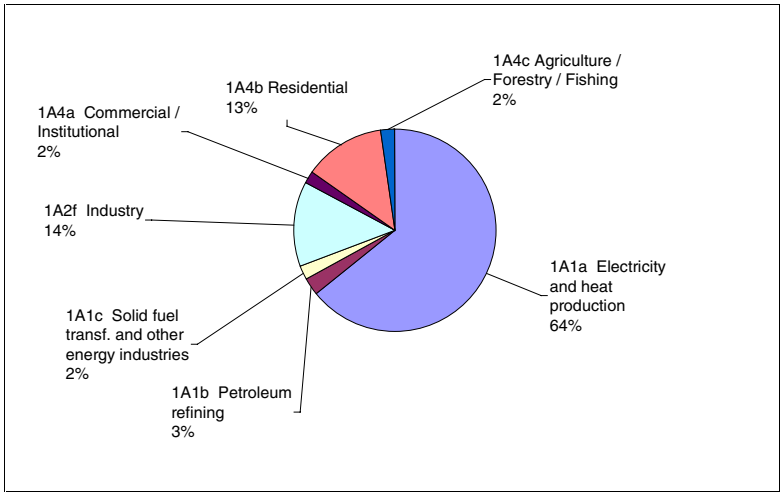

Figure 3.13 N_2O emission sources, stationary combustion plants, 2002

Figure 3.14 shows time-series for N_2O emission. The N_2O emission from stationary combustion decreased 3,6% from 1990 to 2002, but again fluctuations of emission level due to electricity import/export are considerable.

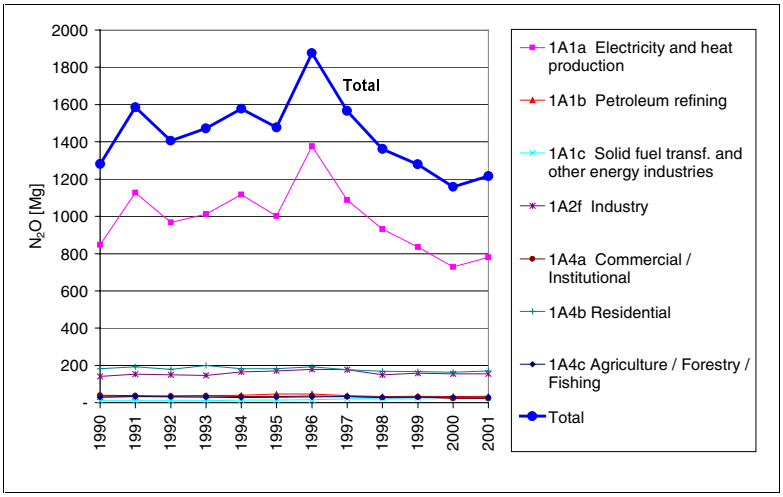

Figure 3.14 N_2O emission time-series for stationary combustion plants

3.2.1.3.4 SO_2, NO_X, NMVOC and CO

The emissions of SO_2, NO_X, NMVOC and CO from Danish stationary combustion plants 2002 are shown in Table 3.10. Further details are shown in Annex 3A.

SO_2 from stationary combustion plants accounts for 83% of the total Danish emission. NO_X, CO and NMVOC account for 37%, 29% and 15% of the total Danish emissions respectively.

Table 3.10 SO_2, NO_X, NMVOC and CO emission from stationary combustion plants 2002

Pollutant	NO_x Gg	CO Gg	NMVOC Gg	SO_2 Gg
1A1 Fuel consumption, Energy industries	53,1	12,5	4,3	10,9
1A2 Fuel consumption, Manufacturing Industries and Construction (Stationary combustion)	14,4	5,2	0,9	6,6
1A4 Fuel consumption, Other sectors (Stationary combustion)	7,4	149,4	13,4	3,6
Total emission from stationary combustion plants	**74,9**	**167,2**	**18,6**	**21,1**
Total Danish emission (gross)	200	577	124	25
		%		
Emission share for stationary combustion	37,4	29,0	15,0	83,3

3.2.2 Methodological issues

The Danish emission inventory is based on the CORINAIR (CORe INventory on AIR emissions) system, which is a European program for air emission inventories. CORINAIR includes methodology structure and software for inventories. The methodology is described in the EMEP/CORINAIR Emission Inventory Guidebook 3rd edition, prepared by the UNECE/EMEP Task Force on Emissions Inventories and Projections (EMEP/CORINAIR 2002). Emission data are stored in an Access database, from which data are transferred to the reporting format.

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

3.2.2.1 Large point sources

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

In the inventory for the year 2002 63 stationary combustion plants are specified as large point sources in the Danish emission database. These point sources include:

- Power plants and decentralised CHP plants (Combined Heat and Power plants)
- Municipal waste incineration plants
- A few large industrial combustion plants
- Petroleum refining plants

The fuel consumption of stationary combustion plants registered as large point sources is 326 PJ (2002). This corresponds to 57% of the overall fuel consumption of stationary combustion.

Further details about the large point sources are shown in Annex 3A. The number of large point sources registered in the databases increased from 1990 to 2002.

If plant specific emission factors are not available, the general area source emission factor is used. Emissions of the greenhouse gases (CO_2, CH_4 and N_2O) from stationary combustion plants, defined as large point sources are all based on the area source emission factors.

Plant specific emission data for other pollutants are obtained from:

- Annual environmental reports
- Annual plant specific reporting of SO_2 and NO_X from power plants >25MW_e prepared for the Danish Energy Authority due to Danish legislation
- Emission data reported by Elsam and E2, the two major electricity suppliers
- Emission data reported from industrial plants

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

3.2.2.2 Area sources

Fuels not combusted in large point sources are included as sector specific area sources in the emission database. Plants like residential boilers, small district heating plants, small CHP plants and some industrial boilers are defined as area sources. Emissions from area sources are based on fuel consumption data and emission factors. Further information about emission factors is given below.

3.2.2.3 Activity rates, fuel consumption

The fuel consumption rates are based on the official Danish energy statistics prepared by the Danish Energy Authority. The Danish Energy Authority aggregates fuel consumption rates to SNAP sector categories (DEA 2003a). Some fuel types in the official Danish energy statistics are added to obtain a less detailed fuel aggregation level, cf. Annex 3A. The calorific values on which the energy statistics are based are also enclosed in the annex.

The fuel consumption of the CRF sector *1A2 Manufacturing industries and construction* (corresponding to SNAP sector *03 Combustion in manufacturing industries)* have not yet been disaggregated to specific industries. In CRF the emissions are included in sector *1A2f Industry, Other* because technically it is not possible to report the emission in the aggregated source category *1A2 Manufacturing industries and construction*. However NERI and the Danish Energy Authority have initiated the work that should ensure that fuel consumption rates of each industrial subsector will be reported next year.

Both traded and not traded fuels are included in the Danish energy statistics. Thus, e.g., an estimation of the annual consumption of non-traded wood is included.

Petroleum coke bought abroad and combusted in Danish residential plants (border trade of 251 TJ) are added to the apparent consumption of petroleum coke and the emissions are included in the inventory.

The Danish Energy Authority compile a database for the fuel consumption of each district heating or power producing plant based on data reported by the plant owners. The fuel consumption of large point sources specified in the Danish emission databases refers to this annually updated database (DEA 2003c).

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

Emissions from non-energy use of fuels have not been included in the Danish inventory yet, but it is however included in the CRF reference approach. The Danish energy statistics include three fuels used for non-energy purposes: Bitumen, white spirit and lube oil.

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

Fuel consumption data are presented in Chapter 3.2.1.2.

3.2.2.4 Emission factors

For each fuel and SNAP (sector and e.g. type of plant) a set of general area source emission factors has been determined. The emission factors are either national referenced or based on the international guidebooks: EMEP/CORINAIR Guidebook (EMEP/CORINAIR 2002) and IPCC Reference Manual (IPCC 1996).

A complete list of emission factors including time-series and references is shown in Annex 3A.

CO_2

The CO_2 emission factors applied for 2002 are shown in Table 3.11. The emission factors and reference of each factor is further discussed in Annex 3A.

Time-series have been estimated for municipal waste and for natural gas. For all other fuels the same emission factor is applied for 1990-2002.

In CRF the CO_2 emission is aggregated to five fuel types: Solid fuel, Liquid fuel, Gas, Biomass and Other fuels. The correspondence list between the NERI fuel categories and the CRF fuel categories is also shown in Table 3.11.

The CO_2 emission factors have been confirmed by the two major power plant owners, both directly (Christiansen 1996 and Andersen 1996) and indirectly. The latter by applying the NERI emission factors in the annual environmental reports for the large power plants and accepting the use of the NERI emission factors in Danish legislation.

Danish legislation concerning CO_2 emission from power plants (Lov nr. 376 1999) has been based on standard CO_2 emission factors for each fuel. Thus power plant owners have not been encouraged to estimate CO_2 emission factors based on their own fuel analysis. In future legislation (Lov om CO_2-kvoter, høringsudgave 2004) owners of large power plants are obliged to verify the applied emission factors. As such improved emission factors will be available for the national emission inventories in the future.

The CO_2 emission from incineration of municipal waste (94,5 + 17,6 kg/GJ) is split in two parts: The emission from combustion of the plastic content of the waste which is included in the national total and the emission from combustion of the rest of the waste, i.e. the biomass part that is reported as a memo item. In CRF the CO_2 emission from combustion of the plastic part of the waste is reported in the fuel category *Other fuels*. However this split is applied for neither fuel consumption nor other emissions, because it is only relevant for CO_2. Thus the full consumption of municipal waste is included in fuel category *Biomass* and the full amount of non-CO_2 emissions from municipal waste combustion is included in the fuel category *Biomass*.

Table 3.11 CO_2 emission factors 2002

Fuel	Emission factor		Unit	Reference type	CRF fuel
	Biomass	Fossil fuel			
Coal		95	kg/GJ	Country specific	Solid
Brown coal briquettes		94,6	kg/GJ	IPCC reference manual	Solid
Coke oven coke		108	kg/GJ	IPCC reference manual	Solid
Petroleum coke		92	kg/GJ	Country specific	Liquid
Wood	102		kg/GJ	CORINAIR	Biomass
Municipal waste	94,5	17,6	kg/GJ	Country specific	Biomass / Other fuels
Straw	102		kg/GJ	Country specific	Biomass
Residual oil		78	kg/GJ	CORINAIR	Liquid
Gas oil		74	kg/GJ	CORINAIR	Liquid
Kerosene		72	kg/GJ	CORINAIR	Liquid
Fish & rape oil	102		kg/GJ	CORINAIR	Biomass
Orimulsion		80	kg/GJ	Country specific	Liquid
Natural gas		57,28	kg/GJ	Country specific	Gas
LPG		65	kg/GJ	CORINAIR	Liquid
Refinery gas		56,9	kg/GJ	Country specific	Liquid
Biogas	83,6		kg/GJ	Country specific	Biomass

CH_4

The CH_4 emission factors applied for 2002 is shown in Table 3.12. In general the same emission factors have been applied for 1990-2002. However for gas engines a time-serie have been estimated.

Emission factors for gas engines, gas turbines and CHP plants combusting wood, straw or municipal waste all refer to emission measurements carried out on Danish plants (Nielsen & Illerup 2003). Other emission factors refer to the EMEP/CORINAIR Guidebook (EMEP/CORINAIR 2002).

Gas engines combusting natural gas or biogas contribute much more to the total CH_4 emission than other stationary combustion plants. The relatively high emission factor for gas engines is well documented based on a very high number of emission measurements on Danish plants. The factor is further discussed in Annex 3A. Due to the considerable consumption of natural gas and biogas in gas engines the IEF (Implied Emission Factor) in CRF sector *1A1*, *1A2* and *1A4*, fuel categories *Gaseous fuels* and *Biomass* is relatively high. The considerable change in IEF is a result of the increasing consumption of natural gas and biogas in gas engines as discussed in Chapter 3.2.1.2.

Table 3.12 CH_4 emission factors 1990-2002

Fuel	ipcc_id	snap_id	Emission factor [g/GJ]	Reference
COAL	1A1a	010101, 010102, 010103	1,5	EMEP/ CORINAIR 2003
COAL	1A1a, 1A2f, 1A4b, 1A4c	010202, 010203, 0301, 0202, 0203	15	EMEP/ CORINAIR 2003
BROWN COAL BRI.	all	all	15	EMEP/ CORINAIR 2003, assuming same emission factor as for coal
COKE OVEN COKE	all	all	15	EMEP/ CORINAIR 2003, assuming same emission factor as for coal
PETROLEUM COKE	all	all	15	EMEP/ CORINAIR 2003
WOOD AND SIMIL.	1A1a	010102, 010103, 010104	2	Nielsen & Illerup 2003
WOOD AND SIMIL.	1A1a, 1A2f, 1A4a, 1A4b, 1A4c	all other	32	EMEP/ CORINAIR 2003
MUNICIP. WASTES	1A1a	010102, 010103, 010104, 010105	0,59	Nielsen & Illerup 2003
MUNICIP. WASTES	1A1a, 1A2f, 1A4a	all other	6	EMEP/ CORINAIR 2003
STRAW	1A1a	010102, 010103	0,5	Nielsen & Illerup 2003
STRAW	1A1a, 1A2f	010202, 010203, 030102, 030105	32	EMEP/ CORINAIR 2003
STRAW	1A4a, 1A4b, 1A4c	0201, 0202, 0203, 020302	200	EMEP/ CORINAIR 2003
RESIDUAL OIL	all	all	3	EMEP/ CORINAIR r 2003
GAS OIL	all	all	1,5	EMEP/ CORINAIR 2003
KEROSENE	all	all	7	EMEP/ CORINAIR 2003
FISH & RAPE OIL	1A1a	010203	32	EMEP/ CORINAIR 2003, assuming same emission factor as straw
FISH & RAPE OIL	1A2f	030105	32	EMEP/ CORINAIR 2003, assuming same emission factor as straw
FISH & RAPE OIL	1A4c	020304	200	EMEP/ CORINAIR 2003, assuming same emission factor as straw
ORIMULSION	1A1a	010101	3	EMEP/ CORINAIR 2003, assuming same emission factor as residual oil
NATURAL GAS	1A1a	0101, 010101, 010102, 010202	6	DGC 2001
NATURAL GAS	1A1a	010103, 010203	15	Gruijthuijsen & Jensen 2000
NATURAL GAS	1A1a, 1Ab, 1Ac, 1A2f, 1A4a, 1A4c	Gas turbines: 010104, 010304, 010504, 030104, 020104, 020303	1,5	Nielsen & Illerup 2003
NATURAL GAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4b, 1A4c	Gas engines: 010105, 010405, 010505, 030105, 020105, 020204, 020304	520	Nielsen & Illerup 2003
NATURAL GAS	1A1c, 1A2f, 1A4a, 1A4b, 1A4c	010502, 0301, 0201, 0202, 0203	6	DGC 2001
NATURAL GAS	1A2f, 1A4a, 1A4b	030103, 030106, 020103, 020202	15	Gruijthuijsen & Jensen 2000
LPG	all	all	1	EMEP/ CORINAIR 2003
REFINERY GAS	1A1b	010303, 010304	2	EMEP/ CORINAIR 2003
BIOGAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4c	Gas engines: 010105, 010405, 010505, 030105, 020105, 020304	323	Nielsen & Illerup 2003
BIOGAS	1A1a, 1A2f, 1A4a, 1A4c	all other	4	EMEP/ CORINAIR 2003

N_2O

The N_2O emission factors applied for the 2002 inventory is shown in Table 3.13. The same emission factors have been applied for 1990-2002.

Emission factors for gas engines, gas turbines and CHP plants combusting wood, straw or municipal waste all refer to emission measurements carried out on Danish plants (Nielsen & Illerup 2003). Other emission factors refer to the EMEP/CORINAIR Guidebook (EMEP/CORINAIR 2002).

Table 3.13 N_2O emission factors 1990-2002

Fuel	ipcc_id	snap_id	Emission factor [g/GJ]	Reference
COAL	all	all	3	EMEP/Corinair 2003
BROWN COAL BRI.	all	all	3	EMEP/Corinair 2003
COKE OVEN COKE	all	all	3	EMEP/Corinair 2003
PETROLEUM COKE	all	all	3	EMEP/Corinair 2003
WOOD AND SIMIL.	1A1a	010102, 010103, 010104	0,8	Nielsen & Illerup 2003
WOOD AND SIMIL.	1A1a	010105, 010202, 010203, 010205	4	EMEP/Corinair 2003
WOOD AND SIMIL.	1A2f, 1A4a, 1A4b, 1A4c	all	4	EMEP/Corinair 2003
MUNICIP. WASTES	1A1a	010102, 010103, 010104, 010105	1,2	Nielsen & Illerup 2003
MUNICIP. WASTES	1A1a	010203	4	EMEP/Corinair 2003
MUNICIP. WASTES	1A2f, 1A4a	030102, 0201, 020103	4	EMEP/Corinair 2003
STRAW	1A1a	010102, 010103	1,4	Nielsen & Illerup 2003
STRAW	1A1a	010202, 010203	4	EMEP/Corinair 2003
STRAW	1A2f, 1A4a, 1A4b, 1A4c	all	4	EMEP/Corinair 2003
RESIDUAL OIL	all	all	2	EMEP/Corinair 2003
GAS OIL	all	all	2	EMEP/Corinair 2003
KEROSENE	all	all	2	EMEP/Corinair 2003
FISH & RAPE OIL	all	all	4	EMEP/Corinair 2003, assuming same emission factor as municipal waste
ORIMULSION	1A1a	010101	2	EMEP/Corinair 2003, assuming same emission factor as residual oil
NATURAL GAS	1A1a	0101, 010101, 010102, 010103, 010202, 010203	1	EMEP/Corinair 2003
NATURAL GAS	1A1a, 1Ab, 1Ac, 1A2f, 1A4a, 1A4c	Gas turbines: 010104, 010304, 010504, 030104, 020104, 020303	2,2	Nielsen & Illerup 2003
NATURAL GAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4b, 1A4c	Gas engines: 010105, 010405, 010505, 030105, 020105, 020204, 020304	1,3	Nielsen & Illerup 2003
NATURAL GAS	1A1c, 1A2f, 1A4a, 1A4b, 1A4c	010502, 0301, 030103, 030106, 0201, 020103, 0202, 020202, 0203	1	EMEP/Corinair 2003
LPG	all	all	2	EMEP/Corinair 2003
REFINERY GAS	all	all	2	EMEP/Corinair 2003
BIOGAS	1A1a	010102, 010103, 010203	2	EMEP/Corinair 2003
BIOGAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4c	010105, 010405, 010505, 030105, 020105, 020304	0,5	Nielsen & Illerup 2003
BIOGAS	1A2f, 1A4a, 1A4c	0301, 030102, 0201, 020103, 0203	2	EMEP/Corinair 2003

SO_2, NO_X, NMVOC and CO

Emission factors 2002 for SO_2, NO_X, NMVOC and CO including time-series and references is shown in Annex 3A. Most country specific emission factors refers to:

- Danish legislation
- A emission measurement program for decentralised CHP plants
- Other Danish research reports
- Calculations based on plant specific emissions from a considerable number of power plants
- Calculations based on plant specific emissions from a considerable number of municipal waste incineration plants

SO_2 and NO_X emissions from large point sources are often plant specific based on emission measurements. Emissions of CO and NMVOC are also plant specific for some plants.

Some of the area source emission factors for power plants and municipal waste CHP plants take into account, that the large plants are included in the inventory as large point sources with plant specific emission data. Thus some area source emission factors are default values assuming that the remaining fuel consumption is combusted in smaller units with less effective flue gas cleaning. The area source emission factors are therefore not necessarily average values for these plant categories.

3.2.3 Uncertainties and time-series consistency

Time-series for fuel consumption and emission are shown and discussed in Chapters 3.2.1.2 and 3.2.1.3.

Uncertainty estimates include uncertainty of the total emission inventory as well as uncertainty of the trend. The GHG emission from stationary combustion plants was estimated with an uncertainty of ±10% and the decrease of the GHG emission was estimated to be 1,3% ± 1,8 %-age points since 1990.

3.2.3.1 Methodology

Greenhouse gases

The Danish uncertainty estimates for GHGs is based on the Tier 1 approach in IPCC Good Practice Guidance (IPCC 2000). The uncertainty have been estimated for the following emission source subcategories to stationary combustion:

- CO_2 emission from each of the applied fuel categories [2]
- CH_4 emission from gas engines
- CH_4 emission from all other stationary combustion plants
- N_2O emission from all stationary combustion plants

The separate uncertainty estimation for gas engine CH_4 emission and CH_4 emission from other plants does not follow the recommendations in the IPCC Good Practice Guidance. The disaggregation is applied because the CH_4 emission from gas engines in Denmark is much larger than the emission from other stationary combustion plants. Furthermore the CH_4 emission factor for gas engines is known with a much smaller uncertainty than the factor for other stationary combustion plants.

Most of the applied uncertainties for activity rates and emission factors are default values from the IPCC Reference Manual. A few of the uncertainty estimates are however based on national estimates.

[2] Brown coal and coke is included in the fuel category coal

Table 3.14 Uncertainty rates for activity rates and emission factors

IPCC Source category	Gas	Activity data uncertainty %	Emission factor uncertainty %
Stationary Combustion, Coal	CO_2	1 [1)]	5 [3)]
Stationary Combustion, Petroleum coke	CO_2	3 [1)]	5 [1)]
Stationary Combustion, Plastic waste	CO_2	5 [4)]	5 [4)]
Stationary Combustion, Residual oil	CO_2	2 [1)]	2 [3)]
Stationary Combustion, Gas oil	CO_2	4 [1)]	5 [1)]
Stationary Combustion, Kerosene	CO_2	4 [1)]	5 [1)]
Stationary Combustion, Orimulsion	CO_2	1 [1)]	2 [3)]
Stationary Combustion, Natural gas	CO_2	3 [1)]	1 [3)]
Stationary Combustion, LPG	CO_2	4 [1)]	5 [1)]
Stationary Combustion, Refinery gas	CO_2	3 [1)]	5 [1)]
Stationary combustion plants, gas engines	CH_4	2,2 [1)]	40 [2)]
Stationary combustion plants, other	CH_4	2,2 [1)]	100 [1)]
Stationary combustion plants	N_2O	2,2 [1)]	1000 [1)]

1) IPCC Reference Manual (default value)
2) Kristensen (2003)
3) Jensen & Lindroth (2002)
4) NERI assumption

Other pollutants

The IPCC methodologies for uncertainty estimates have been adopted for the LRTAP Convention reportings. The methodology is described in a new chapter in the EMEP/CORINAIR Guidebook (EMEP/CORINAIR 1996) called *Good Practice Guidance for CLRTAP Emission Inventories* (Pulles & Aardenne 2002). Uncertainty estimates for SO_2, NO_X, NMVOC and CO is based on this methodology. The uncertainty estimates are based on emission data and uncertainties for each of the main SNAP sectors.

The assumed uncertainties for activity rates and emission factors are based on default values from Pulles & Aardenne 2002. The default uncertainties for emission factors are given in letter codes representing an uncertainty range. It has been assumed that the uncertainties were in the lower end of the range for all sources and pollutants. The uncertainties for emission factors are shown in Table 3.15. The uncertainty for fuel consumption in stationary combustion plants was assumed to be 2%.

Table 3.15 Uncertainty rates for emission factors

SNAP sector	SO_2	NO_x	NMVOC	CO
01	10	20	50	20
02	20	50	50	50
03	10	20	50	20

3.2.3.2 Results

The estimated uncertainties for stationary combustion emission inventories are shown in Table 3.16.

The uncertainty of GHG is estimated to be ±10% and the uncertainty in trend of GHG is ±1,8%-age points. The main sources of uncertainty for GHG emission are N_2O emission (all plants) and CO_2

emission from coal combustion. Main sources of the trend uncertainty for GHG are CO_2 emission from combustion of natural gas and coal.

Detailed calculation sheets are shown in Annex 3A.

Table 3.16 Danish uncertainty estimates, 2002

Pollutant	Uncertainty Total emission [%]	Trend 1990-2002 [%]	Uncertainty Trend [%-age points]
GHG	10,4	-1,3	± 1,8
CO_2	2,6	-2,3	± 1,8
CH_4	39	349	± 351
N_2O	1000	-3,6	± 3,0
SO_2	7	-86,9	± 0,6
NO_X	16	-35,2	± 2,5
NMVOC	38	46	± 15
CO	45	15,3	± 3,0

3.2.4 Source specific QA/QC and verification

A formal QA/QC plan has not yet been developed, but a number of quality control (QC) procedures are performed. The QC procedures for stationary combustion includes:

- Check of time-series of the CRF and SNAP source categories. Considerable changes are controlled and explained.
- Comparison to inventory of the previous year. Any major changes are verified
- Total emission when aggregated to CRF are compared to totals based on SNAP source categories (control of data transfer)
- A manual log table in the emission databases is applied to collect information about recalculations
- The CRF reference approach validates the fuel consumption rates and CO_2 emissions of fuel combustion. Fuel consumption rates and CO_2 emissions are within 2,0% difference (1990-2002). The reference approach is further discussed in Chapter 3.4.1 and in Annex 3A.
- The emission from each large point source is compared to the emission reported the previous year.
- Some automated checks have been prepared for the emission databases:
  - Check of units for fuel rate, emission factor and plant specific emissions
  - Check of emission factors of large point sources. Emission factors of pollutants that are not plant specific should be the same as the emission factor that are defined for area sources.
  - Additional checks of database consistency
- Most emission factor references are now implemented in the emission database itself.
- Annual environmental reports are kept for subsequent control of plant specific emission data
- QA/QC checks of the country specific emission factors have not been performed but most factors are based on work from companies that have implemented some QA/QC work. The two major power plant owners / operators in Denmark: E2 and Elsam both obtained the ISO 14001 certification for environmental management system. Danish Gas Technology Centre and dk-Teknik both run accredited laboratories for emission measurements.

3.2.5 Source specific recalculations

- The CO_2 emission factors for municipal waste, refinery gas and petroleum coke have been changed for some years.

- Petroleum coke: The same CO_2 emission factor (92 kg/GJ) is applied for all years now. In earlier inventories a higher emission factor was applied for 1990-1997. The reference for the emission factor is however based on a fuel analysis carried out in 1993 and thus the change of emission factor was not correct.
- Refinery gas: To improve time-series consistency the same emission factor (56,9 kg/GJ) is now applied for all years. In the inventory reported last year the emission factor 57,1 kg/GJ was applied for 2000 and 2001.
- Municipal waste: An improved CO_2 emission factor for municipal waste has been estimated. See Annex 3A for details.

- Fuel consumption rates for a few stationary combustion sectors have been recalculated as a result of a new estimate for off-road machinery, see Chapter 3.3. The fuel consumption of gas oil and LPG in the SNAP sectors 0203 and 0301 (stationary combustion) is calculated as total emission of the sectors minus the off-road consumption.

- Emission factors for combined heat and power plants have been improved based on a Danish project including collection of existing emission data and performance of a large number of new emission measurements (Nielsen & Illerup 2003). The emission measurements included both CH_4, N_2O, SO_2, NO_X, NMVOC and CO.

- Centralised power plants have been included in the emission databases as point sources in 1993-1994 (was already included as point sources all other years). Plant specific SO_2 and NO_X emission factors are applied. However the area source emission factor applied in former inventories took into account the plant specific data and thus the estimated emission is not changed considerably due to this improvement.

- The SO_2 and NO_X emission factors have been examined and time-series inconsistencies have been corrected.

Further a few minor errors for large point sources have been corrected. These corrections do not include CO_2, CH_4 or N_2O emission.

The recalculations that have been carried out are not a result of the review process but the documentation have been improved on several subjects that was questioned in the review process:

- The CH_4 emission factor, level and time-series
- Reference approach
- Fuel consumption time-series, fluctuations
- Emission from gas flaring

Fuel type correspondence lists (Danish Energy Authority, NERI and CRF)

3.2.6 Source specific planned improvements

Some planned improvements of the emission inventories are discussed below. The planned improvements are all related to the comments in the review process.

3.2.6.1 Disaggregation of fuel consumption in the industrial sector

So far the Danish energy statistics aggregated to SNAP sectors have not specified fuel consumption rates for specific industries. Thus the fuel consumption of *1A2 Manufacturing industries and construction* is included in sector *1A2f Manufacturing industries and construction, Other*. The possible work that is required to make a disaggregation to industrial subsectors has been initiated and is expected to be implemented in the reportings in 2005.

3.2.6.2 Energy statistics update

A full update of fuel consumption according to the updated energy statistics has not been carried out for a few years. A full update is expected to be part of the next emission inventory.

3.2.6.3 Improved documentation for CO_2 emission factors

The CO_2 emission factors applied for the Danish inventories are considered accurate but the documentation will be improved in future inventories.

3.2.6.4 Improved QA/QC and validation

The QA/QC and validation of the inventories for stationary combustion will be improved as part of the work that have been initiated for the Danish inventory as a whole.

3.3 Transport and other mobile sources (CRF sector 1A2, 1A3, 1A4 and 1A5)

The emissions from transport referring to SNAP category 07 (road transport) and the sub-categories in 08 (other mobile sources) are made up in the following IPCC categories:

Table 3.17 SNAP – IPCC correspondence table for transport

SNAP classification	IPCC classification
07 Road transport	1A3b Transport-Road
0801 Military	1A5 Other
0802 Railways	1A3c Railways
0803 Inland waterways	1A3d Transport-Navigation
080402 National sea traffic	1A3d Transport-Navigation
080403 National fishing	1A4c Agriculture/forestry/fisheries
080404 International sea traffic	1A3d Transport-Navigation (international)
080501 Dom. airport traffic (LTO < 1000 m)	1A3a Transport-Civil aviation
080502 Int. airport traffic (LTO < 1000 m)	1A3a Transport-Civil aviation (international)
080503 Dom. cruise traffic (> 1000 m)	1A3a Transport-Civil aviation
080504 Int. cruise traffic (> 1000 m)	1A3a Transport-Civil aviation (international)
0806 Agriculture	1A4c Agriculture/forestry/fisheries
0807 Forestry	1A4c Agriculture/forestry/fisheries
0808 Industry	1A2f Industry-Other
0809 Household and gardening	1A4b Residential

3.3.1 Source category description

In total the energy use for road transport has increased until 2000. After that a stagnation in the total energy use is seen. The CO_2 emissions have developed correspondingly and the most important source is passenger cars followed by heavy-duty vehicles, light duty vehicles and 2-wheelers in decreasing order.

The majority of the CH_4 emissions from road transport come from gasoline passenger cars. The emission development for the latter vehicle category is powered by the somewhat higher emission factors for EURO I gasoline cars (introduced in 1990) than the ones for conventional gasoline cars. For EURO II and III catalyst cars (introduced in 1997 and 2001, respectively) the emission factors are lower than conventional gasoline factors.

An undesirable environmental side effect of the introduction of catalyst cars in 1990 is the increase in the emissions of N_2O. However, for the total road transport the N_2O and CH_4 emission contributions are still small compared to the emissions from the agricultural sector.

The largest contribution to the total GHG emission for road transport comes from CO_2. In 2002 the most important source was passenger cars followed by heavy-duty vehicles, light duty vehicles and 2-wheelers in decreasing order.

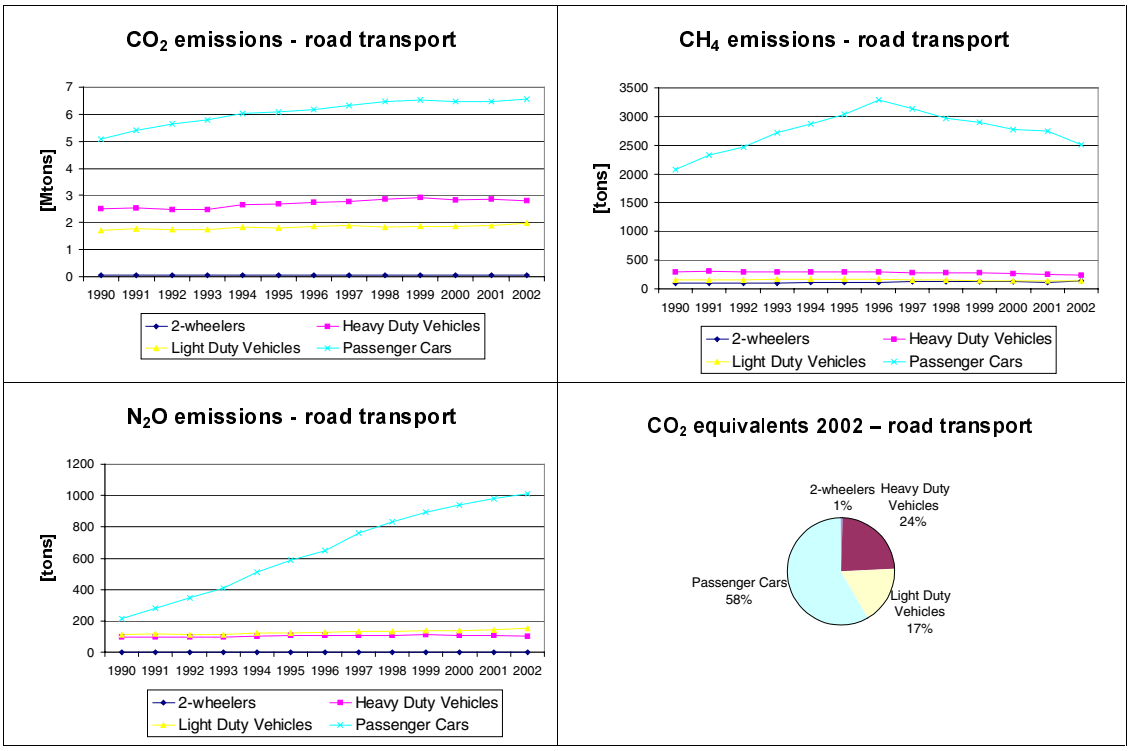

Figure 3.15 Emissions from road transport 1990-2002 and CO_2 equivalents in 2002

It must be noted that the fuel consumption figures behind the Danish inventory for mobile equipment in the agriculture, forestry, industry, household and gardening (residential) and inland waterways (part of navigation) sectors are less certain than the fuel consumption development for other mobile sectors. This is because of the DEA statistical figures, which do not directly provide fuel consumption information for working equipment and machinery in these sectors.

Except for small boats and pleasure crafts (inland waterways) the fuel consumption has made a slight constant decrease from 1990 to 2000 in the above mentioned sectors.

For fuel consumption and thus CO_2 emission the most important sectors are agriculture/forestry/fisheries (CRF Table 1A4c), industry (CRF Table 1A2f), navigation (CRF Table 1A3d), with minor fuel consuming sectors such as civil aviation (CRF Table 1A3a), railways (CRF Table 1A3c), military (CRF Table other: 1A5) and residential.

In the agriculture/forestry/fisheries sector the fuel consumption by agricultural machines accounts for two thirds of the total fuel use. The decrease in fuel consumption is a result of fluctuations in the fuel consumption for fishery and the constant decreasing fuel consumption for agricultural machines between 1990 and 2000.

The navigation sector comprises national sea transport (fuel consumption between two Danish ports) and small boats and pleasure crafts. For the latter categories the fuel consumption has increased significantly from 1990 to 2000, due to more private boats. For national sea transport the fuel consumption has shown some fluctuations in the same time period and the amount of fuel used is actually lower in 2002 than in 1990. The most important explanation for this decreasing fuel

consumption is the shut down of ferry service connections in connection with the opening of the Great Belt link in 1997.

Since the building of the Great Belt Bridge the domestic aviation has decreased, both in terms of number of flights and total jet fuel use, and total emissions. For railways the gradual shift towards electrification explains the lowering trend in diesel fuel consumption and emissions for this transport sector.

For CH_4 the most important sectors are industry (CRF Table 1A2f), residential (CRF Table 1A4b), agriculture/forestry/fisheries (CRF Table 1A4c) and navigation (CRF Table 1A3d), with minor emissions from railways (CRF Table 1A3c), civil aviation (CRF Table 1A3a) and military (CRF Table other: 1A5).

The reasons for high CH_4 emissions in the first two sectors are the use of LPG trucks in the industry and the relatively large amount of gasoline used in the residential sector. Also the appearance of more gasoline fuelled private boats in navigation has caused a significant increase in the emissions from this sector.

For N_2O the emission trend in sub-sectors is the same as for fuel consumption and CO_2 emissions.

For other mobile sources the most important gas is CO_2. Sorted by size the largest contributors in 2002 are agriculture/forestry/fisheries (CRF Table 1A4c), industry (CRF Table 1A2f), navigation (CRF Table 1A3d), railways (CRF Table 1A3c), civil aviation (CRF Table 1A3a), military (CRF Table other: 1A5) and residential (CRF Table 1A4b).

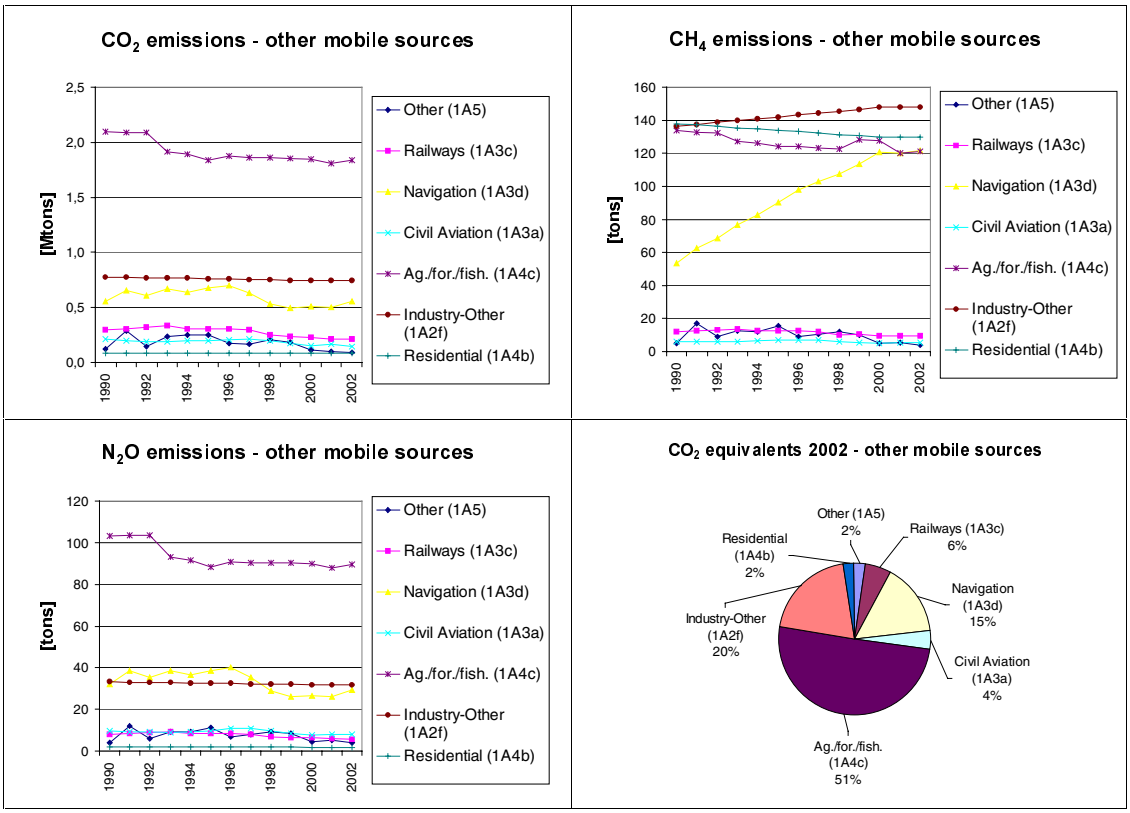

Figure 3.16 Emissions from other mobile sources 1990-2002 and total GHG in CO_2 eqv., 2002

3.3.2 Methodological issues

The description of methodologies and references for the transport part of the Danish inventory is given in two sections; one for road transport and one for the other mobile sources.

3.3.2.1 Methodology and references for Road Transport

For road transport the Tier 1 and Tier 2 approaches are used in parallel to make annual estimates of the Danish emissions as described in the IPCC guidelines (Penman et al. (2000). The actual calculations are made with the European COPERT III model (Ntziachristos et al. 2000). In COPERT III fuel consumption and emission simulations can be made for operationally hot engines taking into account gradually stricter emission standards and emission degradation due to catalyst wear. Furthermore the emission effects of cold start and evaporation are simulated.

Vehicle fleet and mileage data

Corresponding to the COPERT fleet classification all present and future vehicles in the Danish traffic are grouped into vehicle layers. This is a sub-division of all vehicle classes into groups of vehicles with the same average fuel consumption and emission behaviour. An overview of the different layers with years of implementation is given in Annex 3.B.1.

Table 3.18 Model vehicle classes, trip speeds and mileage split.

Vehicle classe	Fuel type	Engine size/weight	Trip speed			Mileage [%]		
			Urban	Rural	Highway	Urban	Rural	Highway
PC	Gasoline	< 1.4 l.	40	70	100	35	46	19
PC	Gasoline	1.4 – 2 l.	40	70	100	35	46	19
PC	Gasoline	> 2 l.	40	70	100	35	46	19
PC	Diesel	< 2 l.	40	70	100	35	46	19
PC	Diesel	> 2 l.	40	70	100	35	46	19
PC	LPG		40	70	100	35	46	19
PC	2-stroke		40	70	100	35	46	19
LDV	Gasoline		40	65	80	35	50	15
LDV	Diesel		40	65	80	35	50	15
Trucks	Gasoline		35	60	80	32	47	21
Trucks	Diesel	3.5 – 7.5 tonnes	35	60	80	32	47	21
Trucks	Diesel	7.5 – 16 tonnes	35	60	80	32	47	21
Trucks	Diesel	16 – 32 tonnes	35	60	80	19	45	36
Trucks	Diesel	> 32 tonnes	35	60	80	19	45	36
Urban buses	Diesel		30	50	70	51	41	8
Coaches	Diesel		35	60	80	32	47	21
Mopeds	Gasoline		30	30	-	81	19	0
Motorcycles	Gasoline	2 stroke	40	70	100	47	39	14
Motorcycles	Gasoline	< 250 cc.	40	70	100	47	39	14
Motorcycles	Gasoline	250 – 750 cc.	40	70	100	47	39	14
Motorcycles	Gasoline	> 750 cc.	40	70	100	47	39	14

Information of the vehicle stock and annual mileage is obtained from the Danish Road Directorate. This covers data for the number of vehicles, annual mileage, mileage split between urban, rural and highway driving and the respective average speeds.

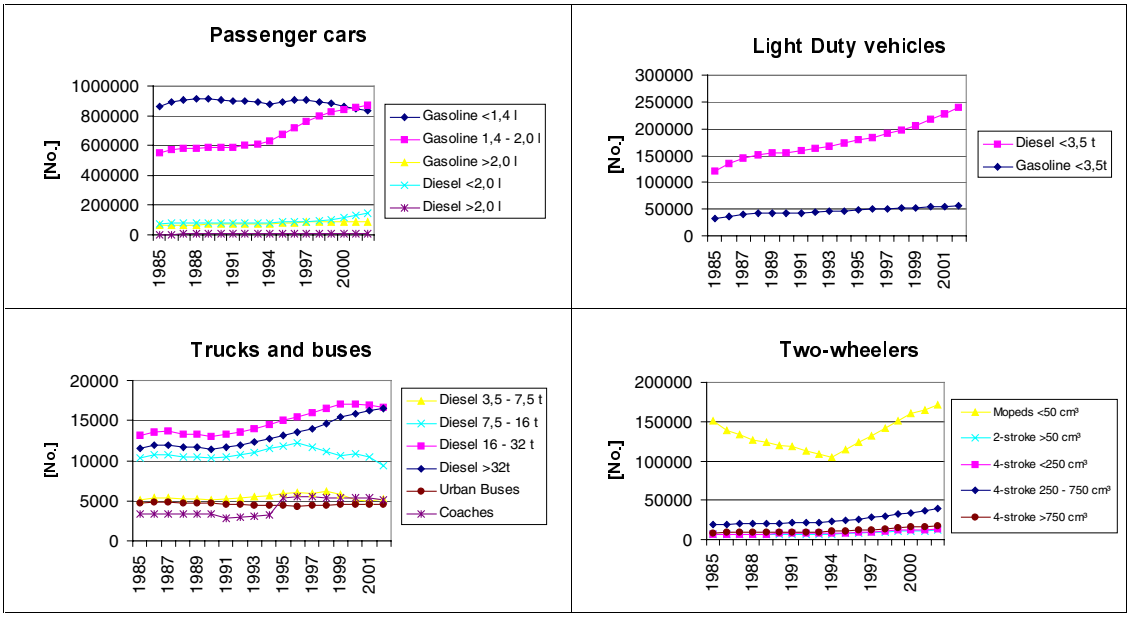

Figure 3.17 Number of vehicles in sub-classes in 1985-2002

The number of vehicles and annual mileages respectively, are provided per first registration year for all vehicle sub-classes. Subsequently the vehicle numbers are summed up in layers, *j*, for each year, *y*, by using the correspondence between layers and first registration year, *i*:

$$N_{j,y} = \sum_{i=FYear(j)}^{LYear(j)} N_{i,y} \quad (1)$$

Weighted annual mileages per layer are calculated as the sum of all mileage driven per first registration year divided with the total number of vehicles in the specific layer.

$$M_{j,y} = \frac{\sum_{i=FYear(j)}^{LYear(j)} N_{i,y} \cdot M_{i,y}}{\sum_{i=FYear(j)}^{LYear(j)} N_{i,y}} \quad (2)$$

Both vehicle numbers and weighted annual mileages per layer are shown in Annex 3.B.1.

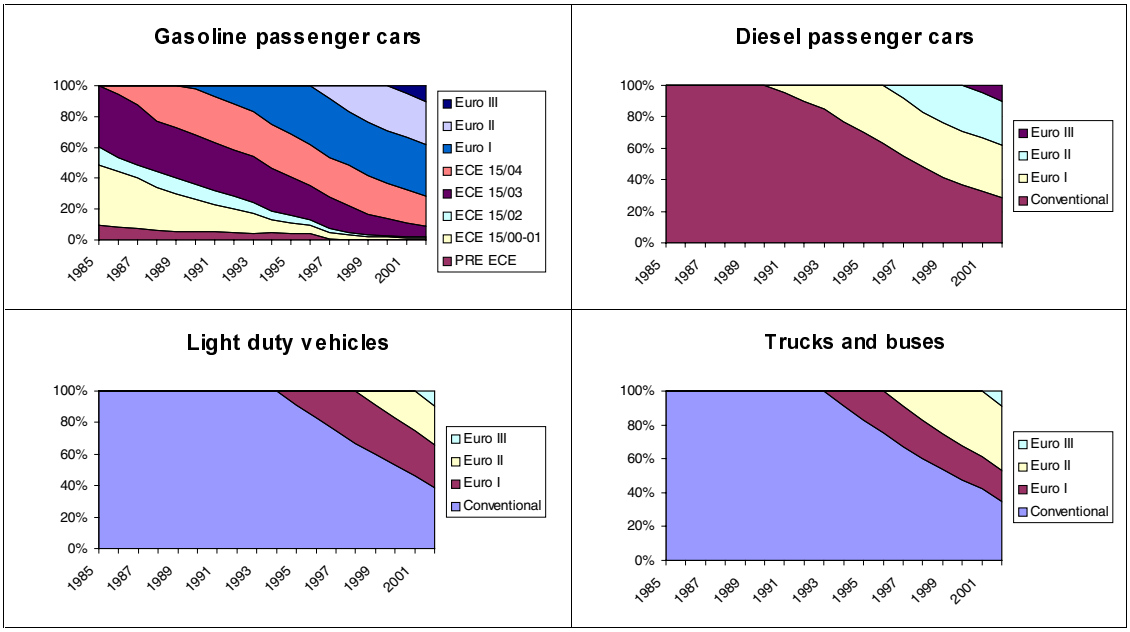

Figure 3.18 Layer distribution of vehicle numbers per vehicle type in 1985-2002

Trip speed dependent fuel consumption and emission factors are taken from the COPERT model using trip speeds as shown in Table 3.18. The factors are listed in Annex 3.B.2. For new layers not represented by actual data, the emission factors are scaled according to reduction factors (cf. Ntziachristos et al. (2000) or Illerup et al. (2003)).

Deterioration factors

For three-way catalyst cars the emissions of NO_X and NMVOC (and CO) gradually increase due to catalyst wear and are therefore modified as a function of total mileage by the so-called deterioration factors. Even though the emission curves may be serrated for the individual vehicles, on average the emissions from catalyst cars stabilise after a given cut-off mileage is reached due to OBD (On Board Diagnostics) and the Danish inspection and maintenance programme. For each forecast year the deterioration factors are calculated per first registration year by using deterioration coefficients and cut-off mileages, as given in Ntziachristos et al. (2000) or Illerup et al. (2002) for the corresponding layer. The deterioration coefficients are given for the two driving cycles "Urban driving Cycle" (UDF) and "Extra Urban driving Cycle" (EUDF: urban and rural), with trip speeds of 19 and 63 km/h, respectively.

Firstly the deterioration factors are calculated for the correspondent trip speeds of 19 and 63 km/h in each case determined by the total cumulated mileage less than or exceeding the cut-off mileage. The formulas 3 and 4 show the calculations for the "Urban driving Cycle":

$$UDF = U_A \cdot MTC + U_B \text{ , MTC} < U_{MAX} \quad (3)$$

$$UDF = U_A \cdot U_{MAX} + U_B \text{ , MTC} >= U_{MAX} \quad (4)$$

Where UDF is the urban deterioration factors, UA and UB the urban deterioration coefficients, MTC = total cumulated mileage, U_{MAX} urban cut-off mileage.

In the case of trip speeds below 19 km/h the deterioration factor, DF, equals UDF, whereas for trip speeds exceeding 63 km/h DF=EUDF. For trip speeds between 19 and 63 km/h the deterioration

factor, DF, is found as an interpolation between UDF and EUDF. Secondly the deterioration factors, one for each of the three road types, are aggregated into layers by taking into account the vehicle numbers and annual mileages per first registration year:

$$DF_{j,y} = \frac{\sum_{i=FYear(j)}^{LYear(j)} DF_{i,y} \cdot N_{i,y} \cdot M_{i,y}}{\sum_{i=FYear(j)}^{LYear(j)} DF_{i,y} \cdot N_{i,y}} \quad (5)$$

where DF is the deterioration factor.

Emissions and fuel consumption for hot engines

Emissions and fuel consumption results for operationally hot engines are calculated for each year and layer and road type. The procedure is to combine fuel consumption and emission factors (and deterioration factors for catalyst vehicles), number of vehicles annual mileage numbers and their road type shares given in Table 3.18. For non-catalyst vehicles this yields:

$$E_{j,k,y} = EF_{j,k,y} \cdot S_k \cdot N_{j,y} \cdot M_{j,y} \quad (6)$$

Here E = fuel use/emission, EF = fuel use/emission factor, S = road type share, k = road type.

For catalyst vehicles the calculations becomes:

$$E_{j,k,y} = DF_{j,k,y} \cdot EF_{j,k,y} \cdot S_k \cdot N_{j,y} \cdot M_{j,y} \quad (7)$$

Extra emissions and fuel consumption for cold engines

Extra emissions of SO_2, NO_x and NMVOC (as well as CO, PM, CH_4, CO_2 and FC) from cold start are simulated separately. In the model each trip is associated with an amount of cold start emission and is assumed to take place under urban driving conditions. The number of trips are distributed evenly in months. Firstly cold emission factors are calculated as the hot emission factor times the cold:hot emission ratio. Secondly the extra emission factor during cold start is found by subtracting the hot emission factor from the cold emission factor. Lastly this extra factor is applied on the fraction of the total mileage driven with a cold engine (the β-factor) for all vehicles in the specific layer.

The cold:hot ratios depend on the average trip length and the monthly ambient temperature distribution and are equivalent for gasoline fuelled conventional passenger cars and vans and for diesel passenger cars and vans, respectively (cf. Ntziachristos et al., 2000). For conventional gasoline and all diesel vehicles the extra emissions become:

$$CE_{j,y} = \beta \cdot N_{j,y} \cdot M_{j,y} \cdot EF_{U,j,y} \cdot (CEr - 1) \quad (8)$$

where CE is the cold extra emissions, β = cold driven fraction, CEr = Cold:Hot ratio.

For catalyst cars the cold:hot ratio is also trip speed dependent. The ratio is however unaffected by catalyst wear. The EURO I ratio is used for all future catalyst technologies. However, in order to comply with gradually stricter emission standards the catalyst light-off temperature must be

reached in even shorter time periods for future EURO standards. Correspondingly the β-factor for gasoline vehicles is step-wise reduced for EURO II onwards.

For catalyst vehicles the cold extra emissions are found from:

$$CE_{j,y} = \beta_{red} \cdot \beta_{EUROI} \cdot N_{j,y} \cdot M_{j,y} \cdot EF_{U,j,y} \cdot (CEr_{EUROI} - 1) \quad (9)$$

where β_{red} = the β reduction factor.

Evaporative emissions from gasoline vehicles

For each year evaporative emissions of hydrocarbons are simulated in the forecast model as hot and warm running loss, hot and warm soak, and diurnal emissions. All emission types are influenced by RVP (Reid Vapour Pressure) and ambient temperature. The emission factors are shown in Ntziachristos et al. (2000).

Running loss emissions originate from vapour generated in the fuel tank during operation. The distinction between hot and warm running loss emissions depend on the engine temperature. In the model hot and warm running loss occur for hot and cold engines, respectively. The emissions are calculated as the annual mileage – broken down on cold and hot mileage totals using the β-factor - times respective emission factors. For vehicles equipped with evaporation control (catalyst cars) the emission factors are only one tenth of the uncontrolled factors used by conventional gasoline vehicles.

$$R_{j,y} = N_{j,y} \cdot M_{j,y} \cdot ((1-\beta) \cdot HR + \beta \cdot WR) \quad (10)$$

where R is the running loss emissions and HR and WR the hot and warm running loss emission factors, respectively.

In the model hot and warm soak emissions for carburettor vehicles also occurs for hot and cold engines, respectively. These emissions are calculated as number of trips – broken down into cold and hot trip numbers using the β-factor - times respective emission factors:

$$S_{j,y}{}^{C} = N_{j,y} \cdot \frac{M_{j,y}}{l_{trip}} \cdot ((1-\beta) \cdot HS + \beta \cdot WS) \quad (11)$$

where S^C is the soak emissions, l_{trip} = the average trip length and *HS* and *WS* is the hot and warm soak emission factors, respectively. Since all catalyst vehicles are assumed to be carbon canister controlled no soak emissions are estimated for this vehicle type. Average maximum and minimum temperatures per month are used in combination with diurnal emission factors to estimate the diurnal emissions from uncontrolled vehicles $E^d(U)$:

$$E_{j,y}{}^{d}(U) = 365 \cdot N_{j,y} \cdot e^{d}(U) \quad (12)$$

Each year's total is the sum of each layer's running loss, soak and diurnal emissions.

Fuel consumption balance

The calculated fuel consumption in the model must equal the statistical fuel sale totals from the Danish Energy Agency (DEA) according to the UNFCCC emissions reporting format. The standard approach to achieve a fuel balance in annual emission inventories is to multiply the annual mileage with a fuel balance factor derived as the ratio between simulated and statistical fuel figures for gasoline and diesel, respectively. This method is also used in the present model.

For gasoline vehicles all mileage numbers are equally scaled in order to obtain a gasoline fuel equilibrium. For diesel fuel the balance is made by adjusting the mileage for light and heavy-duty vehicles and buses, given that the mileage and fuel consumption factors for these vehicles are regarded as the most uncertain parameters in the diesel engine emission simulations.

The final fuel consumption and emission factors are shown in Annex 3.B.3 for 1990-2002. The total fuel consumption and emissions are shown in Annex 3.B.4 per vehicle category and as grand totals for 1990-2002. In Annex 3.B.5 fuel consumption and emission factors and total emissions are given in CollectER format for 1990 and 2002.

3.3.2.2 Methodologies and references for other mobile sources

The off road sector is divided into several sub-sectors; sea transport, fishery, air traffic, railways, military and the working machinery and materiel in the industry, forestry, agriculture and household and gardening sectors. The emission calculations are made using the Tier 2 method for air traffic and off road working machinery and equipment, while for the remaining sectors the Tier 1 method is used.

Activity data

The activity data for air traffic consist of air traffic statistics provided by the Danish Civil Aviation Agency (CAA-DK) and Copenhagen Airport. For 2001 onwards records are given per flight by CAA-DK as data for aircraft type and origin and destination airports. Prior to 2001 detailed LTO/aircraft type statistics are provided by Copenhagen Airport (for this airport only), while CAA-DK has given information of total take off numbers for other Danish airports. Fuel statistics for jet fuel consumption and aviation gasoline are obtained from the DEA.

For off road working machinery and equipment 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). Fuel consumption statistics for diesel, gasoline and LPG are obtained from the DEA in relevant sectors.

The activity data for military, railways, sea transport and fishery consist of fuel consumption information provided by the DEA. For sea transport the basis is fuel sold in Danish ports and the traffic is defined as either national or international depending on the destination of the vessels in question as prescribed by the IPCC guidelines.

For all sectors fuel consumption figures are given in Annex 3.B.5 for the years 1990 and 2002.

Emission factors

For military ground material and railways aggregated emission factors for gasoline and diesel are derived from the road traffic emission simulations made with the COPERT model. The emission factors for the remaining sectors come from the EMEP/CORINAIR guidebook (cf. CORINAIR, 1999). For all sectors emission factors are given in Annex 3.B.5 for the years 1990 and 2002.

Calculation method

For military, railways, national sea traffic and fishing the emissions are estimated with the Tier 1 method using fuel related emission factors and fuel consumption from the DEA.

For aviation the estimates are made separately for Landing and Take Offs (LTOs < 3000 ft) and cruise (> 3000 ft). From 2001 the estimates are made on a city-pair level by combining activity data and emission factors and subsequently group the emission results into domestic and international totals. In a final step a fuel balance is made. The fuel ratio between model estimates and statistical sales is used to modify the model results of cruise fuel consumption and emissions according to the dome-stic and international cruise shares.

Prior to 2001 the calculation scheme is firstly to estimate each year's fuel consumption and emissions for Landing and Take Offs (LTO). Secondly the total cruise fuel consumption is found year by year as the statistical fuel consumption total minus the calculated fuel consumption for LTO. Lastly the cruise fuel consumption is split into domestic and international parts by using the results from a Danish city pair emission inventory in 1998 (Winther, 2001a). For more details of this latter fuel allocation procedure see Winther (2001b).

Off road working machines and equipment are grouped in the sectors: Inland waterways, agriculture, forestry, industry and household and gardening. In general the fuel consumption and emissions are calculated by combining information of the number of different machine types and their respective load factors, engine sizes, annual working hours, and fuel consumption and emission factors.

The simulations take into account the implementation of a two stage emission legislation directive depending on engine size for relevant types of diesel fuelled machinery. Stage I and II of the directive becomes effective for new machinery in use in 1999-2001 and 1999-2003 respectively.

The amount of fuel sold for non-road machinery cannot be derived explicitly from national fuel sale statistics, and hence it is not possible to make a fuel balance in order to achieve a fuel consumption equilibrium. Instead, the non-road fuel consumption amount is estimated directly from the reported activity data by EPA (1992 and 2003) and from EMEP/CORINAIR fuel consumption factors.

For diesel, the calculated fuel consumption is partly covered by the fuel consumption amount in the DEA sectors agriculture and forestry, market gardening, building and construction. The remaining diesel fuel amount is taken from the industry sector. It should be noted that the part of diesel fuel in industry not being used by non-road machinery is included in the sector "Combustion in manufacturing industry" (0301) and "Non-industrial combustion plants" (0203) in the Danish emission inventory. The estimated fuel consumption for gasoline and LPG is maintained by adjusting the amount of fuel used in the simulations for road traffic and household.

The fuel consumption for small boats and pleasure crafts is derived in the same way as for non-road machinery. The estimated figures are subsequently subtracted from the fishery sector (diesel) and road transport (gasoline).

The calculated emissions for other mobile sources are shown per sector in Annex 3.B.5 for the years 1990 and 2002.

3.3.3 Uncertainties and time-series consistency

Uncertainty estimates are made for road transport and other mobile sources using the guidelines and emission factor uncertainties formulated by Penman et al. (2000). The uncertainty factors for the individual activities are based on own judgement. The calculations are shown in Annex 3.B.6.

Tabel 3.19 Emission uncertainties in 2002 and trend uncertainties 1990-2002.

Category	Fuel type	Activity data Uncertainty	Emission factor Uncertainty		
			CO_2	CH_4	N_2O
		%	%	%	%
Civil Aviation	Aviation Gasoline	0	5	100	1000
	Jet Kerosene	0	5	100	1000
Road Transportation	Gasoline	0	5	40	50
	Diesel Oil	2	5	40	50
Railways	Diesel Oil	2	5	100	1000
Navigation	Residual Oil	2	5	100	1000
	Gas/Diesel Oil	0	5	100	1000
Agriculture	Diesel Oil	20	5	100	1000
	Gasoline	20	5	100	1000
Forestry	Diesel Oil	20	5	100	1000
	Gasoline	20	5	100	1000
Industry	Diesel Oil	20	5	100	1000
	Gasoline	20	5	100	1000
	LPG	20	5	100	1000
Household and gardening	Gasoline	20	5	100	1000
Overall uncertainty in 2002			3,6	32,2	56,0
Trend uncertainty			3,5	3,8	193,2

As regards time-series consistency background flight data cannot be made available on a city-pair level from 2000 and backward. However, aided by LTO/aircraft statistics for these years, and the use of proper assumptions a sound level of consistency is obtained anyhow in this part of the transport inventory.

The time-series of emissions for the mobile equipment in the agriculture, forestry, industry, household and gardening (residential) and inland waterways (part of navigation) sectors are less certain than time-series for other sectors. This is because of the DEA statistical figures, which do not directly provide fuel consumption information for working equipment and machinery in these sectors.

For 1990 and 2000 background activity data (stock and operation) exist, but for the years in between 1990 and 2000 and for the years beyond 2000 there is a data gap which is difficult to fill in at present being. At current, estimates for intermediate years and years beyond 2000 are produced by interpolation and using 2000 data, respectively (in both situations a new technology penetration rate is assumed)

3.3.4 Quality assurance/quality control (QA/QC)

For road transport and air traffic the Tier 1 and Tier 2 methods are used independently to provide a quality control of the emission estimations. Firstly the bottom up approach (Tier 2) is used as described in Chapters 1.1 to 1.5. Secondly the estimates are modified according to a fuel balance using the statistical sale figures respectively for road transportation and civil aviation fuel in Den-

mark (Tier 1), as described in the sections 1 and 2. The usage of the Tier 1 method ensures that all fuel for road transport and civil aviation is accounted for in the estimations.

For non-road machinery and working equipment the Tier 2 method determines the amount of fuel used. The subsequent adjustment of fuel totals to be used in the estimates for other sectors (Chapter 2.3) ensure that no double counting of emissions is made.

For the remaining transport sectors the Tier 1 method ensure that all fuel is accounted for in the emission estimations.

As a part of the general QA/QC work all time-series of emissions in the CRF and SNAP source categories are examined and considerate changes are checked and explained. Moreover a comparison is made to the previous year's estimate, and any major changes are verified. As a last point a data transfer control is made from SNAP source categories to aggregated CRF source categories.

3.3.5 Recalculations

- Road transport: An updated COPERT III run was made for the year 1999 to include the deterioration effect for catalyst vehicles and more accurate Danish cold start parameters. The Danish inventory for non-exhaust particulate emissions (tyre and brake wear and road abrasion) has been revised according to the new EMEP/CORINAIR guidebook methodology chapter.
- Railways: Updated NO_x, NMVOC, CH_4, CO and PM emission factors for diesel are used in a time-series from 1985 to 2002 based on real emission measurements carried out by the Danish Railways. For gasoline the minor amount of fuel used by railways is transferred to road transport in the years 1987, 1989-1993 and 1995-2002.
- Inland waterways: A change is made for diesel fuel consumption in relation to Danish energy statistics based on consultations with the Danish Energy Authority and the Technological Institute of Denmark. Now the estimated amount of diesel fuel consumption from 1985-2002 is taken directly from the fishery sector in the statistics.
- Fishery: A part of this sector's diesel fuel consumption is transferred to "Inland waterways" for the years 1985-2002 (see description "Inland waterways").
- International navigation: The Danish Energy Authority has estimated a fuel consumption for the year 1985, which has been included in the Danish inventory.
- Air traffic: Small changes in emission factors are made for the years 2001 and 2002. Now helicopters are included in background flight data and in addition minor changes are made to the real aircraft type - representative aircraft type relation.
- Agriculture/Forestry/Industry/Household and gardening: A change is made for diesel fuel consumption in relation to Danish energy statistics based on consultations with the Danish Energy Authority and the Technological Institute of Denmark. Consequently a correction is made to the sectors "0203: Plants in agriculture, forestry and aquaculture" and "0301: Combustion in boilers, gas turbines and stationary" in order to obtain a fuel balance.

In response to the review comments of last year's NIR report, a recalculation of the 1999 CH_4 emission factors was made (first point of recalculation list). A more thorough description of the general CH_4 emission factor development gives that the factors are much higher for urban driving than for rural and highway driving. Another characteristic is that the emission factors for EURO I gasoline cars (introduced in 1990) are somewhat higher than the ones for conventional gasoline cars. For EURO II and III catalyst cars (introduced in 1997 and 2001, respectively) the emission factors are lower than conventional gasoline factors.

3.3.6 Improvements

It will continuously be aspired to fulfil the requirements from IPCC of good practice in inventory making for transport.This year a note will be made for transport going through the different issues of choices relating to methods (methods used, emission factors, activity data, completeness, time-series consistency, uncertainty assessment), reporting and documentation, and inventory quality assurance/quality control.

The outcome of this transport-related note will result in some changes to the inventory in the future.

3.3.7 Bunkers

In the Danish emission inventories presented in CRF, the distinction between domestic and international emissions from aviation and navigation is made in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. In principle this means that fuel sold (and associated emissions) for flights/sea transportations starting from a seaport/airport in the Kingdom of Denmark, with destinations inside or outside the Kingdom of Denmark, are regarded as domestic or international, respectively.

For aviation the emissions associated with flights inside the Kingdom of Denmark are counted as domestic. The flights from Denmark to Greenland and the Faroe Islands are classified as domestic flights in the inventory background data, and in the real world almost no fuel is bunkered in Greenland/Faroe Islands by other flights than those going to Denmark.

The domestic/international fuel split (and associated emissions) for navigation is not determined with the same precision as for aviation. In this way no special effort has been made to investigate how the fuel quantities sold in Denmark and on the Faroe Islands are classified for vessels going to Greenland/Faroe Islands. For Greenland all marine fuel sales are treated as domestic. However it is considered that this uncertain fuel amount only contribute with a small part of the total fuel sold for navigation purposes in the Kingdom of Denmark.

3.3.8 References

CORINAIR (1999): Atmospheric Emission Inventory Guidebook Vol. 3, Second Edition, EMEP Task Force on Emission Inventories, European Environmental Agency, Copenhagen.

Illerup et al. (2002): Projection Models 2010. Danish Emissions of SO_2, NO_X , NMVOC and NH_3. (2002). NERI technical report no. 414. National Environmental Research Institute. 192 pp.

Ntziachristos, L., Samaras, Z. (2000): COPERT III Computer Programme to Calculate Emissions from Road Transport - Methodology and Emission Factors (Version 2.1). Technical report No 49. European Environment Agency, November 2000, Copenhagen.

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Winther, M. (2001): 1998 Fuel Use and Emissions for Danish IFR Flights. Environmental Project no. 628, 2001. 112 p. Danish EPA. Prepared by the National Environmental Research Institute, Denmark. Electronic report at homepage of Danish EPA http://www.mst.dk/udgiv/Publications/2001/87-7944-661-2/html/.

Winther, M. (2001): Improving fuel statistics for Danish aviation. National Environmental Research Institute, Denmark. 56 p. – NERI Technical Report No. 387.

3.4 Additional information, CRF sector 1A Fuel combustion

3.4.1 Reference approach, feedstocks and non-energy use of fuels

In addition to the sector specific CO_2 emission inventories (the national approach) the CO_2 emission is also estimated using the reference approach described in the IPCC Reference Manual (IPCC 1996).

Data for import, export and stock change used in the reference approach originates from the annual "basic data" table prepared by the Danish Energy Authority and published on their home page (DEA 2003b). A fuel correspondence list is enclosed in Annex 3.A. White spirit is included in the fuel category naphtha. The fraction of oxidised carbon has been assumed to be 1,00. The carbon emission factors are default factors originating from the IPCC Reference Manual (IPCC 1996). The country specific emission factors are not used in the reference approach because it is used for verification.

CRF includes a comparison of the national approach and the reference approach estimates. To make results comparable, the CO_2 emission from the plastic part of municipal waste incineration is added in the reference approach. Further consumption for non-energy purposes is subtracted in the reference approach, because non-energy use of fuels is not included in the Danish national approach yet.

Three fuels are used for non-energy purposes: lube oil, bitumen and white spirit. The total consumption for non-energy purposes is relatively low, i.e. 10,9 PJ in 2002.

In 2002 fuel consumption rates of the two approaches differ 0,05% and the CO_2 emission differ 0,24%. In 1990-2002 the fuel consumption difference is within 1,96% and the CO_2 emission difference is within 1,92% and thus less than the required difference of ±2%.

Comparison of national approach and reference approach is shown in Figure 3.19.

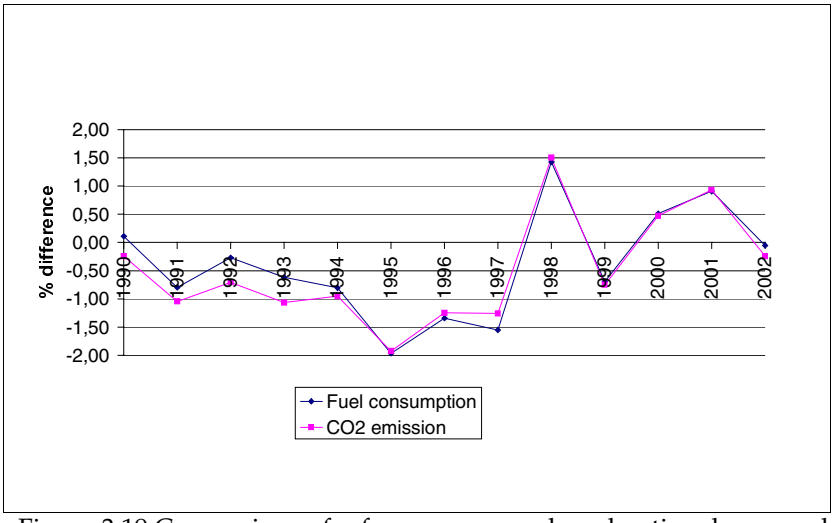

Figure 3.19 Comparison of reference approach and national approach

3.5 Fugitive emissions (CRF sector 1B)

3.5.1 Source category description

3.5.1.1 Fugitive emission from solid fuels, CRF sector 1B1c

Coal mining is not occurring in Denmark, but power plants use a considerable amount of coal. CH_4 emission from storage and handling of coal is included in the Danish inventory.

3.5.1.2 Fugitive emissions from natural gas, transmission and distribution (CRF sector 1B2b)

In the year 2002 the length of transmission pipelines including offshore pipeline is 1439 km. The length of distribution pipelines is 18120 km (cast iron 0 km, steel 2185 km, plastics 15935 km). Two natural gas storages are in operation in Denmark. In 2002 the gas input was 530 Mm^3 and the withdrawal was 542 Mm^3. Emission from gas storage is included in transmission.

3.5.1.3 Flaring, gas (CRF sector 1B2c, Flaring ii)

Off shore flaring of natural gas is the main source in this sector. Flaring in gas treatment and gas storage plants is however also included in the sector.

3.5.2 Methodological issues

3.5.2.1 Fugitive emission from solid fuels, CRF sector 1B1c

The CH_4 emission inventory is based on the Tier 1 of the IPCC Reference Manual (IPCC 1996). The CH_4 emission occurring in Denmark is assumed to be half the post-mining emission.

Coal import refers to the official Danish energy statistics (DEA 2003b). In inventories for 1990-1999 country of origin of the imported coal and the underground fraction in each country is taken into account. The emission factor from 1999 has been applied for the 2000-2002 inventories.

Coal import and emission factors are shown in Table 3.20.

Table 3.20 Coal import and CH_4 emission factor, coal storage and handling

Year	Coal import [Mg coal import]	Emission factor 1) [g/Mg coal import]
1990	10255000	336
1991	12810000	310
1992	11942000	327
1993	10467000	458
1994	11772000	477
1995	13009000	485
1996	13134000	485
1997	13474000	485
1998	8071000	430
1999	7117000	474
2000	6415000	474
2001	6924000	474
2002	6262000	474

1) ½ of total post mining emission factor

3.5.2.2 Fugitive emissions from natural gas, transmission and distribution (CRF sector 1B2b)

Inventories of CH_4 emission from gas transmission and distribution is based on annual environmental reports from the Danish gas transmission company, DONG, and on a Danish emission in-

ventory for the years 1999-2002 reported by the Danish gas sector (transmission and distribution companies) (Karll, 2003). The inventories estimated by the Danish gas sector are based on the work carried out by Marcogas and the International Gas Union (IGU).

In the 1990-1999 inventories fugitive CH_4 emissions from storage facilities and the gas treatment plant are included in the emission factor for transmission. In the 2000-2002 emission inventories transmission, gas storage and gas treatment are registered separately and added.

Gas transmission data are shown in Table 3.21. Emissions from gas storage facilities and venting in the gas treatment plant is shown in Table 3.22. Gas distribution data are shown in Table 3.23.

Table 3.21 CH_4 emission from natural gas transmission

TRANSMISSION		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Transmission rate Mm^3	1)	2739	3496	3616	3992	4321	4689	5705	6956	6641	6795	7079	7289	7287
CH_4 emission Mg	2)		310	93	186	151	536	183	235	156	191	86	157	78
CH_4 IEF kg/Mm^3	3)	88,62	88,62	25,65	46,64	34,98	114,27	36,00	33,78	23,49	28,11	12,15	21,54	10,70

1) In 1990-1997 transmission rates refers to Danish energy statistics, in 1998 transmission rate refers to the annual environmental report of DONG, in 1999-2002 emissions refers to DONG/Danish Gas Technology Centre (Karll 2003)
2) In 1991-95 CH4 emissions are based on the annual environmental report from DONG for the year 1995. In 1996-99 the CH4 emission refers to the annual environmental reports from DONG for the years 1996-99. In 2000-2002 the CH4 emission refers to DONG/Danish Gas Technology Centre (Karll 2003)
3) IEF=Emission/transmission_rate. In 1990 the IEF is assumed to be the same as in 1991

Table 3.22 Additional fugitive CH_4 emissions from natural gas storage facilities and venting in gas treatment plant

	2000	2001	2002
Gas treatment plant	7,55 Mg	0 Mg	67
Gas storage facilities	76,48 Mg	72,68 Mg	

Table 3.23 CH_4 emission from natural gas distribution

DISTRIBUTION		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Distribution rate Mm^3	1)	1574	1814	1921	2185	2362	2758	3254	3276	3403	3297	3181	3675	3420
CH_4 emission Mg	2)										43	49	56	38,9
CH_4 IEF kg/Mm^3	3)	14,56	14,56	14,56	14,56	14,56	14,56	14,56	14,56	14,56	13,04	15,40	15,24	11,37

1) In 1999-2002 distribution rates refers to DONG / Danish Gas Technology Centre / Danish gas distribution companies (Karll 2003), In 1990-98 distribution rates are estimated from the Danish energy statistics. Distribution rates are assumed to equal total Danish consumption rate minus the consumption rates of sectors that receive the gas at high pressure. The following consumers are assumed to receive high pressure gas: Town gas production companies, production platforms and power plants
2) Danish Gas Technology Centre / DONG/ Danish gas distribution companies (Karll 2003)
3) In the years 1999-2002 IEF=CH_4 emission / distribution rate. In 1990-1998 an average IEF of 1999-2001 is assumed.

3.5.2.3 Flaring, gas (CRF sector 1B2c, Flaring ii)

Emissions from off shore flaring are estimated based on data for fuel consumption from the Danish energy statistics (DEA 2003b) and emission factors for flaring. The emissions from flaring in gas treatment and gas storage plants are estimated based on annual environmental reports of the plants.

The fuel consumption rates are shown in Table 3.24. Flaring rates in gas treatment and gas storage plants are not available until 1995.

The emission factors for off shore flaring are shown in Table 3.25. The CO_2 emission factor follows the same time-series as natural gas combusted in stationary combustion plants. All other emission factors are constant in 1990-2002.

The time-series for CO_2 emission from gas flaring fluctuates due to fluctuation of off shore flaring rates as shown in figure 3.20.

Table 3.24 Natural gas flaring rate (DEA 2003b)

Year	Flaring, off shore [TJ]	Gas treatment and gas storage [TJ]
1990	4218	-
1991	8692	-
1992	8977	-
1993	7819	-
1994	7709	-
1995	5964	43
1996	6595	30
1997	9629	35
1998	7053	29
1999	15509	32
2000	10023	29
2001	10806	36
2002	8901	44

Table 3.25 Emission factors for off shore flaring of natural gas

Pollutant	Emission factor	
CO_2	57,28	kg/GJ
CH_4	161,5	g/GJ
N_2O	1	g/GJ
SO_2	0,3	g/GJ
NO_x	308	g/GJ
NMVOC	87,2	g/GJ
CO	200	g/GJ

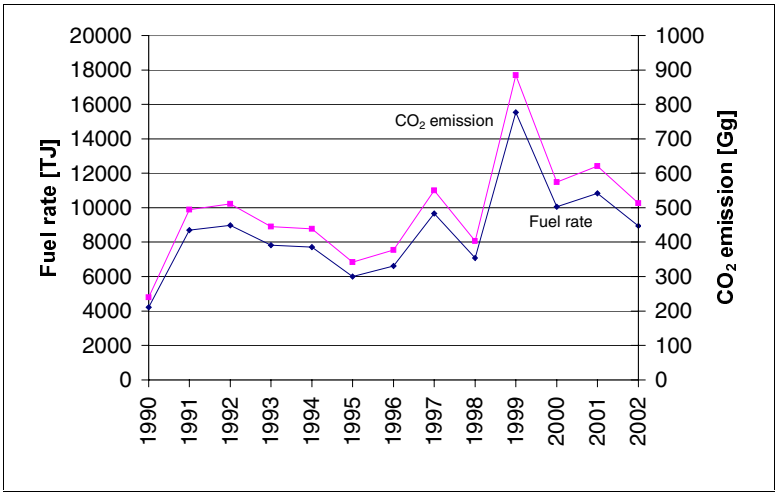

Figure 3.20 time-series for gas flaring and CO_2 emission in sector 1B2c ii Flaring, gas

3.5.2.4 Fugitive emissions from oil (1.B.2.a)

Oil Refineries – Petroleum products processing: In the production process at the refineries a part of the volatile hydrocarbons (VOC) is emitted to the atmosphere. It is assumed that CH_4 accounts for 1 % and NMVOC for 99% of the emissions. The VOC emissions from petroleum refinery processes

cover non-combustion emissions from feed stock handling/storage, petroleum products processing, product storage/handling and flaring. SO_2 is also emitted from the non-combustion processes and includes emissions from products processing and sulphur recovery plants. The emission calculations are based on information form the Danish refineries and the Energy statistic.

Table 3.26 Oil Refineries. Processed crude oil, emissions and emission factors

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Crude oil (1000 Mg)	7263	7798	8232	8356	8910	9802	10522	7910	7906	8106	8406	8284	8045
CH4 emission (Mg)	37	39	42	43	57	48	62	45	45	45	50	44	43
CH4 emission factor (g/Mg)	5	5	5	5	6	5	6	6	6	6	6	5	5
NMVOC emission (Mg)	3667	3937	4203	4219	5855	4546	5875	4547	4558	4558	4983	4338	4302
NMVOC emission factor (g/Mg)	505	505	511	505	657	464	558	575	577	562	593	524	535

3.5.3 Uncertainties and time-series consistency

Estimation of uncertainty is based on the Tier 1 methodology in IPCC Good Practice Guidance. Results of the uncertainty estimates are shown in Table 3.27.

Table 3.27 Uncertainty, CRF sector 1B Fugitive emissions

Pollutant	Uncertainty of emission inventory [%]	Uncertainty of emission trend [%]
CO_2	16	47
CH_4	98	90
N_2O	52	47
GHG	**23**	**60**

The activity rate uncertainty for fugitive emissions from solid fuels (coal import) is assumed to be 2% referring to GPG. The uncertainty of the post mining emission factor is assumed to be 200% also referring to GPG.

Uncertainty of activity rates for oil and gas activities is 15% referring to GPG. The uncertainty of emissions factors for CO_2 is the uncertainty of emissions factors for flaring. This emission factor uncertainty is 5% (GPG). Uncertainties of CH_4 and N_2O emission factors are both assumed to be 50%.

Table 3.28 Uncertainty of activity rates and emission factors

	Uncertainty Activity rate	Uncertainty Emission factor
CO_2	15	5
CH_4, solid fuel	2	200
CH_4, oil and gas	15	50
N_2O	15	50

3.5.4 Source-specific QA/QC and verification

No source-specific QA/QC and verification is performed.

3.5.5 Source-specific recalculations

3.5.5.1 Fugitive emission from solid fuels, CRF sector 1B1c

No recalculation has been carried out since last year.

3.5.5.2 Fugitive emissions from natural gas, transmission and distribution (CRF sector 1B2b)

Last year the emission from transmission and distribution of natural gas was unintentionally added in the CRF sector *1B2bii Transmission*. This year transmission and distribution is reported

separately in CRF. The total emission is not changed. The activity data reported last year was misleading and have been corrected.

3.5.5.3 Flaring, gas (CRF sector 1B2c, Flaring ii)

No recalculation has been carried out since last year.

3.5.6 Source-specific planned improvements

No improvements are planned in this sector.

3.5.7 References

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4 Industrial processes (CRF Sector 2)

4.1 Overview of the sector

The aim of this chapter is to present industrial emissions of greenhouse gases not related to generation of energy. An overview of the identified sources is presented in Table 4.1 with an indication of the contribution to the industrial part of the emission of greenhouse gases in 2002. The emissions are extracted from the CRF tables and presented rounded.

Table 4.1 Overview of industrial greenhouse gas sources (2002).

Process	Code	Gas	Emission tonnes CO_2-eq.	%	Comment
Cement	2A		1,451,771	47.06%	Key-source (2.1% of the total emission of greenhouse gases)
Nitric acid	2B	N_2O:	774,070	25.09%	Key-source (1.1%)
Refrigeration	2F	HFCs+PFCs	520,860	16.88%	Key-source (1.0% when including foam blowing)
Foam blowing	2F	HFCs	160,040	5.19%	
Lime (quicklime)	2A		96,359	3.12%	0.2% when including production of bricks and tiles
Bricks and tiles	2A		27,384	0.89%	
Other	2F	PFCs+ SF_6:	15,689	0.51%	
Container glass	2A		14,640	0.47%	
Aerosols / Metered dose inhalers	2F	HFCs	9,870	0.32%	
Electrical equipment	2F	SF_6:	9,560	0.31%	
Catalysts / fertilisers	2B		3,121	0.10%	
Glass wool	2A		1,629	0.05%	
Steelwork	2C				Production was stopped in 2002; in 2001 the CO_2 emission was estimated to be 46,677 ton
Expanded clay products	2A		-	-	Will be included
Quicklime for sugar production	2A		-	-	Will be included
Iron foundries; coke as reducing agent	2C		-	-	Potential contribution will be investigated
			3,084,993[1]	100.00%	

[1)] CRF, table 10/5 sums up to 3,084.87 1000^3 tonnes CO_2-eq.; the difference may be explained by different rounding.

The sub-sector *Mineral products* (2A) constitute 52%, *Chemical industry* (2B) constitute 25%, and *Consumption of halocarbons and* SF_6 (2F) constitute 23% of the industrial emissions of greenhouse

gasses. The total emission of greenhouse gases (excl. LUCF) in Denmark is estimated to 68.5 Mt CO_2-equivalents of which the industrial processes contribute with 3.1 Mt CO_2-equivalents (4.5%). The key-sources constitute 1-2% of the total emission of greenhouse gases. The trends in greenhouse gases are presented in Table 4.2 and discussed sector by sector below. The emissions are extracted from the CRF tables and presented rounded off.

Table 4.2 Survey of greenhouse gases from industrial processes in different sub-sectors from 1990-2002 (1000^3 tonnes).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
CO_2													
A. Mineral Products	1021	1194	1313	1326	1326	1326	1402	1569	1571	1490	1526	1551	1592
B. Chemical Industry	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.9	1.4	1.8	2.7	3.1	3.1
C. Metal Production	28	28	28	31	34	39	35	35	42	43	41	47	0
N_2O													
B. Chemical Industry	3.4	3.1	2.7	2.6	2.6	2.9	2.7	2.7	2.6	3.1	3.2	2.9	2.5
HFCs (Gg CO_2 eq.)													
F. Consumption of Halocarbons and SF_6	0.0	0.0	3.4	93.9	135	218	330	324	411	503	605	647	672
PFCs (Gg CO_2 eq.)													
F. Consumption of Halocarbons and SF_6	0.0	0.0	0.0	0.0	0.1	0.5	1.7	4.1	9.1	12.5	17.9	22.1	22.2
SF_6 (Gg CO_2 eq.)													
F. Consumption of Halocarbons and SF_6	44.5	63.5	89.1	101	122	107	61.0	73.1	59.5	65.4	59.2	30.4	21.6

CH_4 will probably be emitted from some of the sources leading to emission of CO_2; this emission will be investigated and included in the next inventory.

Note that for the F-gases (HFCs, PFCs and SF_6) the inventories - as can be seen from the CRF tables - might not constitute full coverage of emissions for 1990-1994. For these gases 1995 is considered as the base year.

The present inventory has been improved to cover especially nitric acid production and a part of the metal industry (steelwork) as response to the last review report from UNFCCC (FCCC/WEB/IRI(3)/2003/DKN). Activity data has been included in the CRF tables for "Other production", where breweries results in emission of NMVOC but no N_2O.

A number of improvements have been planned as e.g. inclusion of iron foundries (as suggested in the review report), use of limestone in production of sugar, and manufacturing of products of expanded clay.

As regards other sources pointed out by the reviewers, please refer to the notation keys in the CRF-tables for details regarding industries not present in Denmark as e.g. ammonia production, adipic acid production, production of primary metals (e.g. aluminium and iron).

4.2 Mineral products (CRF Sector 2A)

4.2.1 Source category description

The sub-sector *Mineral products* (2A) covers the following processes:

- Production of cement (SNAP 040612)
- Production of lime (quicklime) (SNAP 040614)
- Production of bricks and tiles (SNAP 040614)
- Production of container glass/glass wool (SNAP 040613)
- Production of products from expanded clay (SNAP 040614)

Production of cement is identified as a key-source; see *Annex 1: Key sources*. CO_2 emissions from expanded clay products are not included in the present NIR.

The time-series for emission of CO_2 from *Mineral products* (2A) are presented in Table 4.3. The emissions are extracted from the CRF tables and presented rounded off.

Table 4.3 Time-series for emission of CO_2 (1000^3 tonnes) from *Mineral products*.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1. Production of Cement	882	1088	1192	1206	1192	1204	1282	1441	1452	1365	1406	1432	1452
2. Production of Lime and Bricks	123	91	106	106	119	108	106	114	103	107	105	104	124
7. Other[1]	16	16	15	14	15	14	14	14	15	18	16	16	16
Total	1021	1194	1313	1326	1326	1326	1402	1569	1571	1490	1526	1551	1592

[1)] Production of container glass and glass wool.

The increase in CO_2 emission is most significant for production of cement. From 1990 to 2002 the CO_2 emission has increased from 1021 to 1592 1000^3 tonnes CO_2 i.e. 56%. The increase can be explained by the increase in the annual production. The emission factor has only changed slightly as the distribution between types of cement especially grey/white cement has been almost constant from 1990-2002.

4.2.2 Methodological issues

The CO_2 emission from production of cement has been estimated from the annual production of cement expressed as TCE (total cement equivalents[3]) and an emission factor from the company (Aalborg Portland, 2003). The emission factor has been estimated by the company from loss of ignition determined for the different kinds of clinkers produced combined with produced amount of grey and white cements. Determination of loss of ignition takes into account all the potential raw materials leading to release of CO_2 and omits the Ca-sources leading to generation of CaO in cement clinker without CO_2 release. The applied methodology is not in accordance with the IPCC-guideline (IPCC (1999) p. 3.10ff) that requires information on production of different types of clinker and corresponding emission factors.

The CO_2 emission from production of burnt lime (quicklime) has been estimated from the annual production of burnt lime as measured by Statistics Denmark (2003) and an emission factor (0.785 kg CO_2/kg CaO) as recommended by IPCC (IPCC (1996), vol. 3, p. 2.8). Hydrated lime (slaked lime) has not been included in the present estimate and the emission factor has not been corrected for potential content of impurities in the final product (e.g. SiO_2 etc.).

The CO_2 emission from production of bricks and tiles has been estimated from information of annual production measured by Statistics Denmark corrected for amount of yellow bricks and tiles. This amount is unknown and therefore assumed to be 50%. The content of $CaCO_3$ and a number of other factors determine the colour of bricks and tiles, and in the present estimate the average content of $CaCO_3$ in clay has been assumed to be 18%. The emission factor (0.44 kg CO_2/kg $CaCO_3$) is based on stoichiometric determination.

For further details on the CO_2 estimation from production of burnt lime and from production of bricks which constitutes a combined activity in the CRF sector activities, refer to Annex 3.C.

The CO_2 emission from production of container glass/glass wool has been estimated from production statistics published in environmental reports from the producers (Rexam Glass Holmegaard, 2002; Saint-Gobain Isover, 2003) and emission factors based on release of CO_2 from specific raw materials (stoichiometric determination).

4.2.3 Uncertainties and time-series consistency

The time-series are presented in Table 4.3. The methodology applied for the years 1990-2002 is considered to be consistent, as the emission factor has been determined by the same approach for all years. The emission factor has only changed slightly as the distribution between types of cement especially grey/white cement has been almost constant from 1990-2002.

For production of lime and bricks as well as container glass and glass wool the same methodology has also been applied for all years. The emission factors are either based on stoichiometric relations or at a standard assumption of $CaCO_2$ content of clay used for bricks.

No source-specific uncertainties have been determined for this sub-sector.

4.2.4 Source-specific QA/QC and verification

The information obtained from specific companies has been compared with default emission factors given in the IPCC guidelines to ensure that they are plausible and in the proper order of mag-

[3] TCE (total cement equivalent) express the total amount of cement produced for sale and the theoretical amount of cement from the produced amount of clinkers for sale.

nitude. The data treatment and transfer from the database to the CRF tables has been controlled as described in the general section on quality assurance/quality control.

4.2.5 Source specific recalculations

No source specific recalculations have been performed regarding emissions from production of mineral products. However, a minor change has been introduced for production of cement, as the activity data for 1998-2001 has been changed to include production of cement clinker for final manufacturing elsewhere. The trend and the size of the recalculation can be found in the table in Chapter 10.3.

4.2.6 Source-specific planned improvements

Regarding production of cement a dialogue with the company will be continued with the aim to get more detailed information on production statistics (i.e. production of different types of clinker) and corresponding emission factors.

The statistics for production of burnt lime will be improved to include hydrated lime and the emission factor will be corrected for impurities in the final product.

Production statistics for glass and glass wool as well as information on consumption of raw materials will be completed for 1990-1995.

The emission of CO_2 from products of expanded clay is not included for the moment. However, this source will be investigated and included in the next NIR.

4.3 Chemical industry (CRF Sector 2B)

4.3.1 Source category description

The sub-sector *Chemical industry* (2B) cover the following processes:

- Production of nitric acid/fertiliser (SNAP 040402/040407)
- Production of catalysts/fertilisers (SNAP 040416/040407)

Production of nitric acid is identified as a key-source.

The time-series for emission of CO_2 and N_2O from *Chemical industry* (2B) are presented in Table 4.4.

The emissions are extracted from the CRF tables and presented rounded off.

Table 4.4 Time-series for emission of GHG from *Chemical industry* (1000^3 tonnes CO_2 eqv.).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
2. Nitric acid production (N_2O)	1043	955	844	795	807	904	834	848	807	950	1004	885	774
5. Other[1] (CO_2)	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.9	1.4	1.8	2.7	3.1	3.1
Total	1045	957	845	797	808	906	836	850	808	952	1006	888	777

1. Production of catalysts/fertilisers.

The emission of N_2O from nitric acid production is the most considerable source of GHG from chemical industry. The trend for N_2O from 1990 to 2002 shows a decrease from 3.4 to 2.5 kt, i.e. 26%. However, the activity and the corresponding emission show considerable fluctuations in the considered period.

From 1996 to 2002 the emission of CO_2 has increased from 1.7 to 3.1 kt, i.e. 82%, due to increase in activity.

4.3.2 Methodological issues

The N_2O emission from production of nitric acid/fertiliser is based on measurement for 2002 (Kemira GrowHow, 2003; Kemira GrowHow, Mogens Bjerre, personal communication). For the previous years the N_2O emission has been estimated from annual production statistics from the company and an emission factor based on the measured 2002 emission.

The CO_2 emission from production of catalysts/fertiliser is based in information in the environmental report from the company (Haldor Topsøe, 2003). In the environmental report, the company has estimated the amount of CO_2 from the process and the amount from energy conversion. For the years 1990-1995 the production as well as the CO_2 emission has been assumed to be the same as in 1996.

4.3.3 Uncertainties and time-series consistency

The time-series are presented in Table 4.4. The applied methodology regarding N_2O is considered to be consistent. The activity data is based on information from the specific company and the applied emission factor has been constant from 1990 to 2001 and based on measurements in 2002. The production equipment has not been changed during the period.

The consistency of the methodology applied for determination cannot be assessed from the available information as the specific company has given a general distribution of CO_2 from energy conversion and processes.

No source-specific uncertainties have been determined for this sub-sector.

4.3.4 Source-specific QA/QC and verification

The information obtained from specific companies has been compared with default emission factors given in the IPCC guidelines to ensure that they are plausible and in the proper order of magnitude. The data treatment and transfer from the database to the CRF tables has been controlled as described in the general section on quality assurance/quality control.

4.3.5 Source specific recalculations

N_2O emissions from nitric acid production have been included for the time-series 1990-2002. The potential of this source as N_2O emitter was pointed out in the review report.

4.3.6 Source-specific planned improvements

The applied emission factor for N_2O from production of nitric acid is based on measurement from one year and this factor will be improved or validated before preparation of the next NIR.

The emission of CO_2 from production of catalysts/fertilisers will be validated be further contact to the company to get further detail on processes leading to generation of CO_2. The production statistics as well as emission of CO_2 will be completed for 1990-1995.

4.4 Metal production (CRF Sector 2C)

4.4.1 Source category description

The sub-sector *Metal production* (2C) cover the following process:

- Steelwork (SNAP 040207)
- Iron foundries (SNAP 030303/0402)

CO_2 emissions from iron foundries are not included in the present NIR.

The time-serie for emission of CO_2 from *Metal production* (2C) is presented in Table 4.5. The emissions are extracted from the CRF tables and presented rounded.

Table 4.5 Time-serie for emission of CO_2 (kt) from *Metal production* .

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1. Iron and steel production	28	28	28	31	34	39	35	35	42	43	41	47	NO/ NE[1]

1. The activity has been stopped in the first half of 2002 to bankruptcy and therefore information for 2002 is not available.

From 1990 to 2001 the CO_2 emission has increased from 28 to 47 1000^3 tonnes i.e. 68%. The increase in CO_2 emission is similar to the increase in the activity as the consumption of metallurgical coke per produced amount of steel sheets and bars has nearly been constant during the period.

4.4.2 Methodological issues

The CO_2 emission from consumption of metallurgical coke at steelwork has been estimated from the annual production of steel sheets and steel bars combined with consumption of metallurgical coke per produced amount (Stålvalseværket, 2002). The carbon source is assumed to be coke and all the carbon is assumed to be converted to CO_2 as the carbon content in the products is assumed to be the same as in the iron scrap. The emission factor (3.6 tonnes CO_2/ton metallurgical coke) is based on values in the IPCC guideline (IPCC (1996), vol. 3, p. 2.26). Emissions of CO_2 for 1990-1991 and for 1993 have been determined with extrapolation and interpolation, respectively.

4.4.3 Uncertainties and time-series consistency

The time-serie shown in Table 4.5 is considered to be consistent as the same methodology has been applied for the whole period. The activity, i.e. produced amount of steel sheets and bars as well as consumption of metallurgical coke, has been published in environmental reports. The emission factor (consumption of metallurgical coke per tonnes of product) has been almost constant from 1994 to 2001. For the remaining years the same emission factor has been applied. In 2002 the production has been stopped.

No source-specific uncertainties have been determined for this sub-sector.

4.4.4 Source specific recalculations

CO_2 emissions from steelworks have been included for the time-series 1990-2001. The possibility of this source was pointed out in the review report.

4.4.5 Source-specific QA/QC and verification

The data treatment and transfer from the database to the CRF tables has been controlled as described in the general section on quality assurance/quality control.

4.4.6 Source-specific planned improvements

Production statistics and information on consumption of raw materials will be completed for 1990-1993. The mass balance (i.e. produced amounts of steel bars and steel sheets as well as consumption of metallurgical coke) for the steelwork will be improved/verified.

The emission of CO_2 from iron foundries is not included for the moment. However, this source will be investigated and included in the next NIR.

4.5 Production of Halocarbons and SF_6 (CRF Sector 2E)

There is no production of Halocarbons and SF_6 in Denmark.

4.6 Metal Production (CRF Sector 2C) and Consumption of Halocarbons and SF_6 (CRF Sector 2F)

4.6.1 Source category description

The sub-sector *Consumption of halocarbons and SF_6* (2F) includes the following source categories and the following F-gases of relevance for Danish emissions:

- 2C: SF6 used in Magnesium Foundries SNAP 040304 SF6
- 2F: Refrigeration SNAP 060502 HFC32, 125, 134a, 152a, 143a, PFC (C_3F_8)
- 2F: Foam blowing SNAP 060504 HFC134a, 152a
- 2F: Aerosols/Metered dose inhalers SNAP 060506 HFC134a
- 2F: Production of electrical equipment SNAP 060507 SF_6
- 2F: Other processes SNAP 060508 SF_6, PFC (C_3F_8)

A quantitative overview is given below for each of these source categories and each F-gases showing their emissions in tons through the times series. The data are extracted from the CRF tables that are part of this submission and presented data are rounded off. It must be noticed that the inventories for the years 1990-1993(1994) might not in fully cover emissions from these gases. The choice of Denmark for the base year for these gases is 1995.

Table 4.6 Consumption of SF_6 used in Magnesium foundries.

2C	SF6 Used in Magnesium Foundries (t)												
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
SF6	1,30	1,30	1,30	1,50	1,90	1,50	0,40	0,60	0,70	0,70	0,89	NO	NO

Table 4.7 Consumption HFCs and PFCs in refrigeration and air condition equipment.

2F	Refrigeration (t)												
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
HFC 32	NE	NE	NE	NE	NE	0,1	0,8	1,8	2,7	3,8	5,7	7,33	8,4
HFC125	NE	NE	NE	NE	0,2	2,6	9,5	15,8	21,8	31,7	43,1	45,05	48,5
HFC134a	NE	NE	0,3	2,6	10,3	14,3	16,3	34,2	45,9	94,3	111,5	127,57	151,3
HFC152a	NE	NE	NE	NE	NE	0,0	0,0	0,1	0,4	0,5	0,6	0,58	0,5
HFC143a	NE	NE	NE	NE	0,2	2,4	8,6	13,7	19,3	29,1	39,6	40,09	43,2
PFC (C3F8)	NE	NE	NE	NE	0,0	0,1	0,2	0,6	1,3	1,8	2,3	2,64	2,7

Table 4.8 Consumption of HFCs in foam blowing.

2F	Foam blowing (t)												
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
HFC 32	NE	NE	NE	NE	NE	NO	NO	NO	NO	NO	NO	3,7	0,0
HFC125	NE	NE	NE	NE	NE	NO	NO	NO	NO	NO	NO	3,7	0,0
HFC134a	NE	NE	2,0	66,4	87,1	135,8	187,5	138,2	164,1	125,0	127,4	131,94	121,8
HFC152a	NE	NE	3,0	30,0	46,0	43,4	32,2	15,2	9,3	37,7	16,2	12,82	12,5

Table 4.9 Consumption of HFCs in aerosols/metered dose inhalers.

2F	Aerosols (t)												
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
HFC134a	NO	NO	NO	NO	NO	NO	NO	NO	0,6	8,1	12,9	9,24	7,6

Table 4.10 Consumption of SF_6 in electrical equipment.

2F	Electrical Equipment (t)												
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
SF6	0,06	0,11	0,11	0,12	0,14	0,16	0,18	0,38	0,27	0,48	0,47	0,53	0,40

Table 4.11 Consumption of PFCs and SF_6 in other processes.

2F	Other (t)												
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
SF6	0,50	1,25	2,32	2,61	3,07	2,83	1,97	2,08	1,52	1,55	1,12	0,75	0,51
PFC (C3F8)	NO	NO	NO	NO	NO	NO	NO	NO	0,00	0,00	0,27	0,52	0,50

The emission of SF_6 has been decreasing in recent years due to the fact that no activity on Magnesium Foundry exists any longer and due to a decrease in the use of electric equipment. Also a decrease in "other", which for SF_6 is used in window plate production use, laboratory use and use in running footwear is occurring.

The emission of HFCs has decreased for the use as a refrigerant and in foam blowing. There is a stagnant tendency 2001-2002. The F-gases are as of March 1, 2001 regulated in two ways. For some types of use there is a ban to use the gases in new installations and for other types of use there is taxation. These regulations seem to have the influence that emissions are stagnant.

The table below quantifies an overview of the emissions of the gases in CO_2 eqv. The reference is the trend table as included in the CRF table for year 2002.

Table 4.12 Time-series for emission of HFCs, PFCs and SF_6.

GREEN-HOUSE GAS EMISSIONS	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
	CO_2 equivalent (Gg)												
HFCs	0,00	0,00	3,44	93,93	134,53	217,73	329,30	323,75	411,20	502,98	604,64	647,32	672,10
PFCs	0,00	0,00	0,00	0,00	0,05	0,50	1,66	4,12	9,10	12,48	17,89	22,13	22,17
SF_6	44,45	63,50	89,15	101,17	122,06	107,36	60,99	73,09	59,46	65,39	59,25	30,43	21,63

The decrease in SF_6 emission has brought its emissions in CO_2 eqv. down to the level of PFC. Seen together and for all uses the by far most dominant group is HFCs. In this grouping the HFCs constitute a key source both with regard to the key source level and trend analysis. In the level analysis the group of HFCs are number 18 out of 21 key sources and they contribute in 2002 to 1.0% of the National total.

4.6.2 Methodological issues

The data for emissions of HFCs, PFCs, and SF_6 has been obtained in continuation of work on inventories for previous years. The determination includes the quantification and determination of any import and export of HFCs, PFCs, and SF_6 contained in products, and takes into account the substances in stock form. This is in accordance with the IPCC-guideline (IPCC (1996), vol. 3, p. 2.43ff).

The following sources of information has been used:

- Importers, agency enterprises, wholesalers, and suppliers
- Consuming enterprises, and trade and industry associations
- Recycling enterprises and chemical waste recycling plants
- Statistics Denmark
- Danish Refrigeration Installers' Environmental Scheme (KMO)
- Previous evaluations of HFCs, PFCs, and SF_6

Data is primarily based on respondents from enterprises and importers resulting from a questionnaire survey.

The Tier 2 - bottom-up analysis used for determination of emissions from HFCs, PFCs, and SF_6 covers the following activities:

- Screening of the market for products in which F-gases are used
- Determining of averages for the content of F-gases per product unit
- Determination of emissions during the lifetime of products and disposal
- Identification of technological development trends that have significance for the emission of F-gases
- Calculation of import and export on the basis of defined key figures, and information from Statistics Denmark on foreign trade and industry information

The determination of emissions of F-gases is based on a calculation of the actual emission. The actual emission is the emission in the evaluation year, accounting for the time laps between con-

sumption and emission. The actual emission includes Danish emissions from production, from products during their lifetimes, and from waste products.

Consumption and emissions of F-gases are wherever possible carried out for individual substances, even though the consumption of certain HFCs has been very limited. This has been done to ensure transparency of evaluation in the determination of GWP-values. However, the continued use of a category for *Other HFCs* has been necessary since not all importers and suppliers have specified records of sales for individual substances.

The potential emissions have been calculated as follows:

Potential emission = import + production - export - destruction/treatment

The substances have in the survey been accounted for according to their trade names, which are mixtures of HFCs used in the CRF etc. In the transfer to the "pure" substances used in the CRF reporting schemes the following relations has been used.

Table 4.13 Time-series for emission of HFCs, PFCs and SF_6.

Pure HFCs HFC Mixtures	HFC-32	HFC-125	HFC-134a	HFC-143a	HFC-152a
HFC-401a					13%
HFC-402a		60%			
HFC-404a		44%	4%	52%	
HFC-407a	23%	25%	52%		
HFC-410a		7%		46%	
HFC-507a		50%		50%	

The survey on the F-gases is reported yearly by the Danish Environmental Protection Agency and the data are kept and calculations performed in spreadsheets. The latest report is available in English from the Danish Environmental Protection Agency (2004a).

4.6.3 Uncertainties and time-series consistency

The time-series for emission of Halocarbons and SF_6 are presented in Chapter 1.2.1 where it was also mentioned that fully consistency in the time-series as regards coverage of the sources is achieved from 1994 (1995). For the whole time-series the same model are used for the data presented in this submission and model parameters are not changed during the time-series.

The uncertainty varies from substance to substance. Uncertainty is greatest for HFC-134a due to a widespread application in products that are imported and exported. The greatest uncertainty in the areas of application is expected to arise from consumption of HFC-404a and HFC-134a in commercial refrigerators and mobile refrigerators. The uncertainty on year to year data is influenced by the uncertainty on the rates at which the substances are released. This results in significant differences in the emission determinations in the short term (approx. five years), differences that balances in the long term.

4.6.4 Source-specific QA/QC and verification

A very comprehensive QC procedure on the data in the model for the whole time-series has for this submission been carried out in connection to the process which provided (1) data for the CRF background Tables 2(II).F. for the years (1993)-2002 and (2) provided data for potential emissions in CRF Tables 2(I). This procedure consisted of a check of the input data for the model for each

substance. As regards the HFCs this checking was done according to their trade names. Conversion was made to the HFCs substances used in the CRF tables etc. A QC was that emission of the substances could be calculated and checked comparing results from the substances as trade names and as the "no-mixture" substances used in the CRF.

4.6.5 Source-specific recalculations

Revisions of the methodology for F-gases emissions were made in spring 2003. However, the full revision was in the April 15, 2003 submissions only made for year 2001. In this submission the full revision for the whole time-series 1990-2002 as regards emissions of F-gases is introduced. This means in this submission recalculated emissions for the years 1990-2000. Further, as explained above data has now been provided to the background Tables 2(II).F. for the years (1993)-2002. This was also a result of a recommendation of the review team. Finally, potential emissions for F-gases in Table 2(I)s2 has been revised also according to the new methodology.

4.6.6 Source-specific planned improvements

It is planned to improve uncertainty estimates and QA/QC procedures.

4.7 References

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5 Solvents and other product use (CRF Sector 3)

5.1 The present NMVOC inventory

Use of solvents is an important source of evaporation of NMVOC and contributed in 2001 with approximately 31 % of the total NMVOC emission. The most important sectors for industrial use of solvents are: Car repairing and treatment, chemical industry, paint application in iron and steel industry, paint manufacturing, the plastic industry, the foodstuff industry, preservation of wood and the printing industry. For these sectors the Government and the industries agreed to reduce the emissions of NMVOC by 40 % from 1988 to 2000. The reduction targets for each trade was estimated by trades and companies.

As a part of an agreement between the Danish Industry and the Danish Environmental Protection Agency the emissions from various industries have been reported to the Danish EPA. The reporting is not annual and linear interpolation is used between the reporting years.

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 (cf. EPA, 1995, no. 50, VOC reduction plants (in Danish). The emission trends are given in Table 5.1.

It is important to notice that not all the use of solvents are included in this agreement and no activity data has been available. A work is going on to improve the emission estimates and in Chapter 5.2 a brief description of the new methodology is given.

5.2 The new methodology regarding solvents

The emissions of Non-Methane Volatile Organic Carbon (NMVOC) from industrial and household use in Denmark has been assessed. Until now the NMVOC inventory in Denmark has been based on questionnaires and interviews with different industries, regarding emissions from specific activities, such as lacquering, painting impregnation etc. However, this approach implies large uncertainties due to the diverse nature of many solvent using processes. For example, it is inaccurate to use emission factors derived from one printwork in an analogue printwork, since the type and combination of inks may vary considerably. Furthermore the employment of abatement techniques will result in loss of validity of estimated emission factors.

A new approach has been introduced, focusing on single chemicals instead of activities. This will lead to a clearer picture of the influence from each specific chemical, which will enable a more detailed differentiation on products and the influence of product use on emissions.

The procedure is to quantify the use of the chemicals and estimate the fraction of the chemicals that is emitted as a consequence of use. Mass balances are simple and functional methods for calculating the use and emissions of chemicals

$$use = production + import - export - destruction/disposal - hold\ up \quad \text{(Eq. 1)}$$

$$emission = use * emission\ factor \quad \text{(Eq. 2)}$$

where "hold up" is the difference in the amount in stock in the beginning and at the end of the year of inventory.

A mass balance can be made for single substances or groups of substances, and the total amount of emitted chemical is obtained by summing up the individual contributions. It is important to perform an in-depth investigation in order to include all relevant emissions from the large amount of chemicals. The method for a single chemical approach is shown in Figure 5.1.

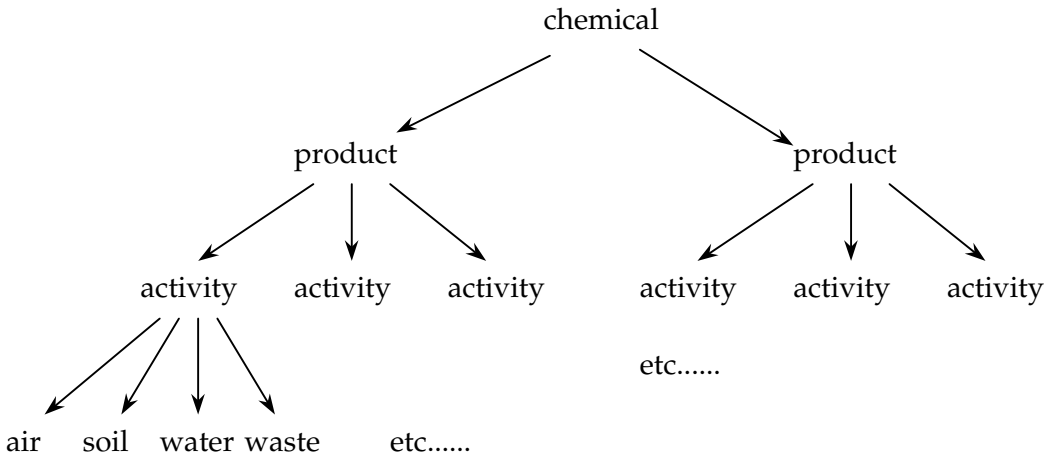

Figure 5.1 Methodological flow in a chemical based emission inventory.

The tasks in a chemical focused approach are

1) Definition of chemicals to be included
2) Quantification of use amounts from Eq. 1
3) Quantification of emission factors for each chemical

In principle all chemicals that can be classified as NMVOC must be included in the analysis, which implies that it is essential to have an explicit definition of NMVOC. The definition of NMVOC is, however, not consistent; In the EMEP-guidelines for calculation and reporting of emissions, NMVOC are defined as "all hydrocarbons and hydrocarbons where hydrogen atoms are partly or fully replaced by other atoms, e.g. S, N, O, halogens) which are volatile under ambient air conditions, excluding CO, CO_2, CH_4, CFCs and halons". The amount of chemicals that fulfil these criteria is large, and a list of 650 single chemicals and a few chemical groups described in "National Atmospheric Emission Inventory", is used. It is probable that the major part will be insignificant in a mass balance, but it is not correct to exclude any chemicals before a more detailed investigation has been made.

Production, import and export figures are extracted from Statistics Denmark, from which a list of 427 single chemicals, a few groups and products is generated. For each of these a *use* amount in tonnes pr. year (from 1995 to 2003) is calculated. It is found that that 44 different NMVOC comprise over 95 % of the total use, and it is these 44 chemicals that are investigated further.

The *use* amounts are distributed according to the SNAP coding, defined in EMEP/CORINAIR Emission Inventory Guidebook, Group 6: Solvent and other product use. In the Nordic SPIN (Substances in Preparations in Nordic Countries) database information is available in a NACE coding system, on industrial use categories and products specified for individual chemicals. In order to perform a spatial disaggregation, by relating the chemicals to specific products and/or activities, the SNAP codes are coupled with NACE codes.

Emission factors, cf. Eq. 2, are obtained from regulators or the industry and can be provided on a site by site basis, or as a single total for whole sectors.

Outputs from the inventory are

- a list where the 44 most predominant NMVOCs are ranked according to emissions to air,
- specification of emissions from industrial sectors and from households,
- contribution from each NMVOC to emissions from industrial sectors and households,
- tidal (annual) trend in NMVOC emissions, expressed as total NMVOC and single chemical, and specified in industrial sectors and households.

Table 5.1 Use of solvents. NMVOC emissions for various sectors

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
0601	**Paint application**	0												
060101	Paint application : manufacture of automobiles													
060102	Paint application : car repairing	0	0	0	0	0	0	0	0	0	0			
060103	Paint application : construction and buildings	9452	9497	9542	9586	9631	9676	9721	9766	9810	9855	9900	9900	9900
060104	Paint application : domestic use (except 06.01.07	9452	9497	9542	9586	9631	9676	9721	9766	9810	9855	9900	9900	9900
060105	Paint application : coil coating													
060106	Paint application : boat building	0	0	0	0	0	0	0	0	0	0			
060107	Paint application : wood	6500	6192	5884	5576	5276	4960	4652	4344	4036	3728	3420	3420	3420
060108	Other industrial paint application	0	0	0	0	0	0	0	0	0	0			
060109	Other non industrial paint application													
0603	**Chemical products manufacturing or processing**													
060301	Polyester processing	470	478	486	494	502	510	518	526	534	542	550	550	550
060302	Polyvinylchloride processing													
060303	Polyurethane processing	3	3	3	3	3	3	3	4	4	4	4	4	4
060304	Polystyrene foam processing (c)	920	919	918	917	916	915	913	913	912	911	910	910	910
060305	Rubber processing													
060306	Pharmaceutical products manufacturing													
060307	Paints manufacturing	300	298	296	294	292	290	288	286	284	282	280	280	280
060308	Inks manufacturing													
060309	Glues manufacturing	24	23	22	20	19	18	17	16	14	13	12	12	12
0603010	Asphalt blowing													
0603011	Adhesive, magnetic tapes, films and photographs													
060314	Other	930	877	823	770	716	663	610	556	503	449	396	396	396
0604	**Other use of solvents and related activities**													
060401	Glass wool enduction													
060402	Mineral wool enduction													
060403	Printing industry	1575	1462	1349	1235	1122	1009	896	783	669	556	443	443	443
060404	Fat, edible and non edible oil extraction	1920	1893	1866	1839	1812	1785	1758	1731	1704	1777	1650	1650	1650
060405	Application of glues and adhesives	2700	2580	2460	2340	2220	2100	1980	1860	1740	1620	1500	1500	1500
060406	Preservation of wood	0	0	0	0	0	0	0	0	0	0			
060407	Underseal treatment and conservation of vehicles	1400	1345	1290	1290	1180	1125	1070	1015	960	905	850	850	850
060408	Domestic solvent use (other than paint application	6653	6807	6961	7115	7269	7423	7576	7730	7884	8038	8192	8192	8192
060409	Vehicles dewaxing													
060411	Domestic use of pharmaceutical products (k)													
060412	Other (preservation of seeds,…)	0	0	0	1696	0	0	0	0	0	0			

6 The emission of greenhouse gasses from the agricultural sector (CRF Sector 4)

The emission of greenhouse gases from the agricultural activities includes CH_4 emission from enteric fermentation and manure management and N_2O emission from manure management and agricultural soils. The emissions are reported in CRF Tables 4.A, 4.B(a), 4.B(b) and 4.D. Furthermore the emission of Non-methane volatile organic compounds (NMVOC) from agricultural soil is given in CRF Table 4s2.

Emission from rice production, burning of savannas and crop residues does not occur in Denmark and Table 4.C, 4.E and 4.F have therefore not been completed. Burning of plant residue has been prohibited since 1989 and may only take place in connection with cultivation of seed grass. It is assumed that the emission is insignificant and hence not included in the emission inventory.

6.1 Overview

Given in CO_2 equivalents the agricultural sector - without LULUCF - contributes with 15% of the overall greenhouse gas emission (GHG) in 2002. Next to the energy sector the agricultural sector is the largest source of GHG emission in Denmark. The major part of the emission is related to the livestock production, which in Denmark is dominated by the production of cattle and pigs. In 2002 the N_2O emission contributed with 63% of the total GHG emission and CH_4 with the remaining 37%.

From 1990 to 2002 the emissions have decreased from 12.8 Gg CO_2 eqv. to 10.1 Gg CO_2 eqv., which corresponds to a 21%-reduction (Table 6.1). In 2003 the GHG emission were recalculated. The re-estimated emission is lower than previous reported, but the reduction from 1990 to 2002 is at the same level. Further explanation is given in Chapter 6.8.

Table 6.1 Emission of GHG in the agricultural sector in Denmark 1990 – 2002 (CRF)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
	Gg CO_2 – eqv.												
N_2O	8 983	8 828	8 527	8 316	8 102	7 903	7 561	7 483	7 454	7 013	6 760	6 625	6 370
CH_4	3 842	3 874	3 883	3 968	3 934	3 931	3 953	3 863	3 907	3 786	3 804	3 845	3 764
Total	12 826	12 702	12 411	12 285	12 036	11 834	11 514	11 346	11 360	10 800	10 564	10 470	10 134

Figure 6.1 shows the distribution of greenhouse gas emission on the main sources. The decreased emissions can be associated with a decrease of N_2O emissions from agricultural soils due to an offensive national environmental policy during the last twenty years. The environmental policy has introduced a series of measures to prevent loss of nitrogen from the agriculture to the aquatic environment. The measures include improved utilisation of nitrogen in husbandry manure, ban on manure application in autumn and winter, increased area with winter green fields to catch nitrogen, a maximum number of animals per hectare and a maximum nitrogen application rates to agricultural crops. The result is a decrease in the N-excretion and emission per produced animal, which has reduced the overall emission of GHG.

From 1990 to 2002 there is no reduction in the estimated CH_4 emission. The emission from enteric fermentation has decreased. The decrease is explained by a fall in the number of cattle. But, on the other hand, the emission from manure management has increased due to the change to more slurry based stable systems, which has a higher emission factor. By coincidence the decrease and the increase have a size as to balance, so the trend for CH_4 emissions from 1990 to 2002 is about zero.

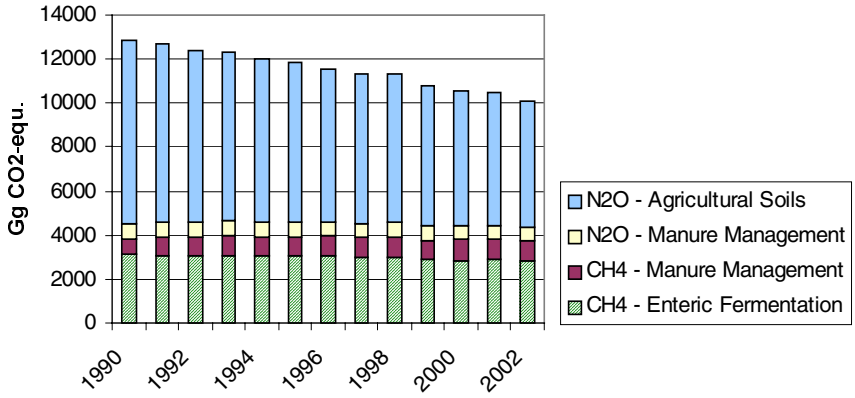

Figure 6.1 Danish greenhouse gas emission 1990 - 2002

6.1.1 References – sources of information

The calculations of the emissions are based on methods described in the IPCC Guideline (IPCC, 1996) and Good Practice Guidance (IPCC, 2000).

Activity data and emission factors are collected and discussed in corporation with specialists and researchers at different institutes such as the Danish Institute of Agricultural Sciences, Statistics Denmark, the Danish Agricultural Advisory Centre, the Danish Plant Directorate and the Danish Environmental Protection Agency. It means that both the data and the methods will be evaluated continuously according to the latest knowledge and information.

Table 6.2 List of institutes involved

References	Abbreviation	Data / information
National Environmental Research Institute	NERI	- reporting - data collecting
Statistics Denmark - Agricultural Statistic (www.dst.dk)	DS	- No. of animal - milk yield - slaughtering data - land use - crop production
Danish Institute of Agricultural Sciences	DIAS	- N-excretion - feeding situation - growth - N-fixed crops - crop residue - N-leaching/runoff - NH_3 emissions factor
The Danish Agricultural Advisory Centre	AAC	- stable type - grassing situation - manure application time and methods
Danish Environmental Protection Agency	EPA	- sewage sludge used as fertiliser - industrial waste used as fertiliser
The Danish Plant Directorate	PD	- organic farming - synthetic fertiliser (contribution and type)
The Danish Energy Authority	DEA	- manure used in bio gas plants

The emission estimates are calculated in a comprehensive agricultural model complex (DIEMA) covering ammonia, CH_4, N_2O and CO_2. Ammonia, CH_4 and N_2O are implemented in a great detail. The submodule covering LULUCF and CO_2 will be implemented in 2004. An overview of DIEMA is given in Figure 6.2.

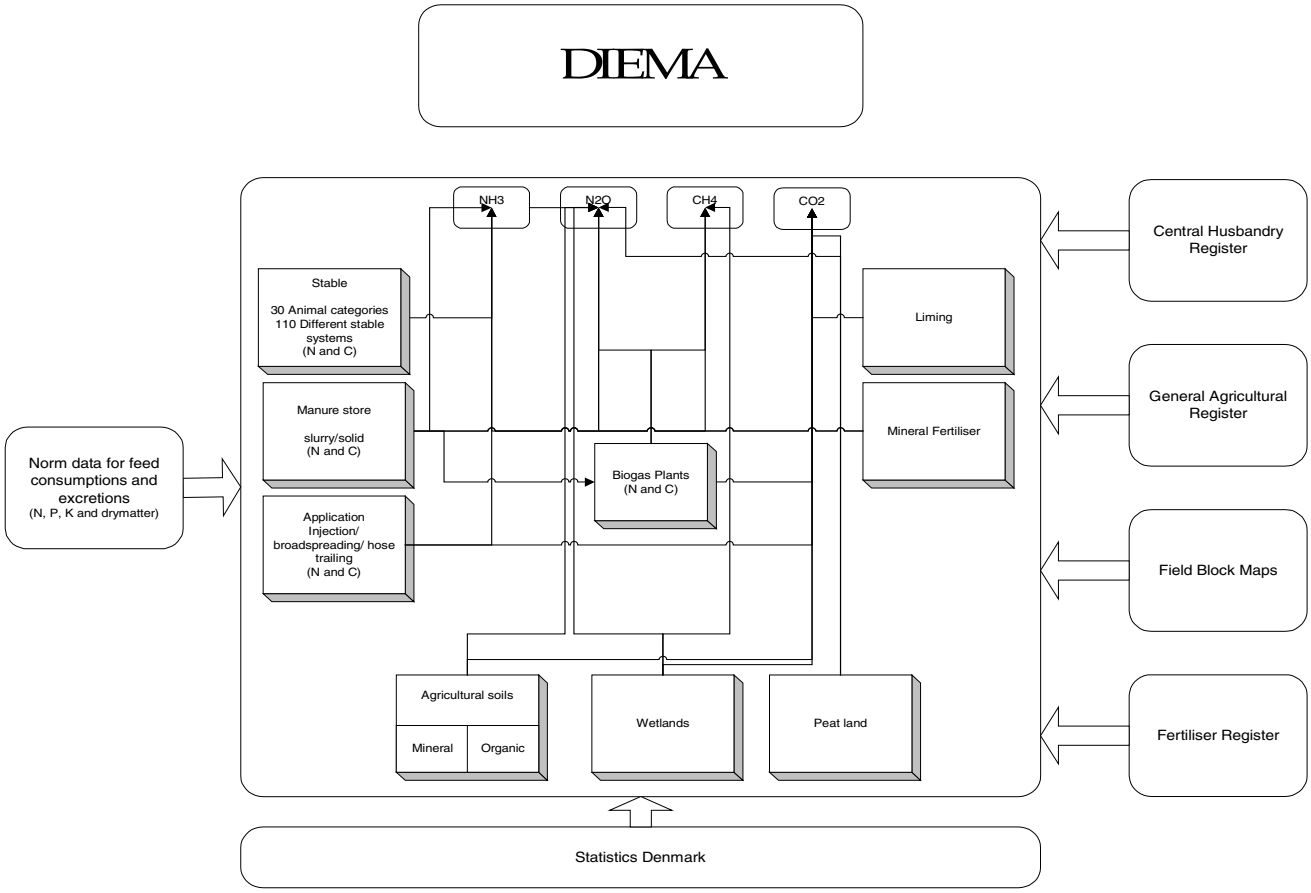

Figure 6.2 DIEMA – Danish Integrated Emission Model for Agriculture

The Danish standards related to feeding consumption, manure type in different stable type, nitrogen content in manure etc. are described and published by the Danish Institute of Agricultural Sciences (Poulsen *et al*. 2001). These standards are updated annually. In 1998 these standards was published in English (Poulsen and Kristensen 1998). The main part of the emission of GHG from the agricultural sector is related to the livestock production. DIEMA is using about 30 livestock categories depending on type of livestock and weight class. Each category is subdivided according to stable type and manure type. The emission is calculated from each category.

6.1.2 Key source identification

Most of the agricultural emission sources can be considered as key sources both for emission level and trend. The most important key source is N_2O emission from agricultural soils, which contributes with 8% of the total national GHG emission.

Table 6.3 Key source identification from the agricultural sector 2002 (Annex 1)

CRF table	Compounds	Emission source	Key source identification
4.A	CH_4	Enteric fermentation	Level/trend
4.B(a)	CH_4	Manure management	Level
4.B(b)	N_2O	Manure management	Level
4.C	CH_4	Rice cultivation	Not occurrence
4.D	N_2O	Direct N_2O emission from nitrogen used in agriculture	Level/trend
4.D	N_2O	Direct N_2O emission from agricultural soils	Level/trend
4.E	CH_4/N_2O	Burning of savannas	Not occurrence
4.F	CH_4/N_2O	Field burning of agricultural residues	Not occurrence

6.2 CH_4 emission from Enteric Fermentation (CRF Sector 4A)

6.2.1 Description

The majority of the CH_4 emission origins from enteric fermentation and 28% of the Danish GHG emission from agricultural activities originates from enteric fermentation (CRF Table 4.). The emission is primarily related to the ruminants and in Denmark particularly from the production of cattle, which in 2002 contributed with 86% of the emission. The emission from the pig production is the second largest source and contributes with 10% of the total emission from enteric fermentation (Figure 6.3).

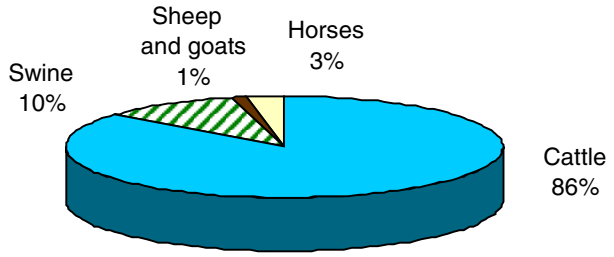

Figure 6.3 CH_4 emissions from enteric fermentation 2002

6.2.2 Methodological issues

6.2.2.1 Implied emission factor

The implied emission factors for all animal categories are based on a Tier 2 approach. The feeding consumptions for all animal categories are based on the Danish norm figures (Poulsen *et al*. 2001). The norm data are based on actual efficacy feeding controls or actual feeding plans at farm level collected by DAAC or DIAS. For cattle approximately 20% of the herd is included and for pigs approximately 35% of all pigs are included. The data are given in Danish feeding units or kg feed stuff and converted to mega joule (MJ). Default values for the methane conversion rate (Y_m) given by IPCC are used. In CRF table 4.A. in category "Non-dairy Cattle" 6% is mentioned, however, 4% is used for estimating the emission from rearing of bull calves. In the CRF, food intake for some categories is given per produced unit and are therefore not comparable with the default values given in IPCC. In the next years CRF will be converted to an average daily feed per head.

Table 6.4 shows the implied emission factors for cattle and pigs. Due to changed data for feeding consumption and stable type distribution the implied emission factor may vary between the years. The category "Non-Dairy Cattle" includes calves, heifer, bulls and suckler cows and the implied emission factor is a weighted average of these different subcategories. The category "Swine" includes sows, piglets and slaughtering pigs.

The increasing emission factor for dairy cattle is a result of an increasing milk yield in average from 6200 litre per cow per year in 1990 to 7500 litre per cow per year in 2002 (Statistics Denmark). The emission factor for "Non-Dairy cattle" is due to different numbers in the different subcategories and changed feeding data. The implied emission factor for pigs is almost at the same level as in 1990. Improved fodder efficacy for slaughtering pigs has resulted in lower implied emission factor for slaughtering pigs, but on the other hand there has been an increase in fodder consumption for sows due to more piglets per sow.

The enteric emission from poultry and fur farming is seen as non-significant.

Table 6.4 Implied emission factor – Enteric Fermentation 1990 – 2002 (CRF)

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
CRF - Table 4.A							Kg CH_4/head/yr							
1.a	Dairy Cows	109.48	109.56	109.63	109.71	116.21	116.32	116.39	116.45	117.22	117.20	117.23	117.22	117.95
1.b	Non-Dairy Cattle	33.72	33.95	34.12	34.34	34.24	34.39	34.44	34.79	34.78	35.22	35.42	35.58	35.80
3.	Sheep	17.17	17.17	17.17	17.17	17.17	17.17	17.17	17.17	17.17	17.17	17.17	17.17	17.17
4.	Goats	13.15	13.15	13.15	13.15	13.15	13.15	13.15	13.15	13.15	13.15	13.15	13.15	13.15
6.	Horses	23.90	23.90	23.90	23.90	23.90	23.90	23.90	23.90	23.90	23.90	23.90	23.90	23.90
8.	Swine	1.07	1.10	1.12	1.10	1.10	1.07	1.11	1.10	1.10	1.13	1.11	1.07	1.08
9.	Poultry	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
10.	Other -fur farming	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

6.2.2.2 Activity data

The number of animals is given in the Agricultural Statistic (Statistics Denmark). For slaughtering pigs and poultry the production level (produced numbers) is used instead of the numbers given in the census. This to improve the emission estimates. Only farms larger than 5 hectares are included in the annual census. An approximate number of sheep, poultry and horses on these smallholdings are added to the number in the Agricultural Statistics in agreement with DAAC. The largest difference is found for horses. In the Agricultural census the number is estimated to 40.000 horses. The total number of horses in 2002 is approximately 153.000, including horses placed on small farms and riding schools.

Buffalo, camels and llamas, mules and donkeys do not occur in Denmark.

6.2.3 Uncertainties and time-series

The uncertainty of CH_4 emission from enteric fermentation is estimated to 20%, which corresponds to the uncertainty given in IPCC using the Tier 2 approach. The uncertainty for the livestock production is relative small and estimated to 0.9% for cattle and pigs by Statistics Denmark. The uncertainties of the emission factor depends on the variations in fodder consumption, energy content in fodder and the methane conventions factor, which are estimated to 20%.

In Table 6.5 is given the development in number of animals (from the census) from 1990 to 2002 and in Table 6.6 is given the total emission from enteric fermentation. The emission from enteric fermentation has decreased by 10% from 1990 to 2002, which is primarily related to a decrease in

the number of cattle from 753000 dairy cattle in 1990 to 610000 in 2002. The number of pigs has increased from 9.5 mio. in 1990 to 12.7 mio. in 2002, but the increase has only minor importance on the emission of CH_4 from enteric fermentation.

Table 6.5 Number of animals from 1990 to 2002 (CRF)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
							1000 head						
Dairy Cattle	753	742	712	714	700	702	701	670	669	640	636	623	610
Non-Dairy Cattle	1 486	1 480	1 478	1 481	1 405	1 388	1 393	1 334	1 308	1 247	1 232	1 284	1 187
Sheep	92	107	102	88	80	81	94	78	83	83	81	92	74
Goats	8	9	9	9	9	9	9	10	10	10	10	11	11
Horses	135	137	138	140	141	143	144	146	147	149	150	152	153
Swine	9 497	9 783	10 455	11 568	10 923	11 084	10 842	11 383	12 095	11 626	11 922	12 608	12 732
Poultry	16 249	15 933	19 041	19 898	19 852	19 619	19 888	18 994	18 674	21 010	21 830	21 236	20 580
Other - fur farming	2 264	2 112	2 283	1 537	1 828	1 850	1 918	2 212	2 345	2 089	2 199	2 304	2 422

Table 6.6 Emission of CH_4 from Enteric Fermentation 1990 – 2002 (CRF)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
							Gg CH_4						
Dairy Cattle	82.45	81.25	78.05	78.35	81.29	81.71	81.55	78.06	78.43	75.03	74.50	73.07	71.90
Non-Dairy Cattle	50.11	50.24	50.42	50.87	48.12	47.73	47.96	46.40	45.51	43.92	43.66	45.67	42.47
Sheep	1.58	1.83	1.76	1.52	1.37	1.39	1.62	1.34	1.43	1.42	1.40	1.59	1.27
Goats	0.11	0.12	0.12	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.13	0.14	0.14
Horses	3.23	3.26	3.30	3.33	3.37	3.41	3.44	3.48	3.51	3.55	3.59	3.62	3.66
Swine	10.14	10.74	11.74	12.71	12.03	11.91	12.03	12.53	13.28	13.09	13.26	13.52	13.79
Poultry	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Other - fur farming	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Total Gg CH_4	147.61	147.44	145.39	146.89	146.32	146.27	146.72	141.93	142.29	137.13	136.52	137.60	133.23
Total Gg CO_2 eqv.	3 100	3 096	3 053	3 085	3 073	3 072	3 081	2 981	2 988	2 880	2 867	2 890	2 798

6.3 CH_4 and N_2O emission from Manure Management (CRF Sector 4B)

6.3.1 Description

The emissions of CH_4 and N_2O from manure management are given in Table 4.B(a) and 4.B(b). This source contributes with 15% of the total emission from the agricultural sector in 2002 and the major part of the emission originates from the production of cattle and swine.

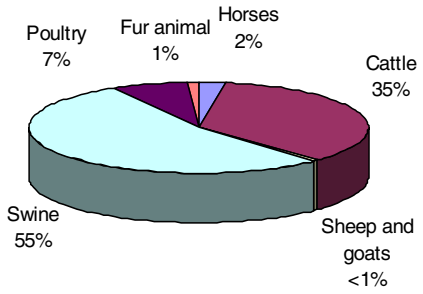

Figure 6.4 Emission of CH_4 and N_2O from manure management in 2002 given in CO_2 eqv.

6.3.2 Methodological issues

6.3.2.1 CH_4 emission

The IPCC Tier 2 approaches are used for estimating the CH_4 emission related to manure management. The amount of manure is calculated for each stable type and estimated as: feed consumption minus the digestibility of the feeding stuff for each group of animals plus straw amendments in the different stable types (Poulsen *et al*. 2001). The straw amendments differ between stable type. The feed consumption (Poulsen *et al*. 2001) includes energy for maintenance, pregnancy and growth and standards for ash contents are used. Default values given in the IPCC guidelines for the methane production B_o and MCF are used. Background data is given in Annex 3 Table A. For liquid systems the MCF in Good Practice Guidance has been changed from 10% to 39% for cold climates. Massé *et al*. (2003) and Husted (1994) has for a climatic condition like Denmarks obtained MCF values around 10% for slurry and hence Denmark continues to use 10% as MCF.

Table 6.7 shows the development in the implied emission factors from 1990 to 2002. The implied emission factor for dairy cattle has increased as a result of a growing milk yield, but also because of changes in stable types. Old tied-up stables with solid manure have been replaced by loose-holdings with slurry based systems. The MCF for liquid manure is ten times higher than solid manure.

For non-dairy cattle there has been an opposite development where an increasing part of the bull-calves is raised in stables with deep litter.

For pigs there has been the same development as for dairy cows with less solid manure and more slurry based systems.

At present it is not possible to register the emission from fur farming in Table 4.B(a). The CRF format, used for the next reporting gives an opportunity to include emission from other categories, e.g. fur farming.

Table 6.7 Implied emission factor – Manure Management 1990 – 2002 (CRF)

CRF		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Table 4.B(a)									Kg CH_4/head/yr					
1a	Dairy Cattle	13.69	14.11	13.57	13.98	14.50	14.68	15.39	14.33	14.59	14.04	16.38	16.99	17.26
1b	Non-Dairy Cattle	2.20	2.09	2.02	1.95	1.87	1.79	1.76	1.72	1.68	1.70	1.67	1.67	1.62
3	Sheep	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
4	Goats	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
6	Horses	1.74	1.74	1.74	1.74	1.74	1.74	1.74	1.74	1.74	1.74	1.74	1.74	1.74
8	Swine	2.25	2.39	2.51	2.49	2.52	2.48	2.59	2.60	2.61	2.71	2.66	2.57	2.59
9	Poultry	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01
*	Other – fur farming	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

* The new CRF format gives possibility to implement emission from "other" animal categories. Emission from fur farming will be implemented in the inventory for 2003.

Biogas plants using animal slurry reduce the emissions of CH_4 and N_2O (Sommer *et al.* 2001). In 2002 there was 20 common facilities and 50 individual farm facilities. The common facilities account for 88% of the treated slurry in 2002 (DEA, 2003). In 2002 about 4%, or 0.64 mio. tonnes of cattle slurry and 0.78 mio. tonnes of pig slurry were treated in biogas plants. The reduction in the CH_4 emission is based on model calculations for an average size biogas plant with a capacity of 550 m^3 per day. For methane a reduction of 30% for cattle slurry and 50% for pig slurry is obtained (Nielsen *et al*. 2002, Sommer *et al.* 2001). Due to the biogas plants the total emission of CH_4 is reduced with 0.82 Gg CH_4 corresponding to 2% reduction.

6.3.2.2 N_2O emission

The N_2O emission from manure management is based on the amount of nitrogen in the manure. The IPCC default emission values are applied – i.e. 2.0% of the N-excretion for solid manure, 0.1% for liquid manure and 0.5% from poultry in stable system without bedding. Nitrogen from poultry without bedding contributes less than 1% of the total amount of nitrogen in manure.

The total amount of nitrogen in the manure has decreased by 5% from 1990 to 2002 (cf. Table 6.8). The excretion rates in Table 6.8, is a weighted value for the different subcategories. Especially the improvement in fodder efficiency for swine has increased the N-excretion per animal. N-excretion from the swine production contributes with a still increasing part of the total N-excretion (Figure 6.5).

Table 6.8 Nitrogen excretion rates per head, 1990 – 2002 (CRF)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Table 4.B(b)								Kg N/head/yr					
Animal categories													
Non-dairy cattle	36.57	36.68	36.80	36.92	36.64	36.56	36.62	36.74	36.77	37.00	37.15	37.72	37.77
Dairy cattle	129.49	128.63	127.76	126.89	126.06	125.22	125.09	124.94	124.82	124.60	125.31	124.91	126.70
Sheep*	21.18	21.33	21.47	21.61	21.76	21.90	20.11	18.32	16.53	14.75	16.95	16.95	16.93
Swine	11.62	11.43	11.17	10.40	10.38	9.62	9.89	9.74	9.65	9.83	9.63	9.30	9.71
Poultry	0.65	0.66	0.58	0.59	0.66	0.62	0.60	0.62	0.62	0.57	0.55	0.57	0.59
Horses	48.89	47.77	46.66	45.54	44.42	43.31	43.31	43.31	43.31	43.31	43.31	43.31	43.31
Fur farming	490	4.83	4.80	4.75	4.70	4.65	4.66	4.65	4.64	4.63	4.63	4.62	4.61
								M kg N/yr					
N-excretion, total	293	291	293	293	283	274	275	274	279	270	270	274	277

* Mother sheep including lambs. The category includes goats.

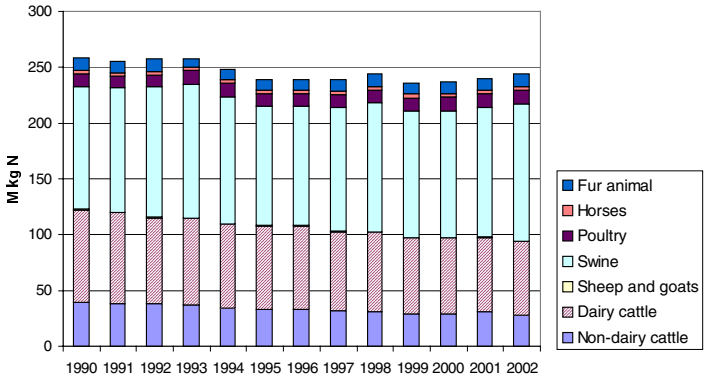

Figure 6.5 The N-excretion distributed on animal categories 1990 – 2002

The reduction of N_2O in relation to the biogas production is not included in the inventory. It is expected this will reduce the emission with 1%. This reduction will be implemented in the emission inventory for 2003.

6.3.3 Uncertainties and time-series

The uncertainty of CH_4 and N_2O emissions from manure management is estimated to 10% for the activity data and 500 percent for the emission factor. The high uncertainty is particular connected to the emission factor for N_2O. The data used for estimating the CH_4 emission is based on Tier 2 approach and reflects the Danish conditions. There is a need for a more accuracy quantifying of the uncertainties based on expert judgement.

As mentioned above the N_2O emission has decreased. Nevertheless, the total emission from manure management in the period from 1990 to 2002 has increased with 10% due to development in the CH_4 emission (Table 6.9).

Table 6.9 Emissions of N_2O and CH_4 from Manure Management 1990 – 2002 (CRF)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
						Gg N_2O							
N_2O emission													
Liquid manure	0.31	0.31	0.31	0.31	0.30	0.28	0.28	0.28	0.29	0.28	0.29	0.29	0.30
Solid manure	1.90	1.90	1.91	1.91	1.86	1.80	1.80	1.81	1.85	1.79	1.69	1.70	1.65
Total Gg N_2O	2.21	2.20	2.22	2.21	2.15	2.09	2.09	2.10	2.14	2.07	1.98	1.99	1.95
Total Gg CO_2 eqv.	686	683	687	686	668	647	647	649	662	640	613	618	605
CH_4 emission													
Total Gg CH_4	35.35	37.06	39.53	42.07	41.01	40.92	41.52	42.04	43.74	43.16	44.61	45.51	46.01
Total Gg CO_2 eqv.	742	778	830	884	861	859	872	883	919	906	937	956	966
Total Manure Management Gg CO_2 eqv.	1428	1461	1517	1570	1529	1506	1519	1532	1581	1546	1550	1574	1571

6.4 N_2O emission from Agricultural Soils (CRF Sector 4D)

6.4.1 Description

The N_2O emissions from agricultural soils given in Table 4.D, contribute with 57% of the total emission from the agricultural sector in 2002. Figure 6.6 shows the distribution on different sources. The main part origins as direct emission of which the largest sources are manure and fertiliser applied on agricultural soil. Another large source is the indirect N_2O emission, where emission from nitrogen leaching is essential. The category "Other" includes emission from sewage sludge and sludge from the industry used as fertiliser.

The emission from agricultural soils only includes N_2O emission. In Table 4s2 it is also an opportunity to register the CH_4 emission in connection with agricultural soils, however no estimates have been made yet.

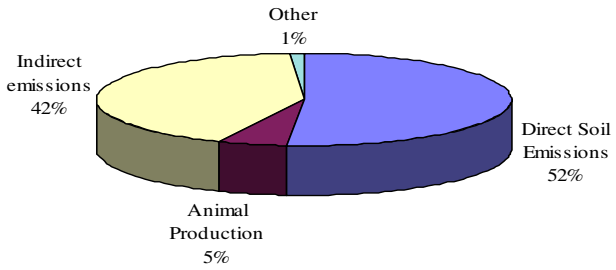

Figure 6.6 N_2O emissions from agricultural soils 2002.

6.4.2 Methodological issues

Emissions of N_2O are closely related to the nitrogen balance.

The IPCC Tier 1a methodology is used to calculate the N_2O emission. The emission factors for all sources are based on the default values given in IPCC. National data for the evaporation of ammonia from the ammonia inventory is applied. A survey is given in Table 6.10. The estimated emissions from the different subsources are shortly described in the following text.

Table 6.10 Emissions factor - N_2O emission from Agricultural Soils 1990 - 2002

Agricultural soils – table 4.D	Ammonia emission	N_2O emission
		kg N_2O -N/kg N
1. Direct Soil Emissions		
Synthetic Fertiliser applied to soils	NH_3 emission = 2%	0.0125
Animal Wastes Applied to Soils	NH_3 emission = (31-25%)	0.0125
N-fixing Crops		0.0125
Crop Residue		0.0125
Cultivation of Histosols		8 kg N_2O-N/ha
2. Animal Production	NH_3 emission = 7%	0.02
3. Indirect Soil Emissions		
Atmospheric Deposition		0.01
Nitrogen Leaching and runoff		0.025
4. Other		
Industrial Waste used as Fertiliser		
Sewage sludge used as Fertiliser		0.0125

6.4.2.1 Direct Emissions

Manure applied to soil

The amount of nitrogen applied on soil is estimated as the N-excretion in the stable minus the emission of ammonia – both are calculated in the ammonia emission inventory. The total N-excretion from 1990 to 2002 has decreased with 6%. Despite the reduction in N-excretion the amount of nitrogen applied on soil is nearly unaltered, which is due to a reduction in the ammonia emission. The percentage of volatile ammonia emission has decreased from 31% in 1990 to 25% in 2002.

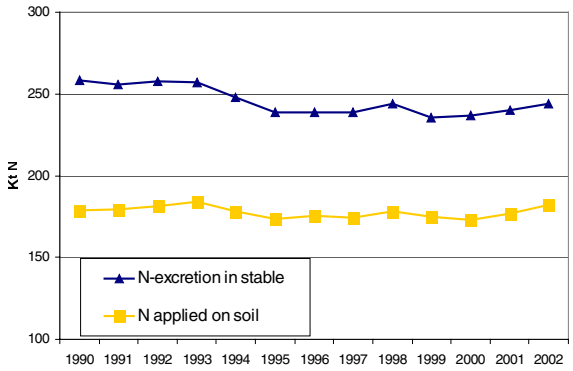

Figure 6.7 Amount of nitrogen excreted and applied on agricultural soil 1990 – 2002

Synthetic fertiliser

The amount of nitrogen applied on soil by use of synthetic fertiliser is estimated from sale estimates by the Danish Plant Directorate, minus the ammonia emission based on estimate from the DIAS (Sommer *et al.* 1992, 1994 and 1996). The Danish value for the FracGASF is considerably lower, i.e. 0.02, than given in IPCC, i.e. 0.10. This is probably due to a small consumption of urea (<1%), which has a high emission factor.

The use of mineral fertiliser includes fertiliser used in parks, golf courses and private gardens. Approximately 1-2 percent of the mineral fertiliser can be related to this use out side the agriculture area.

N-fixing crops

To estimate the emission from N-fixing crops IPCC Tier 1b is applied. The calculated emission is based on nitrogen content, the fraction of dry matter and the content of protein for each harvest crop type. Data for crop yield is based on Statistics Denmark. For nitrogen content in the plants the data is taken from Danish feedstuff tables (Danish Agricultural Advisory Centre). The estimates for the amount of fixed nitrogen in crops are estimated by a model developed by Danish Institute of Agricultural Science (Kristensen 2003, Høgh-Jensen *et al*. 1998, Kyllingsbæk 2000).

In Table 6.11 is given the background data for estimating the N-fixing. The main part of the emission origins from fields with grass and clover.

Table 6.11. Emissions from N-fixing crops 2002

Nitrogen fixing crops			N-fixing		
	Dry matter Fraction	N-Fraction	Variations 1990-2002 kg N/ha	2002 kg N/ha	2002 Kg N fix total
Pulses*	0.85	0.0337	96-179	139	5 572
Lucerne	0.21	0.0064	307-517	449	1 600
Cereals and pulses for green fodder	0.23	0.0061	16-38	23	2 598
Pulses, fodder cabbage etc.	0.23	0.0061	0-1	0	50
Peas for canning*	0.85	0.0337	76-139	111	480
Seeds for sowing	NE	NE	181-186**	182	757
Grass and clover field in rotation	0.13	0.0052	41-94	90	19 685
Grass and clover outside rotation	0.13	0.0052	6-11	9	1 515
Aftermath	0.13	0.0052	6-15	6	1 590
Total N-fix					33 846

* Dry matter content for straw is 0.87 and the N-fraction is 0.010.

** Assumed that N-fix for red clover is 200 kg N/ha and 180 kg N/ha for white clover.

Crop Residue

N_2O emissions from crop residues are calculated as the total aboveground amount of crop residues returned to soil. For cereals the aboveground residues are calculated as the amount straw plus stubble and husks. The total amount of straw is given in the annual census and reduced with the amount used for feeding, bedding and biofuel in power plants. Straw for feeding and bedding is subtracted in the calculation because these amounts of nitrogen removed returnes to the soil via manure. Data for stubble and husks are provided by the Danish Institute of Agricultural Sciences.

Cultivation of Histosols

It is assumed that 10% of the organic soils are in rotation, which in Denmark equivalents 18.400 ha. This area has been estimated to the same level all years. At present no knowledge is available to make a better identification of the histosols. In connection with the implementation of land use in the LULUCF in 2004, new estimates for histosols will be provided.

6.4.2.2 Animal Production

The amount of nitrogen deposit on grass is based on values from the ammonia inventory. It is assumed that 15% of the nitrogen from dairy cattle in average is excreted on grass. The N-excretion is not differing significantly from 1990 to 2002. An emission factor by 7% is used for all animal categories based on investigation from the Netherlands and United Kingdom (Jarvis *et al*. 1989a, Jarvis *et al*., 1989b and Bussink 1994).

6.4.2.3 Indirect Emissions

Atmospheric Deposition

Atmospheric deposition includes all ammonia emissions sources corresponding to the ammonia emission inventory (Hutchings *et al.* 2001). This mean also emission from crops and from ammonia treated straw are taken into account.

Table 6.12. Ammonia emissions 2002 (DIEMA)

Emissions of ammonia	2002
	Tonnes NH_3-N
Manure	64 259
Synthetic fertiliser	4 593
Crops	11 108
NH_3 treated straw	774
Sewage sludge and industrial waste	66
Emission total	80 801

Nitrogen leaching and Run-off

Nitrogen leaching and run-off from 1986 to 2003 has been recalculated by DIAS in 2003 in connection with a new action plan on the aquatic environment. The calculation is based on two different model predictions, SKEP/Daisy and N-Les2 (Børgesen and Grant, 2003). The result of these two calculations differs only marginally. The average of these two model predictions is used when estimating emissions from 1990 to 2002. Since 1990 the use of mineral fertiliser has been reduced by more than 50% and the leaching too.

Figure 6.8 shows the estimated leaching in relation to the nitrogen input from mineral fertiliser, nitrogen in manure and sludge. As it can be seen the average leaching percentage has decreased from 38% to 34%.

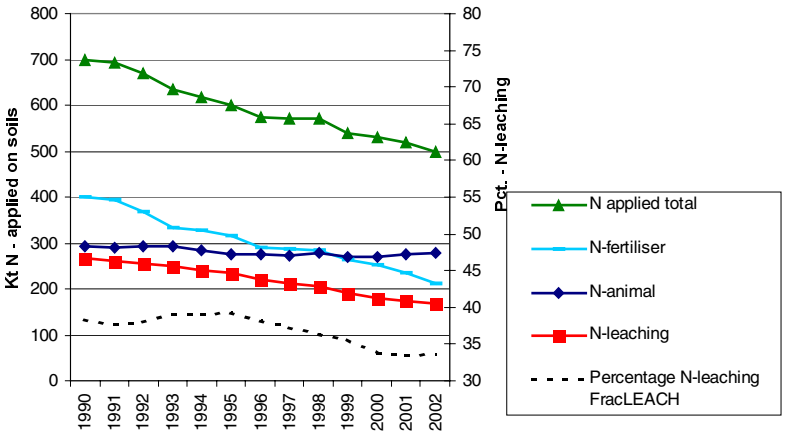

Figure 6.8 Nitrogen applied on agricultural soils and N-leaching from 1990 to 2002

6.4.2.4 Other Emissions

Under the category of "Other" is mentioned nitrogen from industrial waste and sewage sludge used as fertiliser. The amount of nitrogen applied on agricultural soils from these sources is minus the ammonia emission. Information about industrial waste, sewage sludge and the content of ni-

trogen is given by the Danish Environmental Protection Agency. It is assumed that 1.9% of N-input volatises as ammonia because a great part of N is organically bounded in the waste.

6.4.3 Uncertainties and time-series

Uncertainties for the activity data to estimate the emissions from agricultural soils are estimated to 20%. The uncertainties are mainly related to estimation of sources from N-leaching. The emission factors for N_2O are based on IPCC default values. These values are connected with high uncertainties as a result of different soil types and climatic conditions. The default values does not necessary correspond to Danish conditions. The estimate of 95% confidence limit range is between 0.25% to 6% as given in IPCC Guidance (2000). Therefore the uncertainties for the emission factor of agricultural soils and manure management are estimated to 500%.

The N_2O emissions from agricultural soils have been reduced by 30% from 1990 to 2002. This is mainly due to a decrease in use of synthetic fertiliser and a decrease in N-leaching, as a result of the National environmental policy, where action plans have focused on improvement of the nitrogen utilisation.

Table 6.13 Emissions of N_2O from Agricultural Soils 1990 – 2002 (CRF)

CRF – table 4.D	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
							Gg N_2O						
Total N_2O emission	26.76	26.27	25.29	24.61	23.98	23.41	22.30	22.04	21.91	20.56	19.83	19.38	18.60
1. Direct Emissions	13.45	13.22	12.50	12.05	11.76	11.51	11.07	11.12	111.9	10.53	10.31	10.02	9.55
Synthetic Fertiliser	7.69	7.59	7.10	6.39	6.25	6.06	5.58	5.53	5.44	5.05	4.83	4.49	4.05
Animal Waste Applied	3.51	3.52	3.56	3.62	3.50	3.41	3.45	3.42	350	3.43	3.40	3.48	3.58
N-fixing Crops	0.88	0.77	0.65	0.83	0.79	0.73	0.71	0.86	0.95	0.77	0.76	0.71	0.66
Crop Residue	1.13	1.10	0.95	0.98	0.99	1.08	1.10	1.08	1.08	1.05	1.08	1.11	1.03
Cultivation of Histosols	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
2. Animal Production	1.01	1.03	1.03	1.05	1.03	1.04	1.05	1.02	1.01	0.99	0.99	1.01	0.96
3. Indirect Emissions	12.22	11.91	11.63	11.33	11.02	10.68	10.01	9.74	9.53	8.88	8.37	8.14	7.86
Atmospheric Deposition	1.72	1.66	1.64	1.59	1.53	1.45	1.39	1.38	1.40	1.33	1.32	1.31	1.27
N-leaching and Run-of	10.50	10.24	9.99	9.74	9.49	9.23	8.62	8.35	8.13	7.56	7.05	6.84	6.59
4. Other	0.09	0.11	0.13	0.18	0.17	0.18	0.18	0.16	0.17	0.15	0.17	0.21	0.22
Industrial Waste	0.03	0.05	0.06	0.09	0.09	0.09	0.09	0.09	0.10	0.08	0.10	0.14	0.15
Sewage sludge	0.06	0.06	0.07	0.10	0.09	0.09	0.09	0.08	0.07	0.07	0.07	0.07	0.07

6.5 NMVOC emission

Less than 1% of the NMVOC emission origins from the agricultural sector. The emission needs to be reestimated. The definition of the agricultural areas used in the inventory is not consistent for all years. The emission factor for arable land crops and grassland are 393 g/ha and 2120 g/ha, respectively.

6.6 Uncertainties

Table 6.14 shows the estimated uncertainties for some of the emission sources based on expert judgement (Olesen *et al*. 2001, Gyldenkærne, pers. comm., 2004). The uncertainties for the number of animals and hectares grown with different crops are very small. The uncertainty for activity

data is estimated to 2% for enteric fermerntation. The uncertainty is estimated to be 10% and 20% for emissions from manure management and agricultural soils, respectively. The uncertainties concerning the emission factors are estimated to 20% for emission from enteric fermentation and 500% for both manure management and agricultural soils, which is mainly related to the N_2O emission.

There is a need for improving the uncertainty estimates – especially for sources contributing significantly to the total emission from the agricultural sector.

Table 6.14 The estimated uncertainty associated with activities and emission factor for CH_4 and N_2O

Source	Emission	Uncertainty[1]		Quantitative estimation of uncertainy[2]	
		Activity data	Emission factor	Activity data	Emission factor
4.A Enteric Fermentation	CH_4	*	*	2%	20%
4.B Manure Management				10%	500%
	CH_4 – table 4.B(a)	*	**	10%	30%
	N_2O – table 4.B(b)	*	***	10%	500%
4.D Agricultural Soils	N_2O			20%	500%
1. Direct soil emissions					
1a. Syntehetic Fertilizer		*	***		
1.b Animal waste applied to soils		*	***		
1.c N-fixing crops		*	***		
1.d Crop Residue		*	***		
1.e Cultivation of histosols		**	***		
2. Animal production		*	***		
3. Indirect soil emissions					
3.a Atmospheric deposition		*	***		
3.b Leaching and runoff		**	***		
4. Other					
Sewage sludge and industrial waste used as fertilizer		*	***		
Agricultural soils	NMVOC	*	***		

[1] Olesen et al., 2001
[2] Gyldenkærne pers. comm., 2004 (The uncertainties values is used in a uncertainty estimate for total national emission)
* uncertainty < 20%,
** uncertainty 20-50%
*** uncertainty > 50%

6.7 Quality assurance and quality control - QA/QC

To ensure the consistency in the inventory time-series have been worked out for both activity data and emission factors. Considerable variations over the years can reveal miscalculations or changes in methods. These variations are checked and explained or errors have been revised.

Activity data and emission factors are collected and discussed in corporation with specialists and researcher at different institutes and research sections (Table 2). As a consequence both the data and methods are evaluated continuously according to the latest knowledge and information.

6.8 Recalculation

In connection with the implementation of the emission module DIEMA a recalculation of the previous emissions has taken place. In the recalculation, the remarks pointed out by the UNFCCCs review team has also been taken into account. The recalculation has lowered the emission level of GHG from the agricultural sector by approximately 10% compared to the previous emission inventory given in CO_2 eqv. This is mainly due to changes in the N_2O emission.

The previous estimated reduction in the GHG emission from 1990 to 2002 is approximately 18-20 % and almost unaltered.

Table 6.15 Changes in GHG emission in the agricultural sector compared to CRF reported last year

GHG emission	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
						Gg CO_2 eqv.							
Previous emission	14 348	14 096	13 441	13 618	13 174	13 111	12 803	12 354	12 460	12 083	11 868	11 550	
Recalculated emission	12 826	12 702	12 411	12 285	12 036	11 834	11 514	11 346	11 360	10 800	10 564	10 470	10 134
Change Gg CO_2 eqv.	-1 523	-1 394	-1 030	-1 333	-1 139	-1 277	-1 288	-1 008	-1 100	-1 283	-1 304	-1 080	
Change in pct.	-11	-10	-8	-10	-9	-10	-10	-8	-9	-11	-11	-9	

The emission of N_2O is in average for 1990 to 2002 about 15% lower than estimated in the previous emission inventory (Figure 6.7). The reduction is mainly related to an error in the calculation for crop residues where the nitrogen content in crop residues in the previous inventory was too high. This is now corrected in connection with a change in the method from Tier 1a to Tier 1b. Another change, which has influenced the N_2O emission considerably, is an updating of the emissions from N-leaching made by DIAS.

In the previous inventory changes in the CH_4 emission only reflect changes in the number of animal and in some cases changes in distribution of subcategories. In the recalculated inventory, where Tier 2 is used for all animal categories, the change in fodder- and stable conditions is taken into account. Unlike the previous emission inventory, there is no reduction in the estimated CH_4 emission from 1990 to 2001. The emission from enteric fermentation has decreased caused by a reduction in the number of cattle. But, on the other hand, the emission from manure management has increased due to the change to more slurry based stable systems, which has a higher emission factor. The resulting trend for CH_4 emissions from 1990 to 2002 is about zero (Figure 6.7).

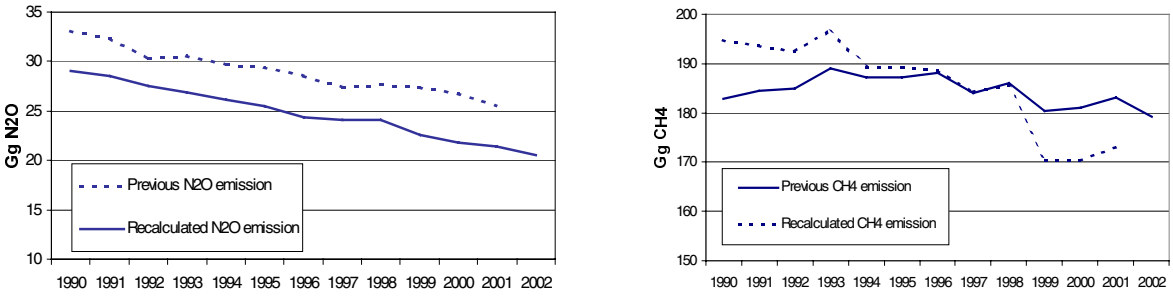

Figure 6.7 Recalculated emissions of CH_4 and N_2O compared to previous emission 1990-2002

Other recalculations since the submission in April 2003:

- The DIEMA model used to calculate the ammonia emissions from livestock production is also used to estimate the GHG emission. The data used to estimate the N_2O emission is now in accordance with the ammonia emission inventory.
- The inventory now includes ammonia emission from crops, ammonia treated straw and sewage sludge and industrial waste used as fertiliser.
- The review report from UNFCCCs secretariat has pointed out an inconsistency between CRF and NIR regarding the emission factor for N_2O emission from manure management. This inconsistency has now been removed by eliminating an error in the CRF where ammonia emission was subtracted.
- Goats have been included in the inventory.
- The emission factor used to calculate the emission from cultivation of histosols is now corrected to 8 kg N_2O-N per ha for all years.
- Reduction in CH_4 as a consequence of biogas treated slurry is now included.
- Recalculation of emissions from N-fixing crops are now based on Tier 1b approach.

6.9 Planned improvements

One of the highest priorities for the next emission inventory is implementation of the CO_2 emission from agricultural soils (LULUC). A first estimate of CO_2 emission from liming and cultivation of organogenic soils is estimated (Gyldenkærne and Mikkelsen 2004). At present, however, no knowledge is available to estimate the emission in relation to changes in the content of organic matter in agricultural soils, as a consequence of changes in cultivation management. Model development for implementation of LULUC will be finish by the end of 2004 and the results will be implemented in the next inventory.

Another high priority is implementation of a formal QA/QC plan. DIAS will be a major contributor to this.

Furthermore the following issues will be in focus to improve the emission inventory:

- Investigate the possibilities to use national data for N_2O emissions.
- The average daily feed intake given in Table 4.A is an expression for the intake per produced unit used to estimate the CH_4 emission from enteric fermentation. This will be changed to an average feed intake per year for each animal category, which are comparably with the default values in IPCC guidelines.
- Include CH_4 emission from manure management from fur animals
- Include reductions of N_2O emission caused by the biogas treated slurry.
- Better uncertainty estimates with priority on emission sources, which have a considerable influence on the total emission.
- Recalculate the NMVOC emissions from agricultural soils.

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7 The Specific methodologies regarding Forestry (CRF Sector 5)

7.1 Removals by Sinks in Forestry

7.1.1 Revisions of methodology and other changes since 2003 in relation to reported C sinks in Forestry

Since the submission to UNFCCC in April 2003 only small methodological revisions has been carried out, but this appendix has been amended with more information in response to the latest review.

7.1.1.1 Forests planted before 1990

In this submission, the calculation of net uptake of CO_2 in forests planted before 1990 has been slightly revised. The revision also includes reported net uptake for the years 1990-2001. In previous submissions, the net uptake was calculated using a 10-year average of harvested biomass 1990-1999. Today harvesting data are available for the recent years, so the net uptake is calculated as the 10-year average gross carbon uptake (due to gross increment) minus annual removals due to harvesting. The changes due to the revisions are generally small as the harvested amounts of wood are relatively stable over the period 1990-2002 (cf. Figure 7.1). However, the year 2000 deviates with a low net CO_2 uptake due to the severe storm in December 1999. The windthrow caused by this storm made the harvested amounts of wood in 2000 more than two times higher than in the average year. The storm-felled amount of wood amounted to 3.6 mio. m^3 distributed over about 20000 ha (Larsen and Johannsen, 2002). Gross increment and consequently gross carbon uptake is negatively affected by the windthrow as the age distribution changes towards low productive reforested stands. As in the previous submission, gross carbon uptake in the period 2000-2002 has been adjusted in order to account for this. With the present revision, both gross carbon uptake and carbon loss due to harvesting incorporates the dynamics brought about by the storm damage in December 1999.

In response to the recommendation made by the review team for the 2003 submission, this chapter has included specific figures for gross CO_2 uptake and loss of CO_2 due to harvesting. Net uptake of CO_2 is calculated from these figures. More information has also been included about the increment data from the Forestry Census and the changes in modelling of annual increment for each tree species category. The intention was to improve the transparency regarding the increased uptake reported for forests planted before 1990. In the 2003 submission, reported CO_2 uptake in forests planted before 1990 increased from 916 Gg yr^{-1} to around 3000 Gg yr^{-1}. The revised CO_2 uptake was the result of better data supplied by the most recent Forestry Census. The changes in data and calculations are mentioned in greater detail later in this chapter. In short, the increase in uptake was due to 1) improved modelling of rates of gross increment and 2) use of individual estimates for gross rates of increment and annual harvests to calculate annual net increment. In submissions until 2002, net annual increment was just a roughly suggested figure mentioned in the Forestry Census 1990 (Statistics Denmark, 1994, p 26). This rough estimate of net annual increment was evaluated as being too modest, mainly due to overestimation of total harvests.

7.1.1.2 Afforestation since 1990

Within this category, just one minor revision of the afforestation areas in the years 1999-2001 was done. The Danish Forest and Nature Agency discovered a minor discrepancy in their database on

land area of subsidized afforestation projects, and the afforestation areas were consequently slightly reduced. This has had almost no effect on CO_2 uptake in the period 1990-2002.

7.1.1.3 Uncertainty of the reported sinks

In response to the review of the 2003 submission a discussion has been added on the probably high but currently unknown uncertainty for CO_2 uptake in forestry. Uncertainty will be addressed for the inventory data in detail when the first results from the new sample-based National Forest Inventory are available in 2007.

7.1.1.4 Forest inventory data and reference values used in calculations

Standing stocks of wood in 1990 and 2000, and annual increments for the periods 1990-99 and 2000-2002 are all obtained from the Forestry Census of 2000 (Larsen and Johannsen, 2002).

The Forestry Census has been carried out roughly every 10 years and is based on questionnaires to forest owners. Detailed information about the census and the methodology can be found in Larsen and Johannsen (2002), and further documentation is available from Danish Forest and Landscape Research Institute[4]. In short, the estimates of standing volume and volume increments in the Forest Census from 1990 and from 2000 are based on questionnaire information from forest owners on forest area distributed to species and age classes, and information on site productivity. Based on standard yield table functions these input data are used to estimate standing volume and rate of increment for each tree species category.

From 2002, a new sample-based National Forest Inventory has been launched which will replace the Forestry Census. The National Forest Inventory will be complete by 2006, and the first background data for use in the NIR is expected from 2007. This type of forest inventory will be quite similar to inventories used in other countries, e.g. Sweden.

In 1990, the forested area was 411000 ha (= 4110 km^2) or approximately 10% of the land area. The forest area is defined as closed canopy high forest. This means that open woodland and open areas within the forest are not included. Broadleaved tree species made up 35% and coniferous species made up 65% of the forest area. In order to enable comparison with the Forestry Census of 2000, standing stocks of wood in 1990 were recalculated in the new Forestry Census using the same growth models and site indices (Larsen and Johannsen, 2002). The recalculated standing stock of wood was 64.8 mill. m^3 (as opposed to the original estimate of 55.2 mill. m^3) equivalent to 15.77 m^3 per km^2, distributed on 40% broadleaved species and 60% coniferous species. This stock of wood was equivalent to 22425 Gg C or 82225 Gg CO_2.

In 2000, the forested area was 468000 ha or approximately 11% of the land area. The increase in forested area is partly a result of afforestation of former arable land (about 27536 ha) and partly a result of a higher number of respondents in the most recent census. Broadleaved tree species made up 37% and coniferous species made up 63% of the forest area. The standing stock of wood was 77.9 mill. m^3 equivalent to 16.65 m^3 per km^2, distributed on 37% broadleaved species and 63% coniferous species. This stock of wood was equivalent to 26803 Gg C or 98278 Gg CO_2.

There is no information on applicable expansion factors for Danish conditions. Expansion factors are needed to convert stem volumes for conifers and total aboveground biomass for the broadleaves to total biomass. Therefore, stemwood volumes for conifers are converted to total biomass by an expansion factor of 1.8 based on Schöne and Schulte (1999), and aboveground biomass for broadleaves are converted to total biomass by an expansion factor of 1.2 based on Vande Walle et al. (2001) and Nihlgård and Lindgren (1977). The difference between expansion factors is

[4] Contact: Dr. V.K. Johannsen, Danish Cebtre for Forest, Landscape and Planning, Hoersholm Kongevej 11, DK-2970 Hoersholm, Denmark. E-mail: vkj@kvl.dk

mainly due to the difference in biomass data for the species categories. The total biomass in m^3 is converted to dry mass by use of tree species-specific wood densities (Moltesen, 1988, see Table 7.1), and carbon content is lastly calculated by using a carbon concentration of 0.5 g C g^{-1} dry mass.

Table 7.1 Wood densities for Danish tree species (Moltesen, 1988).

	Wood denisty (t dry matter/ m^3 fresh volume)
Norway spruce	0.38
Sitka spruce	0.37
Silver fir	0.38
Douglas-fir	0.41
Scots pine	0.43
Mountain pine	0.48
Lodgepole pine	0.37
Larch	0.45
Beech	0.56
Oak	0.57
Ash	0.56
Maple	0.49

The Danish expansion factors and the wood densities result in estimates of C stores that are 46% lower for broadleaves and 20% lower for conifers than when using the IPCC default expansion factor of 1.9 and the volume to dry weight ratios of 0.45 for conifers and 0.65 for broadleaves. The large difference for broadleaves is due to the fact that the reported biomass for broadleaves in the Danish Forestry Census is total aboveground biomass.

The Danish reporting on changes in forest carbon stores only considered the biomass of trees. There is no available systematic information on soil organic carbon for the reporting.

So far, the design of the Danish Forestry Census has not made it possible to quantitatively address *uncertainty* of inventory data used to estimate the reported sink for CO_2 in Danish forests. The uncertainty of the volume and increment estimates in the Forest Census 1990 and 2000 are related to a number of issues: The values of site productivity refer to fully stocked stands, with no border effects and with a given thinning regime. However, a number of these issues are uncertain. The stands are not fully stocked as the estimates are based on a 90% stocking but it may be lower. The very fragmented shape of the Danish forest area results in many borders and hence a reduction in the actual productivity on the area as a whole. Furthermore the yield table functions are based on a certain frequency of thinnings which in turn affect the standing volume. With the changing conditions for the forestry sector, these prescriptions are not followed, which in turn may lead to deviations, both positive and negative, from the estimated volume and increment. Further details and alternative estimates can be found in Johannsen (2002) and Dralle et al. (2002).

Other factors also contribute to uncertainty of the reported sinks. As previously mentioned, the lack of national biomass expansion factors or better expansion functions makes the calculation step from biomass to total biomass the most critical in terms of uncertainty. Basic densities of wood from different tree species are better documented and the C concentration is probably the least variable parameter in calculations.

In recognition of the difficulties in analyses of uncertainty, the estimated uptake of CO_2 in the forestry sector must be treated with caution. However, the assessment of uncertainty will improve significantly from 2007 when the new National Forest Inventory can supply the first national estimate of stocks of wood, increment and harvests based on a design with permanent sampling plots and partial replacement. The new design will enable an assessment of uncertainty related to inventory data.

7.1.1.5 Annual CO_2-sequestration in forests planted before 1990.

Net C sequestration in the periods 1990–1999 and 2000-2001 was the result of a net increase in standing stock of the existing forests. Net C sequestration in existing forests is the result of a relatively low and slightly decreasing harvest intensity, especially for conifers, but it is also partly a result of an uneven age class distribution with relatively many young stands.

The estimated gross wood increment for the period 2000–2002 was updated in the most recent questionnaire-based Forestry Census of 2000. Mean annual increments (m^3 ha^{-1}) for the categories of tree species for the periods 1990-1999 and 2000-2009 are provided in the Forestry Census of 2000. For the period 1990-99 a new increment estimate was calculated based on information from the 1990 Forestry Census, since missing information on site productivity now could be replaced by reference values from the State Forests. Further details on the calculation of the estimates can be found in Johannsen (2002).

Annually harvested amounts of wood (Figure 7.1) are obtained from Statistics Denmark (http://www.statistikbanken.dk/). Commercial harvesting was used in calculations for broadleaved species as wood from thinning operations in young stands is sold as fuel wood and therefore appears in the statistics. For conifers, non-commercial thinning operations are more common. In order to account for this, 20% were added to the figures for commercial harvests of coniferous wood.

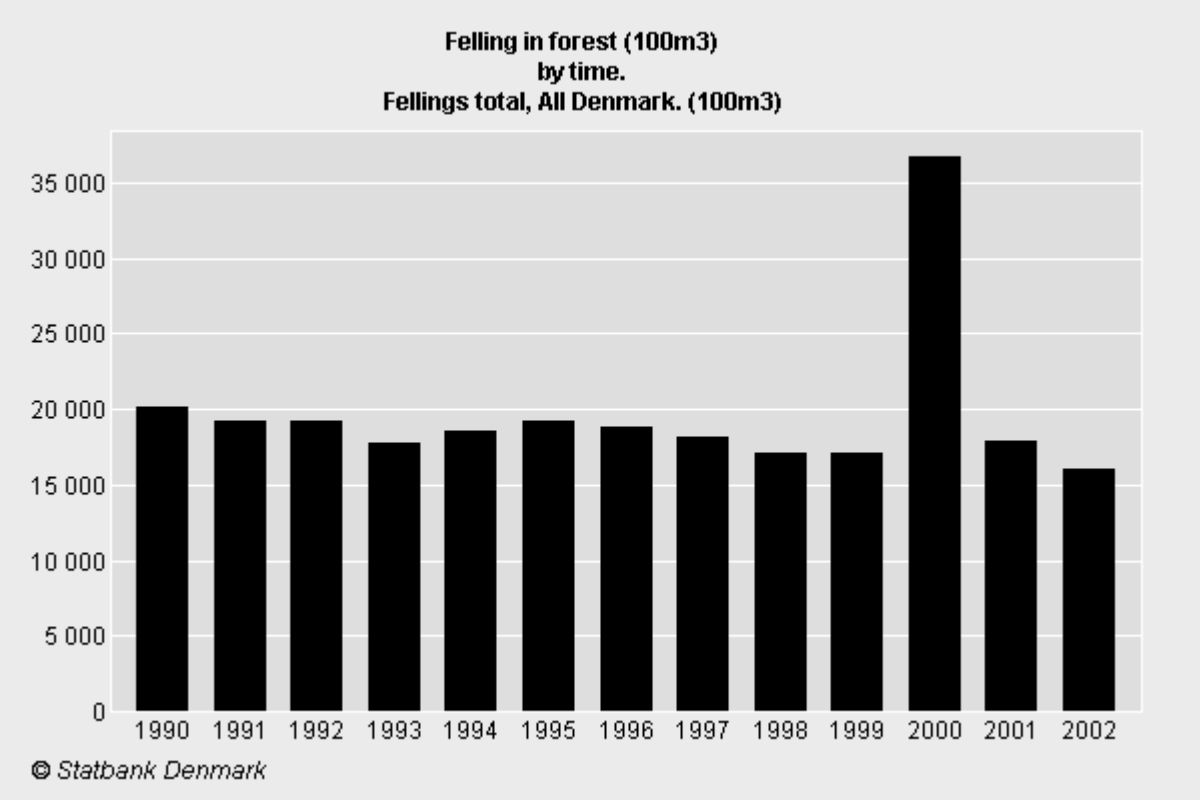

Figure 7.1. Total annual harvests of commercial wood in forests planted before 1990. The peak in 2000 is almost solely due to windthrow of conifers during the storm on Dec. 3, 1999. From http://www.statistikbanken.dk/.

The resulting net annual increment (wood increment minus harvested wood) was around 2.3 mill. m^3 y^{-1} for 1990–1999 and is estimated at around 2.7 mill. m^3 y^{-1} for 2000-2002 (Larsen and Johannsen, 2002). Rates of wood increment are converted to CO_2 uptake by the same method as mentioned above for carbon stocks.

The data on gross uptake of CO_2 due to annual gross increment, annual loss of CO_2 with harvested wood, and the resulting net sink for CO_2 are given in Table 7.2. The resulting net sink for CO_2 in forests existing in 1990 was around 3000 Gg CO_2 yr^{-1} for the period 1990-1999 and somewhat higher (around 3500 Gg CO_2 y^{-1}) for the period 2000-2002. In the year 2000 the sink was much lower than in all other years due to the storm in December 1999.

Table 7.2. Data on gross uptake of CO_2, loss of CO_2 due to harvesting (Figure 7.1) and the resulting net annual sink for CO_2 for the period 1990 – 2002 in forests existing before 1990.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Gross uptake of CO_2 Gg yr^{-1})	-5743	-5743	-5743	-5743	-5743	-5743	-5743	-5743	-5743	-5743	-6083	-6083	-6083
Loss of CO_2 in harvested wood (Gg yr^{-1})	2911	2732	2746	2534	2651	2761	2695	2614	2464	2476	5489	2618	2358
Net annual sink for CO_2 (Gg yr^{-1})	-2832	-3012	-2997	-3210	-3092	-2982	-3048	-3129	-3279	-3268	-594	-3465	-3725

In reports to UNFCCC until 2001, the net sink for CO_2 in forests existing in 1990 was reported as 916 Gg CO_2 y^{-1} for the period 1990-1999. The higher sink for CO_2 currently reported for the period 1990-99 is due to the use of more specific data. In submissions before 2001, the applied net annual increment was a rough estimate made in the Forestry Census of 1990. Now, net annual increment is based on specific data for gross increment and annual harvests by tree species category. This change was made in order to make the calculations more transparent. For 2000-2002, the sink for CO_2 was slightly higher than for 1990-1999. This is mainly attributed to the higher number of respondents to the questionnaire, i.e. the included forest area was larger. Annual increment per ha was quite similar for the two periods. The estimated increment in the period 2000-2009 was adjusted in order to account for the forest damage and changed age distribution caused by the storm in December 1999. The loss of increment was estimated at 182,00 m^3 yr^{-1} for the period 2000-2009.

7.1.1.6 CO_2 sequestration by afforestation of former arable land

In 1989 the Danish Government decided to encourage a doubling of the forested area within a tree generation of approximately 80–100 years (Danish Forest and Nature Agency 2000). In order to reach this target, an afforestation rate of roughly 4–5000 ha yr^{-1} is needed, but the afforestation rate has been much lower than needed with an average afforestation rate of 1837 ha yr^{-1} for the period 1990-2002. Afforestation is carried out on soils formerly used for agriculture (cropland). The annually afforested area is specified in Table 7.3. Data on the area afforested 1990-1998 by state forest districts, other public forest owners and private land owners receiving subsidies is based on an evaluation report on afforestation (Danish Forest and Nature Agency, 2000). Area data for the years 1999-2002 are obtained from the records of Danish Forest and Nature Agency. The area afforested by private land owners without subsidies is estimated by subtracting the afforestation categories mentioned above from the total area afforested per year in the period 1990-99 as recorded in the latest Forestry Census (Larsen and Johannsen, 2002). The Forestry Census included Nordmann's fir plantations for Christmas trees and greenery on arable land as afforestation. These stands made up 40% of the total area afforested 1990-1999. The Nordmann's fir plantations were not included in the afforested area used in the Danish LUCF reporting. Firstly, they never become closed forests as the trees are harvested within a ten-year rotation, and secondly changes in the market for Christmas trees may force landowners to revert the land use to agriculture after a few years.

The approximate distribution of broadleaved and coniferous tree species is obtained from the Forestry Census of 2000 (Larsen and Johannsen, 2002) for all ownership categories except private landowners receiving subsidies. The tree species distribution for the latter category was obtained from the evaluation report on afforestation (Danish Forest and Nature Agency, 2000).

Full carbon accounting is used in a manner by which C-stock changes are based on area multiplied by uptake. Uptake is calculated using a simple carbon storage model based on the Danish yield tables for Norway spruce (representing conifers) and oak (representing broadleaves) (Møller 1933). The amounts of carbon sequestered in annual cohorts of afforested areas are summed up in the model to give the total carbon storage in a specific year.

Table 7.3 Distribution of afforestation area (ha) on different landowners and tree species. Plantations of Nordmann's fir for Christmas trees and greenery are not included in the afforested area.

Year	State forests	Other publicly owned forests	Private forests with subsidies	Private without subsidies	Total area	Broadleaved	Coniferous
1990	107	12	0	611	730	320	410
1991	300	12	70	611	993	527	466
1992	562	12	70	611	1255	721	534
1993	450	149	70	611	1280	738	542
1994	553	149	178	611	1491	912	579
1995	396	141	178	611	1326	790	536
1996	407	146	212	611	1376	833	543
1997	414	267	968	611	2260	1614	646
1998	146	101	547	611	1405	912	493
1999	358	150	3314	611	4433	3622	811
2000	196	150	1764	611	2721	2092	629
2001	175	158	1181	611	2125	1552	573
2002	200	81	1600	611	2492	1959	533

Wood volumes are converted to carbon stores by the same method as mentioned for carbon stocks in 1990 except that a higher expansion factor of 2 is used for both species categories. The higher expansion factor is used in recognition of the age-dependency of expansion factors. The stem biomass represents a much lower proportion of the total biomass for age classes 1-10, thus a higher expansion factor is needed. However, studies in other countries indicate that an expansion factor of 2 clearly underestimates the total biomass for age classes 1-10 (Schöne and Schulte, 1999). As there are no Danish expansion functions including age, it was chosen to use an expansion factor of 2 as a conservative estimate so far. Here is clearly an area for improvement.

Decomposition rates for the various slash components are included in the model. Carbon storage in wood products may be included in the accounting by use of a module with turnover rates for the various wood products. This option was not included in the calculations of the figures presented here. For more information see Danish Energy Agency (2000).

The following carbon pools were included for afforestation stands: whole tree biomass (including roots), and slash. Based on studies of soils in a chronosequence of afforested stands, no significant changes in soil organic matter was expected to take place during the first 30 years following afforestation (Vesterdal et al., 2002). However, yet unpublished results from an EU project (http://www.fsl.dk/afforest/) indicates that this may not be the case following afforestation at other soil types. But there is currently no systematic data available to explore this further. The yield tables used for calculation of carbon stores are valid for yield class 2 (on a scale decreasing from 1 to 4). There is made no distinction between growth rates on different soil types.

The annual CO_2 uptake and the cumulated CO_2 uptake and afforested area since 1990 are given in Table 7.4. As shown in the table, annual sequestration of CO_2 in forests established since 1990 has gradually increased to 73 Gg CO_2 in 2001, for further details see the Annex. The annual CO_2 sequestration will increase much more over the next decades when cohorts of afforestation areas enter the stage of maximum current increment.

Table 7.4 Annual CO_2 uptake, cumulated CO_2 uptake and cumulated afforested area (ha) due to afforestation activities 1990–2002.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Annual CO_2 uptake (Gg yr^{-1})	0	-1	-3	-5	-8	-10	-16	-24	-34	-43	-59	-74	-88
Cumulated CO_2 uptake (Gg)	0	-1	-4	-10	-17	-28	-44	-68	-102	-145	-204	-278	-365
Cumulated afforestation area (ha)	730	1723	2978	4258	5749	7075	8451	10711	12116	16549	19270	21395	23887

During the Kyoto commitment period 2008–2012 (5 years), it is estimated that the Danish afforestation activities will result in sequestration of 384 Gg C equivalent to 1408 Gg CO_2. This amount of C results from the afforestation of 49100 ha of former arable land over the period 1990–2012. The sink capacity is based on a conservative estimate of around 2500 ha of land afforested annually 2003-2012, but it is possible that other instruments in addition to subsidisation will make it possible to increase the rate of afforestation and eventually the sequestration of CO_2.

7.1.1.7 Total contribution of forestry

Table 7.5 gives the figures reported in this NIR distributed to the categories *afforestation* and *forests existing prior to 1990*. Afforestation currently contributes little to the total uptake in forestry, but the annual uptake increases as stands enter the stage of maximum rate of increment and as the afforestation area gradually increases.

Table 7.5 CO_2 stores and annual uptake in forests in Gg, 1990–2002. Uptake due to changes in forest biomass stocks in forests planted before 1990 and due to afforestation of former arable land since 1990.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
CO_2 store in all forests	82225										98278		
Total CO_2 uptake in forests	-2832	-3013	-3000	-3215	-3100	-2992	-3064	-3153	-3313	-3311	-653	-3539	-3813
CO_2 uptake in forests existing before 1990	-2832	-3012	-2997	-3210	-3092	-2982	-3048	-3129	-3279	-3268	-594	-3465	-3725
CO_2 uptake due to afforestation since 1990	0	-1	-3	-5	-8	-10	-16	-24	-34	-43	-59	-74	-88

Output of Excel model used for calculation of the amounts of CO_2 sequestered due to afforestation since 1990.

		Afforestation area, ha				Total CO2 uptake		CO2 uptake per cumulated area		
Planting year	Years after establish-ment	Broad-leaves	Conifers	Total	Cumu-lated area since 1990	Annual Gg/yr	Cumu-lated Gg	Annual CO2 uptake, t/ha	Annual C uptake, t/ha	Running average CO2 uptake since 1990 Gg/ha
1990	0	320	410	730	730	0	0	0,0	0,00	0,00
1991	1	527	466	993	1723	1	1	0,7	0,20	0,73
1992	2	721	534	1255	2978	3	4	1,0	0,28	0,72
1993	3	738	542	1280	4258	5	10	1,2	0,34	0,75
1994	4	912	579	1491	5749	8	17	1,3	0,36	0,75
1995	5	790	536	1326	7075	10	28	1,5	0,40	0,78
1996	6	833	543	1376	8451	16	44	1,9	0,53	0,87
1997	7	1614	646	2260	10711	24	68	2,2	0,61	0,90
1998	8	912	493	1405	12116	34	102	2,8	0,77	1,05
1999	9	3622	811	4433	16549	43	145	2,6	0,71	0,97
2000	10	2092	629	2721	19270	59	204	3,1	0,83	1,06
2001	11	1552	573	2125	21395	74	277	3,4	0,94	1,18
2002	12	1959	533	2492	23887	88	365	3,7	1,00	1,27

The carbon increment model behind the output tables.

Carbon increment models based on oak and spruce, yield class 2										
Based on yield tables in Møller (1933)										
		Broadleaves, oak yield class 2				Conifers, Norway spruce yield class 2				
		With products		Without products		With products		Without products		
Year	Age	Increment t CO2/ha/yr	Storage t CO2/ha	Increment t CO2/ha/yr	Storage t CO2/ha	Increment t CO2/ha/yr	Storage t CO2/ha	Increment t CO2/ha/yr	Storage t CO2/ha	Stored wood for bioenergy t CO2/ha
1990	0	0	0	0	0	0	0	0	0	
1991	1	2	2	2	2	1	1	1	1	0
1992	2	2	4	2	4	1	3	1	3	0
1993	3	2	6	2	6	1	4	1	4	0
1994	4	2	9	2	9	1	6	1	6	0
1995	5	2	11	2	11	1	7	1	7	0
1996	6	6	17	6	17	7	14	7	14	0
1997	7	6	24	6	24	7	21	7	21	0
1998	8	6	30	6	30	7	28	7	28	0
1999	9	6	36	6	36	7	35	7	35	0
2000	10	6	43	6	43	7	41	7	41	0
2001	11	9	51	9	51	12	54	12	54	0
2002	12	9	60	9	60	12	66	12	66	0

Tables used to calculate total uptake of CO_2 based on annual cohorts of broadleaved and coniferous stands.

Summation table for cohorts of areas afforested with broadleaves (t CO2)

	Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
	Area	320	527	721	738	912	790	833	1614	912	3622	2092	1552	1959
Year	Age													
1990	0	0												
1991	1	685	0											
1992	2	685	1128	0										
1993	3	685	1128	1543	0									
1994	4	685	1128	1543	1579	0								
1995	5	685	1128	1543	1579	1952	0							
1996	6	2054	1128	1543	1579	1952	1691	0						
1997	7	2054	3383	1543	1579	1952	1691	1783	0					
1998	8	2054	3383	4629	1579	1952	1691	1783	3454	0				
1999	9	2054	3383	4629	4738	1952	1691	1783	3454	1952	0			
2000	10	2054	3383	4629	4738	5855	1691	1783	3454	1952	7751	0		
2001	11	2739	3383	4629	4738	5855	5072	1783	3454	1952	7751	4477	0	
2002	12	2739	4511	4629	4738	5855	5072	5348	3454	1952	7751	4477	3321	0

Summation table for cohorts of areas afforested with conifers (t CO2)

	Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
	Area (ha)	410	466	534	542	579	536	543	646	493	811	629	573	533
Year	Age (yr)													
1990	0	0												
1991	1	566	0											
1992	2	566	643	0										
1993	3	566	643	737	0									
1994	4	566	643	737	748	0								
1995	5	566	643	737	748	799	0							
1996	6	2829	643	737	748	799	740	0						
1997	7	2829	3215	737	748	799	740	749	0					
1998	8	2829	3215	3685	748	799	740	749	891	0				
1999	9	2829	3215	3685	3740	799	740	749	891	680	0			
2000	10	2829	3215	3685	3740	3995	740	749	891	680	1119	0		
2001	11	5092	3215	3685	3740	3995	3698	749	891	680	1119	868	0	
2002	12	5092	5788	3685	3740	3995	3698	3747	891	680	1119	868	791	0

7.2 References

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8 Waste (CRF Sector 6)

8.1 Overview of the sector

The CRF source category *6.A Solid Waste disposal on Land* and its CH_4 emissions is considered as the dominant source in the CRF sector 6.

As regards the CRF source category *6.B. Waste-water Handling* the CH_4 emission is considered of negligible importance due to aerobic waste water systems. Also N_2O emission is considered of minor importance. Refer to Chapter 8.3.6.

For the CRF source category *6.C. Waste Incineration* the emissions are included in the energy sector since all waste incinerated in Denmark are used in the energy production.

For the source sector *6.D. Other* no activities and emissions are considered.

The CH_4 emission from solid waste disposal on land constitutes a key source category in the key source level analysis. As regards the key source trend analyses it is not a key source since it is number 20 in the list where 18 are keys. In year 2002 it contributes 1.6% to the National total (without LULUCF) and is the seventh most contributing source in the list of 21 key sources in the key source analysis performed in this report (cf. Annex 1).

A quantitative overview of the source category is shown in Table 8.1 below with the amounts of land filled waste, the annual CH_4 emissions from the waste, the CH_4 collected as biogas and used for energy production and the resulting emissions for the years 1990-2002. The amount of waste and the resulting CH_4 emission are to be found as well in the CRF tables of this submission.

The amount of waste deposited has decreased markedly for the time-series. This is a result action plans of the government, the "Action plan for Waste and Recycling 1993-1997" and "Waste 21 1998-2004". The latter plan had inter alia the goal of all waste to recycle 64%, incinerate 24% and deposit 12%. The goal for deposited waste was met in 2000. Further, in 1996 was introduced a municipal obligation to assign combustible waste to incineration.

The decrease of the emission through the time-series is markedly, but much less than the decrease in amount deposited. This is due to the time involved in the processes generating the CH_4, which is reflected in the model used for emission calculation.

Table 8.1

Year	Waste	Annual emission	Biogas collected	Annual net emission	
	kt	kt CH4	kt CH4	kt CH4	kt CO2-eqv.
1990	3175,1	64,0	1,7	62,4	1309,8
1991	3032,3	65,3	1,7	63,7	1337,4
1992	2889,6	66,5	1,7	64,8	1361,1
1993	2746,8	67,4	2,8	64,7	1358,1
1994	2604,0	68,2	2,8	65,5	1374,6
1995	1957,0	68,7	6,0	62,7	1316,2
1996	2507,0	68,8	6,6	62,2	1306,1
1997	2083,0	68,6	9,4	59,2	1243,3
1998	1859,0	68,5	10,4	58,1	1220,4
1999	1467,0	68,2	9,9	58,2	1222,9
2000	1482,0	67,8	10,3	57,5	1206,6
2001	1300,0	66,6	10,0	56,6	1188,2
2002	1174,0	65,1	11,2	53,9	1131,3

The amount of gas being collected has increased due to an increase in installations using the gas for energy production.

8.2 Solid Waste disposal on Land (CRF 6.A)

8.2.1 Source category description

Disposal of waste takes place in Denmark on 135 registered sites (2002). The organic part of the waste deposited at these sites generates CH_4 gas, some of which is collected and used as biogas in energy producing installations at 25 sites (2002).

8.2.2 Methodology

The data used for the amounts of municipal solid waste deposited at solid waste disposal sites, is according to official registration performed by the Danish Environmental Protection Agency in the so-called ISAG database (Danish Environmental Protection Agency, 2004). CH_4 emissions from Solid Waste Disposal Sites are based on a model suited Danish conditions. The model is based on a IPCC Tier 2 approach and is unchanged since the NIR 2003 (Illerup et al., 2003). In Annex 3.E of this report details on the Methodology on CH_4 emission from solid deposited waste are given.

8.2.3 Uncertainty and time-series consistency

A registration of the amount of waste has been done since the start of the 1990s in order to measure the effects of action plans and the activity data is therefore considered as being consistent.

The consistency of the emission factor comes as a result of the same model run for the whole time-series. The time lag in the model is the same for the whole time-series and is within the interval recommended for a first order decay model in the IPCC guidelines.

For consideration of consistency, refer to the Table 8.1

Uncertainty might come from the use of the same waste composition for the whole times-series. Challenges in waste composition in the time-series and the influence on emissions according to the model is a possible item for further analyses

8.2.4 QA/QC and verification

It is a QC-procedure on data input and handling when the CH_4 emission results of the runs of the model are compared/adjusted to the CH_4 emissions in the CRF-tables.

8.2.5 Source specific recalculations

Recalculations have been performed since the April 15 2003 submission. The whole time-series previously submitted was recalculated for two reasons.

For 1996-2001 the emission estimates changed due to adjustments of the waste amounts used in the model. Adjustments of emission are up to 10%.

For 1990-1995 minor corrections of the emission factors in the CRF tables were made to make full agreement between activities and emissions reported in the CRF and the First Order Decay model used for the CH_4 emission estimates. Adjustments of emissions are at maximum 1%.

These recalculations were announced in the NIR 2003 and noticed by the review team. Further the review team noted that data for the sectoral background tables of the CRF was not provided. Please refer to those tables for the CRF of this submission where such an improvement has now been made. Further the general improvement of the use of Notation Keys also has been implemented in this sector.

8.2.6 Source specific planned improvements

As regards the recommendation made by the review team to conduct uncertainty analysis it is planned to do so. Further, the consequence of a change in composition of waste during the time-series will be considered.

8.3 Further, source specific planned improvements

The waste water handling sector will be analysed for Denmark in order to estimate and document the CH_4 and N_2O emissions, which especially for CH_4 is believed to be of only minor importance.

8.4 References

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9 Other (CRF sector 7)

Not relevant for Denmark.

10 Recalculations and improvements

10.1 Explanations and justifications for recalculations

The explanations and justifications for recalculations included in this submission and performed since the submission April 15, 2003 are given in the sector chapters, refer to:

Energy:	
• Stationary Combustion	Chapter3.2.5
• Transport	Chapter3.3.5
• Fugitive emissions	Chapter3.5.5
Industry	
• Mineral Products	Chapter4.2.5
• Chemical Industry	Chapter4.3.5
• Metal Production	Chapter4.4.5
• Consumption of F-gases	Chapter4.5.5
Agriculture	Chapter6.8
LULUCF	Chapter 7
Waste	Chapter8.2.5

10.2 Implications for emission levels

For the *National Total CO_2 Equivalent Emissions without Land-Use Change and Forestry* the general impact of the recalculations performed is small. All the differences for this national total for the time-series as taken from the recalculation tables of the CRF tables for 1990-2001 are negative reflecting that this submissions represents slightly smaller National total emissions than previously submitted. The differences vary between a maximum negative difference of 0,86% (1991) and minimum negative difference of 0.14% (2001). Refer to Table 10.1 below.

For the *National Total CO_2 Equivalent Emissions with Land-Use Change and Forestry* also the general impact of the recalculations is small, although they are bigger than without LULUCF due to recalculations in the LULUCF Sector. The differences vary between a maximum negative difference of 3.51% (1991) and maximum positive difference of 3.85% (2000). These extreme differences refer to recalculated estimates with major changes in the forestry sector for those years. Refer to Chapter 7.

Table 10.1 Recalculations performed year 2004 for inventories 1990-2001. National totals with and without LUCF. The percentage difference for National Totals between this and April 15, 2003 submission

	1990			1991		
	Previous submission	Latest submission	Difference	Previous submission	Latest submission	Difference
	CO2 equivalent (Gg)		(%)	CO2 equivalent (Gg)		(%)
Total CO2 Equivalent Emissions with Land-Use Change and Forestry	66.098,59	65.917,86	-0,27	79.239,18	76.458,40	-3,51
Total CO2 Equivalent Emissions without Land-Use Change and Fores	69.216,59	68.749,86	-0,67	80.157,18	79.471,40	-0,86

1992			1993			1994			1995		
Previous submission	Latest submission	Difference	Previous submission	Latest submission	Difference	Previous submission	Latest submission	Difference	Previous submission	Latest submission	Difference
CO2 equivalent (Gg)		(%)	CO2 equivalent (Gg)		(%)	CO2 equivalent (Gg)		(%)	CO2 equivalent (Gg)		(%)
70.337,63	70.258,84	-0,11	73.086,16	72.410,00	-0,93	76.913,31	76.573,07	-0,44	74.207,17	73.963,41	-0,33
73.458,63	73.258,84	-0,27	76.209,16	75.625,00	-0,77	80.039,31	79.673,07	-0,46	77.335,17	76.955,41	-0,49

1996			1997			1998			1999		
Previous submission	Latest submission	Difference	Previous submission	Latest submission	Difference	Previous submission	Latest submission	Difference	Previous submission	Latest submission	Difference
CO2 equivalent (Gg)		(%)	CO2 equivalent (Gg)		(%)	CO2 equivalent (Gg)		(%)	CO2 equivalent (Gg)		(%)
87.644,33	87.214,31	-0,49	77.802,70	77.519,91	-0,36	72.645,31	72.344,39	-0,41	69.588,76	69.241,31	-0,50
90.778,33	90.278,31	-0,55	80.944,70	80.672,91	-0,34	75.797,31	75.657,39	-0,18	72.749,76	72.552,31	-0,27

2000			2001		
Previous submission	Latest submission	Difference	Previous submission	Latest submission	Difference
CO2 equivalent (Gg)		(%)	CO2 equivalent (Gg)		(%)
64.664,04	67.155,16	3,85	65.879,20	65.774,30	-0,16
68.181,04	67.808,16	-0,55	69.410,20	69.313,30	-0,14

10.3 Implication trends, including time-series consistency

In the considerations leading to performed recalculations the consistency of the time-series back to 1990 ((1993) 1995 for F-gases) is a high priority. As a consequence activity data, emission factors and methodologies are carefully chosen to represent the emissions for the time-series correctly. It is often considerations on the time-series consistency that have led to recalculations for single years when activity data and/or emission factors have been corrected.

It was mentioned in Chapter 10.2 that for the *National Total CO_2 Equivalent Emissions without Land-Use Change and Forestry* the general impact of the recalculations performed is small and that the changes for the whole time-series is between -0.14 and -0.86. However, it should be noted that the small changes on the National Total are an aggregated result of considerable recalculations in different sectors leading to both negative and positive differences compared with the previous submissions. The result of all recalculations performed is shown in the table below and given in CO_2-equivalents. Memo items are not shown. The table is made on CRF source categories where recalculations have been performed. Also the difference on the level of National Total without LULUCF is shown, so the contributions for the source categories to the national result on differences can be directly considered in absolute CO_2-equivalents. The table is based on extracted data from tables in CRF-tables.

It can be seen from the table that the biggest and major recalculations has taken place for N_2O for Agriculture (4.B. manure management and 4.D. soils) and for N_2O for Industrial processes (2.B. Chemical Industry). These recalculations are explained in the sector chapters. The recalculated sources mentioned are key sources.

The second largest change of the recalculations is the CO_2 emission for Energy (1.A.2. Manufacturing Industries and Construction) with a negative difference for the whole time-series and for CO_2 for Energy (1.A.4. Other sectors) with a positive difference. These recalculations are numerically of comparable size, though 1.A.2. being somewhat bigger. Further, adding to this other smaller negative differences for the Energy Sector leads to a negative difference for CO_2 for the Energy Sector as a whole except for 2001.

Also recalculation of CH_4 for Agriculture (4.A. Enteric Fermentation and 4.B. Manure Management) is of importance. For both these activities the differences are negative for 1990-1994. For 1999-2001 the differences are positive. The differences in the net result for CH_4 from Agriculture for 1998-2001 is positive and for 1990-1997 negative.

For details on the trend of the recalculation performed in the Agricultural Sector refer to chapter 6.8.

In conclusion the recalculations performed for some single activities and sectors (Agriculture and Industry) has substantial importance for the whole time-series 1990-2001. For the National Total the recalculations is rather small and negative, since the single activities recalculated by coincidence to some extend equal out.

Table. Recalculation performed year 2004 for 1990-2001. Differences (CO2-eqv) between this and the April 2003 submission. Memo items not shown

GREENHOUSE GAS SOURCE AND SINK CATEGORIES		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
		CO_2	CO_2	CO_2	CO_2	CO_2	CO_2	CO_2	CO_2	CO_2	CO_2	CO_2	CO_2
1.A.	Fuel Combustion Activities	-43,3	-130,6	-57,4	-65,9	-73,2	-55,9	-77,0	-87,0	-0,5	25,0	-30,5	8,0
1.A.1.	Energy Industries	-25,3	-32,4	-31,4	-45,7	-34,8	-35,2	-35,9	-38,5	-33,6	-44,2	-50,6	2,0
1.A.2.	Manufacturing Industries and Construction	-221,9	-210,9	-228,0	-229,2	-139,5	-241,0	-238,3	-213,1	-129,5	-147,6	-83,2	-149,2
1.A.3.	Transport	10,9	-59,9	24,1	33,7	41,6	48,1	53,4	58,1	66,0	70,5	73,5	71,8
1.A.4.	Other Sectors	193,0	172,7	177,9	175,3	59,5	172,1	143,8	106,5	96,6	146,3	29,7	83,4
1.B.	Fugitive Emissions from Fuels	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-0,1	0,0
1.B.2.	Oil and Natural Gas	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-0,1	0,0
2.A.	Mineral Products	15,5	16,1	12,4	15,0	8,5	15,0	13,9	29,5	134,5	88,4	73,4	87,0
2.B.	Chemical Industry	1,7	1,7	1,7	1,7	1,7	1,7	1,7	1,9	1,4	1,8	2,7	3,1
2.C.	Metal Production	28,4	28,5	28,5	31,0	33,5	38,6	35,2	35,0	42,2	43,0	40,7	46,7
2.G.	Other	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
5.A.	Changes in Forest and Other Woody Biomass Stocks	286,0	-2095,0	121,0	-92,0	26,0	136,0	70,0	-11,0	-161,0	-150,0	2864,0	-8,0
		CH4	CH4	CH4	CH4	CH4	CH4	CH4	CH4	CH4	CH4	CH4	CH4
1.A.	Fuel Combustion Activities	3,8	-48,4	-1,4	6,3	1,9	11,0	19,3	-21,0	9,4	-33,8	-42,0	-49,4
1.A.1.	Energy Industries	-2,6	-5,1	-9,3	-3,4	1,4	9,4	6,0	-24,9	-38,1	-38,9	-40,1	-44,2
1.A.2.	Manufacturing Industries and Construction	-0,9	0,9	-1,0	-0,8	-6,8	-6,9	-0,5	-2,1	-1,7	-2,7	-3,3	-3,5
1.A.3.	Transport	-0,3	-1,9	-0,1	0,1	0,3	0,4	0,5	0,6	0,8	-8,5	1,0	1,0
1.A.4.	Other Sectors	7,6	-42,4	8,9	10,4	7,1	8,1	13,2	5,4	48,4	16,3	0,4	-2,8
1.A.5.	Other	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
1.B.	Fugitive Emissions from Fuels	0,0	-168,4	0,0	0,0	-1,2	0,0	0,0	0,0	0,0	0,3	0,0	0,0
1.B.2.	Oil and Natural Gas	0,0	-170,4	0,0	0,0	-1,2	0,0	0,0	0,0	0,0	0,3	0,0	0,0
4.A.	Enteric Fermentation	-88,8	-25,4	-62,1	-69,5	31,1	31,6	44,4	42,7	47,5	151,9	152,4	142,2
4.B.	Manure Management	-157,7	-124,5	-96,7	-94,9	-71,4	-77,5	-51,8	-47,5	-38,3	56,3	76,0	71,3
6.A.	Solid Waste Disposal on Land	-0,6	-0,3	0,3	-0,6	-0,9	-0,5	2,0	2,2	57,0	113,2	9,6	20,4
		N2O	N2O	N2O	N2O	N2O	N2O	N2O	N2O	N2O	N2O	N2O	N2O
1.A.	Fuel Combustion Activities	5,9	11,4	3,2	1,6	2,1	1,8	1,5	-1,3	-6,4	0,0	-15,0	-17,5
1.A.1.	Energy Industries	0,6	3,7	-2,0	-4,0	-3,4	-4,2	-5,3	-8,0	-12,0	-16,0	-18,6	-19,8
1.A.2.	Manufacturing Industries and Construction	0,5	0,7	0,4	0,4	1,3	0,7	1,7	2,1	1,7	0,9	1,3	0,5
1.A.3.	Transport	0,2	-2,2	0,3	0,3	0,4	0,4	0,4	0,5	0,5	7,2	0,6	0,6
1.A.4.	Other Sectors	4,6	9,6	4,6	4,8	3,8	4,9	4,7	4,1	3,4	7,8	1,8	1,2
1.A.5.	Other	0,0	-0,3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0
2.B.	Chemical Industry	1042,9	954,8	843,6	794,9	806,5	903,8	834,3	848,2	806,5	950,2	1003,5	885,3
4.B.	Manure Management	224,5	214,2	206,6	190,2	173,1	160,4	159,9	199,8	196,6	184,5	172,8	176,7
4.D.	Agricultural Soils [(2)]	-1500,5	-1416,4	-1078,2	-1358,7	-1271,5	-1391,3	-1440,7	-1202,8	-1305,6	-1676,0	-1705,7	-1470,6
		HFCs	HFCs	HFCs	HFCs	HFCs	HFCs	HFCs	HFCs	HFCs	HFCs	HFCs	HFCs
2.F.	Consumption of Halocarbons and SF_6	0,0	0,0	-0,2	-1,7	-6,5	-18,1	-41,5	-68,4	-78,2	-94,9	-100,4	0,0
		PFCs	PFCs	PFCs	PFCs	PFCs	PFCs	PFCs	PFCs	PFCs	PFCs	PFCs	PFCs
2.F.	Consumption of Halocarbons and SF_6	0,0	0,0	0,0	0,0	-0,1	-0,4	-1,3	-3,1	-5,9	-7,4	-10,4	0,0
		SF6	SF6	SF6	SF6	SF6	SF6	SF6	SF6	SF6	SF6	SF6	SF6
2.F.	Consumption of Halocarbons and SF_6	1,4	1,4	0,0	-21,6	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Total CO_2 Equivalent Emissions without LULUCF		-466,7	-685,8	-199,8	-584,2	-366,2	-379,8	-500,0	-271,8	-139,9	-197,5	-372,9	-96,9

10.4 Recalculations, including in response to the review process, and planned improvement to the inventory (e.g. institutional arrangements, inventory preparations)

The review process and the review report have been very valuable for the improvements made and the recalculations performed. The final outcome of the review process is the review report available as http://unfccc.int/program/mis/ghg/countrep/denrep03.pdf

In the review process comments were made to a draft version of the review report. These are unpublished but can be made available upon request.

In general the reviewers has pointed out lacks of the use of notation keys in the CRF tables. The insertion of notation keys has for this submission been considerable improved for all sectors.

For the *Energy Sector* as regards *Stationary Combustion* the response to the review report is given in the Energy Chapter, chapter 3.2.5. last paragraph and in chapter 3.2.6. The main message here is that no recalculation has taken place as a result of the comments made by the reviewers, but the documentation has been improved to clarify subjects questioned by the reviewers. The plans for future improvements are given in chapter 3.2.6, where the most important plans are a disaggregation of the fuel consumption in the Industrial Sector and updating of energy statistics. For the *Energy Sector* as regards *Transport* a response to the review team is given in Energy Chapter 3.3.5. Last paragraph and an outline of plans are given in Chapter 3.3.6. For *Energy, fugitive emissions* the recalculations carried out are noted in chapter 3.5.5. In connection to the Energy Sector the review team notes that the inventories for Greenland and Faro Islands are not disaggregated. This note has been discussed and the plan is now to include those emissions under "other" in the relevant CRF source categories. It is important to mention that the emissions for Greenland and Faro Islands are very small compared to Denmark.

For the *Industrial Sector* the review team recommended a number of potential sources to be considered, e.g. N_2O emissions from Nitric acid production. The resources in the sector have been strengthened. N_2O emission from Nitric Acid production has been estimated for 1990-2002. For more details on the response to the recommendation by the review team refer to chapter 4.1. For F-gases a full introduction of recalculated emission estimates as a result of a revision of the model used was announced to the reviewers. This has now been done, the changes are minor, refer to Table in Chapter 10.3. Further, the reviewers noted inconsistencies as regards background information on the potential emission of F-gases in the CRF-tables. These emissions have been changed.

For the *Agricultural Sector* all of the comments of the review team have been carefully considered and action been taken. Details on the response and implementation can be seen in chapter 6.8. In general the inconsistencies pointed out by the reviewers have been removed and the plans for improvements announced to the reviewers have been implemented. Further plans in this sector of highest priority is to include CO_2 from Agricultural soils. For further details and plans refer to chapter 6.9.

For the *LULUCF Sector* the note made by the review team to describe the methodology more transparently has been carefully considered in preparing Chapter 7. This chapter also includes some considerations on uncertainty. Further, notation keys has been inserted in the CRF tables.

For the *Waste Sector* and CH_4 from solid disposal on land small inconsistencies existed between activities and emission factors in the CRF and in FOD model used. The review team noted this. The inconsistencies are now removed. As a part of the general improvement of the use of notation keys, this has also been done in this sector, including that the review team point on the use of "IE"

in Table 6.A. The review team suggested to compare the model used with IPCC default methodology. It is the plan to depending on resources to do so. As regards the recommendation made by the review team to conduct uncertainty analysis it is also planned to do so. The review team had question to waste water-handling system as regards CH_4 and N_2O emissions. The plan is to analyse this in order to estimate and document the CH_4 and N_2O emissions, which especially for CH_4 is believed to be of only minor importance.

In conclusion considerations have been made of all of the review reports suggestions, comments, recommendations and corrections. Improvements in inventories on the items pointed out by reviewers were to be made in a rather short timeframe, but all possible requirements and suggested improvements were made. The time frame is set from the time from receiving the draft review report November 11, 2003 and from receiving the final report February 12, 2004 and until March 31 2004 were the final inventories was to be delivered to the European Commission. For items pointed out by the reviewers but not reflected in this inventory submission there has been put remarks, extended explanations and announcement of plans for improvements.

As regards planned improvement to the inventory as concerns institutional arrangements, inventory preparations no major changes are foreseen. A strengthening on timely delivery of data from other institutions will be carried out. Furthermore, considerations will be made on gaps in data where sources are missing.

Executive summary

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

Annual report
This report is Denmark's National Inventory Report (NIR) due by 15 April 2004 to the United Nations Framework Convention on Climate Change (UNFCCC). The report contains information on Denmark's inventories for all years from 1990 to 2002. The structure of the report is in accordance with the UNFCCC Guidelines on reporting and review and the report includes detailed information on the inventories for all years from the base year to the year of the current annual inventory submission, in order to ensure the transparency of the inventory.

The annual emission inventory for Denmark from 1990 to 2002 is reported in the Common Reporting Format (CRF). The CRF-spreadsheets contain data on emissions, activity data and implied emission factors for each year. Emission trends are given for each greenhouse gas and for the total greenhouse gas emissions in CO_2-equivalents.

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

The NIR and the CRF tables are available to the public on the National Environmental Research Institute's homepage:

http://www.dmu.dk/1_Viden/2_Miljoe-tilstand/3_luft/4_adaei/default_en.asp

Responsible institute
The National Environmental Research Institute (NERI) under the Danish Ministry of Environment is responsible for the annual preparation and submission to the UNFCCC (and the EU) of the National Inventory Report and the GHG inventories in the Common Reporting Format in accordance with the UNFCCC Guidelines. The work concerning the annual greenhouse emission inventory is carried out in co-operation with other Danish ministries, research institutes, organisations and companies.

Greenhouse gasses
The greenhouse gasses reported under the Climate Convention are:

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

The global warming potential values of various gasses have been defined as the warming effect of a given weight of a specific substance relative to CO_2. The purpose of this is to be able to compare and integrate the effects of individual substances on the global climate. The typical lifetimes are 100, 10 and 300 years for CO_2, CH_4 and N_2O, respectively, and the time perspective clearly plays a decisive role. The lifetime chosen is typically 100 years. Then the effect of the various greenhouse gasses can be converted into the equivalent quantity of CO_2, i.e. the quantity of CO_2 giving the same effect in absorbing solar radiation. According to the IPCC, the most recent global warming potential values for a 100-year time horizon are:

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

Based on weight and a 100-year period, methane is thus 21 times more powerful a greenhouse gas than CO_2, and N_2O is 310 times more powerful. Some of the other greenhouse gasses (hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride) have considerably higher global warming potential values. For example, sulphur hexafluoride has a global warming potential of 23,900. The global warming potential values used in this reporting are those prescribed by UNFCCC.

ES.2. Summary of national emission and removal related trends

The greenhouse gas emissions are estimated according to the IPCC guidelines and are aggregated in seven main sectors. The greenhouse gases include CO_2, CH_4, N_2O, HFCs, PFCs and SF_6. Figure ES.1 shows the estimated total greenhouse gas emissions with CO_2 removal by forestry in CO_2 equivalents from 1990 to 2002. The emissions are not corrected for electricity trade or temperature variations. CO_2 is the most important greenhouse gas followed by N_2O and CH_4 in relative importance. The contribution to national totals from HFCs, PFCs and SF_6 is about 1% in 2002. Stationary combustion plants, transport and agriculture are the largest sources. The removal by forestry is about 5% of the total emissions in CO_2 equivalents. The national total greenhouse gas emissions in CO_2 equivalents are almost equal in 1990 and in 2002.

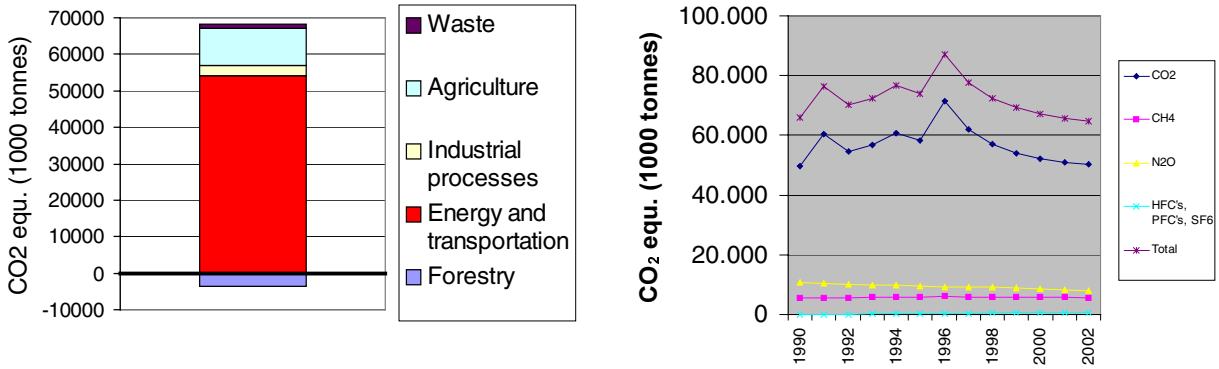


Figure E.S.1 Greenhouse gas emissions in CO_2 equivalents without LUCF. Time series for 1990 to 2002 and distribution on main sectors for 2002.

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

Energy
The largest source to the emission of CO_2 is the energy sector, which includes combustion of fossil fuels like oil, coal and natural gas. Public power and district heating plants contribute with about half of the emissions in the energy sector. About 23% come from the transport sector. The CO_2 emission decreased by about 1% from 2001 to 2002. The reason for the small decrease is mainly due to higher outdoor temperature in 2002 compared with 2001. A relatively large fluctuation in the emission time series 1990 to 2002 is due to cross-country electricity trade. Thus high emissions in 1991 and 1996 reflect a large electricity export and the low emission in 1990 is due to a large import of electricity. The increasing emission of CH_4 is due to increasing use of gas engines in the decentralised cogeneration plants. The CO_2 emission from the transport sector has increased by 18% since 1990 mainly due to increasing road traffic.

Agriculture
The agricultural sector contributes with 15% of the total greenhouse gas emission in CO_2- equivalents and is one of the most important sectors regarding the emissions of N_2O and CH_4. In 2002 the contributions to the total emissions of N_2O and CH_4 were 80% and 67 % respectively. The main reason for a drop of the N_2O emission of about 30% from 1990 to 2002 is because of demands according to legislation to an improved utilisation of nitrogen in manure. This results in less nitrogen excreted per unit produced and a considerably reduction in the use of fertilisers. From 1990 the emissions of CH_4 from enteric fermentation has decreased because of decreasing numbers of cattle. However the emission from manure management have increased due to change in stable systems towards an increase in slurry based stable systems. Altogether the emission of CH_4 for the agriculture sector has been almost constant from 1990 to 2002.

Industrial processes
The emissions from industrial processes – that is emissions from processes other than fuel combustion - amount to 4% of the total national emissions in CO_2- equivalents. The main sources are cement production, nitric acid production, refrigeration, foam blowing and calcination of limestone. The CO_2 emission from cement production – which is the largest source contributing with 2,1% of the national totals – increased with 65% from 1990 to 2002. The second largest source is N_2O from production of nitric acid. The N_2O emission from this production decreased with 26% from 1990 to 2002.

The emissions of HFCs, PFCs and SF_6 have since 1995 and until 2002 increased by 120% mainly due to increasing emissions of HFCs. The use of HFCs, and especially HFC-134a has increased several folds so HFCs has become a very dominating F-gas contributing to the F-gas total from 48% in 1993 to 94% in 2002. HFC-134a is mainly used as a refrigerant. However, the use of HFC-134a is stagnant or falling. This is due to Danish law, which in 2007 forbids new HFC based refrigerant stationary systems. Counter to this trend is the increasing use of air conditioning systems, among these mobile systems.

Waste
Waste disposal is the third largest source to CH_4 emission. The emission has decreased by 14% from 1990 to 2002 where the contribution was 20% of the total CH_4 emission. The decrease is due to increasing use of waste for power and heat production. Since all incinerated waste is used for power and heat production the emissions are included in the energy sector.

ES.4. Other information

ES.4.1 Quality assurance and quality control

A first draft for implementing a Quality Assurance (QA) and Quality Control (QC) plan for greenhouse gas emission inventories performed is included in the report. The plan is in accordance with the guidelines provided by the UNFCCC and the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories.

In the preparation of Denmark's annual emission inventory several quality control (QC) procedures are carried out already and the QA/QC plan will future improve this activity. The Danish Tier 1 QC includes:

- Check of time series of the CRF and SNAP source categories as they are found in the Corinair databases. Considerable trends and changes are checked and explained.
- Comparison to inventory of the previous year on the level of the categories of the CRF as well as on SNAP source categories. Any major changes are checked, verified, etc.
- Total emissions when aggregated to CRF source categories are compared to totals based on SNAP source categories (control of data transfer).
- A manual log table have been introduced in the emission databases to collect information about recalculations

A part from the UNFCCC's In-Depth-Reviews, Quality Assurance (QA) with independent review of the inventories has not yet been carried out. A strategy for implementing a formal QA/QC plan is given in the report.

The main objective is to implement a plan that comprises a frame for documenting and reporting emissions in way that emphasises transparency, consistency, comparability, completeness and accuracy. To fulfil these high criteria a data structure is proposed that describe the pathway from collection of raw data to data compilation and modelling and final reporting. As a first approach a general structure is proposed, but realising the differences in availability and quality in data from the different sectors, the structure is designed to exhibit flexibility towards varying forms of input data.

ES. 4.2. Completeness

The Danish greenhouse gas emission inventory due 15 April 2004 includes all sources identified by the Revised IPPC Guidelines except the following:

- Waste: Wastewater handling systems are considered to produce only minor emissions of CO_2, CH_4 and N_2O but the subject will be investigated further.
- Industrial processes: CO_2 emission from sugar production and production of expanded clay will be included in the next submission. Also CO_2 emissions from use of coke in iron foundries will be included in the next submission.
- Agriculture: The methane conversion factor for poultry and fur farming is not estimated. There is no default value recommended in IPCC (table A-4 in GPG). The CH_4 emissions from manure storage in the field and from cultivation of organogenic soil are not estimated.

In response to review of previous submissions the use of notation key in the Danish CRF-tables is improved and extended.

ES. 4.3. Recalculations and improvements

For the **National Total CO_2 Equivalent Emissions without Land-Use Change and Forestry** the general impact of the recalculations performed is small and the changes for the whole time-series is between -0.14 and -0.86. Therefor the implications of the recalculations on the trend 1990-2002 of the National Total are small.

However, the small changes on the National Total are an aggregated result of considerable recalculations in different sectors leading to both negative and positive differences comparing this submission with the previous. The biggest and major recalculations have taken place for N_2O for Agriculture (4.B. manure management and 4.D. soils) and for N_2O for Industrial processes (2.B. Chemical Industry). These recalculations are explained in the sector chapters. The recalculated sources mentioned are key sources. By coincidence these major recalculations are for Agriculture negative at a size rather close to the positive recalculation for Industry. Especially this is the case for 1990-1997. So the impact on nation total is small for these biggest recalculations.

Next to the biggest recalculations are in size the recalculations for CO_2 for Energy (1.A.2. Manufacturing Industries and Construction) with a negative difference for the whole time-series and for CO_2 for Energy (1.A.4. Other sectors) with a positive difference. These recalculations are numerically of comparable size, though 1.A.2. being somewhat bigger. Further, adding to this other smaller negative differences for the Energy Sector leads to a negative difference for CO_2 for the Energy Sector as a whole except for 2001.

Recalculation of CH_4 emissions for Agriculture - 4.A. Enteric Fermentation and 4.B. Manure Management - also results in significant changes compared to previous submissions. For both activities the differences are negative for 1990-1994. For 1999-2001 the differences are positive. The net result for CH_4 from Agriculture for 1998-2001 is positive differences and for 1990-1997 negative.

For the **National Total CO_2 Equivalent Emissions with Land-Use Change and Forestry** also the general impact of the recalculations is small, although they are bigger than without LULUCF due to recalculations in the LULUCF Sector. The differences vary between a maximum negative difference of 3.51% (1991) and maximum positive difference of 3.85% (2000). These extreme differences refer to recalculated estimates with major changes in the forestry sector for those years.

Annex 1 Key Source Analyses

Annex 1 Key sources

Description of the methodology used for identifying key sources
The key source analysis is carried out according to the Good Practice Guidance, Penman et al (2000). The base year in the analysis is the year 1990 for the greenhouse gases CO_2, CH_4, N_2O and 1995 for the greenhouse F-gases HFC, PFC and SF_6. The base year is unadjusted to electricity trade. The analysis was made for the inventory for the year 2002.

The present key source analysis follows the same approach as the analyses for the years 2000 and 2001 as presented in the NIR2002 and 2003 respectively. The approach is a Tier 1 quantitative analysis. As suggested in the Good Practice Guidance the analysis is carried out without considering LULUCF.

The level assessment of the key source analysis is a ranking of the source categories in accordance to their contributions to the National total of greenhouse gases calculated in CO_2-equivalent units. The level key sources are found from the list of source categories ranked according to their contribution in descending order. Level key sources are those from the top of that list which sum constitutes 95% of the National total.

The trend assessment of the key source analysis is a ranking of the source categories according to their contribution to the trend of the National total of greenhouse gases calculated in CO_2-equivalent units from the base year to the year considered. The trend of the source category is calculated relative to the trend of the National totals and the trend is weighted with the contribution according to the level assessment. The ranking is performed in descending order on this trend. As for the level assessment the cut of line is 95% for the sum of contribution to the trend and those source categories from the top of the list to the cut of line are trend key sources.

Information on the level of disaggregation
The starting point for the choice of source categories is the one presented in the Good Practice Guidance as Table 7.1. This table constitutes a suggested list of source categories for the key source analyses. It is mentioned in the Good Practice Guidance that categories for the key source analyses should be chosen in a way so that emissions from a single category are estimated with the same method and the same emission factor. Therefor for categories in this table, which in our Corinair database are composed of activities with different emission factors splits were made accordingly. Especially in the Energy Sector further splits are made as compared to the Table 7.1 in the Good Practice Guidance.

The source categories for Energy and Stationary combustion are defined according to the fuels and their emission factors, which are (year 2002)

CO2 emission factors, fossil	kg/GJ
COAL	95
BROWN COAL BRI.	95
COKE OVEN COKE	108
PETROLEUM COKE	108
PLASTIC WASTE	18
RESIDUAL OIL	78
GAS OIL	74
KEROSENE	72
ORIMULSION	80
NATURAL GAS	57
LPG	65
REFINERY GAS	57

where Coal, Brown coal and Coke oven coke are aggregated in the key source analyses, also because this split is only available for the year 2002. The other activities constitute in the key source analyses source categories according to these fuels due to the difference in emission factors.

For Energy and Mobil combustion the bases for the source categories is the activities:

Mobile combustion	Civil Aviation
Mobile combustion	Road Transportation
Mobile combustion	Railways
Mobile combustion	Navigation
Mobile combustion	Military
Mobile combustion	national fishing
Mobile combustion	agriculture
Mobile combustion	forestry
Mobile combustion	other Mobil and machinery/industry
Mobile combustion	household and gardening

These categories have been chosen as source categories for the analyses due to differences in fuel used etc.

For the sectors Industry, Agriculture and Waste the source categories are activities found in the CRF source categorisation.

We have chosen to keep this selection of key sources not to loose the comparison to the key source analyses performed for the years 2000 and 2001. Our choice of categories for the analysis identifies 63 source categories, which appear in the table section of this Annex, in Table 3 the key source categories are listed according to the inventory section in which they appear. As compared to the analyses made for year 2000 and 2001 (refer NIR 2002 and 2003) with 59 categories, 4 additional categories from Industry has been identified as a consequence of work to improve our coverage of sources in the Industry sector (refer to the Industry section of this NIR) .

The result of the Key Source analyses for Denmark for the year 2002
The result of the key source level assessment for Denmark for year 2002 is shown in Table 1. A number of 21 key sources were identified and marked as shaded in the Table. For year 2000 and 2001 the number was 20, the one new is one of the new industrial source categories. The entries to Table 1 and 2 for the year 1990 and 2002 are composed from the databases producing the CRF inventory for those years in this report. Note that base year estimates are not used in the level assessment analysis, but are only included in Table 1 to make it uniform with Table 2.

The result of the key source trend assessment for Denmark for year 2002 is shown in Table 2. A number of 18 key sources (17 for year 2001 and 16 for 2000) were identified and marked as shaded in the Table. Note that according to the Good Practice Guidance the analysis implies that contributions to the trend are all calculated mathematically positive to be able to perform the ranking.

Following the reporting suggestion of the Good Practice Guidance the key source analyses is summarised in Table 3. The information in this table is given in order to give **reference to the key source table** (Table 7) to be used in the coming CRF format. In Table 3, all categories used in the analysis are listed and the summary result of the key source analyses is given. It is seen that of the 63 source categories chosen for this analysis, 25 are identified as key source categories. For years 2000 and 2001 out of 59 categories respectively 22 and 23 were key sources. In the key sources analyses for 2002 15 were key sources due to both level and trend (compared to 14 for 2000 and 2001), 7 due to level only (6 for 2000 and 2001) and 4 due to trend only (2 for 2000 and 3 for 2001).

The **Energy Sector and CO_2 emission from Stationary Combustion** contributes to 7 (5 for year 2000 and 7 for 2001) key source categories with respect to level and trend. These 7 key sources are as for 2001 the major fuels Coal, Residual Oil, Gas Oil, Orimulsion and Natural Gas and Plastic Waste (Non biogenic waste in 2001). For those key sources the trend in emission estimates comparing year 1990 and 2002, Coal, Residual Oil and Gas Oil are seen to reduce emissions while Orimulsion, Plastic Waste and Petroleum Coke and especially Natural Gas increase. According to the key source level assessment Coal is for year 2002 as for 2001 the most contributing category with 24.2% of the National total (Table 1). This contribution is increasing since the contribution was 24.0% in 2001 and 23.0% in 2000. Natural gas is in 2002 as in 2001 the third largest contributor with 16.2% (16.0% in 2001 and 15.5% in 2000). Gas Oil is in 2002 as in 2001 the fifth largest contributor with a level of 4.3% in 2002 (in 2001 4.4% and in 2000 4.2%). The rest of the categories mentioned in this paragraph as level and trend key sources contribute each below 4% of the National total in 2002.

The **Energy Sector and CO_2 emission from Mobile Combustion** contributes with Road Transportation as a key source for level and trend with increased emission estimates from year 1990 to 2002. This category is in year 2002 as for 2000 and 2001 the second largest contributor with a level contribution of 16.6% in 2002 as compared to 16.2% in 2001 and 16.4% in 2000.

In the **Industrial Sector**, 3 sources are in 2002 keys with respect to both level and trend. Of these 2 sources are the same as were the only keys with respect both to level and trend for year 2000 and 2001. The 3 keys for 2002 are CO_2 emissions from Cement Production, Emission from substitutes for Ozone Depleting Substances (HFCs and PFCs) and N_2O emission from Nitric Acid production. The latter source is new, please refer to the Chapter on Industry in this NIR. The trends from year 1990 to 2000 for these sources are increased emissions from Cement Production and from substitutes for Ozone Depleting Substances (HFCs and PFCs), while N_2O emissions from Nitric Acid production decreased. As regards the level assessment Cement Production contributes 2.1%, Nitric Acid Production 1.1% and substitutes for Ozone Depleting Substances (HFCs and PFCs) 1%.

In the **Agriculture Sector**, 3 sources are keys with respect both to level and trend as they were in the analysis for the year 2000 and 2001. These key categories are direct N_2O emissions from Agriculture Soils, indirect N_2O emissions from Nitrogen used in Agriculture and CH_4 from Enteric Fermentation. The emission estimates for these 3 sources represent a reduced emission from year 1990 to 2002. According to level assessment these sources are among the 7 most contributing sources, with direct N_2O emissions from Agriculture Soils contributing 4.3%, indirect N_2O emissions from Nitrogen used in Agriculture contributing 4.1% and CH_4 from Enteric Fermentation 4.1%. Compared to contributions in 2001, these contributions were 6.5%, 4.3% and 4.0% respectively.

Tables 7.A1 – 7.A3 of the Good Practice Guidance

As Tables 1 - 3 are below presented the Tables 7.A1 -7.A3 of the Good practice Guidance.

Table 1

Table 7.A1 (of Good Practice Guidance) Tier 1 Analysis - Level Assessment (DK-inventory)							
A IPCC Source Categories (LULUCF not included)			B Direct Greenh. Gas	C Base Year Estimate (1) Mt CO2-eq	D Year 2002 Estimate Mt CO2-eq	E Year 2002 Level Assess-ment	F Year 2002 Cumul. total of Col. E
Energy	CO2 Emission from stationary Combustion	Coal	CO2	24,209	16,708	0,244	0,24
Energy	Mobile combustion	Road Transportation	CO2	9,351	11,389	0,166	0,41
Energy	CO2 Emission from stationary Combustion	Natural gas	CO2	4,330	11,090	0,162	0,57
Agriculture	Direct N2O emissions from Agriculture soils		N2O	4,170	2,962	0,043	0,62
Energy	CO2 Emission from stationary Combustion	Gas oil	CO2	4,564	2,920	0,043	0,66
Agriculture	Indirect N2O emissions from Nitrogen used in agriculture		N2O	4,127	2,803	0,041	0,70
Agriculture	Enteric fermentation		CH4	3,100	2,798	0,041	0,74
Energy	CO2 Emission from stationary Combustion	Residual oil	CO2	2,505	1,923	0,028	0,77
Energy	CO2 Emission from stationary Combustion	Orimulsion	CO2	0,000	1,908	0,028	0,80
Industrial Processes	CO2 emissions from Cement production		CO2	0,882	1,452	0,021	0,82
Energy	Mobile combustion	agriculture	CO2	1,318	1,219	0,018	0,83
Waste	Emission from Solid Waste Disposal sites		CH4	1,310	1,131	0,017	0,85
Agriculture	Manure management		CH4	0,742	0,966	0,014	0,87
Energy	CO2 Emission from stationary Combustion	Refinery gas	CO2	0,806	0,842	0,012	0,88
Industrial Processes	Nitric Acid Production		N2O	1,043	0,774	0,011	0,89
Energy	CO2 Emission from stationary Combustion	Petroleum coke	CO2	0,410	0,762	0,011	0,90
Energy	Mobile combustion	other mobil and machinery	CO2	0,778	0,742	0,011	0,91
Industrial Processes	Emission from substitutes for ODS		HFC and	0,218	0,694	0,010	0,92
Energy	Mobile combustion	national fishing	CO2	0,771	0,612	0,009	0,93
Agriculture	N2O from Manure management		N2O	0,686	0,605	0,009	0,94
Energy	CO2 Emission from stationary Combustion	Plastic waste	CO2	0,369	0,599	0,009	0,95
Energy	Mobile combustion	Navigation	CO2	0,551	0,554	0,008	0,96
Energy	Fugitive emissions	Oil and Natural Gas	CO2	0,240	0,535	0,008	0,96
Energy	Non-CO2 Emission from stationary Combustion		CH4	0,119	0,533	0,008	0,97
Energy	Mobile combustion	Road Transportation	N2O	0,131	0,394	0,006	0,98
Energy	Non-CO2 Emission from stationary Combustion		N2O	0,397	0,383	0,006	0,98
Energy	Mobile combustion	Railways	CO2	0,297	0,210	0,003	0,99
Energy	Mobile combustion	Civil Aviation	CO2	0,216	0,146	0,002	0,99
Industrial Processes	CO2 emissions from Lime production		CO2	0,123	0,124	0,002	0,99
Solvent and Other Product Use			CO2	0,124	0,112	0,002	0,99
Energy	CO2 Emission from stationary Combustion	LPG	CO2	0,194	0,104	0,002	0,99
Energy	Mobile combustion	Military	CO2	0,119	0,089	0,001	0,99
Energy	Mobile combustion	household and gardening	CO2	0,087	0,082	0,001	1,00
Energy	Fugitive emissions	Oil and Natural Gas	CH4	0,021	0,070	0,001	1,00
Energy	Mobile combustion	Road Transportation	CH4	0,055	0,063	0,001	1,00
Energy	Fugitive emissions	Solid Fuels	CH4	0,072	0,062	0,001	1,00
Energy	CO2 Emission from stationary Combustion	Kerosene	CO2	0,366	0,018	<0,001	1,00
Industrial Processes	CO2 emissions Glass Production		CO2	0,016	0,016	<0,001	1,00
Energy	Mobile combustion	agriculture	N2O	0,017	0,016	<0,001	1,00
Industrial Processes	SF6 from other sources of SF6		SF6	0,068	0,012	<0,001	1,00
Energy	Mobile combustion	national fishing	N2O	0,015	0,012	<0,001	1,00
Energy	Mobile combustion	other mobil and machinery	N2O	0,010	0,010	<0,001	1,00
Industrial Processes	SF6 from electrical equipment		SF6	0,004	0,009	<0,001	1,00
Energy	Mobile combustion	Navigation	N2O	0,010	0,009	<0,001	1,00
Energy	Mobile combustion	forestry	CO2	0,005	0,004	<0,001	1,00
Industrial Processes	CO2 emissions Catalysts/Fertilizers and Pesticides		CO2	0,002	0,003	<0,001	1,00
Energy	Mobile combustion	other mobil and machinery	CH4	0,003	0,003	<0,001	1,00
Energy	Fugitive emissions	Oil and Natural Gas	N2O	0,001	0,003	<0,001	1,00
Energy	Mobile combustion	household and gardening	CH4	0,003	0,003	<0,001	1,00
Energy	Mobile combustion	Navigation	CH4	0,001	0,003	<0,001	1,00
Energy	Mobile combustion	Civil Aviation	N2O	0,003	0,002	<0,001	1,00
Energy	Mobile combustion	agriculture	CH4	0,002	0,002	<0,001	1,00
Energy	Mobile combustion	Railways	N2O	0,003	0,002	<0,001	1,00
Energy	Mobile combustion	Military	N2O	0,001	0,001	<0,001	1,00
Energy	Mobile combustion	household and gardening	N2O	0,001	0,001	<0,001	1,00
Energy	Mobile combustion	national fishing	CH4	0,000	0,000	<0,001	1,00
Energy	Mobile combustion	forestry	CH4	0,000	0,000	<0,001	1,00
Energy	Mobile combustion	Railways	CH4	0,000	0,000	<0,001	1,00
Energy	Mobile combustion	Civil Aviation	CH4	0,000	0,000	<0,001	1,00
Energy	Mobile combustion	Military	CH4	0,000	0,000	<0,001	1,00
Energy	Mobile combustion	forestry	N2O	0,000	0,000	<0,001	1,00
Industrial Processes	CO2 emissions Iron and Steel Production		CO2	0,028	0,000	<0,001	1,00
Industrial Processes	SF6 from magnesium Production		SF6	0,036	0,000	<0,001	1,00
Total				69,03	68,49	1,00	
(1) The base year is 1995 for HFC, PFC and SF6; and 1990 for the other greenhouse gases. The base year is unadjusted to electricity trade.							

Table 2

Table 7.A2 (of Good Practice Guidance) Tier 1 Analysis - Trend Assessment (DK-inventory)								
A IPCC Source Categories (LULUCF not included)			B Direct Greenh. Gas	C Base Year Estimate (1) Mt CO2-eq	D Year 2002 Estimate Mt CO2-eq	E Trend Assess-ment	F Contri-bution to Trend %	G Cumul. total of col. F %
Energy	CO2 Emission from stationary Combustion	Coal	CO2	24,21	16,71	0,1076	26,5	26,5
Energy	CO2 Emission from stationary Combustion	Natural gas	CO2	4,33	11,09	0,1000	24,6	51,2
Energy	Mobile combustion	Road Transportation	CO2	9,35	11,39	0,0311	7,7	58,8
Energy	CO2 Emission from stationary Combustion	Orimulsion	CO2	0,00	1,91	0,0281	6,9	65,8
Energy	CO2 Emission from stationary Combustion	Gas oil	CO2	4,56	2,92	0,0237	5,8	71,6
Agriculture	Indirect N2O emissions from Nitrogen used in agriculture		N2O	4,13	2,80	0,0190	4,7	76,3
Agriculture	Direct N2O emissions from Agriculture soils		N2O	4,17	2,96	0,0173	4,3	80,5
Industrial Processes	CO2 emissions from Cement production		CO2	0,88	1,45	0,0085	2,1	82,6
Energy	CO2 Emission from stationary Combustion	Residual oil	CO2	2,51	1,92	0,0083	2,0	84,7
Industrial Processes	Emission from substitutes for ODS		HFC and	0,22	0,69	0,0070	1,7	86,4
Energy	Non-CO2 Emission from stationary Combustion		CH4	0,12	0,53	0,0061	1,5	87,9
Energy	CO2 Emission from stationary Combustion	Petroleum coke	CO2	0,41	0,76	0,0052	1,3	89,2
Energy	CO2 Emission from stationary Combustion	Kerosene	CO2	0,37	0,02	0,0051	1,3	90,5
Energy	Fugitive emissions	Oil and Natural Gas	CO2	0,24	0,54	0,0044	1,1	91,5
Agriculture	Enteric fermentation		CH4	3,10	2,80	0,0041	1,0	92,5
Energy	Mobile combustion	Road Transportation	N2O	0,13	0,39	0,0039	1,0	93,5
Industrial Processes	Nitric Acid Production		N2O	1,04	0,77	0,0038	0,9	94,4
Energy	CO2 Emission from stationary Combustion	Plastic waste	CO2	0,37	0,60	0,0034	0,8	95,3
Agriculture	Manure management		CH4	0,74	0,97	0,0034	0,8	96,1
Waste	Emission from Solid Waste Disposal sites		CH4	1,31	1,13	0,0025	0,6	96,7
Energy	Mobile combustion	national fishing	CO2	0,77	0,61	0,0023	0,6	97,3
Energy	CO2 Emission from stationary Combustion	LPG	CO2	0,19	0,10	0,0013	0,3	97,6
Energy	Mobile combustion	agriculture	CO2	1,32	1,22	0,0013	0,3	97,9
Energy	Mobile combustion	Railways	CO2	0,30	0,21	0,0012	0,3	98,2
Agriculture	N2O from Manure management		N2O	0,69	0,61	0,0011	0,3	98,5
Energy	Mobile combustion	Civil Aviation	CO2	0,22	0,15	0,0010	0,2	98,8
Industrial Processes	SF6 from other sources of SF6		SF6	0,07	0,01	0,0008	0,2	99,0
Energy	Fugitive emissions	Oil and Natural Gas	CH4	0,02	0,07	0,0007	0,2	99,1
Energy	CO2 Emission from stationary Combustion	Refinery gas	CO2	0,81	0,84	0,0006	0,2	99,3
Industrial Processes	SF6 from magnesium Production		SF6	0,04	0,00	0,0005	0,1	99,4
Energy	Mobile combustion	other mobil and machinery	CO2	0,78	0,74	0,0004	0,1	99,5
Energy	Mobile combustion	Military	CO2	0,12	0,09	0,0004	0,1	99,6
Industrial Processes	CO2 emissions Iron and Steel Production		CO2	0,03	0,00	0,0004	0,1	99,7
Energy	Non-CO2 Emission from stationary Combustion		N2O	0,40	0,38	0,0002	0,0	99,8
Solvent and Other Product Use			CO2	0,12	0,11	0,0002	0,0	99,8
Energy	Fugitive emissions	Solid Fuels	CH4	0,07	0,06	0,0001	0,0	99,9
Energy	Mobile combustion	Road Transportation	CH4	0,06	0,06	0,0001	0,0	99,9
Energy	Mobile combustion	Navigation	CO2	0,55	0,55	0,0001	0,0	99,9
Industrial Processes	SF6 from electrical equipment		SF6	0,00	0,01	0,0001	0,0	99,9
Energy	Mobile combustion	household and gardening	CO2	0,09	0,08	0,0001	0,0	99,9
Energy	Mobile combustion	national fishing	N2O	0,02	0,01	0,0000	0,0	100,0
Industrial Processes	CO2 emissions from Lime production		CO2	0,12	0,12	0,0000	0,0	100,0
Energy	Fugitive emissions	Oil and Natural Gas	N2O	0,00	0,00	0,0000	0,0	100,0
Energy	Mobile combustion	Navigation	CH4	0,00	0,00	0,0000	0,0	100,0
Industrial Processes	CO2 emissions Catalysts/Fertilizers and Pesticides		CO2	0,00	0,00	0,0000	0,0	100,0
Energy	Mobile combustion	agriculture	N2O	0,02	0,02	0,0000	0,0	100,0
Energy	Mobile combustion	Navigation	N2O	0,01	0,01	0,0000	0,0	100,0
Energy	Mobile combustion	Railways	N2O	0,00	0,00	0,0000	0,0	100,0
Energy	Mobile combustion	Civil Aviation	N2O	0,00	0,00	0,0000	0,0	100,0
Industrial Processes	CO2 emissions Glass Production		CO2	0,02	0,02	0,0000	0,0	100,0
Energy	Mobile combustion	other mobil and machinery	N2O	0,01	0,01	0,0000	0,0	100,0
Energy	Mobile combustion	other mobil and machinery	CH4	0,00	0,00	0,0000	0,0	100,0
Energy	Mobile combustion	forestry	CO2	0,00	0,00	0,0000	0,0	100,0
Energy	Mobile combustion	household and gardening	CH4	0,00	0,00	0,0000	0,0	100,0
Energy	Mobile combustion	agriculture	CH4	0,00	0,00	0,0000	0,0	100,0
Energy	Mobile combustion	national fishing	CH4	0,00	0,00	0,0000	0,0	100,0
Energy	Mobile combustion	Railways	CH4	0,00	0,00	0,0000	0,0	100,0
Energy	Mobile combustion	household and gardening	N2O	0,00	0,00	0,0000	0,0	100,0
Energy	Mobile combustion	Military	N2O	0,00	0,00	0,0000	0,0	100,0
Energy	Mobile combustion	Military	CH4	0,00	0,00	0,0000	0,0	100,0
Energy	Mobile combustion	Civil Aviation	CH4	0,00	0,00	0,0000	0,0	100,0
Energy	Mobile combustion	forestry	CH4	0,00	0,00	0,0000	0,0	100,0
Energy	Mobile combustion	forestry	N2O	0,00	0,00	0,0000	0,0	100,0
total				69,03	68,49	0,4056	100,0	
(1) The base year is 1995 for HFC, PFC and SF6; and 1990 for the other greenhouse gases. The base year is unadjusted to electricity trade.								

Table 3.

Table 7.A3 (of Good Practice Guidance) Source Category Analysis Summary (DK-inventory)						
Quantitative method used: Tier 1						
A IPCC Source Categories (LULUCF not included)		B Direct Greenh. Gas	C Key Source 2002	D If C is yes criteria for identi-fikation	E Comments	
Energy						
CO2 Emission from stationary Combustion	Coal	CO2	Yes	Level, Trend	See text	
CO2 Emission from stationary Combustion	Petroleum coke	CO2	Yes	Level, Trend	See text	
CO2 Emission from stationary Combustion	Plastic waste	CO2	Yes	Level, Trend	Waste Incineration	
CO2 Emission from stationary Combustion	Residual oil	CO2	Yes	Level, Trend	See text	
CO2 Emission from stationary Combustion	Gas oil	CO2	Yes	Level, Trend	See text	
CO2 Emission from stationary Combustion	Kerosene	CO2	Yes	Trend	See text	
CO2 Emission from stationary Combustion	Orimulsion	CO2	Yes	Level, Trend	See text	
CO2 Emission from stationary Combustion	Natural gas	CO2	Yes	Level, Trend	See text	
CO2 Emission from stationary Combustion	LPG	CO2	No			
CO2 Emission from stationary Combustion	Refinery gas	CO2	Yes	Level		
Mobile combustion	Civil Aviation	CO2	No			
Mobile combustion	Road Transportation	CO2	Yes	Level, Trend	See text	
Mobile combustion	Railways	CO2	No			
Mobile combustion	Navigation	CO2	No			
Mobile combustion	Military	CO2	No			
Mobile combustion	national fishing	CO2	Yes	Level		
Mobile combustion	agriculture	CO2	Yes	Level	See text	
Mobile combustion	forestry	CO2	No			
Mobile combustion	other mobil and machinery/industry	CO2	Yes	Level		
Mobile combustion	household and gardening	CO2	No			
Fugitive emissions	Oil and Natural Gas	CO2	Yes	Trend	See text	
Non-CO2 Emission from stationary Combustion		CH4	Yes	Trend	See text	
Mobile combustion	Civil Aviation	CH4	No			
Mobile combustion	Road Transportation	CH4	No			
Mobile combustion	Railways	CH4	No			
Mobile combustion	Navigation	CH4	No			
Mobile combustion	Military	CH4	No			
Mobile combustion	national fishing	CH4	No			
Mobile combustion	agriculture	CH4	No			
Mobile combustion	forestry	CH4	No			
Mobile combustion	other mobil and machinery/industry	CH4	No			
Mobile combustion	household and gardening	CH4	No			
Fugitive emissions	Solid Fuels	CH4	No			
Fugitive emissions	Oil and Natural Gas	CH4	No			
Non-CO2 Emission from stationary Combustion		N2O	No			
Mobile combustion	Civil Aviation	N2O	No			
Mobile combustion	Road Transportation	N2O	Yes	Trend	See text	
Mobile combustion	Railways	N2O	No			
Mobile combustion	Navigation	N2O	No			
Mobile combustion	Military	N2O	No			
Mobile combustion	national fishing	N2O	No			
Mobile combustion	agriculture	N2O	No			
Mobile combustion	forestry	N2O	No			
Mobile combustion	other mobil and machinery/industry	N2O	No			
Mobile combustion	household and gardening	N2O	No			
Fugitive emissions	Solid Fuels	N2O	No			
Industrial Processes						
CO2 emissions from Cement production		CO2	Yes	Level, Trend	See text	
CO2 emissions from Lime production		CO2	No			
CO2 emissions Glass Production		CO2				
CO2 emissions Catalysts/Fertilizers and Pesticides		CO2				
CO2 emissions Iron and Steel Production		CO2				
Nitric Acid Production		N2O	Yes	Level, Trend	See text	
SF6 from magnesium Production		SF6	No			
SF6 from electrical equipment		SF6	No			
SF6 from other sources of SF6		SF6	No			
Emission from substitutes for ODS		HFC+PFC	Yes	Level, Trend	See text	
Solvent and Other Product Use						
Solvent and Other Product Use		CO2	No			
Agriculture						
Enteric fermentation		CH4	Yes	Level, Trend	See text	
Manure management		CH4	Yes	Level		
N2O from Manure management		N2O	Yes	Level		
Enteric fermentation		CH4	Yes	Level, Trend	See text	
Manure management		CH4	Yes	Level		
N2O from Manure management		N2O	Yes	Level		
Direct N2O emissions from Agriculture soils		N2O	Yes	Level, Trend	See text	
Indirect N2O emissions from Nitrogen used in agriculture		N2O	Yes	Level, Trend	See text	
Waste						
Emission from Solid Waste Disposal sites		CH4	Yes	Level		

ANNEX 2

Please see Annex 3.A and Annex 3.B

ANNEX 3.A Emission inventories for stationary combustion

This Annex is a sector report for stationary combustion that includes more background data and a more detailed methodology description than included in the main NIR report.

1 Methodology and references

The Danish emission inventory is based on the CORINAIR (CORe INventory on AIR emissions) system, which is a European program for air emission inventories. CORINAIR includes methodology structure and software for inventories. The methodology is described in the EMEP/Corinair Emission Inventory Guidebook 3rd edition, prepared by the UNECE/EMEP Task Force on Emissions Inventories and Projections (EMEP/Corinair 2003). Emission data are stored in an Access database, from which data are transferred to the reporting format.

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

1.1 Emission source categories

In the Danish emission database all activity rates and emissions are defined in SNAP sector categories (Selected Nomenclature for Air Pollution). The data from the Danish database are aggregated to the sector codes used for both the Climate Convention and the LRTAP Convention. This sector classification defines 6 main source categories and a number of subcategories. The main source categories are shown in Table 3A-1.

Table 3A-2 shows detailed source categories for the energy sector. The table also shows in which main sector NERI reports the methodology and emissions. In appendix 3A-2 a correspondence list between SNAP sector codes and the IPCC source categories for stationary combustion plants are shown. Stationary combustion is defined as combustion activities in the SNAP source sectors 01-03.

Table 3A-1 IPCC main source categories

1. Energy
2. Industrial Processes
3. Solvent and Other Product Use
4. Agriculture
5. Land-Use Change and Forestry
6. Waste

Table 3A-2 IPCC source categories for the energy sector

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

Stationary combustion plants are included in the emission source subcategories:

- *1A1 Energy, Fuel consumption, Energy Industries*
- *1A2 Energy, Fuel consumption, Manufacturing Industries and Construction*
- *1A4 Energy, Fuel consumption, Other Sectors*

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

The emission source categories used in the reportings will be referred to as IPCC source categories.

The Danish emission inventories are prepared from a complete emission database based on the SNAP categories. Aggregation to IPCC source categories is based on the correspondence list between SNAP and IPCC source categories from the EMEP/Corinair Guidebook (EMEP/Corinair 2003) enclosed in appendix 3A-2.

Emission data shown in tables and figures in this report only includes emissions originating from stationary combustion plants of a given IPCC source category. The IPCC sector codes have been applied unchanged, but some source category names have been changed to reflect the stationary combustion part of the source.

1.2 Large point sources

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

In the inventory for the year 2002 63 stationary combustion plants are specified as large point sources in the Danish emission database. These point sources include:

- Power plants and decentralised CHP plants (combined heat and power plants)
- Municipal waste incineration plants
- A few large industrial combustion plants
- Petroleum refining plants

The fuel consumption of stationary combustion plants registered as large point sources is 326 PJ (2002). This corresponds to 57% of the overall fuel consumption of stationary combustion.

A list of large point sources for 2002 and the fuel consumption rates is shown in appendix 3A-5. It also shows which of the large point source emissions are based on plant specific emission data. The number of large point sources registered in the databases increased from 1990 to 2002. In the emission database for the years before 1990 no large point sources have been registered.

SO_2 and NO_x emissions from large point sources are often plant specific based on emission measurements. Emissions of CO and NMVOC are also plant specific for some plants. Plant specific emission data are obtained from:

- Annual environmental reports
- Annual plant specific reporting of SO_2 and NO_x from power plants >25MW_e prepared for the Danish Energy Authority due to Danish legislation
- Emission data reported by Elsam and E2, the two major electricity suppliers
- Emission data reported from industrial plants

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

If plant specific emission factors are not available the general area source emission factor is used. Emissions of the greenhouse gases (CO_2, CH_4 and N_2O) from the large point sources are all based on the area source emission factors.

1.3 Area sources

Fuels not combusted in large point sources are included as sector specific area sources in the emission database. Plants like residential boilers, small district heating plants, small CHP plants and some industrial boilers are defined as area sources. Emissions from area sources are based on fuel consumption data and emission factors. Further information about emission factors is given below.

1.4 Activity rates, fuel consumption

The fuel consumption rates are based on the official Danish energy statistics prepared by the Danish Energy Authority. The Danish Energy Authority aggregates fuel consumption rates to SNAP sector categories (DEA 2003a). Some fuel types in the official Danish energy statistics are added to obtain a less detailed fuel aggregation level, see appendix 3A-7. The calorific values on which the energy statistics are based are also enclosed in appendix 3A-7.

The fuel consumption of the IPCC sector *1A2 Manufacturing industries and construction* (corresponding to SNAP sector *03 Combustion in manufacturing industries)* have not yet been disaggregated to specific industries. In the Climate Convention reporting the emissions are included in sector *1A2f Industry, Other* because technically it is not possible to report the emission in the aggregated source category *1A2 Manufacturing industries and construction*. However NERI and the Danish Energy Authority have initiated the work that should ensure that fuel consumption rates of each industrial subsector will be reported next year.

Both traded and not traded fuels are included in the Danish energy statistics. Thus e.g. an estimation of the annual consumption of non-traded wood is included.

Petroleum coke bought abroad and combusted in Danish residential plants (border trade of 251 TJ) are added to the apparent consumption of petroleum coke and the emissions are included in the inventory.

The Danish Energy Authority compile a database for the fuel consumption of each district heating and power producing plant based on data reported by the plant owners. The fuel consumption of large point sources specified in the Danish emission databases refers to this database (DEA 2003c).

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

Emissions from non-energy use of fuels have not been included in the Danish inventory yet, but it is however included in the reference approach of the Climate Convention reporting. The Danish energy statistics include three fuels used for non-energy purposes: Bitumen, white spirit and lube oil.

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

Fuel consumption data are presented in chapter 2.

1.5 Emission factors

For each fuel and SNAP (sector and e.g. type of plant) a set of general area source emission factors has been determined. The emission factors are either national referenced or based on the international guidebooks: EMEP/Corinair Guidebook (EMEP/Corinair 2003) and IPCC Reference Manual (IPCC 1996).

A complete list of emission factors including time series is shown in Appendix 3A-4. The emission factors are further discussed below.

Some of the area source emission factors for power plants and municipal waste CHP plants take into account, that the large plants are included in the inventory as large point sources with plant specific emission data. Thus the area source emission factors takes into account that the remaining fuel consumption is combusted in smaller units with less effective flue gas cleaning. The area source emission factors are therefore not necessarily average values for these plant categories.

1.5.1 CO_2

The CO_2 emission factors applied for 2002 are shown in Table 3A-3. For municipal waste and natural gas time series have been estimated. For all other fuels the same emission factor is applied for 1990-2002.

In the reportings for the Climate Convention the CO_2 emission is aggregated to five fuel types: Solid fuel, Liquid fuel, Gas, Biomass and Other fuels. The correspondence list between the NERI fuel categories and the IPCC fuel categories is also shown in Table 3A-3.

Only emissions from fossil fuels are included in the national total CO_2 emission. The biomass emission factors are also shown in the table because emissions from biomass is reported to the Climate Convention as a memo item.

The CO_2 emission from incineration of municipal waste (94,5 + 17,6 kg/GJ) is split in two parts: The emission from combustion of the plastic content of the waste which is included in the national total and the emission from combustion of the rest of the waste – the biomass part, that is reported as a memo item. In the IPCC reportings the CO_2 emission from combustion of the plastic part of the waste is reported in fuel category *Other fuels*. However this split is applied for neither fuel consumption nor other emissions, because it is only relevant for CO_2. Thus the full consumption of municipal waste is included in fuel category *Biomass* and the full amount of non-CO_2 emissions from municipal waste combustion is included in fuel category *Biomass*.

The CO_2 emission factors have been confirmed by the two major power plant owners both directly (Christiansen 1996 and Andersen 1996) and indirectly by applying the NERI emission factors in the annual environmental reports for the large power plants and accepting use of the NERI factors in Danish legislation.

Danish legislation concerning CO_2 emission from power plants (Lov nr. 376 1999) has been based on standard CO_2 emission factors for each fuel. Thus power plant owners have not been encouraged to estimate CO_2 emission factors based on their own fuel analysis. In future legislation (Lov om CO_2-kvoter, høringsudgave 2004) owners of large power plants are obliged to verify the applied emission factors and thus improved emission factors will be available for the national emission inventories in the future.

Table 3A-3 CO_2 emission factors 2002

Fuel	Emission factor		Unit	Reference type	CRF fuel
	Biomass	Fossil fuel			
Coal		95	kg/GJ	Country specific	Solid
Brown coal briquettes		94,6	kg/GJ	IPCC reference manual	Solid
Coke oven coke		108	kg/GJ	IPCC reference manual	Solid
Petroleum coke		92	kg/GJ	Country specific	Liquid
Wood	102		kg/GJ	Corinair	Biomass
Municipal waste	94,5	17,6	kg/GJ	Country specific	Biomass / Other fuels
Straw	102		kg/GJ	Country specific	Biomass
Residual oil		78	kg/GJ	Corinair	Liquid
Gas oil		74	kg/GJ	Corinair	Liquid
Kerosene		72	kg/GJ	Corinair	Liquid
Fish & rape oil	102		kg/GJ	Corinair	Biomass
Orimulsion		80	kg/GJ	Country specific	Liquid
Natural gas		57,28	kg/GJ	Country specific	Gas
LPG		65	kg/GJ	Corinair	Liquid
Refinery gas		56,9	kg/GJ	Country specific	Liquid
Biogas	83,6		kg/GJ	Country specific	Biomass

Coal:

The emission factor 95 kg/GJ is based on Fenhann & Kilde 1994. The CO_2 emission factors have been confirmed by the two major power plant owners in 1996 (Christiansen 1996 and Andersen 1996). Elsam reconfirmed the factor in 2001 (Christiansen 2001). The same emission factor is applied for 1990-2002.

Brown coal briquettes:

The emission factor 94,6 kg/GJ is based on a default value from the IPCC guidelines assuming full oxidation. The default value in the IPCC guidelines is 25,8 t C/TJ corresponding to $25{,}8 \cdot (12+2 \cdot 16)/12$ = 94,6 kg CO_2/GJ, assuming full oxidation. In the inventories for 1990-2001 brown coal briquettes have been included in fuel category coal.

Coke oven coke:

The emission factor 108 kg/GJ is based on a default value from the IPCC guidelines assuming full oxidation. The default value in the IPCC guidelines is 25,8 t C/TJ corresponding to $29{,}5 \cdot (12+2 \cdot 16)/12$ = 108 kg CO_2/GJ, assuming full oxidation. In the inventories for 1990-2001 coke have been included in fuel category coal.

Petroleum coke:

The emission factor 92 kg/GJ have been estimated by SK Energy (former major power plant owner in eastern Denmark) in 1999 based on a fuel analysis carried out by dk-Teknik in 1993 (Bech 1999). The emission factor level was confirmed by a new fuel analysis that is however considered confidential. The same emission factor is applied for 1990-2002.

Wood:

The emission factor for wood 102 kg/GJ refers to Fenhann & Kilde 1994. The factor is based on the interval stated in the EMEP/Corinair Guidebook (EMEP/Corinair 2003) and the actual value is the default value from the Collecter database. The same emission factor is applied for 1990-2002.

Municipal waste:

The CO_2 emission from incineration of municipal waste is split in two parts: The emission from combustion of the plastic content of the waste, which is included in the national total and the

emission from combustion of the rest of the waste – the biomass part, that is reported as a memo item.

The plastic part of waste is estimated to be 6,6 w/w% in 2003 (Hulgaard 2003). The weight share, lower heating values and CO_2 emission factors for different plastic types are estimated by Hulgaard in 2003 (Table 3A-4). The total weight share for plastic and for the different plastic types is assumed to be the same for all years (NERI assumption).

Table 3A-4 Data for plastic waste in Danish municipal waste (Hulgaard 2003)[1)2)]

Plastic type	Mass share of plastic in municipal waste in Denmark		Lower heating value of plastic	Energy content of plastic	CO_2 emission factor for plastic	CO_2 emission factor
	kg plastic/ kg municipal waste	% of plastic	MJ/kg plastic	MJ/kg municipal waste	g/MJ plastic	g/kg municipal waste
PE	0,032	48	41	1,312	72,5	95
PS/EPS	0,02	30	37	0,74	86	64
PVC	0,007	11	18	0,126	79	10
Other (PET, PUR, PC, POM, ABS, PA etc.)	0,007	11	24	0,168	95	16
Total	0,066	100	35,5	2,346	78,7	185

Hulgaard 2003 refers to: 1) TNO report 2000/119, Eco-efficiency of recovery scenarios of plastic packaging, Appendices, July 2001 by P. G. Eggels, AMM Ansems, B. L. van der Ven, for Association of Plastic Manufacturers in Europe 2) Kost, Thomas, Brennstofftechnische Charakterisierung von Haushaltabfällen, Technische Universität Dresden, Eigenverlag des Forums für Abfallwirtschaft und Altlasten e.V., 2001

Based on emission measurements on 5 municipal waste incineration plants (Jørgensen & Johansen 2002) the total CO_2 emission factor for municipal waste incineration has been determined to be 112,1 kg/GJ. The CO_2 emission from the biomass part is the total CO_2 emission minus the CO_2 emission from the plastic part.

The CO_2 emission factor for the plastic part of waste was estimated to be 185g/kg municipal waste (Table 3A-5). The CO_2 emission per GJ of waste is calculated based on the lower heating values for waste shown in Table 3A-5 (DEA 2003b). Time series for the CO_2 emission factor for the plastic part of waste are shown in Table 3A-5.

Emission data from 4 waste incineration plants (Jørgensen & Johansen 2002) show that the part of the carbon contents of the waste that is not oxidised is approximately 0,3%. The unoxidised part of the carbon content is assumed to originate from the biomass part and all carbon originating from plastic is assumed to be oxidised.

Table 3A-5 CO_2 emission factor for municipal waste, plastic part and biomass part

Year	Lower heating value of municipal waste [1] [GJ/Mg]	Plastic part [% of energy]	CO_2 emission factor for plastic [3] [g/kg waste]	CO_2 emission factor for plastic [kg/GJ waste]	CO_2 emission factor for municipal waste, total [2] [kg/GJ waste]	CO_2 emission factor for biomass part of waste [kg/GJ waste]
1990	8,20	28,6	185	22,5	112,1	89,6
1991	8,20	28,6	185	22,5	112,1	89,6
1992	9,00	26,1	185	20,5	112,1	91,6
1993	9,40	25,0	185	19,6	112,1	92,5
1994	9,40	25,0	185	19,6	112,1	92,5
1995	10,00	23,5	185	18,5	112,1	93,6
1996	10,50	22,3	185	17,6	112,1	94,5
1997	10,50	22,3	185	17,6	112,1	94,5
1998	10,50	22,3	185	17,6	112,1	94,5
1999	10,50	22,3	185	17,6	112,1	94,5
2000	10,50	22,3	185	17,6	112,1	94,5
2001	10,50	22,3	185	17,6	112,1	94,5
2002	10,50	22,3	185	17,6	112,1	94,5

1) DEA 2003b
2) Based on data from Jørgensen & Johansen 2002
3) From Table 3A-4

Straw:

The emission factor for wood 102 kg/GJ refers to Fenhann & Kilde 1994. The factor is based on the interval stated in the EMEP/Corinair Guidebook (EMEP/Corinair 2003) and the actual value is the default value from the Collecter database. The same emission factor is applied for 1990-2002.

Residual oil:

The emission factor 78 kg/GJ refers to Fenhann & Kilde 1994. The factor is based on the interval stated in the EMEP/Corinair Guidebook (EMEP/Corinair 2003). The factor is a bit higher than the IPCC default emission factor for residual fuel oil (77,4 kg/GJ assuming full oxidation). The CO_2 emission factors have been confirmed by the two major power plant owners in 1996 (Christiansen 1996 and Andersen 1996). The same emission factor is applied for 1990-2002.

Gas oil:

The emission factor 74 kg/GJ refers to Fenhann & Kilde 1994. The factor is based on the interval stated in the EMEP/Corinair Guidebook (EMEP/Corinair 2003). The factor agrees with the IPCC default emission factor for gas oil (74,1 kg/GJ assuming full oxidation). The CO_2 emission factors have been confirmed by the two major power plant owners in 1996 (Christiansen 1996 and Andersen 1996). The same emission factor is applied for 1990-2002.

Kerosene:

The emission factor 72 kg/GJ refers to Fenhann & Kilde 1994. The factor agrees with the IPCC default emission factor for Other kerosene (71,9 kg/GJ assuming full oxidation). The same emission factor is applied for 1990-2002.

Fish & rape oil:

The emission factor is assumed to be the same as for straw – 102 kg/GJ. In 1990-2000 fish & rape oil have been included in the fuel category straw. The consumption of fish & rape oil is relatively low.

Orimulsion:

The emission factor 80 kg/GJ refers to the Danish Energy Authority (DEA 2004). The IPCC default emission factor is almost the same: 80,7 kg/GJ assuming full oxidation. The CO_2 emission factors have been confirmed by the only major power plant owner that apply orimulsion (Andersen 1996). The same emission factor is applied for 1990-2002.

Natural gas:

The emission factor for natural gas is estimated by the Danish gas transmission company DONG (Lindgren 2003). Only natural gas from the Danish gas fields is applied in Denmark. The calculation is based on the gas analysis carried out daily by DONG. DONG and Danish Gas Technology Centre have calculated emission factors for 2000-2002. The emission factor applied for 1990-1999 refers to Fenhann & Kilde 1994. This emission factor was confirmed by the two major power plant owners in 1996 (Christiansen 1996 and Andersen 1996). Time series for the CO_2 emission factor is shown in table 3A-6.

Table 3A-6 CO_2 emission factor for natural gas

Year	CO_2 emission factor
1990-	56,9 kg/GJ
2000	57,1 kg/GJ
2001	57,25 kg/GJ
2002	57,28 kg/GJ

LPG:

The emission factor 65 kg/GJ refers to Fenhann & Kilde 1994. The emission factor is based on the EMEP/Corinair Guidebook (EMEP/Corinair 2003). The emission factor is somewhat higher than the IPCC default emission factor (63 kg/GJ assuming full oxidation). The same emission factor is applied for 1990-2002.

Refinery gas:

The emission factor applied for refinery gas is the emission factor for natural gas 1990-1999. The emission factor is within the interval of the emission factor for refinery gas stated in the EMEP/Corinair Guidebook (EMEP/Corinair 2003). The same emission factor is applied for 1990-2002.

Biogas:

The emission factor 63,6 kg/GJ is based on a biogas with 65% CH_4 and 35% CO_2. Danish Gas Technology Centre has stated that this is a typical manure based biogas applied in stationary combustion plants (Kristensen 2001).

1.5.2 CH_4

The CH_4 emission factors applied for 2002 is shown in table 3A-7. In general the same emission factors have been applied for 1990-2002. However for gas engines a time series have been estimated.

Emission factors for gas engines, gas turbines and CHP plants combusting wood, straw or municipal waste all refer to emission measurements carried out on Danish plants (Nielsen & Illerup 2003). Other emission factors refer to the EMEP/Corinair Guidebook (EMEP/Corinair 2003).

Gas engines combusting natural gas or biogas contribute much more to the total CH_4 emission than other stationary combustion plants. The relatively high emission factor for gas engines is well documented and further discussed below.

Table 3A-7 CH_4 emission factors 1990-2002

Fuel	ipcc_id	snap_id	Emission factor [g/GJ]	Reference
COAL	1A1a	010101, 010102, 010103	1,5	EMEP/Corinair 2003
COAL	1A1a, 1A2f, 1A4b, 1A4c	010202, 010203, 0301, 0202, 0203	15	EMEP/Corinair 2003
BROWN COAL BRI.	all	all	15	EMEP/Corinair 2003, assuming same emission factor as for coal
COKE OVEN COKE	all	all	15	EMEP/Corinair 2003, assuming same emission factor as for coal
PETROLEUM COKE	all	all	15	EMEP/Corinair 2003
WOOD AND SIMIL.	1A1a	010102, 010103, 010104	2	Nielsen & Illerup 2003
WOOD AND SIMIL.	1A1a, 1A2f, 1A4a, 1A4b, 1A4c	all other	32	EMEP/Corinair 2003
MUNICIP. WASTES	1A1a	010102, 010103, 010104, 010105	0,59	Nielsen & Illerup 2003
MUNICIP. WASTES	1A1a, 1A2f, 1A4a	all other	6	EMEP/Corinair 2003
STRAW	1A1a	010102, 010103	0,5	Nielsen & Illerup 2003
STRAW	1A1a, 1A2f	010202, 010203, 030102, 030105	32	EMEP/Corinair 2003
STRAW	1A4a, 1A4b, 1A4c	0201, 0202, 0203, 020302	200	EMEP/Corinair 2003
RESIDUAL OIL	all	all	3	EMEP/Corinair 2003
GAS OIL	all	all	1,5	EMEP/Corinair 2003
KEROSENE	all	all	7	EMEP/Corinair 2003
FISH & RAPE OIL	1A1a	010203	32	EMEP/Corinair 2003, assuming same emission factor as straw
FISH & RAPE OIL	1A2f	030105	32	EMEP/Corinair 2003, assuming same emission factor as straw
FISH & RAPE OIL	1A4c	020304	200	EMEP/Corinair 2003, assuming same emission factor as straw
ORIMULSION	1A1a	010101	3	EMEP/Corinair 2003, assuming same emission factor as residual oil
NATURAL GAS	1A1a	0101, 010101, 010102, 010202	6	DGC 2001
NATURAL GAS	1A1a	010103, 010203	15	Gruijthuijsen & Jensen 2000
NATURAL GAS	1A1a, 1Ab, 1Ac, 1A2f, 1A4a, 1A4c	Gas turbines: 010104, 010304, 010504, 030104, 020104, 020303	1,5	Nielsen & Illerup 2003
NATURAL GAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4b, 1A4c	Gas engines: 010105, 010405, 010505, 030105, 020105, 020204, 020304	520	Nielsen & Illerup 2003
NATURAL GAS	1A1c, 1A2f, 1A4a, 1A4b, 1A4c	010502, 0301, 0201, 0202, 0203	6	DGC 2001
NATURAL GAS	1A2f, 1A4a, 1A4b	030103, 030106, 020103, 020202	15	Gruijthuijsen & Jensen 2000
LPG	all	all	1	EMEP/Corinair 2003
REFINERY GAS	1A1b	010303, 010304	2	EMEP/Corinair 2003
BIOGAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4c	Gas engines: 010105, 010405, 010505, 030105, 020105, 020304	323	Nielsen & Illerup 2003
BIOGAS	1A1a, 1A2f, 1A4a, 1A4c	all other	4	EMEP/Corinair 2003

1.5.2.1 CHP plants

A considerable part of the electricity production in Denmark is based on decentralised CHP plants and thus well-documented emission factors for these plants are of importance. In a project carried out for the electricity transmission company in Western Denmark Eltra emission factors for CHP plants <25MW_e have been estimated. The work was reported in 2003 (Nielsen & Illerup 2003) and the results have been fully implemented in the inventory reported in 2004.

The work included municipal waste incineration plants, CHP plants combusting wood and straw, natural gas and biogas fuelled (reciprocating) engines and natural gas fuelled gas turbines. CH_4 emission factors for these plants all refers to Nielsen & Illerup 2003. The estimated emission factors

were based on existing emission measurements as well as on emission measurements carried out within the project. The number of emission data sets was comprehensive. Emission factors for subgroups of each plant type were estimated e.g. the CH_4 emission factor for different gas engine types have been determined.

Gas engines, natural gas

SNAP 010105, 010405, 010505, 020105, 020204, 020304 and 030105
The emission factor for natural gas engines was determined to 520 g/GJ in 2000 and the same emission factor has been applied for 2001 and 2002. The emission factor for natural gas engines was based on 291 emission measurements on 114 different plants. The plants from which emission measurements were available represent 44% of the total gas consumption in gas engines. The emission factor was estimated based on fuel consumption of each gas engine type and the emission factor for each engine type. Most emission measurements that was not performed within the project only included emission of total unburned hydrocarbon (CH_4 + NMVOC). A constant disaggregation factor was estimated based on a number of emission measurements including both CH_4 and NMVOC.

The emission factor for lean-burn gas engines is relatively high especially for prechamber engines that account for more than half the gas consumption in the Danish gas engines. However the emission factor for different prechamber engine types differ considerably.

The installation of natural gas engines in decentralised CHP plants in Denmark has taken place since 1990. The first engines installed were relatively small open chamber engines and in the later years mainly prechamber engines were installed. As mentioned prechamber engines have a higher emission factor than open chamber engines and thus the emission factor have changed during the period 1990-2002. A time series for the emission factor have been estimated and is shown below (Nielsen & Illerup 2003). The time series was based on:

- Emission factors for different engine types
- Data for year of installation for each engine and fuel consumption of each engine 1994-2002 from the Danish Energy Authority (DEA 2003c)
- Research concerning the CH_4 emission from gas engines carried out in 1997 (Nielsen & Wit 1997)

Table 3A-8 Time series for the CH_4 emission factor for natural gas fuelled engines

Year	Emission factor [g/GJ]
1990	257
1991	299
1992	347
1993	545
1994	604
1995	612
1996	596
1997	534
1998	525
1999	524
2000	520
2001	520
2002	520

Gas engines, biogas

SNAP 010105, 010405, 010505, 020105, 020304 and 030105
The emission factor for biogas engines was estimated to 323 g/GJ in 2000 and the same emission factor has been applied for 2001 and 2002. The emission factor for biogas engines was based on 18

emission measurements on 13 different plants. The plants from which emission measurements were available represent 18% of the total gas consumption in gas engines.

The emission factor is lower than the factor for natural gas, mainly because most engines are lean-burn open chamber engines - not prechamber engines. A time series for the emission factor have been estimated. The Danish energy statistics only specifies biogas consumption in gas engines from 1998 and the emission factor time series for 1998-2002 is shown below. Though biogas consumption in gas engines actually started before 1998 the error is considered acceptable because the consumption was very low.

Table 3A-9 Time series for the CH_4 emission factor for biogas fuelled engines

Year	Emission factor [g/GJ]
1998	314
1999	318
2000	323
2001	323
2002	323

Gas turbines, natural gas

SNAP 010104, 010304, 010504, 020104, 020303 and 030104
The emission factor for gas turbines was estimated to be below 1,5g/GJ and the emission factor 1,5 g/GJ have been applied for all years. The emission factor was based on emission measurements from 9 plants.

CHP, wood

SNAP 010102 and, 010103 and 010104
The emission factor for CHP plants combusting wood was estimated to be below 2,1g/GJ and the emission factor 2,1 g/GJ have been applied for all years. The emission factor was based on emission measurements from 3 plants.

CHP, straw

SNAP 010102 and 010103
The emission factor for CHP plants combusting straw was estimated to be below 0,5g/GJ and the emission factor 0,5g/GJ has been applied for all years. The emission factor was based on emission measurements from 4 plants.

CHP, municipal waste

SNAP 010102, 010103, 010104 and 010105
The emission factor for CHP plants combusting straw was estimated to be below 0,6g/GJ and the emission factor 0,6g/GJ has been applied for all years. The emission factor was based on emission measurements from 16 plants.

1.5.2.2 Other stationary combustion plants

Emission factors for other plants refer to the EMEP/Corinair Guidebook (EMEP/Corinair 2003), Danish Gas Technology Centre (DGC 2001) or Gruijthuijsen & Jensen 2000. The same emission factors are applied for 1990-2002.

1.5.3 N_2O

The N_2O emission factors applied for the 2002 inventory is shown in table 3A-10. The same emission factors have been applied for 1990-2002.

Emission factors for gas engines, gas turbines and CHP plants combusting wood, straw or municipal waste all refer to emission measurements carried out on Danish plants (Nielsen & Illerup 2003). Other emission factors refer to the EMEP/Corinair Guidebook (EMEP/Corinair 2003).

Table 3A-10 N_2O emission factors 1990-2002

Fuel	ipcc_id	snap_id	Emission factor [g/GJ]	Reference
COAL	all	all	3	EMEP/Corinair 2003
BROWN COAL BRI.	all	all	3	EMEP/Corinair 2003
COKE OVEN COKE	all	all	3	EMEP/Corinair 2003
PETROLEUM COKE	all	all	3	EMEP/Corinair 2003
WOOD AND SIMIL.	1A1a	010102, 010103, 010104	0,8	Nielsen & Illerup 2003
WOOD AND SIMIL.	1A1a	010105, 010202, 010203, 010205	4	EMEP/Corinair 2003
WOOD AND SIMIL.	1A2f, 1A4a, 1A4b, 1A4c	all	4	EMEP/Corinair 2003
MUNICIP. WASTES	1A1a	010102, 010103, 010104, 010105	1,2	Nielsen & Illerup 2003
MUNICIP. WASTES	1A1a	010203	4	EMEP/Corinair 2003
MUNICIP. WASTES	1A2f, 1A4a	030102, 0201, 020103	4	EMEP/Corinair 2003
STRAW	1A1a	010102, 010103	1,4	Nielsen & Illerup 2003
STRAW	1A1a	010202, 010203	4	EMEP/Corinair 2003
STRAW	1A2f, 1A4a, 1A4b, 1A4c	all	4	EMEP/Corinair 2003
RESIDUAL OIL	all	all	2	EMEP/Corinair 2003
GAS OIL	all	all	2	EMEP/Corinair 2003
KEROSENE	all	all	2	EMEP/Corinair 2003
FISH & RAPE OIL	all	all	4	EMEP/Corinair 2003, assuming same emission factor as municipal waste
ORIMULSION	1A1a	010101	2	EMEP/Corinair 2003, assuming same emission factor as residual oil
NATURAL GAS	1A1a	0101, 010101, 010102, 010103, 010202, 010203	1	EMEP/Corinair 2003
NATURAL GAS	1A1a, 1Ab, 1Ac, 1A2f, 1A4a, 1A4c	Gas turbines: 010104, 010304, 010504, 030104, 020104, 020303	2,2	Nielsen & Illerup 2003
NATURAL GAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4b, 1A4c	Gas engines: 010105, 010405, 010505, 030105, 020105, 020204, 020304	1,3	Nielsen & Illerup 2003
NATURAL GAS	1A1c, 1A2f, 1A4a, 1A4b, 1A4c	010502, 0301, 030103, 030106, 0201, 020103, 0202, 020202, 0203	1	EMEP/Corinair 2003
LPG	all	all	2	EMEP/Corinair 2003
REFINERY GAS	all	all	2	EMEP/Corinair 2003
BIOGAS	1A1a	010102, 010103, 010203	2	EMEP/Corinair 2003
BIOGAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4c	010105, 010405, 010505, 030105, 020105, 020304	0,5	Nielsen & Illerup 2003
BIOGAS	1A2f, 1A4a, 1A4c	0301, 030102, 0201, 020103, 0203	2	EMEP/Corinair 2003

1.5.4 SO_2, NO_x, NMVOC and CO

Emission factors 2002 for SO_2, NO_x, NMVOC and CO 2002 are shown in Table 3A-11. Complete time series are shown in appendix 3A-4. Most country specific emission factors refers to:

- Danish legislation
- Danish research reports
- Calculations based on plant specific emissions from a considerable number of power plants
- Calculations based on plant specific emissions from a considerable number of municipal waste incineration plants

Table 3A-11 SO_2, NO_x, NMVOC and CO emission factors 2002

Fuel	IPCC sector	SNAP	SO_2 [g/GJ]	NO_x [g/GJ]	NMVOC [g/GJ]	CO [g/GJ]
COAL	1A1a	010101, 010102, 010103	45	130	1,5	10
COAL	1A1a, 1A2f, 1A4b, 1A4c	010202, 010203, 0301, 0202, 0203	574	95	15	10
BROWN COAL BRI.	1A4b	0202	574	95	15	10
COKE OVEN COKE	1A2f, 1A4b	0301, 0202	574	95	15	10
PETROLEUM COKE	1A2f	0301	573	50	1,5	61
PETROLEUM COKE	1A4a, 1A4b, 1A4c	0201, 0202, 0203	573	50	1,5	1000
WOOD AND SIMIL.	1A1a	010102, 010103, 010104	1,74	69	3,3	79
WOOD AND SIMIL.	1A1a	010105	25	130	48	50
WOOD AND SIMIL.	1A1a, 1A2f	010202, 010203, 010205, 0301, 030102, 030103	25	130	48	240
WOOD AND SIMIL.	1A4a, 1A4c	0201, 020105, 0203	25	130	600	240
WOOD AND SIMIL.	1A4b	0202	25	120	600	9000
MUNICIP. WASTES	1A1a	010102, 010103, 010104, 010105	23,9	124	0,98	7,4
MUNICIP. WASTES	1A1a, 1A2f, 1A4a	010203, 030102, 0201, 020103	67	164	9	10
STRAW	1A1a	010102, 010103	47,1	131	0,8	63
STRAW	1A1a, 1A2f	010202, 010203, 030102, 030105	130	153	50	325
STRAW	1A4a, 1A4c	0201, 0203, 020302	130	153	600	325
STRAW	1A4b	0202	130	153	600	4000
RESIDUAL OIL	1A1a	0101, 010101, 010102, 010103, 010104	290	130	3	15
RESIDUAL OIL	1A1a, 1A4b, 1A4c	010202, 010203, 0201, 0202, 0203, 020302	344	142	3	30
RESIDUAL OIL	1A1b	010303	649	142	3	30
RESIDUAL OIL	1A2f	0301, 030102, 030103	344	130	3	30
RESIDUAL OIL	1A2f	030104	344	130	3	15
RESIDUAL OIL	1A2f	030105	344	130	3	100
RESIDUAL OIL	1A4a, 1A4c	020105, 020304	344	142	3	100
GAS OIL	1A1a	0101, 010101, 010102, 010103	23	220	1,5	15
GAS OIL	1A1a, 1A2f	Gas turbines: 010104, 030104	23	350	2	15
GAS OIL	1A1a, 1A1c, 1A2f, 1A4a, 1A4c	Engines: 010105, 010205, 010505, 030105, 020105, 020304	23	700	100	100
GAS OIL	1A1a, 1A2f	010202, 0301, 030102	23	65	1,5	30
GAS OIL	1A1a, 1A2f	010203, 030103, 030106	23	52	1,5	30
GAS OIL	1A4a, 1A4c	0201, 020103, 0203	23	52	3	30
GAS OIL	1A4b	0202	23	52	3	43
KEROSENE	all	all	5	50	3	20
FISH & RAPE OIL	1A1a	010203	100	153	50	325
FISH & RAPE OIL	1A2f	030105	130	153	50	325
FISH & RAPE OIL	1A4c	020304	100	153	600	325
ORIMULSION	1A1a	010101	12	86	3	15
NATURAL GAS	1A1a	0101, 010101, 010102, 010103	0,3	115	2	15
NATURAL GAS	1A1a, 1A1b, 1A1c, 1A2f, 1A4a, 1A4c	Gas turbines: 010104, 010304, 010504, 030104, 020104, 020303	0,3	124	1,4	6,2
NATURAL GAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4b, 1A4c	Gas engines: 010105, 010405, 010505, 030105, 020105, 020204, 020304	0,3	168	117	175
NATURAL GAS	1A1a, 1A2f	010202, 010203, 0301, 030103, 030106	0,3	50	2	28
NATURAL GAS	1A1c	010502	0,3	250	2	28
NATURAL GAS	1A4a, 1A4c	0201, 020103, 0203	0,3	30	2	28
NATURAL GAS	1A4b	0202, 020202	0,3	30	4	20
LPG	1A1a, 1A2f	010203, 0301, 030106	0,13	96	2	25
LPG	1A4a, 1A4c	0201, 0203	0,13	71	2	25
LPG	1A4b	0202	0,13	47	2	25
REFINERY GAS	1A1b	010303	0,3	100	4	15
REFINERY GAS	1A1b	010304	0,3	170	4	15
BIOGAS	1A1a, 1A2f, 1A4a, 1A4c	010102, 010103, 010203, 0301, 0201, 020103, 0203	11	31	4	36
BIOGAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4c	Gas engines: 010105, 010405, 010505, 030105, 020105, 020304	19,2	540	14	273
BIOGAS	1A2f	030102	11	66	4	36

2 Fuel consumption data

In 2002 the total fuel consumption for stationary combustion plants was 568 PJ of which 490 PJ was fossil fuels. The fuel consumption rates are shown in Appendix 3A-3.

Fuel consumption of the stationary combustion subsectors is shown in Figure 3A-1 and Figure 3A-2. The main part – 59% - of the fuels is combusted in the sector *Electricity and heat production.* Other sectors with high fuel consumption are *Residential* and *Industry*.

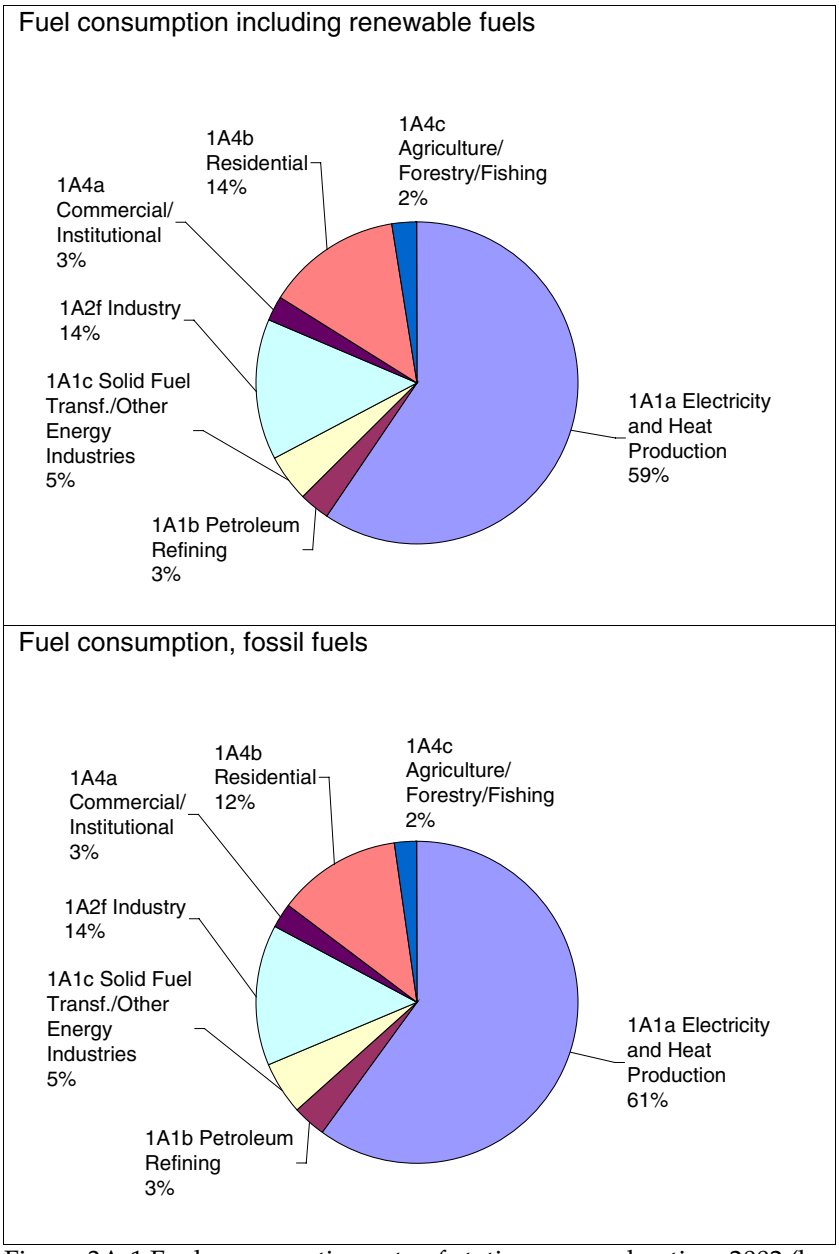


Figure 3A-1 Fuel consumption rate of stationary combustion, 2002 (based on DEA 2003a)

Coal and natural gas are the most utilised fuels for stationary combustion plants. Coal is mainly used in power plants and natural gas is used in power plants and decentralised CHP plants as well as in industry, district heating and households.

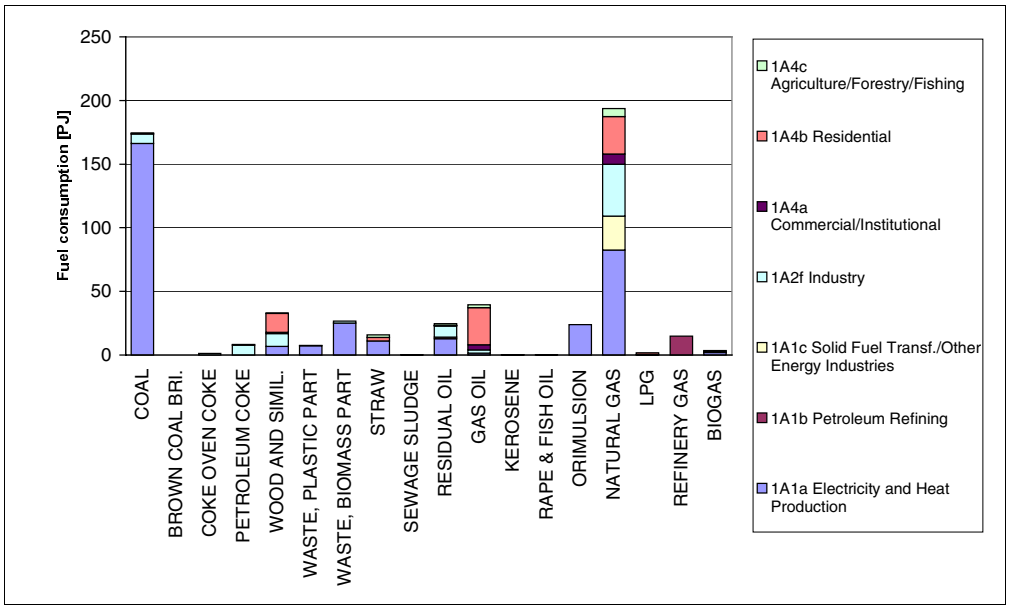


Figure 3A-2 Fuel consumption of stationary combustion plants 2002 (based on DEA 2003a)

Fuel consumption time series for stationary combustion plants are shown in Figure 3A-3. The total fuel consumption has increased by 14% from 1990 to 2002, while the fossil fuel consumption has only increased by 8%. The consumption of natural gas and renewable fuels has increased since 1990 whereas coal consumption has decreased.

The fuel consumption rate fluctuates considerably mainly due to electricity import/export but also due to outdoor temperature variations. The fuel consumption fluctuation is further discussed in chapter 0.

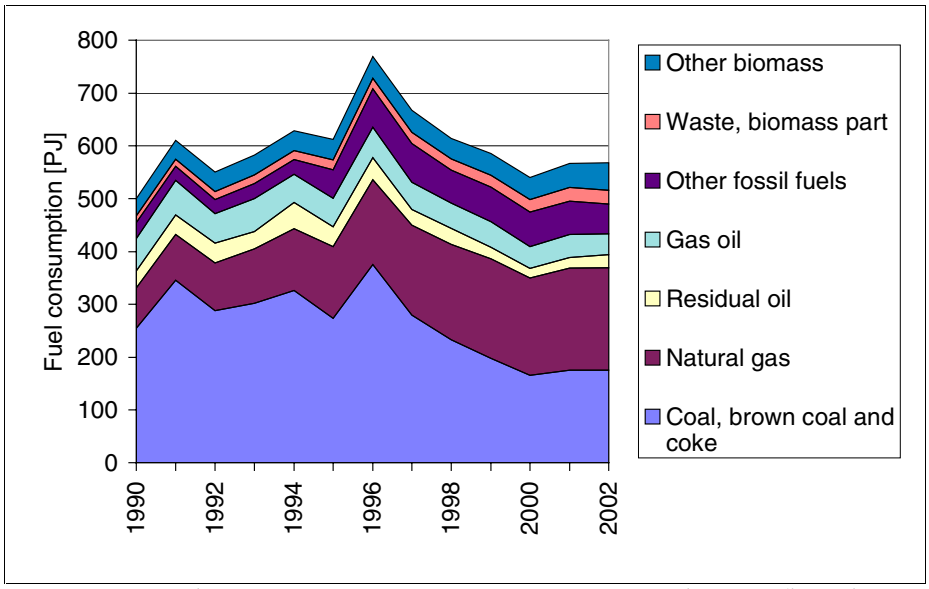


Figure 3A-3 Fuel consumption time series, stationary combustion (based on DEA 2003a)

3 Greenhouse gas emission

The total Danish greenhouse gas (GHG) emission in the year 2002 was 68491 Gg CO_2 equivalent not including land-use change and forestry or 64678 Gg CO_2 equivalent including land-use change and forestry. The greenhouse gas pollutants HFCs, PFCs and SF_6 are not emitted from combustion plants and thus only the pollutants CO_2, CH_4 and N_2O are considered below.

The global warming potentials of CH_4 and N_2O that are applied in greenhouse gas inventories are the factors from the second IPCC assessment report (IPCC 1995):

- 1 g CH_4 equals 21 g CO_2
- 1 g N_2O equals 310 g CO_2

The GHG emissions from stationary combustion are shown in Table 3A-12. The emission from stationary combustion accounts for 55% of the total Danish GHG emission.

The CO_2 emission from stationary combustion plants accounts for 68% of the total Danish CO_2 emission (gross). CH_4 accounts for 9% of the total Danish CH_4 emission and N_2O for only 5% of the total Danish N_2O emission.

Table 3A-12 Greenhouse gas emission for the year 2002 [1)]

	CO_2	CH_4	N_2O
	Gg CO_2 equivalent		
1A1 Fuel consumption, Energy industries	26548	340	264
1A2 Fuel consumption, Manufacturing Industries and Construction[1)]	4815	34	53
1A4 Fuel consumption, Other sectors [1)]	5510	159	66
Total emission from stationary combustion plants	**36873**	**533**	**383**
Total Danish emission (gross)	54164	5635	7976
	%		
Emission share for stationary combustion	68	9	5

1) Only stationary combustion sources of the sector is included

CO_2 is the most important GHG pollutant and accounts for 97,6% of the GHG emission (CO_2 eq.). This is a much higher share than for the total Danish GHG emissions where CO_2 only accounts for 80% of the GHG emission (CO_2 eq.).

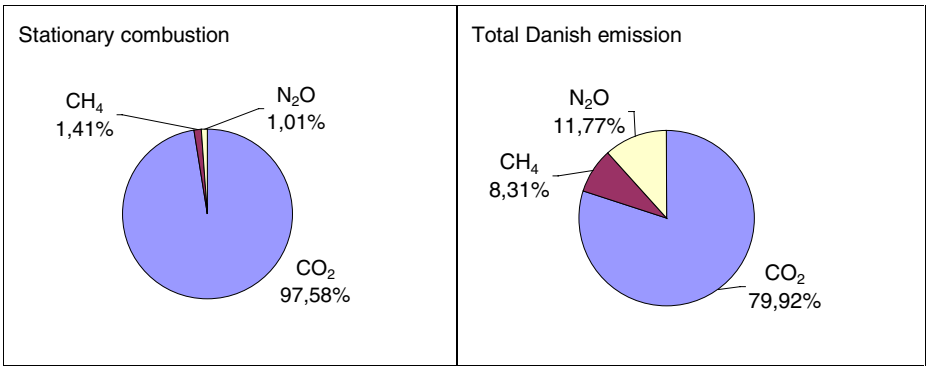


Figure 3A-4 GHG emission (CO_2 equivalent), contribution from each pollutant

Figure 3A-5 shows the time series of GHG emission (CO_2 eq.) from stationary combustion and it is seen that the GHG emission development follows the CO_2 emission development very close by.

Both the CO_2 and the total GHG emission have decreased a little from 1990 to 2002, CO_2 by 2,3% and GHG by 1,3%. However fluctuations of the GHG emission level are large.

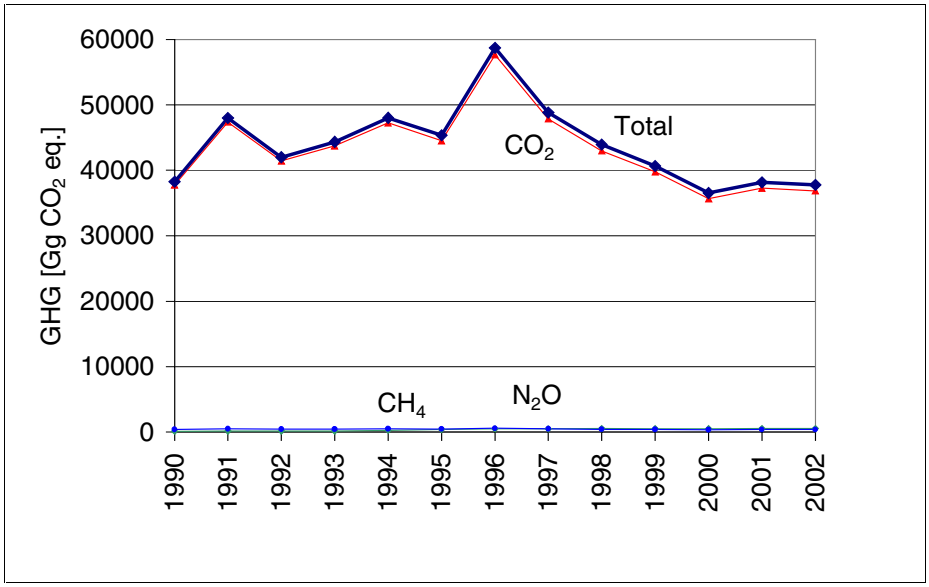


Figure 3A-5 GHG emission time series for stationary combustion

The fluctuations in the time series are a result mainly of electricity import/export but also of outdoor temperature variations between years. These fluctuations are shown in Figure 3A-6. In 1990 the Danish electricity import was large causing relatively low emissions, whereas the emissions are high in 1996 due to a large electricity export. In 2002 the net electricity export was 7453 TJ.

To be able to follow the national energy consumption and for statistical and reporting purposes the Danish Energy Authority produces a correction of the actual emissions without random variations in electricity imports/exports and in ambient temperature. This emission trend, which is smoothly decreasing, is also shown in Figure 3A-6. The corrections are included here to explain the fluctuations in the emission time series. The GHG emission corrected for electricity import/export and ambient temperature has decreased by 20% since 1990, the CO_2 emission by 21%.

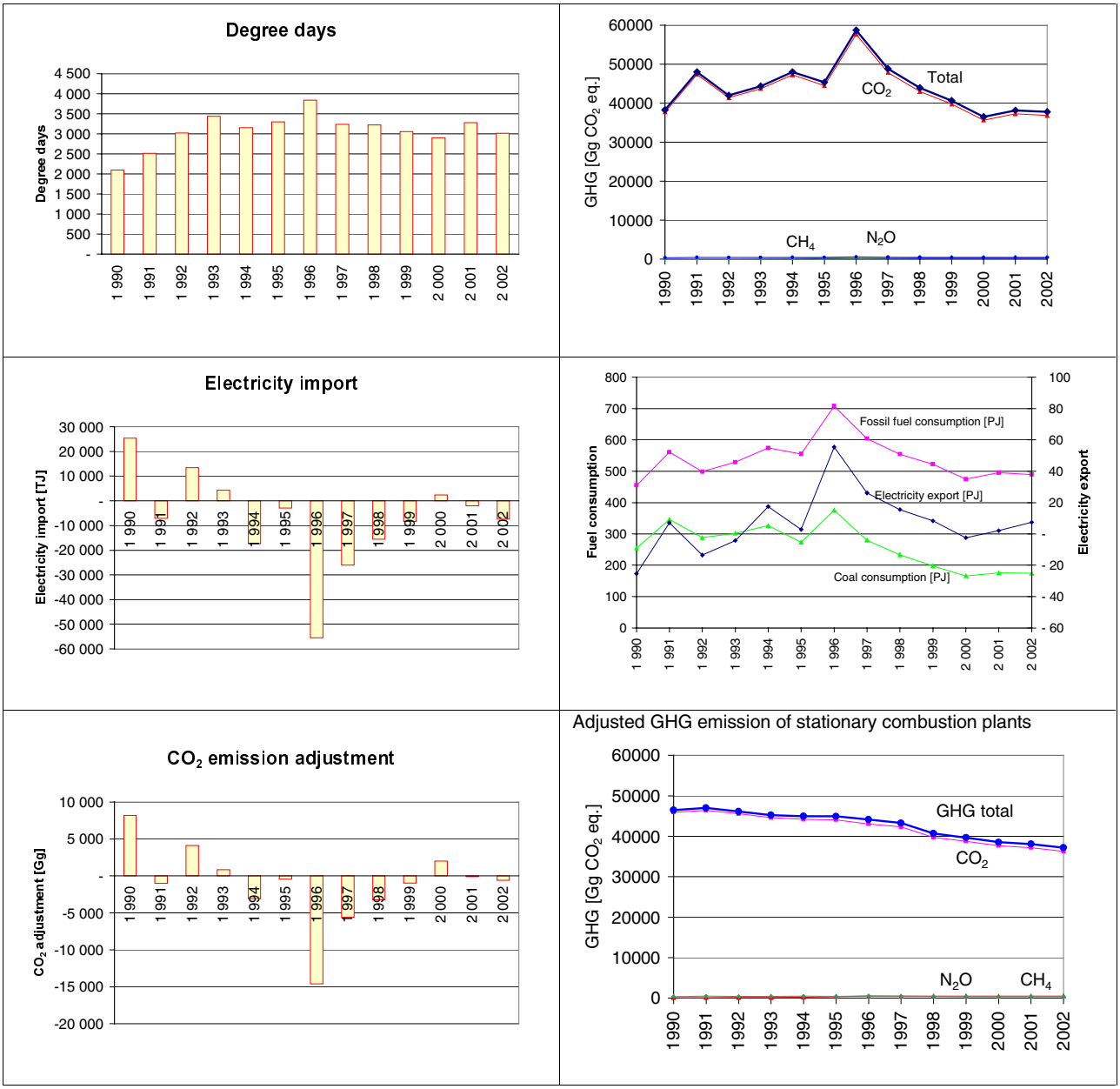


Figure 3A-6 GHG emission time series for stationary combustion, adjusted for electricity import/export and temperature variations (DEA 2003b)

3.1 CO_2

The CO_2 emission from stationary combustion plants is one of the most important GHG emission sources. Thus the CO_2 emission from stationary combustion plants accounts for 68% of the total Danish CO_2 emission. Table 3A-13 shows the CO_2 emission inventory for stationary combustion plants for 2002. Figure 3A-7 shows that *Electricity and heat production* accounts for 65% of the CO_2 emission from stationary combustion. This share is somewhat higher than the fossil fuel consumption share of this sector, which is 61% (Figure 3A-1). Other large CO_2 emission sources are industrial plants and residential plants. These are the sectors that also account for a considerable share of the fuel consumption.

Table 3A-13 CO_2 emission from stationary combustion plants 2002 [1)]

CO_2	2002	
1A1a Electricity and heat production	24083	Gg
1A1b Petroleum refining	948	Gg
1A1c Solid fuel transf. and other energy industries	1517	Gg
1A2f Industry	4815	Gg
1A4a Commercial / Institutional	800	Gg
1A4b Residential	3979	Gg
1A4c Agriculture / Forestry / Fishing	731	Gg
Total	**36873**	**Gg**

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

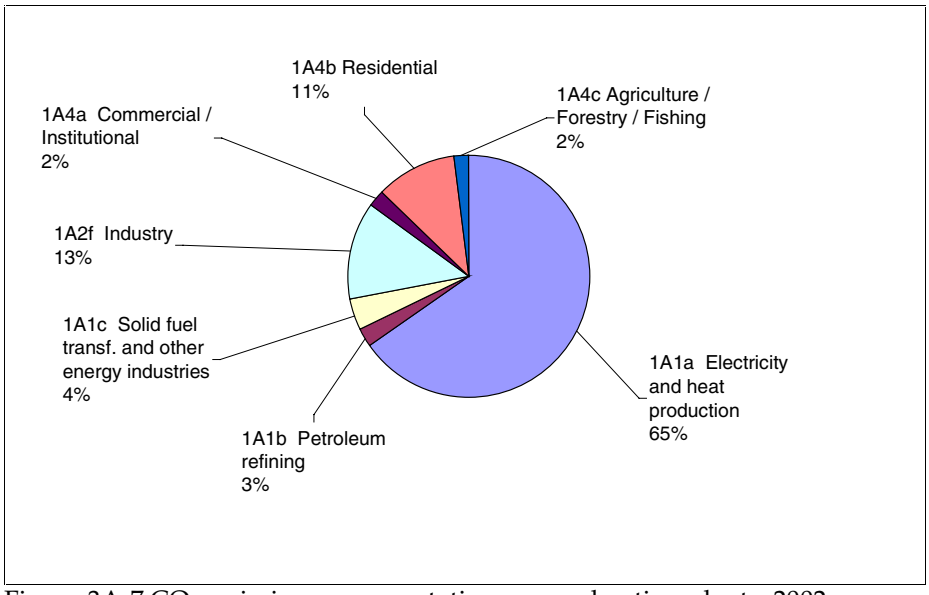


Figure 3A-7 CO_2 emission sources, stationary combustion plants, 2002

The sector *Electricity and heat production* consists of the SNAP source sectors: *Public power* and *District heating*. The CO_2 emissions from each of these subsectors are shown in Table 3A-14. The most important subsector is centralised power plants.

Table 3A-14 CO_2 emission from subsectors to *1A1a Electricity and heat production*

SNAP source	SNAP name	2002	
0101	Public power	0	Gg
010101	Combustion plants ≥ 300MW (boilers)	18823	Gg
010102	Combustion plants ≥ 50MW and < 300 MW (boilers)	971	Gg
010103	Combustion plants <50 MW (boilers)	172	Gg
010104	Gas turbines	2247	Gg
010105	Stationary engines	1608	Gg
0102	District heating plants	-	Gg
010201	Combustion plants ≥ 300MW (boilers)	-	Gg
010202	Combustion plants ≥ 50MW and < 300 MW (boilers)	39	Gg
010203	Combustion plants <50 MW (boilers)	223	Gg
010204	Gas turbines	-	Gg
010205	Stationary engines	0	Gg

CO_2 emission from combustion of biomass fuels is not included in the total CO_2 emission data because biomass fuels are considered CO_2 neutral. The CO_2 emission from biomass combustion is reported as a memo item in the Climate Convention reporting. In 2002 the CO_2 emission from biomass combustion was 8454 Gg.

In Figure 3A-8 the fuel consumption share (fossil fuels) is compared with the CO_2 emission disaggregated to fuel origin. Due to the higher CO_2 emission factor of coal than oil and gas the CO_2 emission share from coal combustion is higher than the fuel consumption share. Coal accounts for 36% of the fossil fuel consumption and for 46% of the CO_2 emission. Natural gas accounts for 39% of the fossil fuel consumption but only for 30% of the CO_2 emission.

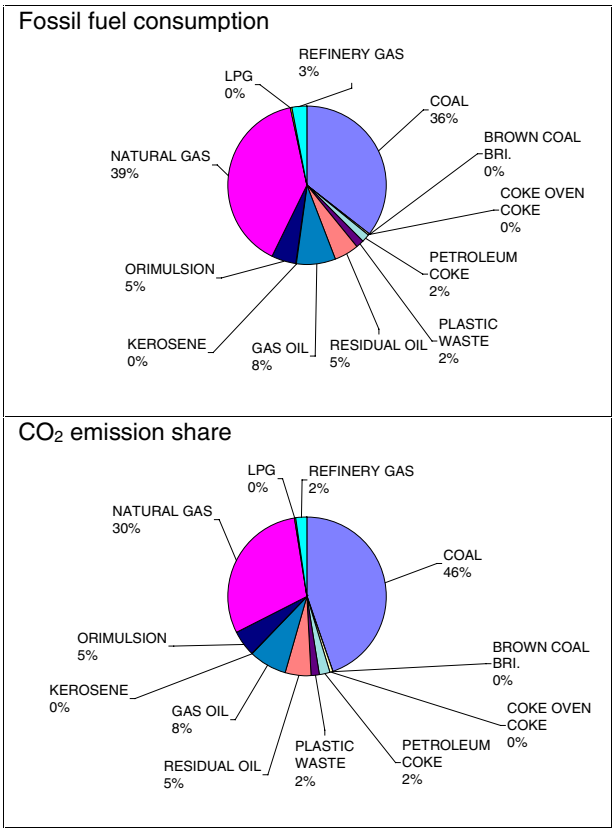


Figure 3A-8 CO_2 emission, fuel origin

Time series for CO_2 emission are shown in Figure 3A-9. Despite an increase in fuel consumption of 14% since 1990 CO_2 emission from stationary combustion has decreased by 2,3% because of the change of fuel type used.

The fluctuations of total CO_2 emission follow the fluctuations of CO_2 emission from *Electricity and heat production* (Figure 3A-9) and in coal consumption (Figure 3A-10). The fluctuations are a result of the electricity import/export as discussed in chapter 7.

Figure 3A-10 compares time series for fossil fuel consumption and CO_2 emission. As mentioned above the consumption of coal has decreased whereas the consumption of natural gas, that has a lower CO_2 emission factor, has increased. The total use of fossil fuels increased by 8% between 1990 and 2002.

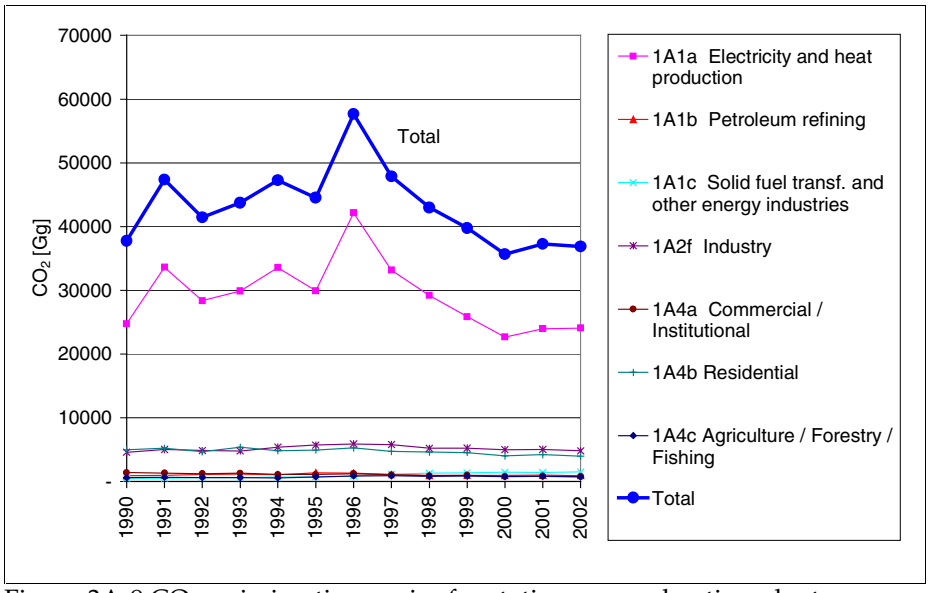


Figure 3A-9 CO_2 emission time series for stationary combustion plants

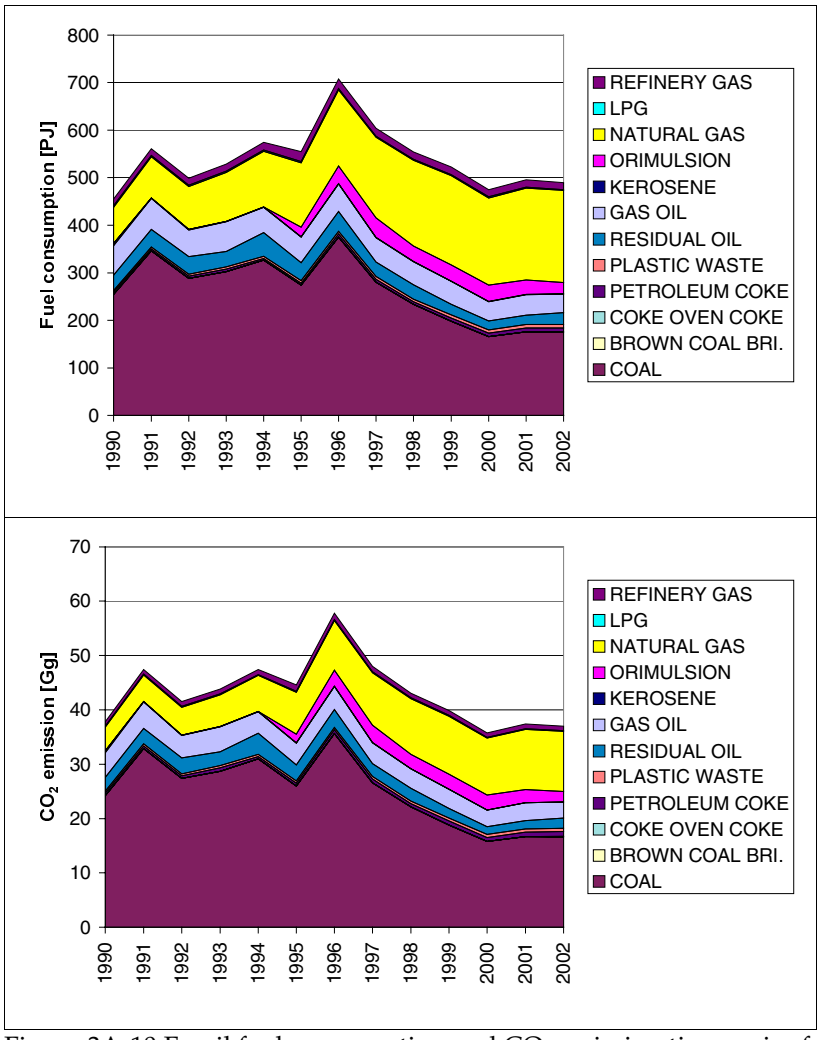


Figure 3A-10 Fossil fuel consumption and CO_2 emission time series for stationary combustion

3.2 CH_4

The CH_4 emission from stationary combustion plants accounts for 9% of the total Danish CH_4 emission. Table 3A-15 shows the CH_4 emission inventory for stationary combustion plants in 2002. Figure 3A-11 shows that *Electricity and heat production* accounts for 63% of the CH_4 emission from stationary combustion and this is close to the fuel consumption share.

Table 3A-15 CH_4 emission from stationary combustion plants 2002 [1)]

CH_4	2002	
1A1a Electricity and heat production	16005	Mg
1A1b Petroleum refining	2	Mg
1A1c Solid fuel transf. and other energy industries	177	Mg
1A2f Industry	1635	Mg
1A4a Commercial / Institutional	974	Mg
1A4b Residential	4479	Mg
1A4c Agriculture / Forestry / Fishing	2112	Mg
Total	25384	Mg

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

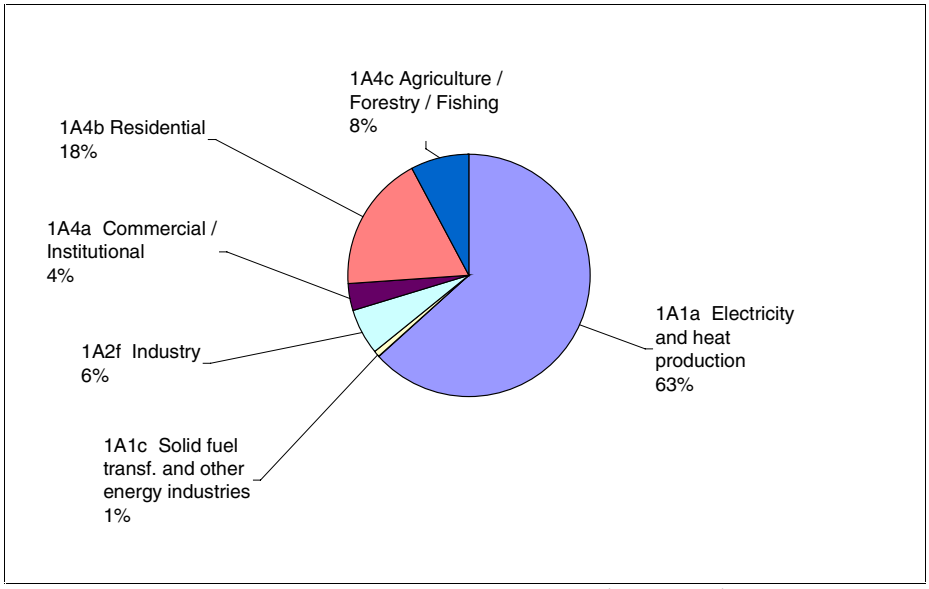


Figure 3A-11 CH_4 emission sources, stationary combustion plants, 2002

The CH_4 emission factor for reciprocating gas engines is much higher than for other combustion plants due to the continuous ignition/burn out of the gas. Especially lean-burn gas engines have a high emission factor as discussed in chapter 1.5.2. A considerable number of lean-burn gas engines are in operation in Denmark and these plants accounts for 75% of the CH_4 emission from stationary combustion plants (Figure 3A-12). The engines are installed in CHP plants and the fuel used is either natural gas or biogas.

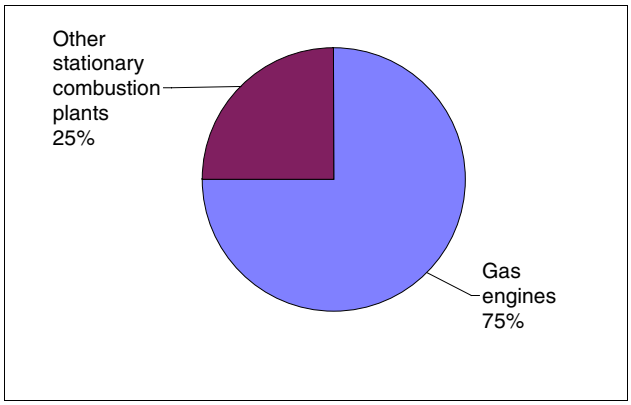


Figure 3A-12 Gas engine CH_4 emission share, 2002

The CH_4 emission from stationary combustion increased by a factor 4,5 since 1990 (Figure 3A-13). This is a result of the considerable number of lean-burn gas engines that was installed in CHP plants in Denmark in this period. Figure 3A-14 shows time series for the fuel consumption rate in gas engines and the corresponding increase of CH_4 emission.

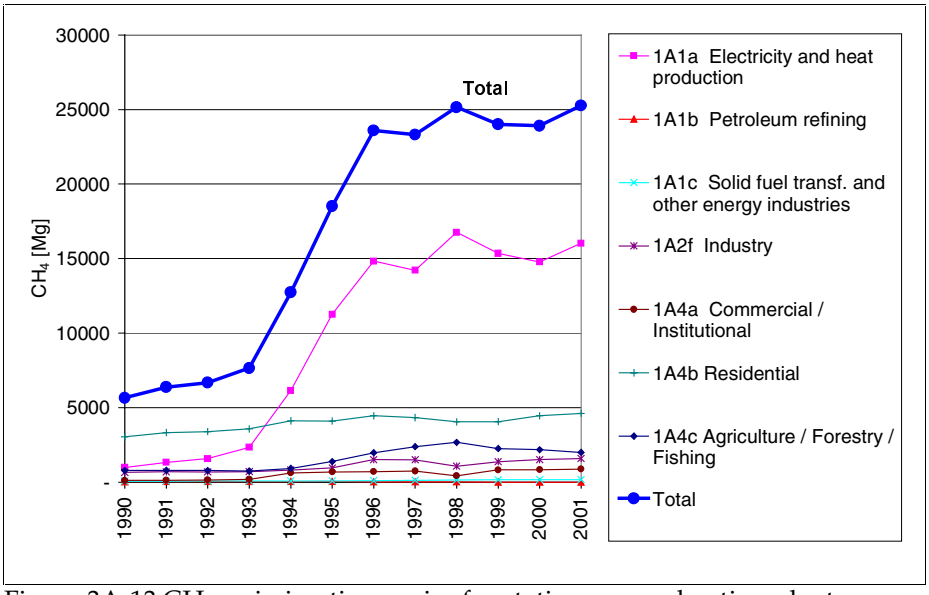
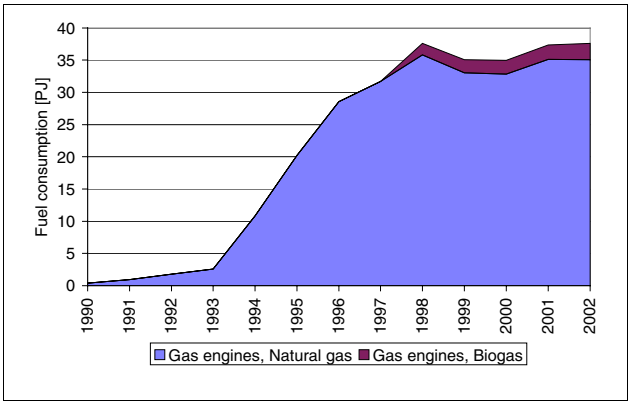


Figure 3A-13 CH_4 emission time series for stationary combustion plants



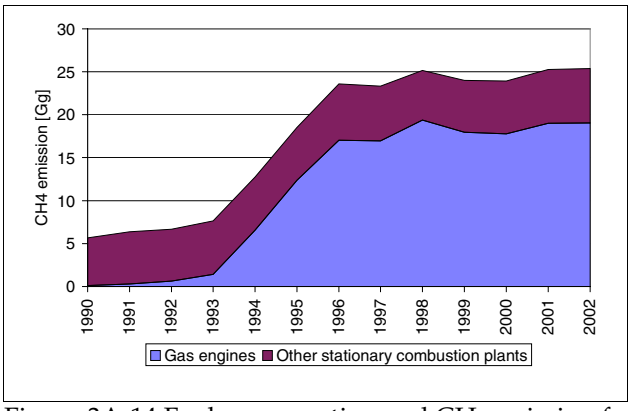


Figure 3A-14 Fuel consumption and CH_4 emission from gas engines, time series

3.3 N_2O

The N_2O emission from stationary combustion plants accounts for 5% of the total Danish N_2O emission. Table 3A-16 shows the N_2O emission inventory for stationary combustion plants in the year 2002. Figure 3A-15 shows that *Electricity and heat production* accounts for 64% of the N_2O emission from stationary combustion. This is only a little higher than the fuel consumption share.

Table 3A-16 N_2O emission from stationary combustion plants 2002 [1)]

N_2O	2002	
1A1a Electricity and heat production	793	Mg
1A1b Petroleum refining	32	Mg
1A1c Solid fuel transf. and other energy industries	27	Mg
1A2f Industry	170	Mg
1A4a Commercial / Institutional	23	Mg
1A4b Residential	163	Mg
1A4c Agriculture / Forestry / Fishing	26	Mg
Total	1234	Mg

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

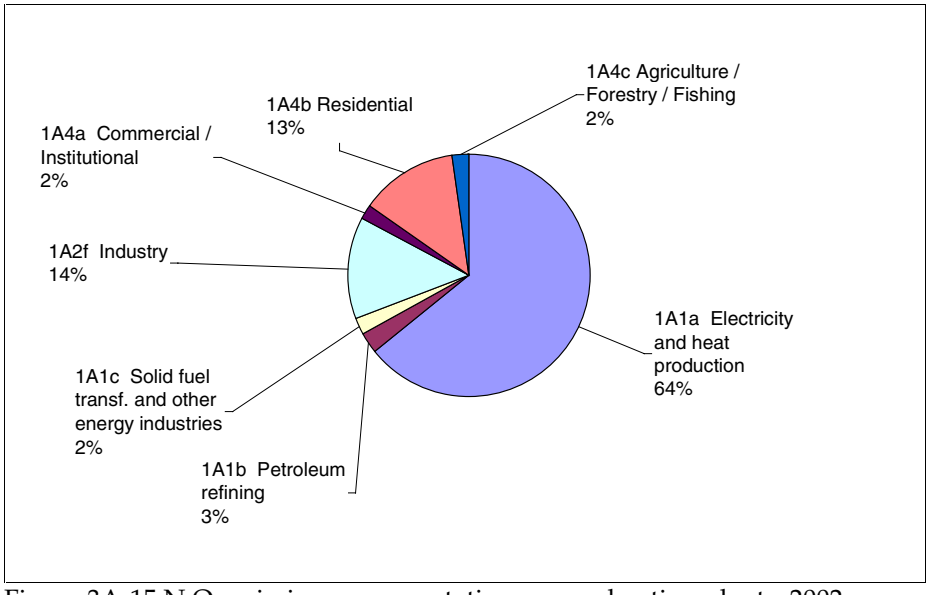


Figure 3A-15 N_2O emission sources, stationary combustion plants, 2002

Figure 3A-16 shows time series for N_2O emission. The N_2O emission from stationary combustion decreased 3,6% from 1990 to 2002, but again fluctuations of emission level due to electricity import/export are considerable.

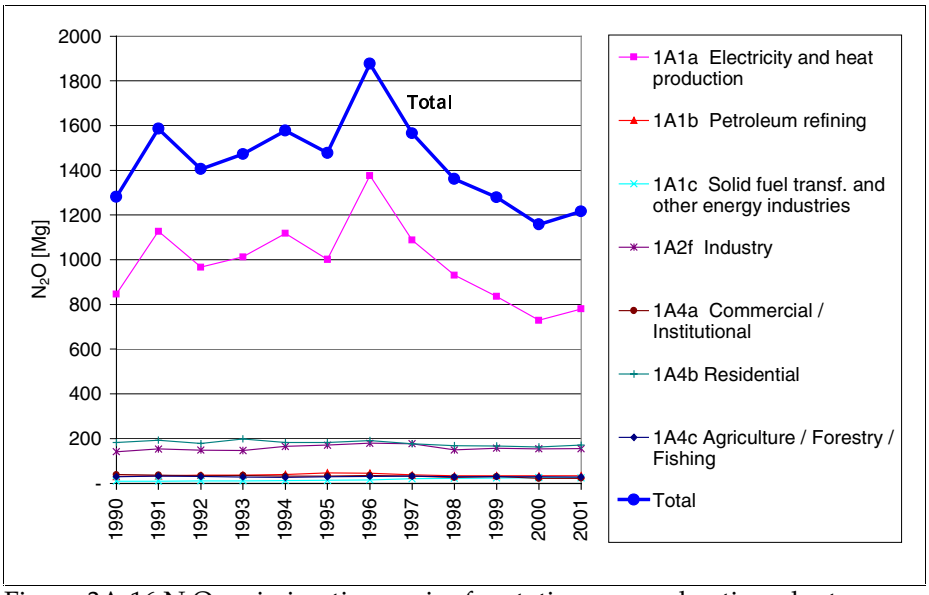


Figure 3A-16 N_2O emission time series for stationary combustion plants

4 SO_2, NO_x, NMVOC and CO

The emissions of SO_2, NO_x, NMVOC and CO from Danish stationary combustion plants 2002 are shown in Table 3A-17. The emission of these pollutants is included in the reporting to the Climate Convention.

SO_2 from stationary combustion plants accounts for 83% of the total Danish emission. NO_x, CO and NMVOC account for 37%, 29% and 15% of the total Danish emissions respectively.

Table 3A-17 SO_2, NO_x, NMVOC and CO emission from stationary combustion 2002 [1)]

Pollutant	NO_x Gg	CO Gg	NMVOC Gg	SO_2 Gg
1A1 Fuel consumption, Energy industries	53,1	12,5	4,3	10,9
1A2 Fuel consumption, Manufacturing Industries and Construction (Stationary combustion)	14,4	5,2	0,9	6,6
1A4 Fuel consumption, Other sectors (Stationary combustion)	7,4	149,4	13,4	3,6
Total emission from stationary combustion plants	**74,9**	**167,2**	**18,6**	**21,1**
Total Danish emission (gross)	200	577	124	25
		%		
Emission share for stationary combustion	37,4	29,0	15,0	83,3

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

4.1 SO_2

Stationary combustion is the most important emission source for SO_2 accounting for 85% of the total Danish emission. Table 3A-18 and Figure 3A-17 show the SO_2 emission inventory for the stationary combustion subsectors. *Electricity and heat production* is the largest emission source accounting for 48% of the emission, but the SO_2 emission share is somewhat smaller than the fuel consumption share of the sector which is 59%. This is possible due to the effective flue gas desulphurization plants installed in power plants combusting coal.

Figure 3A-18 shows the SO_2 emission from *Electricity and heat production* on a disaggregated level. Power plants >300MW_{th} is the main emission source accounting for 73% of the emission.

The SO_2 emission from *Industry* is 31%, which is a remarkably large emission compared with the fuel consumption share. The main emission sources in the industry sector are combustion of coal and residual oil, but also emissions from cement industry and from industrial combustion of petroleum coke are considerable emission sources. Some years ago SO_2 emission from the industry sector only accounted for a small part of the total emission, but as a result of the reduced emissions from power plants the share has now increased. To improve knowledge of the emission from industrial combustion of coal and residual oil knowledge of flue gas cleaning technology used in the industry sector should be examined in the future.

Time series for SO_2 emission from stationary combustion are shown in Figure 3A-19. SO_2 emission from stationary combustion plants has decreased by 95% from 1980 and 83% from 1995. The large emission decrease is mainly a result of the reduced emission from *Electricity and heat production* that have been possible due to installation of desulphurization plants and due to the use of fuels with lower content of sulphur. Despite the considerable reduction of emission from electricity and heat production plants, they still account for 48% of the total emission from stationary combustion as mentioned above. The emission from other sectors also decreased considerably since 1980.

Table 3A-18 SO_2 emission from stationary combustion plants 2002 [1)]

SO_2	2002	
1A1a Electricity and heat production	9936	Mg
1A1b Petroleum refining	927	Mg
1A1c Solid fuel transf. and other energy industries	9	Mg
1A2f Industry	6563	Mg
1A4a Commercial / Institutional	553	Mg
1A4b Residential	1787	Mg
1A4c Agriculture / Forestry / Fishing	1284	Mg
Total	21058	Mg

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

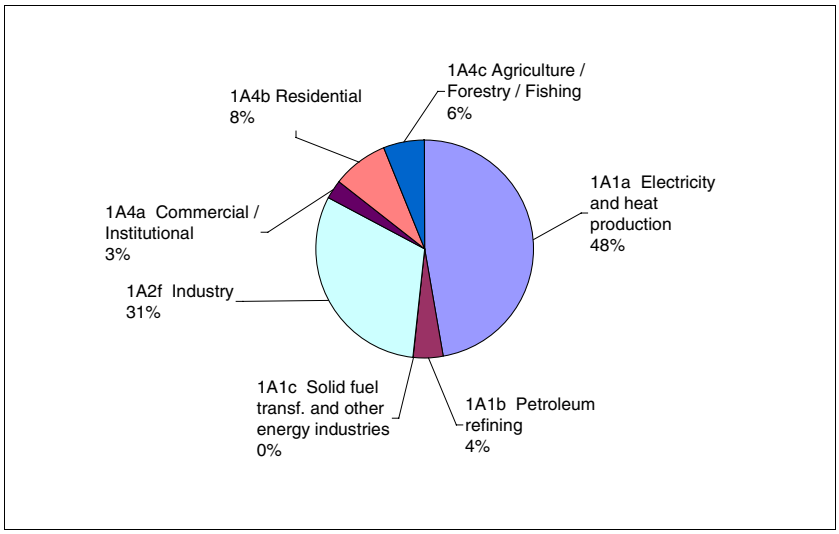


Figure 3A-17 SO_2 emission contribution for stationary combustion

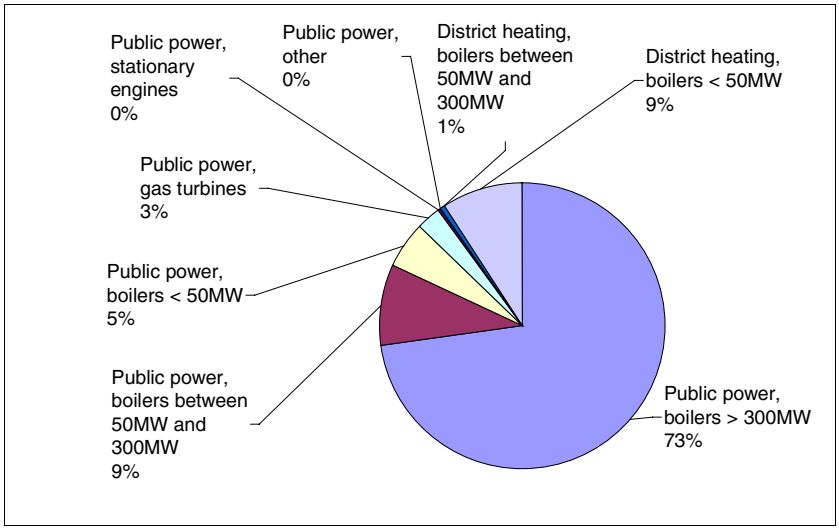


Figure 3A-18 Disaggregated SO_2 emissions from *Energy and heat production*

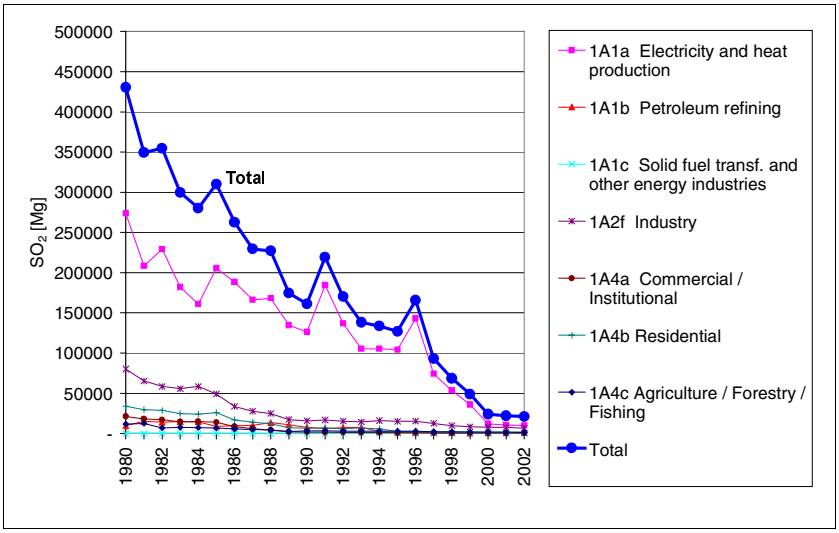


Figure 3A-19 SO_2 emission time series for stationary combustion

4.2 NO_x

Stationary combustion accounts for 37% of the total Danish NO_x emission. Table 3A-19 and Figure 3A-20 show the NO_x emission inventory for stationary combustion subsectors. *Electricity and heat production* is the largest emission source accounting for 60% of the emission from stationary combustion plants. Power plants >50MW_{th} are the main emission source in this sector accounting for 68% of the emission.

Industrial combustion plants are also an important emission source accounting for 19% of the emission. The main industrial emission source is cement production that accounts for 62% of the emission.

Residential plants accounts for 7% of the NO_x emission. The fuel origin of this emission is mainly wood, gas oil and natural gas accounting for 36%, 31% and 22% of the residential plant emission respectively.

Time series for NO_x emission from stationary combustion are shown in Figure 3A-21. NO_x emission from stationary combustion plants has decreased by 50% from 1985 and 34% from 1995. The reduced emission is mainly a result of the reduced emission from *Electricity and heat production* due to installation of low NO_x burners and selective catalytic reduction (SCR) units. The fluctuations of the time series follow the fluctuations of *Electricity and heat production*, which is a result of fuel consumption fluctuations due to electricity import/export. The NO_x emission from all subsectors have been decreased since 1985.

Table 3A-19 NO_x emission from stationary combustion plants 2002 [1)]

	2002	
1A1a Electricity and heat production	44964	Mg
1A1b Petroleum refining	1554	Mg
1A1c Solid fuel transf. and other energy industries	6555	Mg
1A2f Industry	14412	Mg
1A4a Commercial / Institutional	1077	Mg
1A4b Residential	4909	Mg
1A4c Agriculture / Forestry / Fishing	1460	Mg
Total	74931	Mg

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

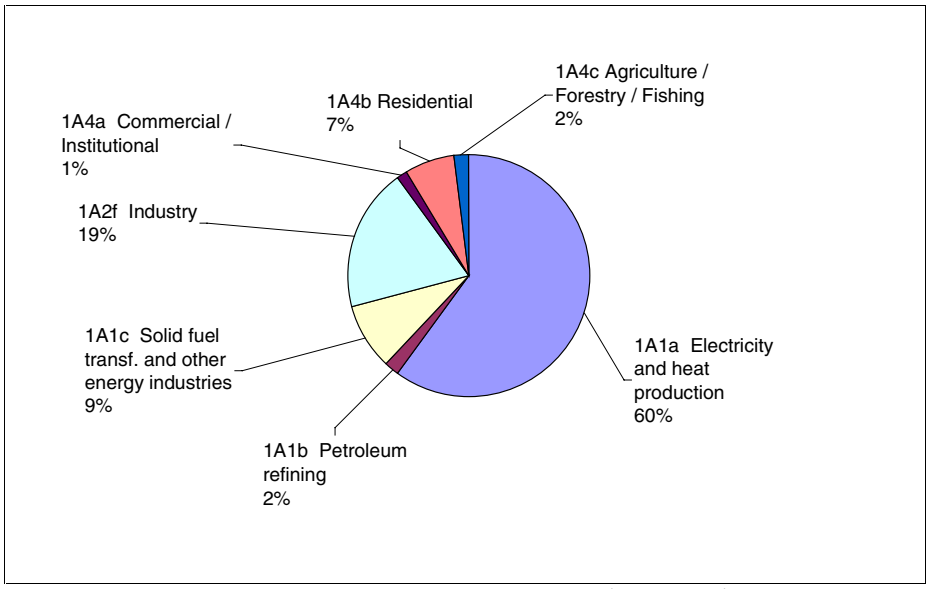


Figure 3A-20 NO_x emission sources, stationary combustion plants, 2002

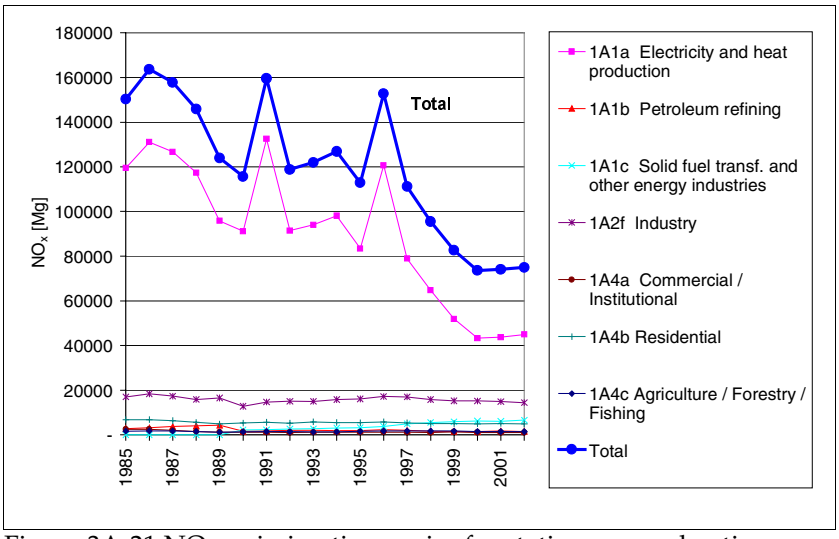


Figure 3A-21 NO_x emission time series for stationary combustion

4.3 NMVOC

Stationary combustion plants account for 15% of the total Danish NMVOC emission. Table 3A-20 and Figure 3A-22 show the NMVOC emission inventory for the stationary combustion subsectors. Residential plants are the largest emission source accounting for 59% of the total emission from stationary combustion plants. The NMVOC emission from residential plants is mainly emitted from wood and straw combustion, see Figure 3A-23.

Electricity and heat production is also a considerable emission source with 23% of the total emission from stationary combustion. Lean-burn gas engines have a relatively high NMVOC emission factor and the engines are the most important emission source in this subsector (see Figure 3A-23). The gas engines are either natural gas or biogas fuelled.

Time series for NMVOC emission from stationary combustion are shown in Figure 3A-24. NMVOC emission from stationary combustion plants has increased by 40% from 1985 and 14% from 1995. The increased emission is mainly a result of the increased use of lean-burn gas engines in CHP plants as discussed in chapter 3.2.

The emission from residential plants is relatively constant, but the NMVOC emission from wood combustion almost doubled since 1990 due to increased wood consumption. However this increase of emission corresponds to a decrease of emission from straw combustion in farmhouse boilers that have taken place at the same time.

The use of wood in residential boilers and stoves is relatively low in 1998-99 resulting in a dive of emission level for residential plants and total these years.

Fuel consumption rates 1985-1989 for the sector agriculture/forestry/fishing have not been updated according to the new energy statistics. This leads to a sudden increase in emission between 1989 and 1990 that is not correct.

Table 3A-20 NMVOC emission from stationary combustion plants 2002 [1)]

	2002	
1A1a Electricity and heat production	4240	Mg
1A1b Petroleum refining	4	Mg
1A1c Solid fuel transf. and other energy industries	55	Mg
1A2f Industry	926	Mg
1A4a Commercial / Institutional	748	Mg
1A4b Residential	10964	Mg
1A4c Agriculture / Forestry / Fishing	1657	Mg
Total	18594	Mg

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

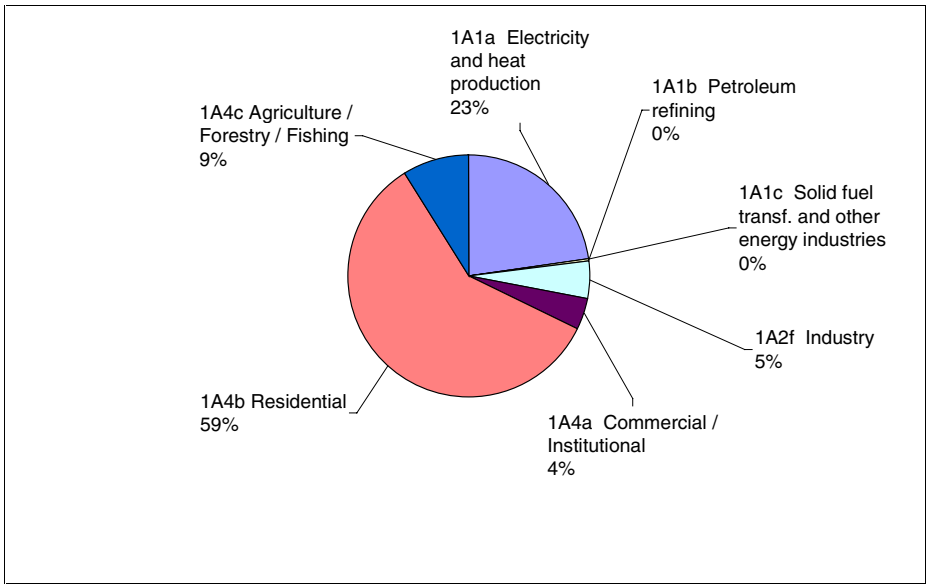


Figure 3A-22 NMVOC emission sources, stationary combustion plants, 2002

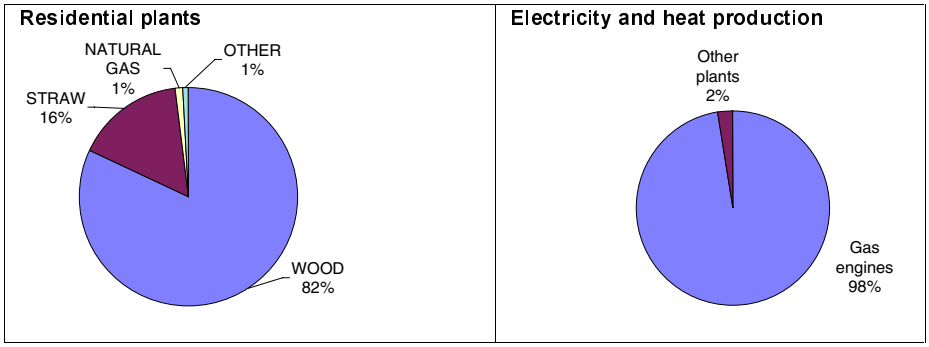


Figure 3A-23 NMVOC emission from residential plants and from electricity and heat production, 2002

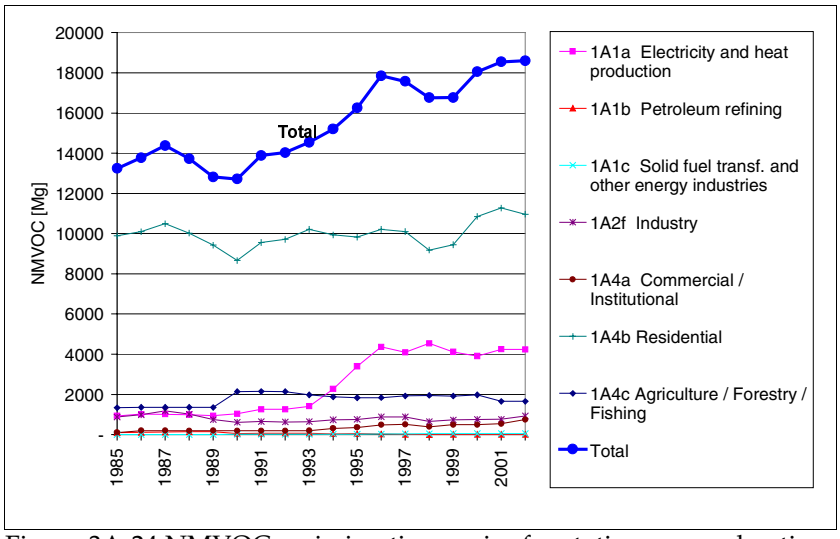


Figure 3A-24 NMVOC emission time series for stationary combustion

4.4 CO

Stationary combustion accounts for 29% of the total Danish CO emission. Table 3A-21 and Figure 3A-25 show the CO emission inventory for stationary combustion subsectors. Residential plants are the largest emission source accounting for 88% of the emission.

Wood combustion accounts for 90% of the emission from residential plants, see Figure 3A-26. This in spite of the fact that the fuel consumption share is only 19%. Combustion of straw is also a considerable emission source whereas the emission from other fuels used in residential plants is almost negligible.

Time series for CO emission from stationary combustion is shown in Figure 3A-27. The CO emission from stationary combustion plants has increased by 40% from 1985 and 6% from 1995. The time series for stationary combustion plants follow the time series for residential plants.

The wood consumption in residential plants increased 65% since 1990 causing an increase of the CO emission. The increase in CO from residential plants is less than the increase in wood consumption because CO emission from straw fired farmhouse boilers has decreased considerably. Both the annual straw consumption in residential plants and the CO emission factor for farmhouse boilers have decreased.

Table 3A-21 CO emission from stationary combustion plants 2002 [1)]

	2002	
1A1a Electricity and heat production	11528	Mg
1A1b Petroleum refining	263	Mg
1A1c Solid fuel transf. and other energy industries	749	Mg
1A2f Industry	5203	Mg
1A4a Commercial / Institutional	909	Mg
1A4b Residential	147045	Mg
1A4c Agriculture / Forestry / Fishing	1480	Mg
Total	167176	Mg

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

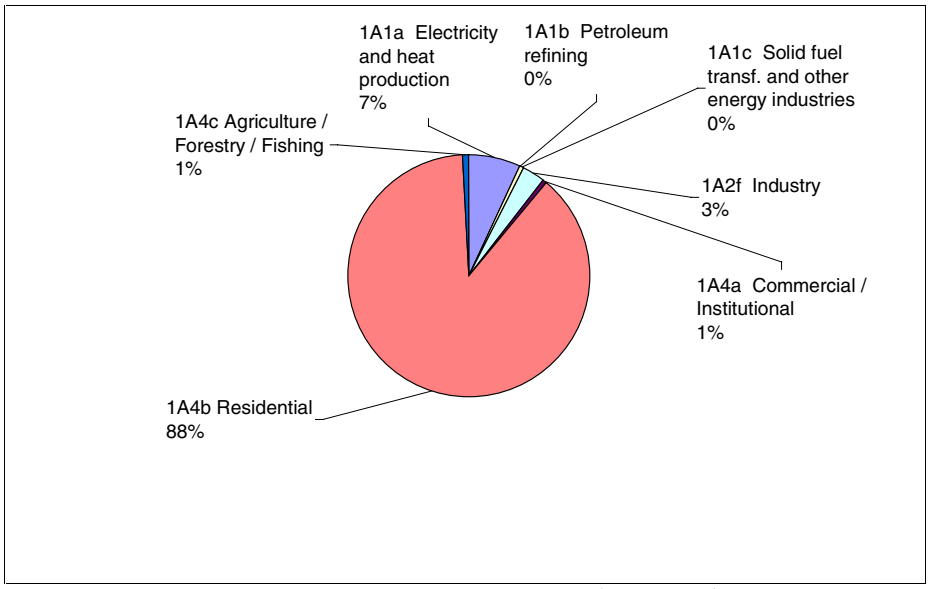


Figure 3A-25 CO emission sources, stationary combustion plants, 2002

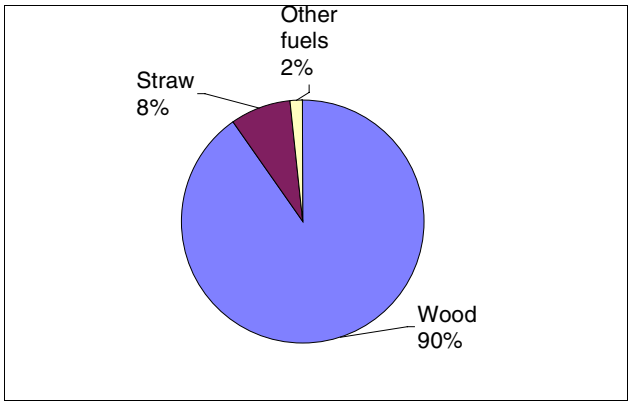


Figure 3A-26 CO emission sources, residential plants, 2002

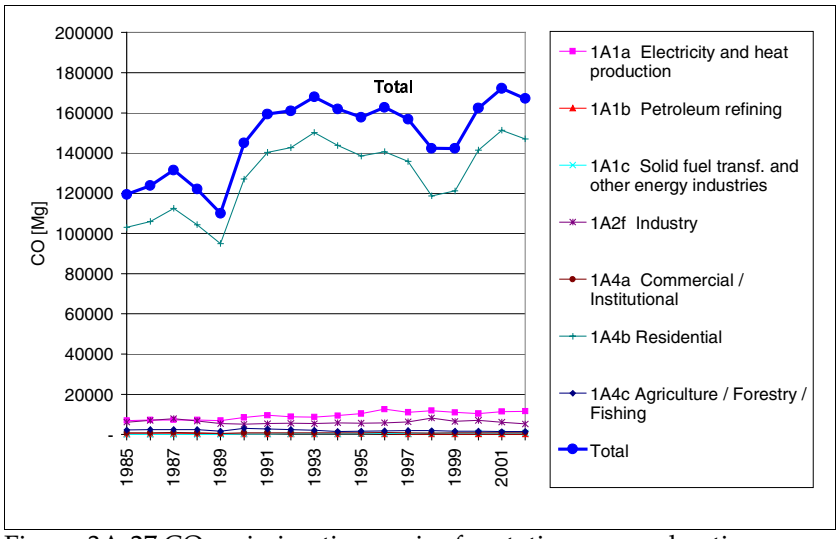


Figure 3A-27 CO emission time series for stationary combustion

5 QA/QC and validation

A formal QA/QC plan has not yet been developed, but a number of quality control (QC) procedures are performed. The QC procedures for stationary combustion includes:

- Check of time series of the IPCC and SNAP source categories. Considerable changes are controlled and explained.
- Comparison to inventory of the previous year. Any major changes are verified
- Total emission when aggregated to IPCC reporting tables are compared to totals based on SNAP source categories (control of data transfer)
- A manual log table in the emission databases is applied to collect information about recalculations
- The IPCC reference approach validates the fuel consumption rates and CO_2 emissions of fuel combustion. Fuel consumption rates and CO_2 emissions are within 2,0% difference (1990-2002). The reference approach is further discussed in below.
- The emission from each large point source is compared to the emission reported the previous year.
- Some automated checks have been prepared for the emission databases:
  - Check of units for fuel rate, emission factor and plant specific emissions
  - Check of emission factors of large point sources. Emission factors of pollutants that are not plant specific should be the same as the emission factor that are defined for area sources.
  - Additional checks of database consistency
- Most emission factor references are now implemented in the emission database itself.
- Annual environmental reports are kept for subsequent control of plant specific emission data
- QA/QC checks of the country specific emission factors have not been performed but most factors are based on work from companies that have implemented some QA/QC work. The two major power plant owners / operators in Denmark: E2 and Elsam both obtained the ISO 14001 certification for environmental management system. Danish Gas Technology Centre and dk-Teknik both run accredited laboratories for emission measurements.

5.1 Reference approach

In addition to the sector specific CO_2 emission inventories (the national approach) the CO_2 emission is also estimated using the reference approach described in the IPCC Reference Manual (IPCC 1996). The reference approach is based on data for fuel production, import, export, and stock change. The CO_2 emission inventory based on the reference approach is reported to the Climate Convention and used for verification of the official data in the national approach.

Data for import, export and stock change used in the reference approach originates from the annual "basic data" table prepared by the Danish Energy Authority and published on their home page (DEA 2003b). The fraction of carbon oxidised has been assumed to be 1,00. The carbon emission factors are default factors originating from the IPCC Reference Manual (IPCC 1996). The country specific emission factors are not used in the reference approach because it is used for verification.

The Climate Convention reporting tables include a comparison of the national approach and the reference approach estimates. To make results comparable, the CO_2 emission from the plastic part of municipal waste incineration is added in the reference approach. Further consumption for non-energy purposes is subtracted in the reference approach, because non-energy use of fuels is not included in the Danish national approach yet.

Three fuels are used for non-energy purposes: lube oil, bitumen and white spirit. The total consumption for non-energy purposes is relatively low – 10,9 PJ in 2002.

In 2002 fuel consumption rates of the two approaches differ 0,05% and the CO_2 emission differ 0,24%. In 1990-2002 the fuel consumption difference is within 1,96% and the CO_2 emission difference is within 1,92%. According to the IPCC Good Practice Guidance (IPCC 2000) the difference should be within 2%. The reference approach for 2002 and the comparison with the Danish national approach are shown in appendix 3A-9. The appendix also includes a correspondence list for the fuel categories (Danish Energy Authority/IPCC reference approach).

Comparison of national approach and reference approach is shown in Figure 3A-28.

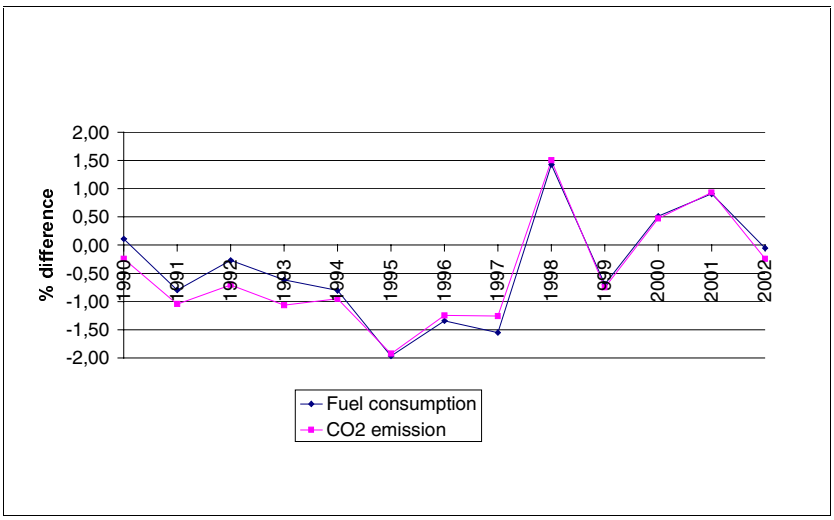


Figure 3A-28 Comparison of reference approach and national approach

6 Uncertainty

According to the IPCC Good Practice Guidance (IPCC 2000) uncertainty estimates should be included in the annual National Inventory Report.

Uncertainty estimates include uncertainty of the total emission inventory as well as uncertainty of the trend. The GHG emission from stationary combustion plants was estimated with an uncertainty of ±10% and the decrease of the GHG emission was estimated to be 1,3% ± 1,8 %-age points since 1990.

6.1 Methodology

6.1.1 Greenhouse gases

The Danish uncertainty estimates for GHGs is based on the tier 1 approach in IPCC Good Practice Guidance (IPCC 2000). The uncertainty have been estimated for the following emission source subcategories to stationary combustion:

- CO_2 emission from each of the applied fuel categories [1]
- CH_4 emission from gas engines
- CH_4 emission from all other stationary combustion plants
- N_2O emission from all stationary combustion plants

The separate uncertainty estimation for gas engine CH_4 emission and CH_4 emission from other plants does not follow the recommendations in the IPCC Good Practice Guidance. The disaggregation is applied because in Denmark the CH_4 emission from gas engines is much larger than the emission from other stationary combustion plants and the CH_4 emission factor for gas engines is known with a much smaller uncertainty than the factor for other stationary combustion plants.

Most of the applied uncertainties for activity rates and emission factors are default values from the IPCC Reference Manual. A few of the uncertainty estimates are however based on national estimates.

[1] Brown coal and coke is included in the fuel category coal

Table 3A-22 Uncertainty rates for activity rates and emission factors

IPCC Source category	Gas	Activity data uncertainty %	Emission factor uncertainty %
Stationary Combustion, Coal	CO_2	1 [1)]	5 [3)]
Stationary Combustion, Petroleum coke	CO_2	3 [1)]	5 [1)]
Stationary Combustion, Plastic waste	CO_2	5 [4)]	5 [4)]
Stationary Combustion, Residual oil	CO_2	2 [1)]	2 [3)]
Stationary Combustion, Gas oil	CO_2	4 [1)]	5 [1)]
Stationary Combustion, Kerosene	CO_2	4 [1)]	5 [1)]
Stationary Combustion, Orimulsion	CO_2	1 [1)]	2 [3)]
Stationary Combustion, Natural gas	CO_2	3 [1)]	1 [3)]
Stationary Combustion, LPG	CO_2	4 [1)]	5 [1)]
Stationary Combustion, Refinery gas	CO_2	3 [1)]	5 [1)]
Stationary combustion plants, gas engines	CH_4	2,2 [1)]	40 [2)]
Stationary combustion plants, other	CH_4	2,2 [1)]	100 [1)]
Stationary combustion plants	N_2O	2,2 [1)]	1000 [1)]

1) IPCC Reference Manual (default value)
2) Kristensen (2003)
3) Jensen & Lindroth (2002)
4) NERI assumption

6.1.2 Other pollutants

The IPCC methodologies for uncertainty estimates have been adopted for the LRTAP Convention reportings. The methodology is described in a new chapter in the EMEP/Corinair Guidebook (EMEP/Corinair 1996) called *Good Practice Guidance for CLRTAP Emission Inventories* (Pulles & Aardenne 2002). Uncertainty estimates for SO_2, NO_x, NMVOC and CO is based on this methodology. The uncertainty estimates are based on emission data and uncertainties for each of the main SNAP sectors.

The assumed uncertainties for activity rates and emission factors are based on default values from Pulles & Aardenne 2002. The default uncertainties for emission factors are given in letter codes representing an uncertainty range. It has been assumed that the uncertainties were in the lower end of the range for all sources and pollutants. The uncertainties for emission factors are shown in Table 3A-23. The uncertainty for fuel consumption in stationary combustion plants was assumed to be 2%.

Table 3A-23 Uncertainty rates for emission factors

SNAP sector	SO_2	NO_x	NMVOC	CO
01	10	20	50	20
02	20	50	50	50
03	10	20	50	20

6.2 Results

The estimated uncertainties for stationary combustion emission inventories are shown in Table 3A-24. Detailed calculation sheets are shown in appendix 3A-6.

The uncertainty of GHG is estimated to be ±10% and the uncertainty in trend of GHG is ±1,8%-age points. The main sources of uncertainty for GHG emission are N_2O emission (all plants) and CO_2 emission from coal combustion. Main sources of the trend uncertainty for GHG are CO_2 emission from combustion of natural gas and coal.

Table 3A-24 Danish uncertainty estimates, 2002

Pollutant	Uncertainty Total emission [%]	Trend 1990-2002 [%]	Uncertainty Trend [%-age points]
GHG	10,4	-1,3	± 1,8
CO_2	2,6	-2,3	± 1,8
CH_4	39	349	± 351
N_2O	1000	-3,6	± 3,0
SO_2	7	-86,9	± 0,6
NO_x	16	-35,2	± 2,5
NMVOC	38	46	± 15
CO	45	15,3	± 3,0

7 Improvements / recalculations

- The CO_2 emission factors for municipal waste, refinery gas and petroleum coke have been changed for some years.

  ° Petroleum coke: The same CO_2 emission factor (92 kg/GJ) is applied for all years now. In earlier inventories a higher emission factor was applied for 1990-1997. The reference for the emission factor is however based on a fuel analysis carried out in 1993 and thus the change of emission factor was not correct.

  ° Refinery gas: To improve time series consistency the same emission factor (56,9 kg/GJ) is now applied for all years. In the inventory reported last year the emission factor 57,1 kg/GJ was applied for 2000 and 2001.

  ° Municipal waste: An improved CO_2 emission factor for municipal waste has been estimated.

- Fuel consumption rates for a few stationary combustion sectors have been recalculated as a result of a new estimate for off road machinery, see chapter 3.3. The fuel consumption of gas oil and LPG in the SNAP sectors 0203 and 0301 (stationary combustion) are calculated as total emission of the sectors minus the off road consumption.

- Emission factors for combined heat and power plants have been improved based on a Danish project including collection of existing emission data and performance of a large number of new emission measurements (Nielsen & Illerup 2003). The emission measurements included both CH_4, N_2O, SO_2, NO_x, NMVOC and CO.

- Centralised power plants have been included in the emission databases as point sources in 1993-1994 (was already included as point sources all other years). Plant specific SO_2 and NO_x emission factors are applied. However the area source emission factor applied in former inventories took into account the plant specific data and thus the estimated emission is not changed considerably due to this improvement.

- The SO_2 and NO_x emission factors have been examined and time series inconsistencies have been corrected.

Further a few minor errors for large point sources have been corrected. These corrections do not include CO_2, CH_4 or N_2O emission.

8 Future improvements

Some planned improvements of the emission inventories are discussed below.

8.1 Disaggregation of fuel consumption in the industrial sector

So far the Danish energy statistics aggregated to SNAP sectors have not specified fuel consumption rates for specific industries. Thus the fuel consumption of *1A2 Manufacturing industries and construction* is included in sector *1A2f Manufacturing industries and construction, Other*. The work that is required to make a disaggregation to industrial subsectors possible have been initiated and it is expected to be implemented in the reportings in 2005.

The new energy statistics will for each industrial sector specify the consumption in boilers, gas turbines, gas engines and in process combustion. This split will improve the inventory because the process combustion emission factors might differ considerably from the emission factors for boilers.

8.2 Energy statistics update

A full update of fuel consumption according to the updated energy statistics has not been carried out for a few years. A full update is expected to be part of the next emission inventory.

8.3 Improved documentation for CO_2 emission factors

The CO_2 emission factors applied for the Danish inventories are considered accurate but the documentation will be improved in future inventories.

8.4 QA/QC and validation

The QA/QC and validation of the inventories for stationary combustion will be improved as part of a general improvement of the QA/QC of the Danish emission inventories as a whole.

9 References

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Appendix

Appendix 3A-1: The Danish emission inventory for the year 2002 reported to the Climate Convention in 2004

Appendix 3A-2: IPCC/SNAP source correspondence list

Appendix 3A-3: Fuel rate

Appendix 3A-4: Emission factors

Appendix 3A-5: Large point sources

Appendix 3A-6: Uncertainty estimates

Appendix 3A-7: Lower Calorific Value (LCV) of fuels

Appendix 3A-8: Adjustment of CO_2 emission

Appendix 3A-9: Reference approach

Appendix 3A-1 The Danish emission inventory for the year 2002 reported to the Climate Convention

Table 3A-25 The Danish emission inventory for the year 2002 reported to the Climate Convention in 2004

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**50.350,92**	**5.634,72**	**7.976,44**	**672,10**	**22,17**	**21,63**	**64.677,98**
1. Energy	**52.457,27**	**739,38**	**832,02**				**54.028,68**
A. Fuel Combustion (Sectoral Approach)	51.921,90	607,59	829,13				53.358,61
1. Energy Industries	26.548,40	339,86	264,23				27.152,50
2. Manufacturing Industries and Construction	5.557,12	37,43	62,44				5.656,99
3. Transport	12.300,06	66,07	407,17				12.773,31
4. Other Sectors	7.427,53	164,13	94,01				7.685,68
5. Other	88,78	0,09	1,27				90,13
B. Fugitive Emissions from Fuels	535,37	131,80	2,90				670,07
1. Solid Fuels	0,00	62,28	0,00				62,28
2. Oil and Natural Gas	535,37	69,52	2,90				607,79
2. Industrial Processes	**1.594,90**	**0,00**	**774,07**	**672,10**	**22,17**	**21,63**	**3.084,87**
A. Mineral Products	1.591,78	0,00	0,00				1.591,78
B. Chemical Industry	3,12	0,00	774,07	0,00	0,00	0,00	777,19
C. Metal Production	0,00	0,00	0,00		0,00	0,00	0,00
D. Other Production	NE						0,00
E. Production of Halocarbons and SF_6				0,00	0,00	0,00	0,00
F. Consumption of Halocarbons and SF_6				672,10	22,17	21,63	715,89
G. Other	0,00	0,00	0,00	0,00	0,00	0,00	0,00
3. Solvent and Other Product Use	**111,75**		**0,00**				**111,75**
4. Agriculture	**0,00**	**3.764,05**	**6.370,35**				**10.134,40**
A. Enteric Fermentation		2.797,90					2.797,90
B. Manure Management		966,15	605,36				1.571,50
C. Rice Cultivation		0,00					0,00
D. Agricultural Soils [2]		0,00	5.765,00				5.765,00
E. Prescribed Burning of Savannas		0,00	0,00				0,00
F. Field Burning of Agricultural Residues		0,00	0,00				0,00
G. Other		0,00	0,00				0,00
5. Land-Use Change and Forestry [1]	**-3.813,00**	**0,00**	**0,00**				**-3.813,00**
6. Waste	**0,00**	**1.131,28**	**0,00**				1.131,28
A. Solid Waste Disposal on Land	0,00	1.131,28					1.131,28
B. Wastewater Handling		0,00	0,00				0,00
C. Waste Incineration	0,00	0,00	0,00				0,00
D. Other	0,00	0,00	0,00				0,00
7. Other *(please specify)*	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
							0,00
Memo Items:							
International Bunkers	**5.018,91**	**2,23**	**80,26**				**5.101,41**
Aviation	2.053,39	0,82	22,17				2.076,38
Marine	2.965,52	1,41	58,09				3.025,03
Multilateral Operations	**0,00**	**0,00**	**0,00**				**0,00**
CO_2 Emissions from Biomass	**8.453,62**						**8.453,62**

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).

[2] See footnote 4 to Summary 1.A of this common reporting format.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 emissions	CO_2 removals	Net CO_2 emissions / removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	0,00	-3.813,00	-3.813,00			-3.813,00
B. Forest and Grassland Conversion	0,00		0,00	0,00	0,00	0,00
C. Abandonment of Managed Lands	0,00	0,00	0,00			0,00
D. CO_2 Emissions and Removals from Soil	0,00	0,00	0,00			0,00
E. Other	0,00	0,00	0,00	0,00	0,00	0,00
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	0,00	-3.813,00	-3.813,00	0,00	0,00	-3.813,00

Total CO_2 Equivalent Emissions without Land-Use Change and Forestry [a]	68.490,98
Total CO_2 Equivalent Emissions with Land-Use Change and Forestry [a]	64.677,98

GREENHOUSE GAS SOURCE AND SINK CATEGORIES		CO_2 emissions	CO_2 removals	CH_4	N_2O	HFCs[1]		PFCs[1]		SF_6		NO_x	CO	NMVOC	SO_2
						P	A	P	A	P	A				
		(Gg)				CO_2 equivalent (Gg)						(Gg)			
Total National Emissions and Removals		**54.163,92**	**-3.813,00**	**268,32**	**25,73**	**1.281,10**	**672,10**	**13,62**	**22,17**	**1,40**	**0,00**	**200,29**	**576,63**	**123,77**	**25,28**
1. Energy		**52.457,27**		**35,21**	**2,68**							**199,87**	**576,63**	**83,98**	**25,28**
A. Fuel Combustion	Reference Approach[2]	51.196,34													
	Sectoral Approach[2]	51.921,90		28,93	2,67							197,12	553,59	77,46	24,87
B. Fugitive Emissions from Fuels		535,37		6,28	0,01							2,75	23,05	6,52	0,40
2. Industrial Processes		**1.594,90**		**0,00**	**2,50**	**1.281,10**	**672,10**	**13,62**	**22,17**	**1,40**	**0,00**	**0,43**	**0,00**	**0,58**	**0,00**
3. Solvent and Other Product Use		**111,75**			**0,00**							**0,00**	**0,00**	**38,01**	**0,00**
4. Agriculture [3]		**0,00**	**0,00**	**179,24**	**20,55**							**0,00**	**0,00**	**1,21**	**0,00**
5. Land-Use Change and Forestry		[4] **0,00**	[4] **-3.813,00**	**0,00**	**0,00**							**0,00**	**0,00**	**0,00**	**0,00**
6. Waste		**0,00**		**53,87**	**0,00**							**0,00**	**0,00**	**0,00**	**0,00**
7. Other		**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
Memo Items:															
International Bunkers		**5.018,91**		**0,11**	**0,26**							**90,00**	**8,52**	**2,55**	**39,68**
Aviation		2.053,39		0,04	0,07							8,71	1,60	0,38	0,07
Marine		2.965,52		0,07	0,19							81,29	6,91	2,17	39,61
Multilateral Operations		**0,00**		**0,00**	**0,00**							**0,00**	**0,00**	**0,00**	**0,00**
CO_2 Emissions from Biomass		**8.453,62**													

Appendix 3A-2 IPCC/SNAP source correspondence list

Table 3A-26 Correspondence list for IPCC source categories 1A1, 1A2 and 1A4 and SNAP

SNAP_id	SNAP_name	IPCC source
01	Combustion in energy and transformation industries	
0101	Public power	1A1a
010101	Combustion plants >= 300 MW (boilers)	1A1a
010102	Combustion plants >= 50 and < 300 MW (boilers)	1A1a
010103	Combustion plants < 50 MW (boilers)	1A1a
010104	Gas turbines	1A1a
010105	Stationary engines	1A1a
0102	District heating plants	1A1a
010201	Combustion plants >= 300 MW (boilers)	1A1a
010202	Combustion plants >= 50 and < 300 MW (boilers)	1A1a
010203	Combustion plants < 50 MW (boilers)	1A1a
010204	Gas turbines	1A1a
010205	Stationary engines	1A1a
0103	Petroleum refining plants	1A1b
010301	Combustion plants >= 300 MW (boilers)	1A1b
010302	Combustion plants >= 50 and < 300 MW (boilers)	1A1b
010303	Combustion plants < 50 MW (boilers)	1A1b
010304	Gas turbines	1A1b
010305	Stationary engines	1A1b
010306	Process furnaces	1A1b
0104	Solid fuel transformation plants	1A1c
010401	Combustion plants >= 300 MW (boilers)	1A1c
010402	Combustion plants >= 50 and < 300 MW (boilers)	1A1c
010403	Combustion plants < 50 MW (boilers)	1A1c
010404	Gas turbines	1A1c
010405	Stationary engines	1A1c
010406	Coke oven furnaces	1A1c
010407	Other (coal gasification, liquefaction, ...)	1A1c
0105	Coal mining, oil/gas extraction, pipeline compressors	
010501	Combustion plants >= 300 MW (boilers)	1A1c
010502	Combustion plants >= 50 and < 300 MW (boilers)	1A1c
010503	Combustion plants < 50 MW (boilers)	1A1c
010504	Gas turbines	1A1c
010505	Stationary engines	1A1c
02	Non-industrial combustion plants	
0201	Commercial and institutional plants (t)	1A4a
020101	Combustion plants >= 300 MW (boilers)	1A4a
020102	Combustion plants >= 50 and < 300 MW (boilers)	1A4a
020103	Combustion plants < 50 MW (boilers)	1A4a
020104	Stationary gas turbines	1A4a
020105	Stationary engines	1A4a
020106	Other stationary equipments (n)	1A4a
0202	Residential plants	1A4b
020201	Combustion plants >= 50 MW (boilers)	1A4b
020202	Combustion plants < 50 MW (boilers)	1A4b
020203	Gas turbines	1A4b
020204	Stationary engines	1A4b
020205	Other equipments (stoves, fireplaces, cooking,...)	1A4b
0203	Plants in agriculture, forestry and aquaculture	1A4c
020301	Combustion plants >= 50 MW (boilers)	1A4c
020302	Combustion plants < 50 MW (boilers)	1A4c
020303	Stationary gas turbines	1A4c
020304	Stationary engines	1A4c
020305	Other stationary equipments (n)	1A4c
03	Combustion in manufacturing industry	
0301	Comb. in boilers, gas turbines and stationary	1A2f
030101	Combustion plants >= 300 MW (boilers)	1A2f
030102	Combustion plants >= 50 and < 300 MW (boilers)	1A2f
030103	Combustion plants < 50 MW (boilers)	1A2f
030104	Gas turbines	1A2f
030105	Stationary engines	1A2f
030106	Other stationary equipments (n)	1A2f
0302	Process furnaces without contact	
030203	Blast furnace cowpers	1A2a
030204	Plaster furnaces	1A2f
030205	Other furnaces	1A2f

0303	Processes with contact	
030301	Sinter and pelletizing plants	1A2a
030302	Reheating furnaces steel and iron	1A2a
030303	Gray iron foundries	1A2a
030304	Primary lead production	1A2b
030305	Primary zinc production	1A2b
030306	Primary copper production	1A2b
030307	Secondary lead production	1A2b
030308	Secondary zinc production	1A2b
030309	Secondary copper production	1A2b
030310	Secondary aluminium production	1A2b
030311	Cement (f)	1A2f
030312	Lime (includ. iron and steel and paper pulp industr.)(f)	1A2f
030313	Asphalt concrete plants	1A2f
030314	Flat glass (f)	1A2f
030315	Container glass (f)	1A2f
030316	Glass wool (except binding) (f)	1A2f
030317	Other glass (f)	1A2f
030318	Mineral wool (except binding)	1A2f
030319	Bricks and tiles	1A2f
030320	Fine ceramic materials	1A2f
030321	Paper-mill industry (drying processes)	1A2d
030322	Alumina production	1A2b
030323	Magnesium production (dolomite treatment)	1A2b
030324	Nickel production (thermal process)	1A2b
030325	Enamel production	1A2f
030326	Other	1A2f
08 1)	Other mobile sources and machinery	
0804 1)	Maritime activities	
080403 1)	National fishing	1A4c
0806 1)	Agriculture	1A4c
0807 1)	Forestry	1A4c
0808 1)	Industry	1A2f
0809 1)	Household and gardening	1A4b

1) Not stationary combustion. Included in a IPCC sector that also includes stationary combustion plants

Appendix 3A-3 Fuel rate

Table 3A-27 Fuel consumption rate of stationary combustion plants [GJ]

Fuel id	Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
102	Coal	254836476	345917382	288115109	302081632	326290582	273898654	375387102	280010525	233354509	197985454	165920864	175451125	174639322
106	Brown coal briquettes	0	0	0	0	0	0	0	0	0	0	0	0	18922
107	Coke	0	0	0	0	0	0	0	0	0	0	0	0	1068454
110	Petroleum coke	4459475	4403578	4562877	5928457	3806509	4598627	6130172	6271959	5546731	7032313	7040383	8062464	8281655
111	Wood and simil.	18239133	20313133	21410173	22701233	23886440	23537165	25253215	25607369	22545580	23329536	25990200	28363689	32754200
114	Municipal waste	16384900	17727900	18829500	20469900	21468400	24152480	26146928	27925960	27322665	28522787	30265050	33037670	33972344
115	Industrial waste	0	0	0	0	0	0	33813	0	0	0	0	0	0
116	Wood waste	0	0	0	0	0	0	0	0	0	607044	0	0	0
117	Straw	13225200	14050200	14624200	14103200	12757200	13074202	13475808	13358144	13363126	14370434	13053790	13698057	15732839
118	Sewage sludge	0	0	0	0	0	0	0	0	0	0	40162	0	64508
203	Residual oil	32115775	37019669	37331722	32497828	49806706	37527011	41791443	30158107	30173567	22563263	18860843	19702838	24648453
204	Gas oil	61673820	65349403	55972785	62122851	53198037	53923308	57846146	51497273	48357982	48060167	41016114	43806222	39462159
206	Kerosene	5086000	943300	783700	771300	649600	580700	539700	436570	414294	255606	169963	286786	256128
215	Fish and rape oil	0	0	0	0	0	0	0	0	0	0	0	191475	127243
225	Orimulsion	0	0	0	0	0	19968824	36885721	40611318	32580001	34190630	34148181	30243687	23846400
301	Natural gas	76099387	86421571	90523947	103173352	117014079	135645220	160599207	169726176	180201988	187958727	183757321	193449631	193610189
303	LPG	2979387	2747776	2403579	2425299	2399108	2491400	2693594	2227826	2399970	2143219	1985058	1732002	1598822
308	Refinery gas	14169000	14537000	14865000	15405000	16390999	21005286	20271224	17091995	15224935	15724000	15219727	15534154	14792686
309	Biogas	751600	910100	898900	1076800	1409100	2055800	2244826	2714861	2662881	2640444	2980430	3046907	3331097
Total		**500020152**	**610341012**	**550321492**	**582756852**	**629076761**	**612458677**	**769298899**	**667638083**	**614148228**	**585383624**	**540448085**	**566606707**	**568205421**

Table 3A-28 Detailed fuel consumption data for stationary combustion plants [GJ]

ipcc_id	fuel	fuel_gr_abbr	snap_id	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1A1a	102	COAL	010101	219780959	303105248	252745120	269458670	294708124	241921428	346038108	254306486	210718948	176640613	146911420	158990462	161608383
1A1a	102	COAL	010102	10643051	15546752	12426136	10490330	10438182	11678411	8910896	8671430	8884368	8238010	6224846	4970502	4684578
1A1a	102	COAL	010103							1760100	-	-	33747	35480	24354	779
1A1a	102	COAL	0102	6017000	6635000	5173000	3581000	1661900	1213900	454200	-					
1A1a	102	COAL	010202											371	1494	363
1A1a	102	COAL	010203									9000	6562	3551	439	-
1A1a	110	PETROLEUM COKE	010102				1239200									
1A1a	111	WOOD AND SIMIL.	010101									263719	-		920	65930
1A1a	111	WOOD AND SIMIL.	010102			172000	515200	943000	643600	335925	453186	528441	705526	1090331	1181886	892421
1A1a	111	WOOD AND SIMIL.	010103							306000	332100	41468	327025	297612	341452	1049148
1A1a	111	WOOD AND SIMIL.	010104													117062
1A1a	111	WOOD AND SIMIL.	010105											428	60394	-
1A1a	111	WOOD AND SIMIL.	0102	3217000	3648000	4096000	3750500	3556400	3775100	4185900	4217100					
1A1a	111	WOOD AND SIMIL.	010202										193908	179937	249689	227284
1A1a	111	WOOD AND SIMIL.	010203									4699721	3911382	3882223	4300369	4451351
1A1a	111	WOOD AND SIMIL.	010205											53040	-	-
1A1a	114	MUNICIP. WASTES	010101									1288015	1278184	1230861	2809020	3502130
1A1a	114	MUNICIP. WASTES	010102		1300000	2005000	3990000	4904200	5881780	7152947	10831534	11023094	17039832	18305718	17902293	19002825
1A1a	114	MUNICIP. WASTES	010103							738400	-	3027000	5911296	8361289	8343163	7236828
1A1a	114	MUNICIP. WASTES	010104											416975	-	-
1A1a	114	MUNICIP. WASTES	010105											-	756908	-
1A1a	114	MUNICIP. WASTES	0102	15470800	15416500	15753900	15381300	15339500	13702100	11824900	10622800					
1A1a	114	MUNICIP. WASTES	010202						3254000	4612251	4649086	4617704				
1A1a	114	MUNICIP. WASTES	010203							582330	630840	6492514	2809156	1395589	2302823	2430354
1A1a	115	INDUSTR. WASTES	010202							33813						
1A1a	116	WOOD WASTES	010102										607044			
1A1a	117	STRAW	010101								740153	1013770	1339800	1119600	1587710	2643060
1A1a	117	STRAW	010102	479000	985000	1487000	1643200	1846200	2612602	1503708	1306291	1751935	2429408	1826796	1746030	1640945
1A1a	117	STRAW	010103							2176100	1715900	958000	1058701	640340	1905033	1890837
1A1a	117	STRAW	010104												101730	1215692
1A1a	117	STRAW	0102	4268000	4587000	4659000	4606000	3700000	3893600	3871000	3670800					
1A1a	117	STRAW	010202										141564	150510	97600	64873
1A1a	117	STRAW	010203									3889315	3639251	3290636	3418313	3435882
1A1a	203	RESIDUAL OIL	0101											17206	533	656
1A1a	203	RESIDUAL OIL	010101	7171573	10052580	8691120	8420050	22142392	10770398	15795457	7447256	11369048	6955499	4045724	5869702	5018057
1A1a	203	RESIDUAL OIL	010102	826465	390420	1778880	774628	306421	600920	382538	333923	353400	755210	513002	235650	232919
1A1a	203	RESIDUAL OIL	010103							453500	535000			82101	117384	75269
1A1a	203	RESIDUAL OIL	010104										14114	117319	1767903	6684079
1A1a	203	RESIDUAL OIL	0102	2046900	2326800	1286200	1059500	1802400	1970500	1852700	1681400					
1A1a	203	RESIDUAL OIL	010202							22250	66495	492445	135957	58729	86854	121947
1A1a	203	RESIDUAL OIL	010203									1097303	956510	650393	611104	453278
1A1a	204	GAS OIL	0101											6427	4864	2497
1A1a	204	GAS OIL	010101									112000	537423	135602	138238	92395
1A1a	204	GAS OIL	010102	300000	474940	698630	294270	286600	342600	16653	18113	13235	302722	278595	89748	107821
1A1a	204	GAS OIL	010103							486000	465100	15405	40495	-	66635	17133
1A1a	204	GAS OIL	010104		18060	22370	30730					148871	61852	91382	38714	75233
1A1a	204	GAS OIL	010105									130410	104311	74249	79770	64070
1A1a	204	GAS OIL	0102	1941000	813000	744000	947000	1034200	803700	1183200	999900					
1A1a	204	GAS OIL	010202							152994	73314	426455	257831	399458	826687	166763
1A1a	204	GAS OIL	010203									788287	296697	230214	354986	808046
1A1a	204	GAS OIL	010205											190	-	-

1A1a	215	RAPE & FISH OIL	010203													190810	126336
1A1a	225	ORIMULSION	010101						19913424	36885721	40611318	32580001	34190630	34148181	30243687	23846400
1A1a	225	ORIMULSION	010102						55400							
1A1a	301	NATURAL GAS	0101											14558	11364	2
1A1a	301	NATURAL GAS	010101	4005028	4394781	3279455	4422200	6283990	10453816	12217008	10956960	20808855	21307826	23541558	20514966	19246614
1A1a	301	NATURAL GAS	010102	115700	766090	3257796	6479498	7524400	6751996	1346036	5620044	10551198	2416632	1456749	4258088	2893865
1A1a	301	NATURAL GAS	010103							11131660	11810929	691382	926574	680624	739539	654790
1A1a	301	NATURAL GAS	010104	2107800	2107800	2107800	2614600	6012900	4839582	6245516	6875564	7759802	21656759	22973678	25003005	30027783
1A1a	301	NATURAL GAS	010105	313500	814300	1639900	2401700	8490200	16758500	22539550	24339600	28976521	26619884	25826778	28098555	27998258
1A1a	301	NATURAL GAS	0102	11033000	13655000	12350000	11420000	7488700	6618900	4207670	2592500	15753				
1A1a	301	NATURAL GAS	010202							381483	466411	539227	270693	217700	286968	291201
1A1a	301	NATURAL GAS	010203									2999618	1889688	1416762	1762910	1482478
1A1a	303	LPG	010102		1000	1000	3000		600							
1A1a	303	LPG	010103							-						
1A1a	303	LPG	0102	9000	13000	10000	-	2700	100		-					
1A1a	303	LPG	010203											246	-	-
1A1a	308	REFINERY GAS	010102			132300	221400		156700							
1A1a	308	REFINERY GAS	010103							35200	40100					
1A1a	308	REFINERY GAS	0102								-					
1A1a	309	BIOGAS	010102	235600	393800	359500	537400	639700	666100	94326	40561	50269	29597	25771	23338	20466
1A1a	309	BIOGAS	010103							742600	1028200		103711	134968	123991	89445
1A1a	309	BIOGAS	010105									1515688	1500477	1548734	1589322	1757220
1A1a	309	BIOGAS	0102	57500	69800	131500	149500	159900	286900	272200	393300					
1A1a	309	BIOGAS	010203									194984		21733	11129	12650
1A1b	203	RESIDUAL OIL	0103	1309200	2038100	3568700	3490200		-							
1A1b	203	RESIDUAL OIL	010303								1005700	32049	16612	-	-	-
1A1b	203	RESIDUAL OIL	010306					3336717	2333787	2244019	616254	1073951	1073388	1322995	1442929	1362640
1A1b	204	GAS OIL	0103		40000	44500	29100	49300	33300							
1A1b	204	GAS OIL	010303							21700	87000					
1A1b	301	NATURAL GAS	010304											-	-	-
1A1b	303	LPG	0103		-	4600		8000	15000							
1A1b	303	LPG	010303							20700	18000					
1A1b	308	REFINERY GAS	0103	13978100	14411900	14630500	15075200									
1A1b	308	REFINERY GAS	010303							1340730	1866363	511593	1518794	1170793	1300559	995654
1A1b	308	REFINERY GAS	010304					2386000	2289723	2524072	2361788	2484108	2654000	2400233	2457089	2455232
1A1b	308	REFINERY GAS	010306					14004999	18548164	16336522	12771044	12202506	11551206	11648701	11776506	11341800
1A1c	204	GAS OIL	010406									15603				
1A1c	204	GAS OIL	010505													150
1A1c	301	NATURAL GAS	010405											-	-	-
1A1c	301	NATURAL GAS	010406									911835				
1A1c	301	NATURAL GAS	010502	8751400	8961800	10382600	10499400	11997600	12589447	14994291	19586715	21938219	23580170	25026374	24383156	26226872
1A1c	301	NATURAL GAS	010504	376300	376900	376900	376900	349800	411700	338690	392000	126150	274178	164410	232982	246307
1A1c	301	NATURAL GAS	010505	4900	9500	9500	9500	3500	12700	9080	8100	8790	13883	13250	11887	11470
1A1c	309	BIOGAS	010405											-	-	-
1A1c	309	BIOGAS	010502					6800	56500	64800	61900					
1A1c	309	BIOGAS	010505										29028	32507	28627	39855
1A2f	102	COAL	0301	10023993	10334985	7832879	8789663	9412925	8446538	8041600	6908700	4469247	5126053	4849360	4465330	2316222
1A2f	102	COAL	030102						1051344	1449890	1466575	1405667	1411682	1063375	997381	808823
1A2f	102	COAL	030103									206631				
1A2f	102	COAL	030311	5018873	6048697	6577274	6602369	6913652	7224934	7067609	7209034	6627624	5638061	5708047	4718458	4348589
1A2f	107	COKE OVEN COKE	0301													1065641
1A2f	110	PETROLEUM COKE	0301	300246	-	56107	122868	-	98156	110000	33600	25858	38999	285426	127924	223785
1A2f	110	PETROLEUM COKE	030311	2499252	2991306	3234048	3230652	3469025	3707398	4966161	5229890	4774684	6398880	6474743	7656733	7543476
1A2f	111	WOOD AND SIMIL.	0301	5776000	5961000	6130000	6303000	7484200	6954700	7142500	7393900	4729903	3997800	3836511	4310038	7474992

1A2f	111	WOOD AND SIMIL.	030102									228152	1424571	1557075	1411227	2148172
1A2f	111	WOOD AND SIMIL.	030103									322116	413749	439542	428603	424290
1A2f	114	MUNICIP. WASTES	0301						-							
1A2f	114	MUNICIP. WASTES	030102									481				-
1A2f	114	MUNICIP. WASTES	030311											505233	795492	1787613
1A2f	117	STRAW	030102										1496	-	-	-
1A2f	117	STRAW	030105											386	91	-
1A2f	118	SEWAGE SLUDGE	030311											40162	-	64508
1A2f	203	RESIDUAL OIL	0301	16487584	17678972	17238144	14022407	16716100	15349840	14900000	12921800	9365957	7921335	8241264	7292390	7435663
1A2f	203	RESIDUAL OIL	030102						201556	513500	418614	747697	770215	648553	306379	736719
1A2f	203	RESIDUAL OIL	030103									63565	128184	139691	89445	64340
1A2f	203	RESIDUAL OIL	030104										6787	-	-	-
1A2f	203	RESIDUAL OIL	030105												22	10
1A2f	203	RESIDUAL OIL	030311	1762853	2152997	2366678	2397243	2618777	2840311	1771379	1863965	2538540	885967	858853	784	591804
1A2f	204	GAS OIL	0301	665870	1575591	1361528	1007507	525669	1594421	2155217	2092813	1730029	2537653	2212978	3188376	2618024
1A2f	204	GAS OIL	030102											3138	5071	222
1A2f	204	GAS OIL	030103									1965	64	82107	19	165
1A2f	204	GAS OIL	030104											51	-	897
1A2f	204	GAS OIL	030105											103	511	-
1A2f	204	GAS OIL	030106	6098	-	8644	2762	9433	-	-	8178	15604	70265	8070	10000	7066
1A2f	206	KEROSENE	0301	69600	45700	38300	35500	30500	24500	30900	27800	13363	8909	7552	25543	2993
1A2f	215	RAPE & FISH OIL	030105													242
1A2f	301	NATURAL GAS	0301	23284500	24940500	25814500	27902100	33016700	33445300	32857200	34089100	34898549	32466636	28746747	32058619	31365984
1A2f	301	NATURAL GAS	030102						2661779	2464665	2971625	2961903	3100115	2690206	2869052	1190136
1A2f	301	NATURAL GAS	030103									542888	126872	116411	117965	14626
1A2f	301	NATURAL GAS	030104	-				150300	838200	2971200	3941400	2141369	6486855	6756339	6138931	6723657
1A2f	301	NATURAL GAS	030105	2600	2600	2600	2600	23500	224500	1144400	1251500	679952	1224637	1556394	1641970	1545295
1A2f	301	NATURAL GAS	030106	136059	-	37696	70154	53489	-	-	5228	31735	38608	50809	83000	25558
1A2f	303	LPG	0301	1482591	1561267	1410087	1238800	1311475	1465219	1616519	1256440	1267455	970603	621768	370289	287019
1A2f	303	LPG	030106												11000	-
1A2f	308	REFINERY GAS	0301	190900	125100	102200	108400	-	10700	34700	52700	26728				
1A2f	309	BIOGAS	0301	10000	10000	10000	10000	32600	269700	210100	255100	83042	32727	54758	28077	36860
1A2f	309	BIOGAS	030102									4943	16116	15755	58579	70934
1A2f	309	BIOGAS	030103									2122				
1A2f	309	BIOGAS	030105									193	269	1487	23805	18344
1A4a	102	COAL	0201	88600	10700	95900	84100	91100	66700	41700	43400	2306				
1A4a	110	PETROLEUM COKE	0201	62000	104200	90200	96400	92000	70400	90500	97800	70544	50434	12070	12086	5355
1A4a	111	WOOD AND SIMIL.	0201	204500	204500	204500	204500	270200	334700	527200	555200	510825	540696	575926	632817	972070
1A4a	111	WOOD AND SIMIL.	020105												97	598
1A4a	114	MUNICIP. WASTES	0201	914100	1011400	1070600	1098600	1224700	1314600	1236100	1191700	873857	1476975	35615	115302	-
1A4a	114	MUNICIP. WASTES	020103										7344	13770	12669	12594
1A4a	117	STRAW	0201										2057	-	-	-
1A4a	203	RESIDUAL OIL	0201	1070600	865200	600300	516900	846600	780300	718800	729300	418154	485684	342842	203459	348147
1A4a	203	RESIDUAL OIL	020105										66	-	-	-
1A4a	204	GAS OIL	0201	11794800	10622900	9062300	9007000	7158100	6579100	6704500	6184200	5496730	5788419	4957566	4736649	4031234
1A4a	204	GAS OIL	020103									3303	39101	71306	44010	43890
1A4a	204	GAS OIL	020105											859	673	488
1A4a	206	KEROSENE	0201	569100	209800	207000	188900	154600	124300	103300	96459	127964	117233	63008	79642	145428
1A4a	301	NATURAL GAS	0201	6357600	7223900	7348100	9497400	7098800	7807000	10221840	7523200	7272911	6653203	5854391	6431733	6679517
1A4a	301	NATURAL GAS	020103									55495	10802	43211	67208	49523
1A4a	301	NATURAL GAS	020104		-			16900	35800	44200	37300	21153	30736	23335	31001	42862
1A4a	301	NATURAL GAS	020105	26200	55700	92400	110800	710800	770500	866640	1056400	342953	985737	967874	1048143	1098129
1A4a	303	LPG	0201	82800	77100	76500	122200	125200	131000	138000	128600	84733	110343	121621	119345	136552
1A4a	309	BIOGAS	0201	448500	436500	397900	379900	557700	751900	835600	913700	452365	366842	423606	396023	396057

1A4a	309	BIOGAS	020103									4557	71845	86680	84512	74286
1A4a	309	BIOGAS	020105									272454	433844	504895	501385	487668
1A4b	102	COAL	0202	746200	1290600	1008800	947100	757700	487800	169700	161700	127147	182354	45201	48680	15370
1A4b	106	BROWN COAL BRI.	0202													18922
1A4b	107	COKE OVEN COKE	0202													2813
1A4b	110	PETROLEUM COKE	0202	760877	697484	709922	739137	245484	483073	677611	588069	474591	454761	261990	262393	509008
1A4b	111	WOOD AND SIMIL.	0202	8954433	10412433	10720473	11859633	11564240	11760665	12668890	12569083	11134265	11615183	13847545	15248320	14760273
1A4b	117	STRAW	0202	5086900	5086900	5086900	4712400	4326600	3940800	3555000	3551500	3446584	3443104	3611833	2901450	2901450
1A4b	203	RESIDUAL OIL	0202	216900	218600	167700	129900	95200	62800	66300	45900	43266	50365	35611	26881	148870
1A4b	204	GAS OIL	0202	46463200	50638400	42913600	49967100	43678600	43287900	45295600	39595500	37849748	35675468	30275667	31506271	28997757
1A4b	206	KEROSENE	0202	4404800	659600	512000	520800	437800	410800	382600	287211	251843	118954	91190	159051	99599
1A4b	301	NATURAL GAS	0202	17362100	20432600	21436600	24900900	23928600	26141800	29457418	27737600	27650326	29396072	27562772	29557603	28080877
1A4b	301	NATURAL GAS	020202									14779	31289	55319	69007	30105
1A4b	301	NATURAL GAS	020204	-	-	3100	3100	1171200	1189400	1602560	1622500	1706977	1531350	1439173	1450266	1391882
1A4b	303	LPG	0202	1119162	825126	680245	929257	834898	758090	788512	725371	928931	987953	1179124	1185770	1144455
1A4b	309	BIOGAS	0202	-	-	-	-		-	-	-	10000				
1A4c	102	COAL	0203	2517800	2945400	2256000	2128400	2307000	1807600	1453300	1243200	903571	708372	1079213	1234026	856215
1A4c	110	PETROLEUM COKE	0203	837100	610588	472600	500200	-	239600	285900	322600	201054	89239	6154	3328	31
1A4c	111	WOOD AND SIMIL.	0203	87200	87200	87200	68400	68400	68400	86800	86800	86970	199696	230030	197877	170609
1A4c	117	STRAW	0203	3391300	3391300	3391300	3141600	2884400	2627200	2370000	2373500	2297722	2309253	2407889	1934300	1934300
1A4c	117	STRAW	020302									5800	5800	5800	5800	5800
1A4c	203	RESIDUAL OIL	0203	1223700	1296000	1634000	1687000	1942100	2616600	3071000	2492500	2578192	2407370	1782543	1644780	1368564
1A4c	203	RESIDUAL OIL	020302												2069	2170
1A4c	203	RESIDUAL OIL	020304											4017	4570	3321
1A4c	204	GAS OIL	0203	502852	1166512	1117213	837382	456135	1282287	1830282	1973155	1610337	2347866	2183377	2712277	2423485
1A4c	204	GAS OIL	020304											4774	2723	4824
1A4c	206	KEROSENE	0203	42500	28200	26400	26100	26700	21100	22900	25100	21124	10510	8213	22550	8108
1A4c	215	RAPE & FISH OIL	020304												665	665
1A4c	301	NATURAL GAS	0203	2156400	2613800	2318700	2393800	2244200	2816600	3153760	3374200	2421915	3618456	3467279	3662566	3188151
1A4c	301	NATURAL GAS	020303						-	7760	34400	37904	77171	61906	59503	64369
1A4c	301	NATURAL GAS	020304	66300	66300	66300	68700	448500	1277700	2396580	3432900	4093829	3223901	3032714	2859644	3039877
1A4c	303	LPG	0203	285834	270283	221147	132042	116835	121391	129863	99415	118851	74320	62299	45598	30796
1A4c	309	BIOGAS	0203					12400	24700	25200	22100	60000	14684	64084	69300	115430
1A4c	309	BIOGAS	020304									12264	41304	65452	108819	211882
TOTAL				500020152	610341012	550321492	582756852	629076761	612458677	769298899	667638083	614148228	585383624	540448085	566606707	568205421

Appendix 3A-4 Emission factors

Table 3A-29 CO_2 emission factors

Fuel	Emission factor		Unit	Reference type	CRF fuel
	Biomass	Fossil fuel			
Coal		95	kg/GJ	Country specific	Solid
Brown coal briquettes		94,6	kg/GJ	IPCC reference manual	Solid
Coke oven coke		108	kg/GJ	IPCC reference manual	Solid
Petroleum coke		92	kg/GJ	Country specific	Liquid
Wood	102		kg/GJ	Corinair	Biomass
Municipal waste	94,5	17,6	kg/GJ	Country specific	Biomass / Other fuels
Straw	102		kg/GJ	Country specific	Biomass
Residual oil		78	kg/GJ	Corinair	Liquid
Gas oil		74	kg/GJ	Corinair	Liquid
Kerosene		72	kg/GJ	Corinair	Liquid
Fish & rape oil	102		kg/GJ	Corinair	Biomass
Orimulsion		80	kg/GJ	Country specific	Liquid
Natural gas		57,28	kg/GJ	Country specific	Gas
LPG		65	kg/GJ	Corinair	Liquid
Refinery gas		56,9	kg/GJ	Country specific	Liquid
Biogas	83,6		kg/GJ	Country specific	Biomass

Time series for natural gas and municipal waste are shown below. All other emission factors are the same for 1990-2002.

Table 3A-30 CO_2 emission factors, time series

Year	Natural gas [kg/GJ]	Municipal waste, plastic [kg/GJ]	Municipal waste biomass [kg/GJ]
1990	56,9	22,5	+89,6
1991	56,9	22,5	+89,6
1992	56,9	20,5	+91,6
1993	56,9	19,6	+92,5
1994	56,9	19,6	+92,5
1995	56,9	18,5	+93,6
1996	56,9	17,6	+94,5
1997	56,9	17,6	+94,5
1998	56,9	17,6	+94,5
1999	56,6	17,6	+94,5
2000	57,1	17,6	+94,5
2001	57,25	17,6	+94,5
2002	57,28	17,6	+94,5

Table 3A-31 CH_4 emission factors and referneces 2002

Fuel	ipcc_id	snap_id	Emission factor [g/GJ]	Reference
COAL	1A1a	010101, 010102, 010103	1,5	EMEP/Corinair 2003
COAL	1A1a, 1A2f, 1A4b, 1A4c	010202, 010203, 0301, 0202, 0203	15	EMEP/Corinair 2003
BROWN COAL BRI.	all	all	15	EMEP/Corinair 2003, assuming same emission factor as for coal
COKE OVEN COKE	all	all	15	EMEP/Corinair 2003, assuming same emission factor as for coal
PETROLEUM COKE	all	all	15	EMEP/Corinair 2003
WOOD AND SIMIL.	1A1a	010102, 010103, 010104	2	Nielsen & Illerup 2003
WOOD AND SIMIL.	1A1a, 1A2f, 1A4a, 1A4b, 1A4c	all other	32	EMEP/Corinair 2003
MUNICIP. WASTES	1A1a	010102, 010103, 010104, 010105	0,59	Nielsen & Illerup 2003
MUNICIP. WASTES	1A1a, 1A2f, 1A4a	all other	6	EMEP/Corinair 2003
STRAW	1A1a	010102, 010103	0,5	Nielsen & Illerup 2003
STRAW	1A1a, 1A2f	010202, 010203, 030102, 030105	32	EMEP/Corinair 2003
STRAW	1A4a, 1A4b, 1A4c	0201, 0202, 0203, 020302	200	EMEP/Corinair 2003
RESIDUAL OIL	all	all	3	EMEP/Corinair 2003
GAS OIL	all	all	1,5	EMEP/Corinair 2003
KEROSENE	all	all	7	EMEP/Corinair 2003
FISH & RAPE OIL	1A1a	010203	32	EMEP/Corinair 2003, assuming same emission factor as straw
FISH & RAPE OIL	1A2f	030105	32	EMEP/Corinair 2003, assuming same emission factor as straw
FISH & RAPE OIL	1A4c	020304	200	EMEP/Corinair 2003, assuming same emission factor as straw
ORIMULSION	1A1a	010101	3	EMEP/Corinair 2003, assuming same emission factor as residual oil
NATURAL GAS	1A1a	0101, 010101, 010102, 010202	6	DGC 2001
NATURAL GAS	1A1a	010103, 010203	15	Gruijthuijsen & Jensen 2000
NATURAL GAS	1A1a, 1Ab, 1Ac, 1A2f, 1A4a, 1A4c	Gas turbines: 010104, 010304, 010504, 030104, 020104, 020303	1,5	Nielsen & Illerup 2003
NATURAL GAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4b, 1A4c	Gas engines: 010105, 010405, 010505, 030105, 020105, 020204, 020304	520	Nielsen & Illerup 2003
NATURAL GAS	1A1c, 1A2f, 1A4a, 1A4b, 1A4c	010502, 0301, 0201, 0202, 0203	6	DGC 2001
NATURAL GAS	1A2f, 1A4a, 1A4b	030103, 030106, 020103, 020202	15	Gruijthuijsen & Jensen 2000
LPG	all	all	1	EMEP/Corinair 2003
REFINERY GAS	1A1b	010303, 010304	2	EMEP/Corinair 2003
BIOGAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4c	Gas engines: 010105, 010405, 010505, 030105, 020105, 020304	323	Nielsen & Illerup 2003
BIOGAS	1A1a, 1A2f, 1A4a, 1A4c	all other	4	EMEP/Corinair 2003

Time series for CH_4 emission factors for gas engines are shown below. All other CH_4 emission factors are the same for 1990-2002.

Table 3A-32 CH_4 emission factors, time series

Year			1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
NATURAL GAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4b, 1A4c	Gas engines: 010105, 010405, 010505, 030105, 020105, 020204, 020304	257	299	347	545	604	612	596	534	525	524	520	520	520
BIOGAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4c	Gas engines: 010105, 010405, 010505, 030105, 020105, 020304									314	318	323	323	323

Table 3A-33 N_2O emission factors and references 2002

Fuel	ipcc_id	snap_id	Emission factor [g/GJ]	Reference
COAL	all	all	3	EMEP/Corinair 2003
BROWN COAL BRI.	all	all	3	EMEP/Corinair 2003
COKE OVEN COKE	all	all	3	EMEP/Corinair 2003
PETROLEUM COKE	all	all	3	EMEP/Corinair 2003
WOOD AND SIMIL.	1A1a	010102, 010103, 010104	0,8	Nielsen & Illerup 2003
WOOD AND SIMIL.	1A1a	010105, 010202, 010203, 010205	4	EMEP/Corinair 2003
WOOD AND SIMIL.	1A2f, 1A4a, 1A4b, 1A4c	all	4	EMEP/Corinair 2003
MUNICIP. WASTES	1A1a	010102, 010103, 010104, 010105	1,2	Nielsen & Illerup 2003
MUNICIP. WASTES	1A1a	010203	4	EMEP/Corinair 2003
MUNICIP. WASTES	1A2f, 1A4a	030102, 0201, 020103	4	EMEP/Corinair 2003
STRAW	1A1a	010102, 010103	1,4	Nielsen & Illerup 2003
STRAW	1A1a	010202, 010203	4	EMEP/Corinair 2003
STRAW	1A2f, 1A4a, 1A4b, 1A4c	all	4	EMEP/Corinair 2003
RESIDUAL OIL	all	all	2	EMEP/Corinair 2003
GAS OIL	all	all	2	EMEP/Corinair 2003
KEROSENE	all	all	2	EMEP/Corinair 2003
FISH & RAPE OIL	all	all	4	EMEP/Corinair 2003, assuming same emission factor as municipal waste
ORIMULSION	1A1a	010101	2	EMEP/Corinair 2003, assuming same emission factor as residual oil
NATURAL GAS	1A1a	0101, 010101, 010102, 010103, 010202, 010203	1	EMEP/Corinair 2003
NATURAL GAS	1A1a, 1Ab, 1Ac, 1A2f, 1A4a, 1A4c	Gas turbines: 010104, 010304, 010504, 030104, 020104, 020303	2,2	Nielsen & Illerup 2003
NATURAL GAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4b, 1A4c	Gas engines: 010105, 010405, 010505, 030105, 020105, 020204, 020304	1,3	Nielsen & Illerup 2003
NATURAL GAS	1A1c, 1A2f, 1A4a, 1A4b, 1A4c	010502, 0301, 030103, 030106, 0201, 020103, 0202, 020202, 0203	1	EMEP/Corinair 2003
LPG	all	all	2	EMEP/Corinair 2003
REFINERY GAS	all	all	2	EMEP/Corinair 2003
BIOGAS	1A1a	010102, 010103, 010203	2	EMEP/Corinair 2003
BIOGAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4c	010105, 010405, 010505, 030105, 020105, 020304	0,5	Nielsen & Illerup 2003
BIOGAS	1A2f, 1A4a, 1A4c	0301, 030102, 0201, 020103, 0203	2	EMEP/Corinair 2003

The same N_2O emission factors are applied for 1990-2002

Table 3A-34 SO_2, NO_x, NMVOC and CO emission factors and references 2002

Fuel	IPCC sector	SNAP	SO_2 [g/GJ]	Ref.	NO_x [g/GJ]	Ref.	NMVOC [g/GJ]	Ref.	CO [g/GJ]	Ref.
COAL	1A1a	010101, 010102, 010103	45	9	130	9	1,5	1	10	3
COAL	1A1a, 1A2f, 1A4b, 1A4c	010202, 010203, 0301, 0202, 0203	574	29	95	29	15	1	10	1
BROWN COAL BRI.	1A4b	0202	574	29	95	29	15	29	10	29
COKE OVEN COKE	1A2f, 1A4b	0301, 0202	574	29	95	29	15	29	10	29
PETROLEUM COKE	1A2f	0301	573	24	50	1	1,5	1	61	4
PETROLEUM COKE	1A4a, 1A4b, 1A4c	0201, 0202, 0203	573	24	50	1	1,5	1	1000	1
WOOD AND SIMIL.	1A1a	010102, 010103, 010104	1,74	31	69	31	3,3	31	79	31
WOOD AND SIMIL.	1A1a	010105	25	22	130	22	48	1	50	3
WOOD AND SIMIL.	1A1a, 1A2f	010202, 010203, 010205, 0301, 030102, 030103	25	22	130	22	48	1	240	4
WOOD AND SIMIL.	1A4a, 1A4c	0201, 020105, 0203	25	22	130	22	600	1	240	4
WOOD AND SIMIL.	1A4b	0202	25	22	120	22	600	1	9000	12, 13
MUNICIP. WASTES	1A1a	010102, 010103, 010104, 010105	23,9	31	124	31	0,98	31	7,4	31
MUNICIP. WASTES	1A1a, 1A2f, 1A4a	010203, 030102, 0201, 020103	67	9	164	9	9	1	10	9
STRAW	1A1a	010102, 010103	47,1	31	131	31	0,8	31	63	31
STRAW	1A1a, 1A2f	010202, 010203, 030102, 030105	130	5	153	4, 28	50	1	325	4, 5
STRAW	1A4a, 1A4c	0201, 0203, 020302	130	5	153	4, 28	600	1	325	4, 5
STRAW	1A4b	0202	130	5	153	4, 28	600	1	4000	1, 6, 7

RESIDUAL OIL	1A1a	0101, 010101, 010102, 010103, 010104	290	9	130	28	3	1	15	3
RESIDUAL OIL	1A1a, 1A4b, 1A4c	010202, 010203, 0201, 0202, 0203, 020302	344	25	142	4	3	1	30	1
RESIDUAL OIL	1A1b	010303	649	9	142	4	3	1	30	1
RESIDUAL OIL	1A2f	0301, 030102, 030103	344	25	130	28	3	1	30	1
RESIDUAL OIL	1A2f	030104	344	25	130	28	3	1	15	1
RESIDUAL OIL	1A2f	030105	344	25	130	28	3	1	100	1
RESIDUAL OIL	1A4a, 1A4c	020105, 020304	344	25	142	4	3	1	100	1
GAS OIL	1A1a	0101, 010101, 010102, 010103	23	27	220	9	1,5	1	15	3
GAS OIL	1A1a, 1A2f	Gas turbines: 010104, 030104	23	27	350	9	2	1	15	3
GAS OIL	1A1a, 1A1c, 1A2f, 1A4a, 1A4c	Engines: 010105, 010205, 010505, 030105, 020105, 020304	23	27	700	-	100	1	100	1
GAS OIL	1A1a, 1A2f	010202, 0301, 030102	23	27	65	28	1,5	1	30	1
GAS OIL	1A1a, 1A2f	010203, 030103, 030106	23	27	52	4	1,5	1	30	1
GAS OIL	1A4a, 1A4c	0201, 020103, 0203	23	27	52	4	3	1	30	1
GAS OIL	1A4b	0202	23	27	52	4	3	1	43	1
KEROSENE	all	all	5	30	50	1	3	1	20	1
FISH & RAPE OIL	1A1a	010203	100	15	153	15	50	15	325	15
FISH & RAPE OIL	1A2f	030105	130	15	153	15	50	15	325	15
FISH & RAPE OIL	1A4c	020304	100	15	153	15	600	15	325	15
ORIMULSION	1A1a	010101	12	9	86	9	3	16	15	16
NATURAL GAS	1A1a	0101, 010101, 010102, 010103	0,3	17	115	9	2	14	15	3
NATURAL GAS	1A1a, 1A1b, 1A1c, 1A2f, 1A4a, 1A4c	Gas turbines: 010104, 010304, 010504, 030104, 020104, 020303	0,3	17	124	31	1,4	31	6,2	31
NATURAL GAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4b, 1A4c	Gas engines: 010105, 010405, 010505, 030105, 020105, 020204, 020304	0,3	17	168	31	117	31	175	31
NATURAL GAS	1A1a, 1A2f	010202, 010203, 0301, 030103, 030106	0,3	17	50	4	2	14	28	4
NATURAL GAS	1A1c	010502	0,3	17	250	32	2	14	28	4
NATURAL GAS	1A4a, 1A4c	0201, 020103, 0203	0,3	17	30	4	2	14	28	4
NATURAL GAS	1A4b	0202, 020202	0,3	17	30	4	4	11	20	11
LPG	1A1a, 1A2f	010203, 0301, 030106	0,13	-	96	32	2	1	25	1
LPG	1A4a, 1A4c	0201, 0203	0,13	-	71	-	2	1	25	1
LPG	1A4b	0202	0,13	-	47	32	2	1	25	1
REFINERY GAS	1A1b	010303	0,3	23	100	1	4	1	15	1
REFINERY GAS	1A1b	010304	0,3	23	170	9	4	1	15	1
BIOGAS	1A1a, 1A2f, 1A4a, 1A4c	010102, 010103, 010203, 0301, 0201, 020103, 0203	11	26	31	4	4	1	36	8
BIOGAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4c	Gas engines: 010105, 010405, 010505, 030105, 020105, 020304	19,2	31	540	31	14	31	273	31
BIOGAS	1A2f	030102	11	26	66		4	1	36	8

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2. -
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4. Luftvejledningen, Begrænsning af luftforurening fra virksomheder, Vejledning fra Miljøstyrelsen Nr. 2 2002 (Danish legislation)
5. Halm til energiformål, Teknik – Miljø – Økonomi, 2. udgave, 1998, Videncenter for halm og flisfyring (In Danish)
6. Emissioner fra halm- og flisfyr, dk-Teknik 1990 (In Danish)
7. Danish Technological Institute, personal communication
8. dk-Teknik, personal communication
9. Calculation based on annual environmental reports of Danish plants year 2000
10. Technical note from Danish Gas Technology Centre, Eltra PSO 2002 (In Danish, not published)
11. Energi- og miljøoversigt, Danish Gas Technology Centre 2000 (In Danish)
12. Miljøprojekt 149/1990 Emissionsundersøgelse for pejse og brændeovne, Miljøstyrelsen (In Danish)
13. Miljøprojekt 249/1994 Emissioner af dioxiner fra pejse og brændeovne, Miljøstyrelsen (In Danish)
14. Naturgas – Energi og miljø, Danish Gas Technology Centre, 2000 (In Danish)
15. Same emission factors as for straw is assumed
16. Same emission factors as residual oil assumed
17. Calculation based on S content of natural gas 6mg(S)/m_n^3 gas. S content from the Danish natural gas transmission company DONG
18. -
19. -
20. -
21. -
22. Træ til energiformål, Teknik – Miljø – Økonomi, 2. udgave, 1999, Videncenter for halm og flisfyring (In Danish)
23. Same emission factor as for natural gas assumed
24. Bekendtgørelseom begrænsning af svovlindholdet i visse flydende og faste brændstoffer, Bekendtgørelse 698 af 22/09/1998 (Danish legislation)
25. Assumed 0,7% S. Product data from Shell and Statoil
26. S content stated by plant owners (~200 ppm H2S)
27. Assumed 0,05% S. Bilag 750, Kom 97/0105 and product sheets from Q8, Shell and Statoil
28. Bekendtgørelse om begrænsning af emissioner af svovldioxid, kvælstofoxider og støv fra store fyringsanlæg, Bekendtgørelse 689 af 15/10/1990 (Danish legislation)
29. Same emission factor as for coal is assumed
30. Product sheet from Shell
31. Nielsen & Illerup 2003
32. IPCC 1996

Time series for emission factors for SO_2, NO_x, NMVOC and CO that are not the same in 1990-2002 are shown below. All other factors are constant in 1990-2002.

Table 3A-35 SO_2, NO_x, NMVOC and CO emission factors time series

pollutant	fuel	fuel_gr_abbr	IPCC	SNAP	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
SO_2	102	COAL	1A1a	010101	506	571	454	386	343	312	420	215	263	193	64	47	45
SO_2	102	COAL	1A1a	010102	506	571	454	386	343	312	420	215	263	193	64	47	45
SO_2	102	COAL	1A1a	010103							420	215	263	193	64	47	45
SO_2	110	PETROLEUM COKE	1A2f	0301	745	745	745	745	745	745	745	745	745	745	745	573	573
SO_2	110	PETROLEUM COKE	1A4a	0201	745	745	745	745	745	745	745	745	745	745	745	573	573
SO_2	110	PETROLEUM COKE	1A4b	0202	745	745	745	745	745	745	745	745	745	745	745	573	573
SO_2	110	PETROLEUM COKE	1A4c	0203	745	745	745	745	745	745	745	745	745	745	745	573	573
SO_2	114	MUNICIP. WASTES	1A1a	010102		116	95	73	52	30				25	23,9	23,9	23,9
SO_2	114	MUNICIP. WASTES	1A1a	010103							29	28	26	25	23,9	23,9	23,9
SO_2	114	MUNICIP. WASTES	1A1a	0102	138	131	124	117	110	103	95	88					
SO_2	114	MUNICIP. WASTES	1A1a	010203									81	74	67	67	67
SO_2	114	MUNICIP. WASTES	1A2f	030102									81				67
SO_2	114	MUNICIP. WASTES	1A4a	0201	138	131	124	117	110	103	95	88	81	74	67	67	67
SO_2	114	MUNICIP. WASTES	1A4a	020103										74	67	67	67
SO_2	203	RESIDUAL OIL	1A1a	0101											403	315	290
SO_2	203	RESIDUAL OIL	1A1a	010101										369	403	315	290
SO_2	203	RESIDUAL OIL	1A1a	010102	446	470	490	475	1564	351				369	403	315	290
SO_2	203	RESIDUAL OIL	1A1a	010103							408	344			403	315	290
SO_2	203	RESIDUAL OIL	1A1a	010104											403	315	290
SO_2	203	RESIDUAL OIL	1A1a	0102	495	495	495	495	495	495	495	344					
SO_2	203	RESIDUAL OIL	1A1b	0103	5869	3021	2048	2155		495							
SO_2	203	RESIDUAL OIL	1A2f	0301	495	495	495	495	495	495	495	344	344	344	344	344	344
SO_2	203	RESIDUAL OIL	1A4a	0201	495	495	495	495	495	495	495	344	344	344	344	344	344
SO_2	203	RESIDUAL OIL	1A4b	0202	495	495	495	495	495	495	495	344	344	344	344	344	344
SO_2	203	RESIDUAL OIL	1A4c	0203	495	495	495	495	495	495	495	344	344	344	344	344	344
SO_2	204	GAS OIL	1A1a	010102	94	94	94	94	94	23				23	23	23	23
SO_2	204	GAS OIL	1A1a	0102	94	94	94	94	94	23	23	23					
SO_2	204	GAS OIL	1A1b	0103		94	94	94	94	23							
SO_2	204	GAS OIL	1A2f	0301	94	94	94	94	94	23	23	23	23	23	23	23	23
SO_2	204	GAS OIL	1A2f	030106	94	94	94	94	94	23	23	23	23	23	23	23	23
SO_2	204	GAS OIL	1A4a	0201	94	94	94	94	94	23	23	23	23	23	23	23	23
SO_2	204	GAS OIL	1A4b	0202	94	94	94	94	94	23	23	23	23	23	23	23	23
SO_2	204	GAS OIL	1A4c	0203	94	94	94	94	94	23	23	23	23	23	23	23	23
SO_2	225	ORIMULSION	1A1a	010101							147	149				10	12
NO_x	102	COAL	1A1a	010101	342	384	294	289	267	239	250	200	177	152	129	122	130
NO_x	102	COAL	1A1a	010102	342	384	294	289	267	239	250	200	177	152	129	122	130
NO_x	102	COAL	1A1a	010103							200	200	177	152	129	122	130
NO_x	102	COAL	1A1a	010203									200	200	95	95	95
NO_x	102	COAL	1A2f	0301	200	200	200	200	200	200	200	200	200	200	95	95	95
NO_x	102	COAL	1A4b	0202	200	200	200	200	200	200	200	200	200	200	95	95	95
NO_x	102	COAL	1A4c	0203	200	200	200	200	200	200	200	200	200	200	95	95	95
NO_x	203	RESIDUAL OIL	1A1a	0101											129	122	130
NO_x	203	RESIDUAL OIL	1A1a	010101										152	129	122	130
NO_x	203	RESIDUAL OIL	1A1a	010102	342	384	294	289	267	239				152	129	122	130
NO_x	203	RESIDUAL OIL	1A1a	010103							250	200			129	122	130
NO_x	203	RESIDUAL OIL	1A1a	010104											129	122	130
NO_x	204	GAS OIL	1A1a	0102	100	95	90	85	52	52	52	52					
NO_x	204	GAS OIL	1A1b	0103		95	90	85	80	75							
NO_x	204	GAS OIL	1A2f	0301	100	95	90	85	52	52	70	65	65	65	65	65	65
NO_x	225	ORIMULSION	1A1a	010101							139	138				88	86
NO_x	301	NATURAL GAS	1A1a	010104	161	157	153	149	145	141		134	131	127	124	124	124
NO_x	301	NATURAL GAS	1A1a	010105	276	241	235	214	199	194	193	170	167	167	168	168	168
NO_x	301	NATURAL GAS	1A1c	010504	161	157	153	149	145	141	138	134	131	127	124	124	124
NO_x	301	NATURAL GAS	1A1c	010505	276	241	235	214	199	194	193	170	167	167	168	168	168
NO_x	301	NATURAL GAS	1A2f	030104	161				145	141	138	134	131	127	124	124	124
NO_x	301	NATURAL GAS	1A2f	030105	276	241	235	214	199	194	193	170	167	167	168	168	168
NO_x	301	NATURAL GAS	1A4a	020104		157			145	141	138	134	131	127	124	124	124
NO_x	301	NATURAL GAS	1A4a	020105	276	241	235	214	199	194	193	170	167	167	168	168	168
NO_x	301	NATURAL GAS	1A4b	020204	276	241	235	214	199	194	193	170	167	167	168	168	168

NO_x	301	NATURAL GAS	1A4c	020303						141	138	134	131	127	124	124	124
NO_x	301	NATURAL GAS	1A4c	020304	276	241	235	214	199	194	193	170	167	167	168	168	168
NO_x	309	BIOGAS	1A1a	010105									578	559	540	540	540
NO_x	309	BIOGAS	1A1c	010505										559	540	540	540
NO_x	309	BIOGAS	1A2f	030105									578	559	540	540	540
NO_x	309	BIOGAS	1A4a	020105									578	559	540	540	540
NO_x	309	BIOGAS	1A4c	020304									578	559	540	540	540
NMVOC	301	NATURAL GAS	1A1a	010105	58	67	78	122	136	137	134	120	118	118	117	117	117
NMVOC	301	NATURAL GAS	1A1c	010505	58	67	78	122	136	137	134	120	118	118	117	117	117
NMVOC	301	NATURAL GAS	1A2f	030105	58	67	78	122	136	137	134	120	118	118	117	117	117
NMVOC	301	NATURAL GAS	1A4a	020105	58	67	78	122	136	137	134	120	118	118	117	117	117
NMVOC	301	NATURAL GAS	1A4b	020204	58	67	78	122	136	137	134	120	118	118	117	117	117
NMVOC	301	NATURAL GAS	1A4c	020304	58	67	78	122	136	137	134	120	118	118	117	117	117
CO	111	WOOD AND SIMIL.	1A1a	0102	400	373	347	320	293	267	240	240					
CO	111	WOOD AND SIMIL.	1A2f	0301	400	373	347	320	293	267	240	240	240	240	240	240	240
CO	111	WOOD AND SIMIL.	1A4a	0201	400	373	347	320	293	267	240	240	240	240	240	240	240
CO	111	WOOD AND SIMIL.	1A4c	0203	400	373	347	320	293	267	240	240	240	240	240	240	240
CO	114	MUNICIP. WASTES	1A1a	010102		85	70	55	40	25				10	7,4	7,4	7,4
CO	114	MUNICIP. WASTES	1A1a	010103							10	10	10	10	7,4	7,4	7,4
CO	114	MUNICIP. WASTES	1A1a	0102	100	85	70	55	40	25	10	10					
CO	114	MUNICIP. WASTES	1A4a	0201	100	85	70	55	40	25	10	10	10	10	10	10	10
CO	117	STRAW	1A1a	0102	600	554	508	463	417	371	325	325					
CO	117	STRAW	1A4b	0202	8500	8500	8500	8500	8500	7500	6500	5500	4500	4000	4000	4000	4000
CO	117	STRAW	1A4c	0203	600	554	508	463	417	371	325	325	325	325	325	325	325
CO	301	NATURAL GAS	1A1a	010105	181	202	203	217	216	212	211	174	174	174	175	175	175
CO	301	NATURAL GAS	1A1c	010505	181	202	203	217	216	212	211	174	174	174	175	175	175
CO	301	NATURAL GAS	1A2f	030105	181	202	203	217	216	212	211	174	174	174	175	175	175
CO	301	NATURAL GAS	1A4a	020105	181	202	203	217	216	212	211	174	174	174	175	175	175
CO	301	NATURAL GAS	1A4b	020204	181	202	203	217	216	212	211	174	174	174	175	175	175
CO	301	NATURAL GAS	1A4c	020304	181	202	203	217	216	212	211	174	174	174	175	175	175
CO	309	BIOGAS	1A1a	010105									265	269	273	273	273
CO	309	BIOGAS	1A1c	010505										269	273	273	273
CO	309	BIOGAS	1A2f	030105									265	269	273	273	273
CO	309	BIOGAS	1A4a	020105									265	269	273	273	273
CO	309	BIOGAS	1A4c	020304									265	269	273	273	273

Appendix 3A-5 Large point sources

Table 3A-38 Large point sources, fuel consumption in 2002 (1A1, 1A2 and 1A4)

lps_id	lps name	part_id	snap_id	fuel_id	fuel	fuel consumption [GJ]	IPCC source
001	Amagervaerket	01	010101	102	COAL	2064946	1A1a
001	Amagervaerket	01	010101	203	RESIDUAL OIL	184904	1A1a
001	Amagervaerket	02	010101	102	COAL	3290774	1A1a
001	Amagervaerket	02	010101	203	RESIDUAL OIL	214191	1A1a
001	Amagervaerket	03	010101	102	COAL	13750850	1A1a
001	Amagervaerket	03	010101	203	RESIDUAL OIL	86228	1A1a
002	Svanemoellevaerket	05	010101	204	GAS OIL	720	1A1a
002	Svanemoellevaerket	05	010101	301	NATURAL GAS	1679600	1A1a
002	Svanemoellevaerket	07	010104	204	GAS OIL	42	1A1a
002	Svanemoellevaerket	07	010104	301	NATURAL GAS	3787960	1A1a
003	H.C.Oerstedsvaerket	03	010101	203	RESIDUAL OIL	438313	1A1a
003	H.C.Oerstedsvaerket	03	010101	301	NATURAL GAS	1928414	1A1a
003	H.C.Oerstedsvaerket	07	010101	203	RESIDUAL OIL	584175	1A1a
003	H.C.Oerstedsvaerket	07	010101	301	NATURAL GAS	2737670	1A1a
004	Kyndbyvaerket	21	010101	203	RESIDUAL OIL	198245	1A1a
004	Kyndbyvaerket	22	010101	203	RESIDUAL OIL	296933	1A1a
004	Kyndbyvaerket	26	010101	203	RESIDUAL OIL	215426	1A1a
004	Kyndbyvaerket	28	010101	203	RESIDUAL OIL	57826	1A1a
004	Kyndbyvaerket	41	010105	204	GAS OIL	1432	1A1a
004	Kyndbyvaerket	51	010104	204	GAS OIL	14126	1A1a
004	Kyndbyvaerket	52	010104	204	GAS OIL	10578	1A1a
005	Masnedoevaerket	12	010102	111	WOOD AND SIMIL.	125807	1A1a
005	Masnedoevaerket	12	010102	117	STRAW	467182	1A1a
005	Masnedoevaerket	12	010102	204	GAS OIL	991	1A1a
005	Masnedoevaerket	31	010104	204	GAS OIL	21913	1A1a
007	Stigsnaesvaerket	01	010101	102	COAL	2272643	1A1a
007	Stigsnaesvaerket	01	010101	203	RESIDUAL OIL	143140	1A1a
007	Stigsnaesvaerket	02	010101	102	COAL	6796315	1A1a
007	Stigsnaesvaerket	02	010101	203	RESIDUAL OIL	111473	1A1a
008	Asnaesvaerket	01	010101	203	RESIDUAL OIL	77287	1A1a
008	Asnaesvaerket	02	010101	102	COAL	4755522	1A1a
008	Asnaesvaerket	02	010101	203	RESIDUAL OIL	134726	1A1a
008	Asnaesvaerket	03	010101	102	COAL	379041	1A1a
008	Asnaesvaerket	03	010101	203	RESIDUAL OIL	35793	1A1a
008	Asnaesvaerket	04	010101	102	COAL	3724192	1A1a
008	Asnaesvaerket	04	010101	203	RESIDUAL OIL	38991	1A1a
008	Asnaesvaerket	05	010101	203	RESIDUAL OIL	580710	1A1a
008	Asnaesvaerket	05	010101	225	ORIMULSION	23846400	1A1a
009	Statoil Raffinaderi	01	010306	203	RESIDUAL OIL	682280	1A1b
009	Statoil Raffinaderi	01	010306	308	REFINERY GAS	6568024	1A1b
010	Avedoerevaerket	01	010101	102	COAL	16051850	1A1a
010	Avedoerevaerket	01	010101	203	RESIDUAL OIL	61806	1A1a
010	Avedoerevaerket	01	010101	204	GAS OIL	14695	1A1a
010	Avedoerevaerket	02	010104	111	WOOD AND SIMIL.	117062	1A1a
010	Avedoerevaerket	02	010104	117	STRAW	1215692	1A1a
010	Avedoerevaerket	02	010104	203	RESIDUAL OIL	6624653	1A1a
010	Avedoerevaerket	02	010104	301	NATURAL GAS	7757769	1A1a
011	Fynsvaerket	03	010101	102	COAL	963550	1A1a
011	Fynsvaerket	03	010101	114	MUNICIP. WASTES	890980	1A1a
011	Fynsvaerket	03	010101	203	RESIDUAL OIL	61930	1A1a
011	Fynsvaerket	03	010101	301	NATURAL GAS	5913280	1A1a
011	Fynsvaerket	07	010101	102	COAL	12160620	1A1a
011	Fynsvaerket	07	010101	203	RESIDUAL OIL	206020	1A1a
011	Fynsvaerket	08	010101	114	MUNICIP. WASTES	2611150	1A1a
011	Fynsvaerket	08	010101	203	RESIDUAL OIL	55000	1A1a
012	Studstrupvaerket	03	010101	102	COAL	10941110	1A1a
012	Studstrupvaerket	03	010101	203	RESIDUAL OIL	238500	1A1a
012	Studstrupvaerket	04	010101	102	COAL	16009780	1A1a
012	Studstrupvaerket	04	010101	117	STRAW	889080	1A1a
012	Studstrupvaerket	04	010101	203	RESIDUAL OIL	150990	1A1a
014	Vendsysselvaerket	03	010101	102	COAL	18869460	1A1a
014	Vendsysselvaerket	03	010101	203	RESIDUAL OIL	216600	1A1a
014	Vendsysselvaerket	03	010101	204	GAS OIL	14840	1A1a
017	Shell Raffinaderi	01	010306	203	RESIDUAL OIL	680360	1A1b
017	Shell Raffinaderi	01	010306	308	REFINERY GAS	4773776	1A1b
017	Shell Raffinaderi	05	010304	308	REFINERY GAS	2455232	1A1b
018	Skaerbaekvaerket	01	010101	203	RESIDUAL OIL	341140	1A1a
018	Skaerbaekvaerket	03	010101	204	GAS OIL	41190	1A1a
018	Skaerbaekvaerket	03	010101	301	NATURAL GAS	6987650	1A1a
019	Enstedvaerket	03	010101	102	COAL	30974580	1A1a
019	Enstedvaerket	03	010101	203	RESIDUAL OIL	150200	1A1a
019	Enstedvaerket	04	010101	111	WOOD AND SIMIL.	65930	1A1a
019	Enstedvaerket	04	010101	117	STRAW	1753980	1A1a
019	Enstedvaerket	04	010101	204	GAS OIL	20950	1A1a
020	Esbjergvaerket	03	010101	102	COAL	18603150	1A1a
020	Esbjergvaerket	03	010101	203	RESIDUAL OIL	137510	1A1a
022	Oestkraft	05	010102	203	RESIDUAL OIL	9320	1A1a
022	Oestkraft	06	010102	102	COAL	713024	1A1a
022	Oestkraft	06	010102	111	WOOD AND SIMIL.	37905	1A1a
022	Oestkraft	06	010102	203	RESIDUAL OIL	30781	1A1a
023	Danisco Ingredients	01	030102	102	COAL	542112,9	1A2f
023	Danisco Ingredients	01	030102	301	NATURAL GAS	21035,91	1A2f
024	Dansk Naturgas Behandlingsanlaeg	01	010502	301	NATURAL GAS	379362,15	1A1c

025	Horsens Kraftvarmevaerk	01	010102	111	WOOD AND SIMIL.	2969	1A1a
025	Horsens Kraftvarmevaerk	01	010102	114	MUNICIP. WASTES	859200	1A1a
025	Horsens Kraftvarmevaerk	02	010104	301	NATURAL GAS	893452	1A1a
026	Herningvaerket	01	010102	111	WOOD AND SIMIL.	243170	1A1a
026	Herningvaerket	01	010102	203	RESIDUAL OIL	15820	1A1a
026	Herningvaerket	01	010102	301	NATURAL GAS	2560550	1A1a
027	Vestforbraendingen	01	010102	114	MUNICIP. WASTES	2021880	1A1a
027	Vestforbraendingen	01	010102	204	GAS OIL	23457,67	1A1a
027	Vestforbraendingen	02	010102	114	MUNICIP. WASTES	2966608	1A1a
028	Amagerforbraendingen	01	010102	114	MUNICIP. WASTES	4142540	1A1a
029	Randersvaerket	01	010102	102	COAL	2920674	1A1a
029	Randersvaerket	01	010102	309	BIOGAS	20466	1A1a
029	Randersvaerket	02	010102	204	GAS OIL	45623	1A1a
030	Grenaavaerket	01	010102	102	COAL	1050880	1A1a
030	Grenaavaerket	01	010102	111	WOOD AND SIMIL.	39000	1A1a
030	Grenaavaerket	01	010102	114	MUNICIP. WASTES	137208	1A1a
030	Grenaavaerket	01	010102	117	STRAW	787673	1A1a
030	Grenaavaerket	01	010102	203	RESIDUAL OIL	50258	1A1a
030	Grenaavaerket	01	010102	204	GAS OIL	9378	1A1a
031	Hilleroedvaerket	01	010104	301	NATURAL GAS	3190706	1A1a
032	Helsingoervaerket	01	010104	301	NATURAL GAS	2019878	1A1a
032	Helsingoervaerket	02	010105	301	NATURAL GAS	20789	1A1a
034	Stora Dalum	01	030102	301	NATURAL GAS	1169100	1A2f
035	Assens Sukkerfabrik	01	030102	102	COAL	266710	1A2f
035	Assens Sukkerfabrik	01	030102	203	RESIDUAL OIL	120935	1A2f
035	Assens Sukkerfabrik	01	030102	309	BIOGAS	22754	1A2f
036	Kolding Kraftvarmevaerk	01	010103	114	MUNICIP. WASTES	726736,3	1A1a
036	Kolding Kraftvarmevaerk	02	010103	114	MUNICIP. WASTES	323698	1A1a
037	Maabjergvaerket	02	010102	111	WOOD AND SIMIL.	443570	1A1a
037	Maabjergvaerket	02	010102	114	MUNICIP. WASTES	1742510	1A1a
037	Maabjergvaerket	02	010102	117	STRAW	386090	1A1a
037	Maabjergvaerket	02	010102	301	NATURAL GAS	209580	1A1a
038	Soenderborg Kraftvarmevaerk	01	010102	114	MUNICIP. WASTES	481102	1A1a
038	Soenderborg Kraftvarmevaerk	02	010104	301	NATURAL GAS	1178454	1A1a
039	Kara Affaldsforbraendingsanlaeg	01	010102	114	MUNICIP. WASTES	1801188,4	1A1a
039	Kara Affaldsforbraendingsanlaeg	01	010102	301	NATURAL GAS	9771,52	1A1a
040	Viborg Kraftvarmevaerk	01	010104	301	NATURAL GAS	2334004	1A1a
042	Nordforbraendingen	01	010102	114	MUNICIP. WASTES	1015274,5	1A1a
045	Aalborg Portland	01	030311	102	COAL	4348589	1A2f
045	Aalborg Portland	01	030311	110	PETROLEUM COKE	7543476	1A2f
045	Aalborg Portland	01	030311	114	MUNICIP. WASTES	1787613	1A2f
045	Aalborg Portland	01	030311	118	SEWAGE SLUDGE	64508	1A2f
045	Aalborg Portland	01	030311	203	RESIDUAL OIL	591804	1A2f
046	Aarhus Nord	01	010102	114	MUNICIP. WASTES	1830728	1A1a
047	Reno Nord	01	010103	111	WOOD AND SIMIL.	1038717	1A1a
047	Reno Nord	01	010103	114	MUNICIP. WASTES	699226,5	1A1a
048	Silkeborg Kraftvarmevaerk	01	010104	301	NATURAL GAS	3207206	1A1a
049	Rensningsanlægget Lynetten	01	020103	114	MUNICIP. WASTES	12593,92	1A4a
049	Rensningsanlægget Lynetten	01	020103	204	GAS OIL	43889,5	1A4a
049	Rensningsanlægget Lynetten	01	020103	309	BIOGAS	74286	1A4a
050	I/S Fasan	01	010203	114	MUNICIP. WASTES	934589,7	1A1a
051	AVV Forbrændingsanlæg	01	010103	114	MUNICIP. WASTES	662682	1A1a
052	I/S REFA Kraftvarmeværk	01	010103	114	MUNICIP. WASTES	970453,6	1A1a
053	Svendborg Kraftvarmeværk	01	010102	114	MUNICIP. WASTES	548898	1A1a
053	Svendborg Kraftvarmeværk	01	010102	301	NATURAL GAS	5093,23	1A1a
054	Kommunekemi	01	010102	114	MUNICIP. WASTES	141708	1A1a
054	Kommunekemi	01	010102	203	RESIDUAL OIL	42084	1A1a
054	Kommunekemi	01	010102	204	GAS OIL	18113,34	1A1a
054	Kommunekemi	02	010102	114	MUNICIP. WASTES	655105	1A1a
054	Kommunekemi	02	010102	203	RESIDUAL OIL	37729	1A1a
054	Kommunekemi	02	010102	204	GAS OIL	5093,26	1A1a
054	Kommunekemi	03	010102	114	MUNICIP. WASTES	658875	1A1a
054	Kommunekemi	03	010102	203	RESIDUAL OIL	46927	1A1a
054	Kommunekemi	03	010102	204	GAS OIL	5164,99	1A1a
054	Kommunekemi	04	010104	301	NATURAL GAS	109,36	1A1a
055	I/S Fælles Forbrænding	01	010203	114	MUNICIP. WASTES	282819,6	1A1a
056	Vestfyns Forbrænding	01	010203	114	MUNICIP. WASTES	228332	1A1a
058	I/S Reno Syd	01	010103	114	MUNICIP. WASTES	643403	1A1a
059	I/S Kraftvarmeværk Thisted	01	010103	111	WOOD AND SIMIL.	985,8	1A1a
059	I/S Kraftvarmeværk Thisted	01	010103	114	MUNICIP. WASTES	551449,5	1A1a
059	I/S Kraftvarmeværk Thisted	01	010103	117	STRAW	2668	1A1a
060	Knudmoseværket	01	010103	114	MUNICIP. WASTES	36080	1A1a
060	Knudmoseværket	01	010103	301	NATURAL GAS	8205,37	1A1a
061	Kavo I/S Energien	01	010103	114	MUNICIP. WASTES	674320,5	1A1a
062	VEGA	01	010203	114	MUNICIP. WASTES	589029	1A1a
063	Hadsund Bys Fjernvarmeværk	01	010203	111	WOOD AND SIMIL.	30400	1A1a
063	Hadsund Bys Fjernvarmeværk	01	010203	114	MUNICIP. WASTES	201660	1A1a
064	Aars Fjernvarmeforsyning	01	010103	111	WOOD AND SIMIL.	9445	1A1a
064	Aars Fjernvarmeforsyning	01	010103	114	MUNICIP. WASTES	521349	1A1a
065	Haderslev Kraftvarmeværk	01	010103	114	MUNICIP. WASTES	666358	1A1a
065	Haderslev Kraftvarmeværk	01	010103	301	NATURAL GAS	54	1A1a
066	Frederiskhavn Affaldskraftvarmeværk	01	010103	114	MUNICIP. WASTES	352602	1A1a
066	Frederiskhavn Affaldskraftvarmeværk	01	010103	204	GAS OIL	1761	1A1a
067	Vejen Kraftvarmeværk	01	010103	114	MUNICIP. WASTES	408470	1A1a
068	Bofa I/S	01	010203	114	MUNICIP. WASTES	193924	1A1a
069	DTU	01	010104	301	NATURAL GAS	1194192	1A1a
070	Næstved Kraftvarmeværk	01	010104	301	NATURAL GAS	407112	1A1a
071	Maricogen	01	030104	204	GAS OIL	896,7	1A2f
071	Maricogen	01	030104	301	NATURAL GAS	2302648	1A2f
072	Hjørring KVV	01	010104	301	NATURAL GAS	1397583	1A1a

Table 3A-39 Large point sources, plant specific emissions (IPCC 1A1, 1A2 and 1A4) [2)]

ID	Plant	Part	SNAP	IPCC sector	SO_2	NO_x	NMVOC	CO
001	Amagervaerket	01	010101	1A1a	x	x		
001	Amagervaerket	02	010101	1A1a	x	x		
001	Amagervaerket	03	010101	1A1a	x	x		
002	Svanemoellevaerket	05	010101	1A1a		x		
002	Svanemoellevaerket	07	010104	1A1a		x		
003	H.C.Oerstedsvaerket	03	010101	1A1a	x	x		
003	H.C.Oerstedsvaerket	07	010101	1A1a	x	x		
004	Kyndbyvaerket	21	010101	1A1a	x	x		
004	Kyndbyvaerket	22	010101	1A1a	x	x		
004	Kyndbyvaerket	26	010101	1A1a	x	x		
004	Kyndbyvaerket	28	010101	1A1a	x	x		
004	Kyndbyvaerket	51	010104	1A1a	x	x		
004	Kyndbyvaerket	52	010104	1A1a	x	x		
005	Masnedoevaerket	12	010102	1A1a	x	x		
005	Masnedoevaerket	31	010104	1A1a	x	x		
007	Stigsnaesvaerket	01	010101	1A1a	x	x		
007	Stigsnaesvaerket	02	010101	1A1a	x	x		
008	Asnaesvaerket	02	010101	1A1a	x	x		
008	Asnaesvaerket	03	010101	1A1a	x	x		
008	Asnaesvaerket	04	010101	1A1a	x	x		
008	Asnaesvaerket	05	010101	1A1a	x	x		
009	Statoil Raffinaderi	01	010306	1A1b	x			
010	Avedoerevaerket	01	010101	1A1a	x	x		
010	Avedoerevaerket	02	010104	1A1a	x	x		
011	Fynsvaerket	03	010101	1A1a	x	x		
011	Fynsvaerket	07	010101	1A1a	x	x		
011	Fynsvaerket	08	010101	1A1a	x	x		x
012	Studstrupvaerket	03	010101	1A1a	x	x		
012	Studstrupvaerket	04	010101	1A1a	x	x		
014	Vendsysselvaerket	03	010101	1A1a	x	x		
017	Shell Raffinaderi	01	010306	1A1b	x	x		
017	Shell Raffinaderi	05	010304	1A1b	x	x		
018	Skaerbaekvaerket	01	010101	1A1a	x	x		
018	Skaerbaekvaerket	03	010101	1A1a	x	x		
019	Enstedvaerket	03	010101	1A1a	x	x		
019	Enstedvaerket	04	010101	1A1a	x	x		
020	Esbjergvaerket	03	010101	1A1a	x	x		
022	Oestkraft	05	010102	1A1a	x	x		
022	Oestkraft	06	010102	1A1a	x	x		
023	Danisco Ingredients	01	030102	1A2f	x			
024	Dansk Naturgas Behandlingsanlaeg	01	010502	1A1c		x		
025	Horsens Kraftvarmevaerk	01	010102	1A1a	x	x		x
025	Horsens Kraftvarmevaerk	02	010104	1A1a		x		
026	Herningvaerket	01	010102	1A1a	x	x		
027	Vestforbraendingen	01	010102	1A1a	x	x		x
027	Vestforbraendingen	02	010102	1A1a				
028	Amagerforbraendingen	01	010102	1A1a	x	x	x	x
029	Randersvaerket	01	010102	1A1a	x	x		
030	Grenaavaerket	01	010102	1A1a	x	x		
031	Hilleroedvaerket	01	010104	1A1a		x		
032	Helsingoervaerket	01	010104	1A1a		x		
032	Helsingoervaerket	02	010105	1A1a				
034	Stora Dalum	01	030102	1A2f		x		
035	Assens Sukkerfabrik	01	030102	1A2f	x			
036	Kolding Kraftvarmevaerk	01	010103	1A1a	x		x	x
036	Kolding Kraftvarmevaerk	02	010103	1A1a	x		x	x
037	Maabjergvaerket	02	010102	1A1a	x	x	x	x
038	Soenderborg Kraftvarmevaerk	01	010102	1A1a	x	x		x
038	Soenderborg Kraftvarmevaerk	02	010104	1A1a		x		
039	Kara Affaldsforbraendingsanlaeg	01	010102	1A1a	x			x
040	Viborg Kraftvarmevaerk	01	010104	1A1a		x		
042	Nordforbraendingen	01	010102	1A1a	x			x
046	Aarhus Nord	01	010102	1A1a	x			
047	Reno Nord	01	010103	1A1a	x			x
048	Silkeborg Kraftvarmevaerk	01	010104	1A1a		x		
049	Rensningsanlægget Lynetten	01	020103	1A4a	x			
050	I/S Fasan	01	010203	1A1a	x	x		
051	AVV Forbrændingsanlæg	01	010103	1A1a	x			x
053	Svendborg Kraftvarmeværk	01	010102	1A1a	x	x	x	x

054	Kommunekemi	01	010102	1A1a	x			x
054	Kommunekemi	02	010102	1A1a	x			x
054	Kommunekemi	03	010102	1A1a	x			x
054	Kommunekemi	04	010104	1A1a		x		
056	Vestfyns Forbrænding	01	010203	1A1a	x	x		x
058	I/S Reno Syd	01	010103	1A1a	x			x
059	I/S Kraftvarmeværk Thisted	01	010103	1A1a	x			x
060	Knudmoseværket	01	010103	1A1a	x			x
061	Kavo I/S Energien	01	010103	1A1a	x		x	x
062	VEGA	01	010203	1A1a	x	x		x
063	Hadsund Bys Fjernvarmeværk	01	010203	1A1a	x			x
065	Haderslev Kraftvarmeværk	01	010103	1A1a	x	x		x
066	Frederiskhavn Affaldskraftvarmeværk	01	010103	1A1a	x	x		x
067	Vejen Kraftvarmeværk	01	010103	1A1a	x	x		x
068	Bofa I/S	01	010203	1A1a	x			x
069	DTU	01	010104	1A1a		x		
070	Næstved Kraftvarmeværk	01	010104	1A1a		x		x
071	Maricogen	01	030104	1A2f		x		
072	Hjørring KVV	01	010104	1A1a		x		
Total					10536	36620	22	490

Appendix 3A-6 Uncertainty estimates

Table 3A-40 Uncertainty estimation, GHG

IPCC Source category	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty i trend in national emissions introduced by emission factor uncertarinty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		Gg CO_2 eq	Gg CO_2 eq	%	%	%	%	%	%	%	%	%
Stationary Combustion, Coal	CO_2	24209	16708	1	5	5,099	2,254	-0,187	0,437	-0,935	0,617	1,120
Stationary Combustion, Petroleum coke	CO_2	410	762	3	5	5,831	0,118	0,009	0,020	0,047	0,084	0,096
Stationary Combustion, Plastic waste	CO_2	369	599	5	5	7,071	0,112	0,006	0,016	0,031	0,111	0,115
Stationary Combustion, Residual oil	CO_2	2505	1923	2	2	2,828	0,144	-0,014	0,050	-0,029	0,142	0,145
Stationary Combustion, Gas oil	CO_2	4564	2920	4	5	6,403	0,495	-0,041	0,076	-0,207	0,432	0,479
Stationary Combustion, Kerosene	CO_2	366	18	4	5	6,403	0,003	-0,009	0,000	-0,045	0,003	0,045
Stationary Combustion, Orimulsion	CO_2	0	1908	1	2	2,236	0,113	0,050	0,050	0,100	0,070	0,122
Stationary Combustion, Natural gas	CO_2	4330	11090	3	1	3,162	0,928	0,178	0,290	0,178	1,229	1,242
Stationary Combustion, LPG	CO_2	194	104	4	5	6,403	0,018	-0,002	0,003	-0,011	0,015	0,019
Stationary Combustion, Refinery gas	CO_2	806	842	3	5	5,831	0,130	0,001	0,022	0,006	0,093	0,094
Stationary combustion plants, gas engines	CH_4	2	400	2,2	40	40,060	0,424	0,010	0,010	0,416	0,033	0,417
Stationary combustion plants, other	CH_4	117	133	2,2	100	100,024	0,352	0,000	0,003	0,047	0,011	0,048
Stationary combustion plants	N_2O	397	383	2,2	1000	1000,002	10,124	0,000	0,010	-0,248	0,031	0,250
Total		38269	37789				109,062					3,335
Total uncertainties		**Overall uncertainty i the year (%):**					**10,443**		**Trend uncertainty (%):**			**1,826**

Table 3A-41 Uncertainty estimation, CO_2

IPCC Source category	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty i trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		Gg CO_2	Gg CO_2	%	%	%	%	%	%	%	%	%
Stationary Combustion, Coal	CO_2	24209	16708	1	5	5,099	2,254	-0,187	0,437	-0,935	0,617	1,120
Stationary Combustion, Petroleum coke	CO_2	410	762	3	5	5,831	0,118	0,009	0,020	0,047	0,084	0,096
Stationary Combustion, Plastic waste	CO_2	369	599	5	5	7,071	0,112	0,006	0,016	0,031	0,111	0,115
Stationary Combustion, Residual oil	CO_2	2505	1923	2	2	2,828	0,144	-0,014	0,050	-0,029	0,142	0,145
Stationary Combustion, Gas oil	CO_2	4564	2920	4	5	6,403	0,495	-0,041	0,076	-0,207	0,432	0,479
Stationary Combustion, Kerosene	CO_2	366	18	4	5	6,403	0,003	-0,009	0,000	-0,045	0,003	0,045
Stationary Combustion, Orimulsion	CO_2	0	1908	1	2	2,236	0,113	0,050	0,050	0,100	0,070	0,122
Stationary Combustion, Natural gas	CO_2	4330	11090	3	1	3,162	0,928	0,178	0,290	0,178	1,229	1,242
Stationary Combustion, LPG	CO_2	194	104	4	5	6,403	0,018	-0,002	0,003	-0,011	0,015	0,019
Stationary Combustion, Refinery gas	CO_2	806	842	3	5	5,831	0,130	0,001	0,022	0,006	0,093	0,094
Total	CO_2	37753,414	36873,43				6,581					3,115

Total uncertainties	Overall uncertainty i the year (%):	2,565	Trend uncertainty (%):	1,765

Table 3A-42 Uncertainty estimation, CH_4

IPCC Source category	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty i trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		Mg CH_4	Mg CH_4	%	%	%	%	%	%	%	%	%
Stationary combustion plants, gas engines	CH4	106	19046	2,2	40	40,060	30,058	3,283	3,368	131,303	10,477	131,720
Stationary combustion plants, other	CH4	5549	6338	2,2	100	100,024	24,975	-3,251	1,121	-325,129	3,487	325,147
Total	CH_4	5656	25384				1527,23					123071
Total uncertainties			**Overall uncertainty i the year (%):**				**39,080**			**Trend uncertainty (%):**		**350,815**

Table 3A-43 Uncertainty estimation, N_2O

IPCC Source category	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty i trend in national emissions introduced by emission factor uncertarinty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		Gg N_2O	Gg N_2O	%	%	%	%	%	%	%	%	%
Stationary combustion plants	N_2O	1,281	1,234	2,200	1000,000	1000,002	1000,002	0,000	0,964	0,000	2,998	2,998
Total	N_2O	1,281	1,234				1000005					8,987
Total uncertainties			**Overall uncertainty i the year (%):**				**1000,002**		**Trend uncertainty (%):**			**2,998**

Table 3A-44 Uncertainty estimation, SO_2

SNAP	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in	Type A sensitivity	Type B sensitivity	Uncertainty i trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		Mg SO_2	Mg SO_2	%	%	%	%	%	%	%	%	%
01	SO_2	134117	10872	2	10	10,198	5,265	-0,041	0,067	-0,408	0,191	0,450
02	SO_2	11425	3623	2	20	20,100	3,458	0,013	0,022	0,264	0,064	0,272
03	SO_2	15812	6563	2	10	10,198	3,179	0,028	0,041	0,279	0,115	0,301
Total	SO_2	161355	21058				49,782					0,367

Total uncertainties	Overall uncertainty i the year (%):	**7,056**	Trend uncertainty (%):	**0,606**

Table 3A-45 Uncertainty estimation, NO_x

SNAP	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty i trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		Mg NO_x	Mg NO_x	%	%	%	%	%	%	%	%	%
01	NO_x	94994	53073	2	20	20,100	14,236	-0,073	0,4589	-1,452	1,298	1,948
02	NO_x	7871	7446	2	50	50,040	4,973	0,020	0,0644	1,014	0,182	1,030
03	NO_x	12798	14412	2	20	20,100	3,866	0,053	0,1246	1,057	0,352	1,114
Total	NO_x	115662	74931				242,349					6,097

Total uncertainties	Overall uncertainty i the year (%):	**15,568**	Trend uncertainty (%):	**2,469**

Table 3A-46 Uncertainty estimation, NMVOC

SNAP	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty i trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		Mg NMVOC	Mg NMVOC	%	%	%	%	%	%	%	%	%
01	NMVOC	1108	4299	2	50	50,040	11,570	0,211	0,3382	10,528	0,957	10,571
02	NMVOC	10991	13369	2	50	50,040	35,979	-0,211	1,0517	-10,556	2,975	10,967
03	NMVOC	614	926	2	50	50,040	2,491	0,002	0,0728	0,110	0,206	0,234
Total	NMVOC	12713	18594				1434,549					232,074

Total uncertainties	Overall uncertainty i the year (%):	**37,875**	Trend uncertainty (%):	**15,234**

Table 3A-47 Uncertainty estimation, CO

SNAP	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty i trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		Mg CO	Mg CO	%	%	%	%	%	%	%	%	%
01	CO	8982	12539	2	20	20,100	1,508	0,015	0,086	0,301	0,245	0,388
02	CO	130963	149434	2	50	50,040	44,729	-0,010	1,030	-0,517	2,914	2,959
03	CO	5100	5203	2	20	20,100	0,626	-0,005	0,036	-0,093	0,101	0,138
Total	CO	145045	167176				2003,377					8,928

Total uncertainties	Overall uncertainty i the year (%):	44,759	Trend uncertainty (%):	2,988

Appendix 3A-7 Lower Calorific Value (LCV) of fuels

Table 3A-48 Time series for calorific values of fuels (Danish Energy Authority, DEA 2003b)

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Crude Oil, Average	GJ / ton	42,40	42,40	42,40	42,70	42,70	42,70	42,70	43,00	43,00	43,00	43,00	43,00	43,00
Crude Oil, Golf	GJ / ton	41,80	41,80	41,80	41,80	41,80	41,80	41,80	41,80	41,80	41,80	41,80	41,80	41,80
Crude Oil, North Sea	GJ / ton	42,70	42,70	42,70	42,70	42,70	42,70	42,70	43,00	43,00	43,00	43,00	43,00	43,00
Refinery Feedstocks	GJ / ton	41,60	41,60	41,60	41,60	41,60	41,60	41,60	42,70	42,70	42,70	42,70	42,70	42,70
Refinery Gas	GJ / ton	52,00	52,00	52,00	52,00	52,00	52,00	52,00	52,00	52,00	52,00	52,00	52,00	52,00
LPG	GJ / ton	46,00	46,00	46,00	46,00	46,00	46,00	46,00	46,00	46,00	46,00	46,00	46,00	46,00
Naphtha (LVN)	GJ / ton	44,50	44,50	44,50	44,50	44,50	44,50	44,50	44,50	44,50	44,50	44,50	44,50	44,50
Motor Gasoline	GJ / ton	43,80	43,80	43,80	43,80	43,80	43,80	43,80	43,80	43,80	43,80	43,80	43,80	43,80
Aviation Gasoline	GJ / ton	43,80	43,80	43,80	43,80	43,80	43,80	43,80	43,80	43,80	43,80	43,80	43,80	43,80
JP4	GJ / ton	43,80	43,80	43,80	43,80	43,80	43,80	43,80	43,80	43,80	43,80	43,80	43,80	43,80
Other Kerosene	GJ / ton	43,50	43,50	43,50	43,50	43,50	43,50	43,50	43,50	43,50	43,50	43,50	43,50	43,50
JP1	GJ / ton	43,50	43,50	43,50	43,50	43,50	43,50	43,50	43,50	43,50	43,50	43,50	43,50	43,50
Gas/Diesel Oil	GJ / ton	42,70	42,70	42,70	42,70	42,70	42,70	42,70	42,70	42,70	42,70	42,70	42,70	42,70
Fuel Oil	GJ / ton	40,40	40,40	40,40	40,40	40,40	40,40	40,70	40,65	40,65	40,65	40,65	40,65	40,65
Orimulsion	GJ / ton	27,60	27,60	27,60	27,60	27,60	28,13	28,02	27,72	27,84	27,58	27,62	27,64	27,71
Petroleum Coke	GJ / ton	31,40	31,40	31,40	31,40	31,40	31,40	31,40	31,40	31,40	31,40	31,40	31,40	31,40
Waste Oil	GJ / ton	41,90	41,90	41,90	41,90	41,90	41,90	41,90	41,90	41,90	41,90	41,90	41,90	41,90
White Spirit	GJ / ton	43,50	43,50	43,50	43,50	43,50	43,50	43,50	43,50	43,50	43,50	43,50	43,50	43,50
Bitumen	GJ / ton	39,80	39,80	39,80	39,80	39,80	39,80	39,80	39,80	39,80	39,80	39,80	39,80	39,80
Lubricants	GJ / ton	41,90	41,90	41,90	41,90	41,90	41,90	41,90	41,90	41,90	41,90	41,90	41,90	41,90
Natural Gas	GJ / 1000 Nm3	39,00	39,00	39,00	39,30	39,30	39,30	39,30	39,60	39,90	40,00	40,15	39,99	40,06
Town Gas	GJ / 1000 m^3							17,00	17,00	17,00	17,00	17,01	16,88	17,39
Electricity Plant Coal	GJ / ton	25,30	25,40	25,80	25,20	24,50	24,50	24,70	24,96	25,00	25,00	24,80	24,90	25,15
Other Hard Coal	GJ / ton	26,10	26,50	26,50	26,50	26,50	26,50	26,50	26,50	26,50	26,50	26,50	26,50	26,50
Gas Plant Coal	GJ / ton													
Coke	GJ / ton	31,80	29,30	29,30	29,30	29,30	29,30	29,30	29,30	29,30	29,30	29,30	29,30	29,30
Brown Coal Briquettes	GJ / ton	18,30	18,30	18,30	18,30	18,30	18,30	18,30	18,30	18,30	18,30	18,30	18,30	18,30
Straw	GJ / ton	14,50	14,50	14,50	14,50	14,50	14,50	14,50	14,50	14,50	14,50	14,50	14,50	14,50
Wood Chips	GJ/Rummeter	2,80	2,80	2,80	2,80	2,80	2,80	2,80	2,80	2,80	2,80	2,80	2,80	2,80
Firewood, Hardwood	GJ / m3	10,40	10,40	10,40	10,40	10,40	10,40	10,40	10,40	10,40	10,40	10,40	10,40	10,40
Firewood, Conifer	GJ / m3	7,60	7,60	7,60	7,60	7,60	7,60	7,60	7,60	7,60	7,60	7,60	7,60	7,60
Wood Pellets	GJ / ton	17,50	17,50	17,50	17,50	17,50	17,50	17,50	17,50	17,50	17,50	17,50	17,50	17,50
Wood Waste	GJ / ton	14,70	14,70	14,70	14,70	14,70	14,70	14,70	14,70	14,70	14,70	14,70	14,70	14,70
Wood Waste	GJ/Rummeter	3,20	3,20	3,20	3,20	3,20	3,20	3,20	3,20	3,20	3,20	3,20	3,20	3,20
Biogas	GJ / 1000 m3								23,00	23,00	23,00	23,00	23,00	23,00
Waste Combustion	GJ / ton	8,20	8,20	9,00	9,40	9,40	10,00	10,50	10,50	10,50	10,50	10,50	10,50	10,50
Fish Oil	GJ / ton	37,20	37,20	37,20	37,20	37,20	37,20	37,20	37,20	37,20	37,20	37,20	37,20	37,20

Table 3A-49 Fuel category correspondence list, Danish Energy Authority, NERI and Climate convention reportings (CRF)

Danish Energy Authority	NERI Emission database	CRF fuel category
Other Hard Coal	Coal	Solid
Coke	Coke oven coke	Solid
Electricity Plant Coal	Coal	Solid
Brown Coal Briquettes	Brown coal briq.	Solid
Orimulsion	Orimulsion	Liquid
Petroleum Coke	Petroleum coke	Liquid
Fuel Oil	Residual oil	Liquid
Waste Oil	Residual oil	Liquid
Gas/Diesel Oil	Gas oil	Liquid
Other Kerosene	Kerosene	Liquid
LPG	LPG	Liquid
Refinery Gas	Refinery gas	Liquid
Town Gas	Natural gas	Gas
Natural Gas	Natural gas	Gas
Straw	Straw	Biomass
Wood Waste	Wood and simil.	Biomass
Wood Pellets	Wood and simil.	Biomass
Wood Chips	Wood and simil.	Biomass
Firewood, Hardwood & Conifer	Wood and simil.	Biomass
Waste Combustion	Municip. wastes	Biomass 1)
Fish Oil	Municip. wastes	Biomass 1)
Biogas	Biogas	Biomass
Biogas, other	Biogas	Biomass
Biogas, landfill	Biogas	Biomass
Biogas, sewage sludge	Biogas	Biomass

1) CO_2 from plastic part included in Other fuels

Appendix 3A-8 Adjustment of CO_2 emission

Table 3A-50 Basis of adjustment calculation of CO_2 emission (ref. Danish Energy Authority)

Degree Days		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Actual Degree Days	Degree days	2 093	2 515	3 022	3 434	3 148	3 297	3 837	3 236	3 217	3 056	2 902	3279	3011
Normal Degree Days	Degree days	2 691	2 691	3 370	3 370	3 370	3 370	3 370	3 370	3 370	3 370	3 370	3 370	3370
Actual emission	1000 tonnes	52724		56713		62728		73075		59400	56464	52468	54025	53024
Adjusted emission	1000 tonnes	60903		60823		59652		58468		56151	55488	54468	53907	52427

Appendix 3A-9 Reference approach

TABLE 1.A(b) SECTORAL BACKGROUND DATA FOR ENERGY
CO_2 from Fuel Combustion Activities - Reference Approach (IPCC Worksheet 1-1)
(Sheet 1 of 1)

FUEL TYPES			Unit	Production	Imports	Exports	International bunkers	Stock change	Apparent consumption
Liquid Fossil	Primary Fuels	Crude Oil	TJ	780.813,92	140.204,04	########		-2.898,93	333.677,81
		Orimulsion	TJ	0,00	19.583,49	0,00		-4.199,15	23.782,63
		Natural Gas Liquids	TJ	0,00	0,00	0,00		0,00	0,00
	Secondary Fuels	Gasoline	TJ		44.006,18	49.306,91	25,34	137,61	-5.463,68
		Jet Kerosene	TJ		24.820,65	15.996,45	29.090,37	664,51	-20.930,67
		Other Kerosene	TJ		0,00	0,00	0,00	0,00	0,00
		Shale Oil	TJ		0,00	0,00		0,00	0,00
		Gas / Diesel Oil	TJ		73.362,94	41.739,16	21.579,48	-3.966,14	14.010,44
		Residual Fuel Oil	TJ		26.955,06	47.901,72	17.546,65	-1.244,05	-37.249,26
		LPG	TJ		149,27	4.558,78		-23,92	-4.385,59
		Ethane	TJ		0,00	0,00		0,00	0,00
		Naphtha	TJ		938,25	57,38		-6,99	887,86
		Bitumen	TJ		7.473,56	41,51		83,38	7.348,67
		Lubricants	TJ		2.582,63	346,85	110,41	42,57	2.082,81
		Petroleum Coke	TJ		8.664,83	543,79		-93,76	8.214,81
		Refinery Feedstocks	TJ		7.283,68	0,00		424,35	6.859,33
		Other Oil	TJ		0,00	0,00		0,00	0,00
Liquid Fossil Totals									
Solid Fossil	Primary Fuels	Anthracite [2]	TJ	0,00	0,00	0,00		0,00	0,00
		Coking Coal	TJ	0,00	0,00	0,00		0,00	0,00
		Other Bit. Coal	TJ	0,00	158.044,91	4.235,26	0,00	-19.912,86	173.722,51
		Sub-bit. Coal	TJ	0,00	0,00	0,00	0,00	0,00	0,00
		Lignite	TJ	0,00	0,00	0,00		0,00	0,00
		Oil Shale	TJ	0,00	0,00	0,00		0,00	0,00
		Peat	TJ	0,00	0,00	0,00		0,00	0,00
	Secondary Fuels	BKB & Patent Fuel	TJ		17,40	0,00		-1,52	18,92
		Coke Oven/Gas Coke	TJ		1.124,50	0,00		57,66	1.066,84
Solid Fuel Totals									
Gaseous Fossil		Natural Gas (Dry)	TJ	318.323,54	3.657,13	########		-367,42	193.737,53
Total									
Biomass total									
		Solid Biomass	TJ	77.945,91	4.208,61	0,00		0,00	82.154,51
		Liquid Biomass	TJ	0,00	0,00	0,00		0,00	0,00
		Gas Biomass	TJ	3.361,79	0,00	0,00		0,00	3.361,79

Conversion factor [1] (TJ/Unit)	(1)	Apparent consumption (TJ)	Carbon emission factor (t C/TJ)	Carbon content (Gg C)	Carbon stored (Gg C)	Net carbon emissions (Gg C)	Fraction of carbon oxidized	Actual CO_2 emissions (Gg CO_2)
1,00	NCV	333.677,81	20,00	6.673,56		6.673,56	1,00	24.469,71
1,00	NCV	23.782,63	22,00	523,22		523,22	1,00	1.918,47
1,00	NCV	0,00	17,20	0,00		0,00	1,00	0,00
1,00	NCV	-5.463,68	18,90	-103,26		-103,26	1,00	-378,63
1,00	NCV	-20.930,67	19,50	-408,15		-408,15	1,00	-1.496,54
1,00	NCV	0,00	19,60	0,00		0,00	1,00	0,00
1,00	NCV	0,00	20,00	0,00		0,00	1,00	0,00
1,00	NCV	14.010,44	20,20	283,01	0,00	283,01	1,00	1.037,71
1,00	NCV	-37.249,26	21,10	-785,96		-785,96	1,00	-2.881,85
1,00	NCV	-4.385,59	17,20	-75,43	0,00	-75,43	1,00	-276,58
1,00	NCV	0,00	16,80	0,00	0,00	0,00	1,00	0,00
1,00	NCV	887,86	20,00	17,76	13,21	4,54	1,00	16,66
1,00	NCV	7.348,67	22,00	161,67	171,60	-9,93	1,00	-36,41
1,00	NCV	2.082,81	20,00	41,66	21,89	19,76	1,00	72,47
1,00	NCV	8.214,81	27,50	225,91		225,91	1,00	828,33
1,00	NCV	6.859,33	20,00	137,19		137,19	1,00	503,02
1,00	NCV	0,00	20,00	0,00		0,00	1,00	0,00
		328.835,15		6.691,16	206,71	6.484,45		23.776,33
1,00	NCV	0,00	26,80	0,00		0,00	1,00	0,00
1,00	NCV	0,00	25,80	0,00	0,00	0,00	1,00	0,00
1,00	NCV	173.722,51	25,80	4.482,04		4.482,04	1,00	16.434,15
1,00	NCV	0,00	26,20	0,00		0,00	1,00	0,00
1,00	NCV	0,00	27,60	0,00		0,00	1,00	0,00
1,00	NCV	0,00	29,10	0,00		0,00	1,00	0,00
1,00	NCV	0,00	28,90	0,00		0,00	1,00	0,00
1,00	NCV	18,92	25,80	0,49		0,49	1,00	1,79
1,00	NCV	1.066,84	29,50	31,47		31,47	1,00	115,40
		174.808,28		4.514,00	0,00	4.514,00		16.551,34
1,00	NCV	193.737,53	15,30	2.964,18	0,00	2.964,18	1,00	10.868,68
		697.380,95		**14.169,34**	**206,71**	**13.962,64**		**51.196,34**
		85.516,30		2.533,07	0,00	2.533,07		9.287,92
1,00	NCV	82.154,51	29,90	2.456,42		2.456,42	1,00	9.006,87
1,00	NCV	0,00	20,00	0,00		0,00	1,00	0,00
1,00	NCV	3.361,79	22,80	76,65		76,65	1,00	281,05

TABLE 1.A(c) COMPARISON OF CO_2 EMISSIONS FROM FUEL COMBUSTION
(Sheet 1 of 1)

Denmark
2002
2004, Mar 15

FUEL TYPES	Reference approach		National approach [1]		Difference [2]	
	Energy consumption (PJ)	CO_2 emissions (Gg)	Energy consumption (PJ)	CO_2 emissions (Gg)	Energy consumption (%)	CO_2 emissions (%)
Liquid Fuels (excluding international bunkers)	328,84	23.776,33	316,54	23.451,78	3,88	1,38
Solid Fuels (excluding international bunkers)	174,81	16.551,34	175,73	16.707,92	-0,52	-0,94
Gaseous Fuels	193,74	10.868,68	193,61	11.089,99	0,07	-2,00
Other [3]	-10,87	599,05	1,00	672,21	-1.184,61	-10,88
Total [3]	**686,51**	**51.795,39**	**686,88**	**51.921,90**	**-0,05**	**-0,24**

[1] "National approach" is used to indicate the approach (if different from the Reference approach) followed by the Party to estimate its CO_2 emissions from fuel combustion reported in the national GHG inventory.
[2] Difference of the Reference approach over the National approach (i.e. difference = 100% x ((RA-NA)/NA), where NA = National approach and RA = Reference approach).
[3] Emissions from biomass are not included.

Note: In addition to estimating CO_2 emissions from fuel combustion by sector, Parties should also estimate these emissions using the IPCC Reference approach, as found in the IPCC Guidelines, Worksheet 1-1(Volume 2. Workbook). The Reference approach is to assist in verifying the sectoral data. Parties should also complete the above tables to compare the alternative estimates, and if the emission estimates lie more than 2 percent apart, should explain the source of this difference in the documentation box provided.

Documentation Box:
Non-energy use of fuels is not included in the Danish National Approach. Fuel consumption for non-energy is subtracted in Reference Approach to make results comparable. Inclusion of these fuels in future inventories will be considered.
CO2 emission from plastic part of municipal wastes is included in the Danish National Approach.
CO2 emission from the plastic part of municipal wastes is added in Reference Approach. (Other fuels of sources 1A1, 1A2 and 1A4)

Fuel category correspondence list for the reference approach

Reference approach		Danish energy statistics
Biomass	Gas Biomass	Biogas, other
Biomass	Gas Biomass	Biogas, landfill
Biomass	Gas Biomass	Biogas, sewage sludge
Biomass	Solid Biomass	Fish oil
Biomass	Solid Biomass	Waste combustion, plastic
Biomass	Solid Biomass	Waste combustion, other
Biomass	Solid Biomass	Firewood
Biomass	Solid Biomass	Straw
Biomass	Solid Biomass	Wood Chips
Biomass	Solid Biomass	Firewood
Biomass	Solid Biomass	Wood Pellets
Liquid fossil	Bitumen	Bitumen
Liquid fossil	Crude oil	Crude Oil
Liquid fossil	Ethane	-
Liquid fossil	Gas/diesel oil	Gas/Diesel Oil
Liquid fossil	Gasoline	Aviation Gasoline
Liquid fossil	Gasoline	Motor Gasoline
Liquid fossil	Jet Kerosene	JP1
Liquid fossil	Jet Kerosene	JP4
Liquid fossil	LPG	LPG
Liquid fossil	Lubricants	Lubricants
Liquid fossil	Naphtha	White Spirit
Liquid fossil	Naphtha	Naphtha (LVN)
Liquid fossil	Natural gas	Natural Gas
Liquid fossil	Natural gas liquids	-
Liquid fossil	Orimulsion	Orimulsion
Liquid fossil	Other kerosene	Other Kerosene
Liquid fossil	Other oil	Waste oil
Liquid fossil	Petroleum coke	Petroleum Coke
Liquid fossil	Refinery feedstocks	Refinery Feedstocks
Liquid fossil	Residual fuel oil	Fuel Oil
Liquid fossil	Shale oil	-
Solid fossil	anthracite	-
Solid fossil	BKB & Patent fuel	Brown Coal Briquettes
Solid fossil	Coke oven/gas coke	Coke
Solid fossil	Coking Coal	-
Solid fossil	Oil Shale	-
Solid fossil	Other Bit. Coal	Other Hard Coal
Solid fossil	Other Bit. Coal	Electricity Plant Coal
Solid fossil	Peat	-
Solid fossil	Sub-bit. coal	-

Annex 3 Other detailed methodological descriptions for individual source or sink categories (where relevant)

3B Transport

Annex 3.B.1 Fleet data 1990-2002 for road transport (No. vehicles)

Sector	Subsector	Tech	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Passenger Cars	Gasoline <1,4 l	PRE ECE	46209	44014	42804	36466	39959	37597	37130	3434	2761	2103	1744	1614	1475
Passenger Cars	Gasoline <1,4 l	ECE 15/00-01	187912	161642	139010	119424	80742	67991	53302	44338	31104	22511	17980	15837	14155
Passenger Cars	Gasoline <1,4 l	ECE 15/02	86959	80041	73306	66422	50119	43384	35052	26097	17585	10873	7348	5544	4203
Passenger Cars	Gasoline <1,4 l	ECE 15/03	300791	294878	288227	280146	261998	250043	235177	215301	183113	147111	118929	97930	79016
Passenger Cars	Gasoline <1,4 l	ECE 15/04	272012	270182	268686	268154	265860	262990	259954	265188	264791	254032	235890	219216	194543
Passenger Cars	Gasoline <1,4 l	Euro I	10000	49608	87121	122067	177991	230063	282488	289374	275572	273582	270268	267260	261791
Passenger Cars	Gasoline <1,4 l	Euro II								58502	119142	170981	209279	205833	201734
Passenger Cars	Gasoline <1,4 l	Euro III												34695	73385
Passenger Cars	Gasoline 1,4 - 2,0 l	PRE ECE	35940	34233	33292	28362	31079	29242	28879	2671	2148	1635	1356	1255	1147
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/00-01	127631	109641	94188	80844	54600	45991	36079	30465	21520	15647	12537	11077	9923
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/02	55063	50674	46402	42040	31712	27445	22173	16509	11141	6870	4642	3500	2659
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/03	174545	170750	166596	161592	150612	143386	133413	122642	103931	83270	67222	55300	44572
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/04	180298	178950	177873	177525	176045	174195	172298	176155	179510	172582	160800	149915	133745
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro I	10000	45647	82427	119744	184854	250826	322960	330407	315731	313279	309587	306414	300335
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro II								80440	163821	235099	287758	283021	277385
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro III												47705	100904
Passenger Cars	Gasoline >2,0 l	PRE ECE	3423	3260	3171	2701	2960	2785	2750	254	205	156	129	120	109
Passenger Cars	Gasoline >2,0 l	ECE 15/00-01	10781	9234	7914	6781	4567	3849	3022	2619	1881	1366	1110	986	885
Passenger Cars	Gasoline >2,0 l	ECE 15/02	4392	4043	3702	3355	2531	2191	1770	1318	888	549	371	280	212
Passenger Cars	Gasoline >2,0 l	ECE 15/03	24667	24157	23595	22912	21429	20432	19053	17571	14934	12016	9722	8009	6459
Passenger Cars	Gasoline >2,0 l	ECE 15/04	15679	15524	15390	15339	15120	14844	14546	14977	23975	22975	21251	19699	17377
Passenger Cars	Gasoline >2,0 l	Euro I	10000	13961	17871	21674	28044	34257	40813	41567	31121	30887	30519	30193	29586
Passenger Cars	Gasoline >2,0 l	Euro II								7313	14893	21373	26160	25729	25217
Passenger Cars	Gasoline >2,0 l	Euro III												4337	9173
Passenger Cars	Diesel <2,0 l	Euro I		4041	8031	11912	18412	24751	31440	31580	31998	35415	39518	43826	48984
Passenger Cars	Diesel <2,0 l	Euro II								7316	15312	24505	33856	37328	41736
Passenger Cars	Diesel <2,0 l	Euro III												6313	15219
Passenger Cars	Diesel <2,0 l	Conventional	79709	75788	72288	68529	62139	58843	55000	48153	43893	43004	42861	42885	42300
Passenger Cars	Diesel >2,0 l	Euro I		213	423	627	969	1303	1655	1662	1684	1864	2087	2313	2583
Passenger Cars	Diesel >2,0 l	Euro II								385	806	1290	1789	1971	2202
Passenger Cars	Diesel >2,0 l	Euro III												332	801
Passenger Cars	Diesel >2,0 l	Conventional	3702	3556	3425	3281	3040	2905	2746	2461	2266	2237	2228	2229	2187
Passenger Cars	LPG	Conventional	286	286	288	289	289	301	311	172	97	44	32	63	21
Passenger Cars	2-Stroke	Conventional	5417	4804	4308	3747	3029	2443	1665	1248	761	400	300	200	150
Sector	Subsector	Tech	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Light Duty Vehicles	Gasoline <3,5t	Conventional	42333	43215	44179	45486	47261	44601	41519	37209	34454	31489	28488	25423	21615

Light Duty Vehicles	Gasoline <3,5t	Euro I						4259	8524	12645	17212	16632	15979	15527	15049
Light Duty Vehicles	Gasoline <3,5t	Euro II										4705	9299	14017	13917
Light Duty Vehicles	Gasoline <3,5t	Euro III													5140
Light Duty Vehicles	Diesel <3,5 t	Conventional	155543	158781	162324	167129	173650	163877	152553	142109	131572	122992	115695	105397	92990
Light Duty Vehicles	Diesel <3,5 t	Euro I						15648	31318	48292	65727	64964	64894	64370	64743
Light Duty Vehicles	Diesel <3,5 t	Euro II										18376	37766	58112	59870
Light Duty Vehicles	Diesel <3,5 t	Euro III													22112
Heavy Duty Vehicles	Gasoline >3,5 t	Conventional	250	255	260	268	279	288	295	261	274	253	257	249	249
Heavy Duty Vehicles	Diesel 3,5 - 7,5 t	Conventional	5108	5214	5330	5488	5205	4891	4532	3999	3692	3079	2406	1979	1739
Heavy Duty Vehicles	Diesel 3,5 - 7,5 t	Euro I					497	1004	1506	1440	1435	1269	1057	951	956
Heavy Duty Vehicles	Diesel 3,5 - 7,5 t	Euro II								529	1087	1487	1703	1990	2064
Heavy Duty Vehicles	Diesel 3,5 - 7,5 t	Euro III													484
Heavy Duty Vehicles	Diesel 7,5 - 16 t	Conventional	10286	10500	10734	11052	10482	9850	9126	7800	6603	5613	5085	4210	3136
Heavy Duty Vehicles	Diesel 7,5 - 16 t	Euro I					1001	2022	3033	2808	2566	2314	2235	2024	1724
Heavy Duty Vehicles	Diesel 7,5 - 16 t	Euro II								1032	1945	2710	3600	4234	3724
Heavy Duty Vehicles	Diesel 7,5 - 16 t	Euro III													872
Heavy Duty Vehicles	Diesel 16 - 32 t	Conventional	13034	13306	13602	14005	13283	12481	11564	10720	9832	8982	7933	6814	5525
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro I					1268	2562	3844	3859	3821	3702	3486	3276	3037
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro II								1419	2896	4336	5616	6853	6560
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro III													1537
Heavy Duty Vehicles	Diesel >32t	Conventional	11446	11684	11944	12298	11664	10960	10154	9337	8720	8180	7361	6527	5486
Heavy Duty Vehicles	Diesel >32t	Euro I					1114	2250	3376	3362	3389	3371	3234	3138	3016
Heavy Duty Vehicles	Diesel >32t	Euro II								1236	2568	3949	5211	6564	6514
Heavy Duty Vehicles	Diesel >32t	Euro III													1526
Buses	Urban Buses	Conventional	4753	4561	4522	4490	4083	3635	3261	2946	2792	2542	2319	2319	1977
Buses	Urban Buses	Euro I					390	746	1084	1060	972	913	852	852	752
Buses	Urban Buses	Euro II								390	729	1053	1345	1345	1525
Buses	Urban Buses	Euro III													346
Buses	Coaches	Conventional	3327	2868	3007	3086	2927	4507	4156	3662	3369	3007	2724	2724	2165
Buses	Coaches	Euro I					280	925	1381	1318	1173	1080	1001	1001	823
Buses	Coaches	Euro II								485	879	1246	1579	1579	1670
Buses	Coaches	Euro III													379
Mopeds	<50 cm³	Conventional	120000	118000	113000	109000	105000	114167	123333	132500	141667	150833	150522	149460	146077
Mopeds	<50 cm³	97/24/EC I											9478	15540	24923
Motorcycles	2-stroke >50 cm³	Conventional	6617	6804	6904	7111	7406	7672	8214	8980	9598	10385	11054	11367	11582
Motorcycles	4-stroke <250 cm³	Conventional	7499	7712	7824	8059	8394	8695	9310	10177	10878	11769	11916	11367	12882
Motorcycles	4-stroke <250 cm³	97/24/EC											613	1074	1348
Motorcycles	4-stroke 250 - 750 cm³	Conventional	20622	21207	21516	22162	23083	23911	25602	27986	29914	32365	32768	33910	35424
Motorcycles	4-stroke 250 - 750 cm³	97/24/EC											1685	2953	3707
Motorcycles	4-stroke >750 cm³	Conventional	9374	9639	9780	10074	10492	10869	11637	12721	13597	14712	14894	15414	16102
Motorcycles	4-stroke >750 cm³	97/24/EC											766	1342	1685

Annex 3.B.1 Mileage data 1990-2002 for road transport (km)

Sector	Subsector	Tech	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Passenger Cars	Gasoline <1,4 l	PRE ECE	10352	11120	11847	12282	12679	12387	12152	11935	11988	11691	11507	11922	11743
Passenger Cars	Gasoline <1,4 l	ECE 15/00-01	12073	12735	13119	13036	12679	12387	12152	11935	11988	11691	11507	11922	11743
Passenger Cars	Gasoline <1,4 l	ECE 15/02	13225	13605	14495	15028	15513	13532	12152	11935	11988	11691	11507	11922	11743
Passenger Cars	Gasoline <1,4 l	ECE 15/03	16370	16830	16920	16820	16701	15701	14867	14403	14225	13461	12591	11922	11743
Passenger Cars	Gasoline <1,4 l	ECE 15/04	19941	20341	20763	20356	19947	18688	17564	16233	15648	14929	14356	12416	13780
Passenger Cars	Gasoline <1,4 l	Euro I	22535	23984	25041	25397	25885	24768	23130	22344	21207	19843	18497	18409	17226
Passenger Cars	Gasoline <1,4 l	Euro II								25981	25671	24357	24054	22954	21396
Passenger Cars	Gasoline <1,4 l	Euro III												25954	25172
Passenger Cars	Gasoline 1,4 - 2,0 l	PRE ECE	10352	11120	11847	12282	12679	12387	12152	11935	11988	11691	11507	11922	11743
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/00-01	12073	12735	13119	13036	12679	12387	12152	11935	11988	11691	11507	11922	11743
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/02	13225	13605	14495	15028	15513	13532	12152	11935	11988	11691	11507	11922	11743
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/03	16370	16830	16920	16820	16701	15701	14867	14403	14225	13461	12591	11922	11743
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/04	19941	20341	20763	20356	19947	18688	17564	16233	15648	14929	14356	12416	13780
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro I	22535	23984	25041	25397	25885	24768	23130	22344	21207	19843	18497	18409	17226
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro II								25981	25671	24357	24054	22954	21396
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro III												25954	25172
Passenger Cars	Gasoline >2,0 l	PRE ECE	10352	11120	11847	12282	12679	12387	12152	11935	11988	11691	11507	11922	11743
Passenger Cars	Gasoline >2,0 l	ECE 15/00-01	12073	12735	13119	13036	12679	12387	12152	11935	11988	11691	11507	11922	11743
Passenger Cars	Gasoline >2,0 l	ECE 15/02	13225	13605	14495	15028	15513	13532	12152	11935	11988	11691	11507	11922	11743
Passenger Cars	Gasoline >2,0 l	ECE 15/03	16370	16830	16920	16820	16701	15701	14867	14403	14225	13461	12591	11922	11743
Passenger Cars	Gasoline >2,0 l	ECE 15/04	19941	20341	20763	20356	19947	18688	17564	16233	15648	14929	14356	12416	13780
Passenger Cars	Gasoline >2,0 l	Euro I	22535	23984	25041	25397	25885	24768	23130	22344	21207	19843	18497	18409	17226
Passenger Cars	Gasoline >2,0 l	Euro II								25981	25671	24357	24054	22954	21396
Passenger Cars	Gasoline >2,0 l	Euro III												25954	25172
Passenger Cars	Diesel <2,0 l	Euro I		44822	44911	43972	44800	44746	43410	41641	39363	38090	35677	34320	33095
Passenger Cars	Diesel <2,0 l	Euro II								47992	47256	46753	45221	42794	41107
Passenger Cars	Diesel <2,0 l	Euro III												48385	48362
Passenger Cars	Diesel <2,0 l	Conventional	30874	30888	30400	29591	29501	29228	28169	27809	27304	27242	26288	22832	25212
Passenger Cars	Diesel >2,0 l	Euro I		44822	44911	43972	44800	44746	43410	41641	39363	38090	35677	34320	33095
Passenger Cars	Diesel >2,0 l	Euro II								47992	47256	46753	45221	42794	41107
Passenger Cars	Diesel >2,0 l	Euro III												48385	48362
Passenger Cars	Diesel >2,0 l	Conventional	30874	30888	30400	29591	29501	29228	28169	27809	27304	27242	26288	22832	25212
Passenger Cars	LPG	Conventional	16370	16830	16920	16820	16701	15701	14867	12868	14225	13461	12591	11922	11743
Passenger Cars	2-Stroke	Conventional	16370	16830	16920	16820	16701	15701	14867	12868	14225	13461	12591	11922	11743

Sector	Subsector	Tech	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Light Duty Vehicles	Gasoline <3,5t	Conventional	20255	20573	21208	21167	21003	20157	20005	19559	18762	18082	18101	16619	18399
Light Duty Vehicles	Gasoline <3,5t	Euro I						20157	20005	19559	18762	18082	18101	16619	18399
Light Duty Vehicles	Gasoline <3,5t	Euro II										18082	18101	16619	18399
Light Duty Vehicles	Gasoline <3,5t	Euro III													18399
Light Duty Vehicles	Diesel <3,5 t	Conventional	40234	40672	38721	37230	38732	36909	37282	37023	35010	34193	32789	32130	32060
Light Duty Vehicles	Diesel <3,5 t	Euro I						36909	37282	37023	35010	34193	32789	32130	32060
Light Duty Vehicles	Diesel <3,5 t	Euro II										34193	32789	32130	32060
Light Duty Vehicles	Diesel <3,5 t	Euro III													32060
Heavy Duty Vehicles	Gasoline >3,5 t	Conventional	24464	24848	25614	25565	25367	24346	24162	21140	21559	21272	22009	23191	25362
Heavy Duty Vehicles	Diesel 3,5 - 7,5 t	Conventional	41061	41509	39516	37996	39528	37666	38048	30803	31809	33583	34246	44099	43711
Heavy Duty Vehicles	Diesel 3,5 - 7,5 t	Euro I					39528	37666	38048	30803	31809	33583	34246	44099	43711
Heavy Duty Vehicles	Diesel 3,5 - 7,5 t	Euro II								30803	31809	33583	34246	44099	43711
Heavy Duty Vehicles	Diesel 3,5 - 7,5 t	Euro III													43711
Heavy Duty Vehicles	Diesel 7,5 - 16 t	Conventional	49634	50175	47767	45929	47781	45532	45991	43199	42348	39158	37550	20945	17878
Heavy Duty Vehicles	Diesel 7,5 - 16 t	Euro I					47781	45532	45991	43199	42348	39158	37550	20945	17878
Heavy Duty Vehicles	Diesel 7,5 - 16 t	Euro II								43199	42348	39158	37550	20945	17878
Heavy Duty Vehicles	Diesel 7,5 - 16 t	Euro III													17878
Heavy Duty Vehicles	Diesel 16 - 32 t	Conventional	68996	69748	66402	63845	66422	63294	63934	64717	65653	66838	64092	68254	66841
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro I					66422	63294	63934	64717	65653	66838	64092	68254	66841
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro II								64717	65653	66838	64092	68254	66841
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro III													66841
Heavy Duty Vehicles	Diesel >32t	Conventional	68996	69748	66402	63845	66422	63294	63934	64717	65653	66838	64092	68254	66841
Heavy Duty Vehicles	Diesel >32t	Euro I					66422	63294	63934	64717	65653	66838	64092	68254	66841
Heavy Duty Vehicles	Diesel >32t	Euro II								64717	65653	66838	64092	68254	66841
Heavy Duty Vehicles	Diesel >32t	Euro III													66841
Buses	Urban Buses	Conventional	104096	107730	104029	103324	108850	103224	103953	103313	102311	99871	95765	93590	93770
Buses	Urban Buses	Euro I					108850	103224	103953	103313	102311	99871	95765	93590	93770
Buses	Urban Buses	Euro II								103313	102311	99871	95765	93590	93770
Buses	Urban Buses	Euro III													93770
Buses	Coaches	Conventional	93315	98696	98846	98624	108850	90022	85021	83545	82509	81021	77850	76121	76267
Buses	Coaches	Euro I					108850	90022	85021	83545	82509	81021	77850	76121	76267
Buses	Coaches	Euro II								83545	82509	81021	77850	76121	76267
Buses	Coaches	Euro III													76267
Mopeds	<50 cm³	Conventional	2056	2137	2235	2304	2315	2211	2188	2141	2151	1794	1614	1175	1306
Mopeds	<50 cm³	97/24/EC I											1614	1175	1306
Motorcycles	2-stroke >50 cm³	Conventional	5815	6072	6372	6557	6584	6279	6220	6106	6168	5971	6029	5563	6228
Motorcycles	4-stroke <250 cm³	Conventional	5815	6072	6372	6557	6584	6279	6220	6106	6168	5971	6029	5563	6228
Motorcycles	4-stroke <250 cm³	97/24/EC											6029	5563	6228
Motorcycles	4-stroke 250 - 750 cm³	Conventional	5815	6072	6372	6557	6584	6279	6220	6106	6168	5971	6029	5563	6228
Motorcycles	4-stroke 250 - 750 cm³	97/24/EC											6029	5563	6228
Motorcycles	4-stroke >750 cm³	Conventional	5815	6072	6372	6557	6584	6279	6220	6106	6168	5971	6029	5563	6228
Motorcycles	4-stroke >750 cm³	97/24/EC											6029	5563	6228

Annex 3.B.2 Basis emission factors (g/km)

Sector	Subsector	Tech	FCu	FCr	FCh	CO2u	CO2r	CO2h	CH4u	CH4r	CH4h	N2Ou	N2Or	N2Oh
Passenger Cars	Gasoline <1,4 l	PRE ECE	67,5	55,0	62,7	216	176	201	0,092	0,029	0,026	0,005	0,005	0,005
Passenger Cars	Gasoline <1,4 l	ECE 15/00-01	58,2	44,5	48,6	186	142	155	0,092	0,029	0,026	0,005	0,005	0,005
Passenger Cars	Gasoline <1,4 l	ECE 15/02	53,2	45,2	51,2	170	144	164	0,092	0,029	0,026	0,005	0,005	0,005
Passenger Cars	Gasoline <1,4 l	ECE 15/03	53,2	45,2	51,2	170	144	164	0,092	0,029	0,026	0,005	0,005	0,005
Passenger Cars	Gasoline <1,4 l	ECE 15/04	51,4	43,4	47,7	164	139	153	0,092	0,029	0,026	0,005	0,005	0,005
Passenger Cars	Gasoline <1,4 l	Euro I	51,1	38,0	43,9	164	121	140	0,038	0,018	0,021	0,053	0,016	0,035
Passenger Cars	Gasoline <1,4 l	Euro II	51,1	38,0	43,9	164	121	140	0,038	0,018	0,021	0,053	0,016	0,035
Passenger Cars	Gasoline <1,4 l	Euro III	51,1	38,0	43,9	164	121	140	0,038	0,018	0,021	0,053	0,016	0,035
Passenger Cars	Gasoline 1,4 - 2,0 l	PRE ECE	79,3	67,0	76,4	253	214	244	0,092	0,029	0,026	0,005	0,005	0,005
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/00-01	67,8	51,1	60,3	217	163	193	0,092	0,029	0,026	0,005	0,005	0,005
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/02	61,7	50,7	59,7	197	162	191	0,092	0,029	0,026	0,005	0,005	0,005
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/03	61,7	50,7	59,7	197	162	191	0,092	0,029	0,026	0,005	0,005	0,005
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/04	61,7	49,1	52,1	197	157	166	0,092	0,029	0,026	0,005	0,005	0,005
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro I	65,9	44,0	48,0	211	141	154	0,039	0,017	0,016	0,053	0,016	0,035
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro II	65,9	44,0	48,0	211	141	154	0,039	0,017	0,016	0,053	0,016	0,035
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro III	65,9	44,0	48,0	211	141	154	0,039	0,017	0,016	0,053	0,016	0,035
Passenger Cars	Gasoline >2,0 l	PRE ECE	96,5	80,0	88,3	309	256	282	0,092	0,029	0,026	0,005	0,005	0,005
Passenger Cars	Gasoline >2,0 l	ECE 15/00-01	73,8	57,1	66,3	236	183	212	0,092	0,029	0,026	0,005	0,005	0,005
Passenger Cars	Gasoline >2,0 l	ECE 15/02	75,3	63,3	70,7	241	202	226	0,092	0,029	0,026	0,005	0,005	0,005
Passenger Cars	Gasoline >2,0 l	ECE 15/03	75,3	63,3	70,7	241	202	226	0,092	0,029	0,026	0,005	0,005	0,005
Passenger Cars	Gasoline >2,0 l	ECE 15/04	71,1	58,1	69,9	227	186	223	0,092	0,029	0,026	0,005	0,005	0,005
Passenger Cars	Gasoline >2,0 l	Euro I	79,4	46,4	51,1	254	148	163	0,040	0,017	0,010	0,053	0,016	0,035
Passenger Cars	Gasoline >2,0 l	Euro II	79,4	46,4	51,1	254	148	163	0,040	0,017	0,010	0,053	0,016	0,035
Passenger Cars	Gasoline >2,0 l	Euro III	79,4	46,4	51,1	254	148	163	0,040	0,017	0,010	0,053	0,016	0,035
Passenger Cars	Diesel <2,0 l	Euro I	52,7	42,2	47,4	167	133	150	0,004	0,005	0,009	0,027	0,027	0,027
Passenger Cars	Diesel <2,0 l	Euro II	52,7	42,2	47,4	167	133	150	0,004	0,005	0,009	0,027	0,027	0,027
Passenger Cars	Diesel <2,0 l	Euro III	52,7	42,2	47,4	167	133	150	0,004	0,005	0,009	0,027	0,027	0,027
Passenger Cars	Diesel <2,0 l	Conventional	57,5	41,2	50,1	182	130	158	0,004	0,005	0,009	0,027	0,027	0,027
Passenger Cars	Diesel >2,0 l	Euro I	52,7	42,2	47,4	167	133	150	0,004	0,005	0,009	0,027	0,027	0,027
Passenger Cars	Diesel >2,0 l	Euro II	52,7	42,2	47,4	167	133	150	0,004	0,005	0,009	0,027	0,027	0,027
Passenger Cars	Diesel >2,0 l	Euro III	52,7	42,2	47,4	167	133	150	0,004	0,005	0,009	0,027	0,027	0,027
Passenger Cars	Diesel >2,0 l	Conventional	57,5	41,2	50,1	182	130	158	0,004	0,005	0,009	0,027	0,027	0,027
Passenger Cars	LPG	Conventional	59,0	45,0	54,0	176	135	161	0,080	0,035	0,025	0,015	0,015	0,015
Passenger Cars	2-Stroke	Conventional	111,5	66,0	56,9	357	211	182	0,150	0,040	0,025	0,005	0,005	0,005

Sector	Subsector	Tech	FCu	FCr	FCh	CO2u	CO2r	CO2h	CH4u	CH4r	CH4h	N2Ou	N2Or	N2Oh
Light Duty Vehicles	Gasoline <3,5t	Conventional	82,3	59,9	56,5	263	191	181	0,150	0,040	0,025	0,006	0,006	0,006
Light Duty Vehicles	Gasoline <3,5t	Euro I	96,5	70,4	66,5	308	225	212	0,038	0,020	0,016	0,053	0,016	0,035
Light Duty Vehicles	Gasoline <3,5t	Euro II	96,5	70,4	66,5	308	225	212	0,038	0,020	0,016	0,053	0,016	0,035
Light Duty Vehicles	Gasoline <3,5t	Euro III	96,5	70,4	66,5	308	225	212	0,038	0,020	0,016	0,053	0,016	0,035
Light Duty Vehicles	Diesel <3,5 t	Conventional	76,7	65,9	72,1	242	208	228	0,005	0,005	0,005	0,017	0,017	0,017
Light Duty Vehicles	Diesel <3,5 t	Euro I	68,9	58,2	63,7	218	184	201	0,005	0,005	0,005	0,017	0,017	0,017
Light Duty Vehicles	Diesel <3,5 t	Euro II	68,9	58,2	63,7	218	184	201	0,005	0,005	0,005	0,017	0,017	0,017
Light Duty Vehicles	Diesel <3,5 t	Euro III	68,9	58,2	63,7	218	184	201	0,005	0,005	0,005	0,017	0,017	0,017
Heavy Duty Vehicles	Gasoline >3,5 t	Conventional	225,0	150,0	165,0	719	480	528	0,140	0,110	0,070	0,006	0,006	0,006
Heavy Duty Vehicles	Diesel 3,5 - 7,5 t	Conventional	95,8	87,1	109,2	303	275	345	0,085	0,023	0,020	0,030	0,030	0,030
Heavy Duty Vehicles	Diesel 3,5 - 7,5 t	Euro I	95,8	87,1	109,2	303	275	345	0,085	0,023	0,020	0,030	0,030	0,030
Heavy Duty Vehicles	Diesel 3,5 - 7,5 t	Euro II	95,8	87,1	109,2	303	275	345	0,085	0,023	0,020	0,030	0,030	0,030
Heavy Duty Vehicles	Diesel 3,5 - 7,5 t	Euro III	95,8	87,1	109,2	303	275	345	0,085	0,023	0,020	0,030	0,030	0,030
Heavy Duty Vehicles	Diesel 7,5 - 16 t	Conventional	186,8	147,0	169,1	590	465	534	0,085	0,023	0,020	0,030	0,030	0,030
Heavy Duty Vehicles	Diesel 7,5 - 16 t	Euro I	186,8	147,0	169,1	590	465	534	0,085	0,023	0,020	0,030	0,030	0,030
Heavy Duty Vehicles	Diesel 7,5 - 16 t	Euro II	186,8	147,0	169,1	590	465	534	0,085	0,023	0,020	0,030	0,030	0,030
Heavy Duty Vehicles	Diesel 7,5 - 16 t	Euro III	186,8	147,0	169,1	590	465	534	0,085	0,023	0,020	0,030	0,030	0,030
Heavy Duty Vehicles	Diesel 16 - 32 t	Conventional	295,3	227,0	230,7	933	717	729	0,175	0,080	0,070	0,030	0,030	0,030
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro I	295,3	227,0	230,7	933	717	729	0,175	0,080	0,070	0,030	0,030	0,030
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro II	295,3	227,0	230,7	933	717	729	0,175	0,080	0,070	0,030	0,030	0,030
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro III	295,3	227,0	230,7	933	717	729	0,175	0,080	0,070	0,030	0,030	0,030
Heavy Duty Vehicles	Diesel >32t	Conventional	392,8	311,5	297,4	1241	984	940	0,175	0,080	0,070	0,030	0,030	0,030
Heavy Duty Vehicles	Diesel >32t	Euro I	392,8	311,5	297,4	1241	984	940	0,175	0,080	0,070	0,030	0,030	0,030
Heavy Duty Vehicles	Diesel >32t	Euro II	392,8	311,5	297,4	1241	984	940	0,175	0,080	0,070	0,030	0,030	0,030
Heavy Duty Vehicles	Diesel >32t	Euro III	392,8	311,5	297,4	1241	984	940	0,175	0,080	0,070	0,030	0,030	0,030
Buses	Urban Buses	Conventional	315,8	253,3	219,0	998	800	692	0,175	0,080	0,070	0,030	0,030	0,030
Buses	Urban Buses	Euro I	315,8	253,3	219,0	998	800	692	0,175	0,080	0,070	0,030	0,030	0,030
Buses	Urban Buses	Euro II	315,8	253,3	219,0	998	800	692	0,175	0,080	0,070	0,030	0,030	0,030
Buses	Urban Buses	Euro III	315,8	253,3	219,0	998	800	692	0,175	0,080	0,070	0,030	0,030	0,030
Buses	Coaches	Conventional	281,8	214,6	198,3	890	678	627	0,175	0,080	0,070	0,030	0,030	0,030
Buses	Coaches	Euro I	281,8	214,6	198,3	890	678	627	0,175	0,080	0,070	0,030	0,030	0,030
Buses	Coaches	Euro II	281,8	214,6	198,3	890	678	627	0,175	0,080	0,070	0,030	0,030	0,030
Buses	Coaches	Euro III	281,8	214,6	198,3	890	678	627	0,175	0,080	0,070	0,030	0,030	0,030
Mopeds	<50 cm³	Conventional	25,0	25,0	0,0	80	80	0	0,219	0,000	0,000	0,001	0,000	0,000
Mopeds	<50 cm³	97/24/EC I	25,0	25,0	0,0	80	80	0	0,219	0,000	0,000	0,001	0,000	0,000
Motorcycles	2-stroke >50 cm³	Conventional	30,4	32,4	37,0	97	104	118	0,150	0,150	0,150	0,002	0,002	0,002
Motorcycles	4-stroke <250 cm³	Conventional	23,2	26,7	35,6	74	85	114	0,200	0,200	0,200	0,002	0,002	0,002
Motorcycles	4-stroke <250 cm³	97/24/EC	23,2	26,7	35,6	74	85	114	0,200	0,200	0,200	0,002	0,002	0,002
Motorcycles	4-stroke 250 - 750 cm³	Conventional	28,6	28,6	34,7	92	92	111	0,200	0,200	0,200	0,002	0,002	0,002
Motorcycles	4-stroke 250 - 750 cm³	97/24/EC	28,6	28,6	34,7	92	92	111	0,200	0,200	0,200	0,002	0,002	0,002
Motorcycles	4-stroke >750 cm³	Conventional	37,5	34,4	38,6	120	110	123	0,200	0,200	0,200	0,002	0,002	0,002
Motorcycles	4-stroke >750 cm³	97/24/EC	37,5	34,4	38,6	120	110	123	0,200	0,200	0,200	0,002	0,002	0,002

Sector	Subsector	Tech	COu	COr	COh	NOxu	NOxr	NOxh	NMVOCu	NMVOCr	NMVOCh
Passenger Cars	Gasoline <1,4 l	PRE ECE	27,505	19,333	15,520	1,849	2,062	2,023	2,262	1,568	1,221
Passenger Cars	Gasoline <1,4 l	ECE 15/00-01	18,966	14,480	18,620	1,849	2,062	2,023	1,770	1,227	1,095
Passenger Cars	Gasoline <1,4 l	ECE 15/02	15,859	8,200	8,260	1,619	2,102	2,909	1,757	1,032	0,924
Passenger Cars	Gasoline <1,4 l	ECE 15/03	16,752	8,793	7,620	1,680	2,253	3,276	1,757	1,032	0,924
Passenger Cars	Gasoline <1,4 l	ECE 15/04	9,087	4,956	4,292	1,691	2,089	2,662	1,388	0,866	0,672
Passenger Cars	Gasoline <1,4 l	Euro I	1,898	0,557	3,176	0,314	0,356	0,593	0,175	0,064	0,082
Passenger Cars	Gasoline <1,4 l	Euro II	1,898	0,557	3,176	0,314	0,356	0,593	0,175	0,064	0,082
Passenger Cars	Gasoline <1,4 l	Euro III	1,898	0,557	3,176	0,314	0,356	0,593	0,175	0,064	0,082
Passenger Cars	Gasoline 1,4 - 2,0 l	PRE ECE	27,505	19,333	15,520	2,164	2,683	3,130	2,262	1,568	1,221
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/00-01	18,966	14,480	18,620	2,164	2,683	3,130	1,770	1,227	1,095
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/02	15,859	8,200	8,260	1,831	2,377	3,283	1,757	1,032	0,924
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/03	16,752	8,793	7,620	1,917	2,580	3,472	1,757	1,032	0,924
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/04	9,087	4,956	4,292	2,122	2,757	3,524	1,388	0,866	0,672
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro I	2,583	0,937	2,402	0,323	0,349	0,530	0,138	0,066	0,067
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro II	2,583	0,937	2,402	0,323	0,349	0,530	0,138	0,066	0,067
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro III	2,583	0,937	2,402	0,323	0,349	0,530	0,138	0,066	0,067
Passenger Cars	Gasoline >2,0 l	PRE ECE	27,505	19,333	15,520	2,860	4,090	5,500	2,262	1,568	1,221
Passenger Cars	Gasoline >2,0 l	ECE 15/00-01	18,966	14,480	18,620	2,860	4,090	5,500	1,770	1,227	1,095
Passenger Cars	Gasoline >2,0 l	ECE 15/02	15,859	8,200	8,260	2,066	2,675	3,680	1,757	1,032	0,924
Passenger Cars	Gasoline >2,0 l	ECE 15/03	16,752	8,793	7,620	2,806	3,441	4,604	1,757	1,032	0,924
Passenger Cars	Gasoline >2,0 l	ECE 15/04	9,087	4,956	4,292	2,293	2,750	3,687	1,388	0,866	0,672
Passenger Cars	Gasoline >2,0 l	Euro I	3,838	0,814	0,976	0,427	0,406	0,521	0,232	0,147	0,105
Passenger Cars	Gasoline >2,0 l	Euro II	3,838	0,814	0,976	0,427	0,406	0,521	0,232	0,147	0,105
Passenger Cars	Gasoline >2,0 l	Euro III	3,838	0,814	0,976	0,427	0,406	0,521	0,232	0,147	0,105
Passenger Cars	Diesel <2,0 l	Euro I	0,432	0,109	0,165	0,679	0,488	0,619	0,073	0,028	0,020
Passenger Cars	Diesel <2,0 l	Euro II	0,432	0,109	0,165	0,679	0,488	0,619	0,073	0,028	0,020
Passenger Cars	Diesel <2,0 l	Euro III	0,432	0,109	0,165	0,679	0,488	0,619	0,073	0,028	0,020
Passenger Cars	Diesel <2,0 l	Conventional	0,651	0,472	0,384	0,520	0,433	0,528	0,141	0,081	0,052
Passenger Cars	Diesel >2,0 l	Euro I	0,432	0,109	0,165	0,679	0,488	0,619	0,073	0,028	0,020
Passenger Cars	Diesel >2,0 l	Euro II	0,432	0,109	0,165	0,679	0,488	0,619	0,073	0,028	0,020
Passenger Cars	Diesel >2,0 l	Euro III	0,432	0,109	0,165	0,679	0,488	0,619	0,073	0,028	0,020
Passenger Cars	Diesel >2,0 l	Conventional	0,651	0,472	0,384	0,824	0,723	0,861	0,141	0,081	0,052
Passenger Cars	LPG	Conventional	2,043	2,373	9,723	2,203	2,584	2,861	1,002	0,632	0,465
Passenger Cars	2-Stroke	Conventional	20,700	7,500	8,700	0,300	1,020	0,720	15,250	7,160	5,875

Sector	Subsector	Tech	COu	COr	COh	NOxu	NOxr	NOxh	NMVOCu	NMVOCr	NMVOCh
Light Duty Vehicles	Gasoline <3,5t	Conventional	14,925	6,075	7,389	2,671	3,118	3,387	1,727	0,689	0,421
Light Duty Vehicles	Gasoline <3,5t	Euro I	4,187	0,862	1,087	0,427	0,400	0,429	0,181	0,090	0,062
Light Duty Vehicles	Gasoline <3,5t	Euro II	4,187	0,862	1,087	0,427	0,400	0,429	0,181	0,090	0,062
Light Duty Vehicles	Gasoline <3,5t	Euro III	4,187	0,862	1,087	0,427	0,400	0,429	0,181	0,090	0,062
Light Duty Vehicles	Diesel <3,5 t	Conventional	1,124	1,009	1,060	1,673	0,843	0,834	0,126	0,101	0,096
Light Duty Vehicles	Diesel <3,5 t	Euro I	0,393	0,328	0,423	1,138	0,975	1,022	0,126	0,101	0,096
Light Duty Vehicles	Diesel <3,5 t	Euro II	0,393	0,328	0,423	1,138	0,975	1,022	0,126	0,101	0,096
Light Duty Vehicles	Diesel <3,5 t	Euro III	0,393	0,328	0,423	1,138	0,975	1,022	0,126	0,101	0,096
Heavy Duty Vehicles	Gasoline >3,5 t	Conventional	70,000	55,000	55,000	4,500	7,500	7,500	6,860	5,390	3,430
Heavy Duty Vehicles	Diesel 3,5 - 7,5 t	Conventional	3,156	2,170	1,777	3,247	2,169	2,615	1,688	1,082	0,838
Heavy Duty Vehicles	Diesel 3,5 - 7,5 t	Euro I	3,156	2,170	1,777	3,247	2,169	2,615	1,688	1,082	0,838
Heavy Duty Vehicles	Diesel 3,5 - 7,5 t	Euro II	3,156	2,170	1,777	3,247	2,169	2,615	1,688	1,082	0,838
Heavy Duty Vehicles	Diesel 3,5 - 7,5 t	Euro III	3,156	2,170	1,777	3,247	2,169	2,615	1,688	1,082	0,838
Heavy Duty Vehicles	Diesel 7,5 - 16 t	Conventional	3,156	2,170	1,777	6,684	4,293	4,091	1,688	1,082	0,838
Heavy Duty Vehicles	Diesel 7,5 - 16 t	Euro I	3,156	2,170	1,777	6,684	4,293	4,091	1,688	1,082	0,838
Heavy Duty Vehicles	Diesel 7,5 - 16 t	Euro II	3,156	2,170	1,777	6,684	4,293	4,091	1,688	1,082	0,838
Heavy Duty Vehicles	Diesel 7,5 - 16 t	Euro III	3,156	2,170	1,777	6,684	4,293	4,091	1,688	1,082	0,838
Heavy Duty Vehicles	Diesel 16 - 32 t	Conventional	3,156	2,170	1,777	12,561	9,060	7,610	1,598	1,025	0,788
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro I	3,156	2,170	1,777	12,561	9,060	7,610	1,598	1,025	0,788
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro II	3,156	2,170	1,777	12,561	9,060	7,610	1,598	1,025	0,788
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro III	3,156	2,170	1,777	12,561	9,060	7,610	1,598	1,025	0,788
Heavy Duty Vehicles	Diesel >32t	Conventional	3,156	2,170	1,777	18,269	13,523	11,517	1,598	1,025	0,788
Heavy Duty Vehicles	Diesel >32t	Euro I	3,156	2,170	1,777	18,269	13,523	11,517	1,598	1,025	0,788
Heavy Duty Vehicles	Diesel >32t	Euro II	3,156	2,170	1,777	18,269	13,523	11,517	1,598	1,025	0,788
Heavy Duty Vehicles	Diesel >32t	Euro III	3,156	2,170	1,777	18,269	13,523	11,517	1,598	1,025	0,788
Buses	Urban Buses	Conventional	4,687	3,204	2,494	15,288	11,731	9,853	1,138	0,696	0,479
Buses	Urban Buses	Euro I	4,687	3,204	2,494	15,288	11,731	9,853	1,138	0,696	0,479
Buses	Urban Buses	Euro II	4,687	3,204	2,494	15,288	11,731	9,853	1,138	0,696	0,479
Buses	Urban Buses	Euro III	4,687	3,204	2,494	15,288	11,731	9,853	1,138	0,696	0,479
Buses	Coaches	Conventional	3,227	2,053	1,612	12,210	8,260	7,844	1,713	1,090	0,837
Buses	Coaches	Euro I	3,227	2,053	1,612	12,210	8,260	7,844	1,713	1,090	0,837
Buses	Coaches	Euro II	3,227	2,053	1,612	12,210	8,260	7,844	1,713	1,090	0,837
Buses	Coaches	Euro III	3,227	2,053	1,612	12,210	8,260	7,844	1,713	1,090	0,837
Mopeds	<50 cm^3	Conventional	15,000	15,000	0,000	0,030	0,030	0,000	8,781	9,000	0,000
Mopeds	<50 cm^3	97/24/EC I	15,000	15,000	0,000	0,030	0,030	0,000	8,781	9,000	0,000
Motorcycles	2-stroke >50 cm^3	Conventional	23,380	25,490	27,500	0,032	0,088	0,133	9,190	8,252	8,210
Motorcycles	4-stroke <250 cm^3	Conventional	22,380	26,300	38,600	0,130	0,242	0,362	1,350	0,760	1,120
Motorcycles	4-stroke <250 cm^3	97/24/EC	22,380	26,300	38,600	0,130	0,242	0,362	1,350	0,760	1,120
Motorcycles	4-stroke 250 - 750 cm^3	Conventional	20,440	21,517	25,810	0,136	0,251	0,374	1,150	0,744	0,810
Motorcycles	4-stroke 250 - 750 cm^3	97/24/EC	20,440	21,517	25,810	0,136	0,251	0,374	1,150	0,744	0,810
Motorcycles	4-stroke >750 cm^3	Conventional	14,880	18,030	24,300	0,148	0,266	0,392	2,320	1,410	0,990
Motorcycles	4-stroke >750 cm^3	97/24/EC	14,880	18,030	24,300	0,148	0,266	0,392	2,320	1,410	0,990

Sector	Subsector	Tech	NH3u	NH3r	NH3h
Passenger Cars	Gasoline <1,4 l	PRE ECE	0,002	0,002	0,002
Passenger Cars	Gasoline <1,4 l	ECE 15/00-01	0,002	0,002	0,002
Passenger Cars	Gasoline <1,4 l	ECE 15/02	0,002	0,002	0,002
Passenger Cars	Gasoline <1,4 l	ECE 15/03	0,002	0,002	0,002
Passenger Cars	Gasoline <1,4 l	ECE 15/04	0,002	0,002	0,002
Passenger Cars	Gasoline <1,4 l	Euro I	0,070	0,100	0,100
Passenger Cars	Gasoline <1,4 l	Euro II	0,070	0,100	0,100
Passenger Cars	Gasoline <1,4 l	Euro III	0,070	0,100	0,100
Passenger Cars	Gasoline 1,4 - 2,0 l	PRE ECE	0,002	0,002	0,002
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/00-01	0,002	0,002	0,002
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/02	0,002	0,002	0,002
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/03	0,002	0,002	0,002
Passenger Cars	Gasoline 1,4 - 2,0 l	ECE 15/04	0,002	0,002	0,002
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro I	0,070	0,100	0,100
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro II	0,070	0,100	0,100
Passenger Cars	Gasoline 1,4 - 2,0 l	Euro III	0,070	0,100	0,100
Passenger Cars	Gasoline >2,0 l	PRE ECE	0,002	0,002	0,002
Passenger Cars	Gasoline >2,0 l	ECE 15/00-01	0,002	0,002	0,002
Passenger Cars	Gasoline >2,0 l	ECE 15/02	0,002	0,002	0,002
Passenger Cars	Gasoline >2,0 l	ECE 15/03	0,002	0,002	0,002
Passenger Cars	Gasoline >2,0 l	ECE 15/04	0,002	0,002	0,002
Passenger Cars	Gasoline >2,0 l	Euro I	0,070	0,100	0,100
Passenger Cars	Gasoline >2,0 l	Euro II	0,070	0,100	0,100
Passenger Cars	Gasoline >2,0 l	Euro III	0,070	0,100	0,100
Passenger Cars	Diesel <2,0 l	Euro I	0,001	0,001	0,001
Passenger Cars	Diesel <2,0 l	Euro II	0,001	0,001	0,001
Passenger Cars	Diesel <2,0 l	Euro III	0,001	0,001	0,001
Passenger Cars	Diesel <2,0 l	Conventional	0,001	0,001	0,001
Passenger Cars	Diesel >2,0 l	Euro I	0,001	0,001	0,001
Passenger Cars	Diesel >2,0 l	Euro II	0,001	0,001	0,001
Passenger Cars	Diesel >2,0 l	Euro III	0,001	0,001	0,001
Passenger Cars	Diesel >2,0 l	Conventional	0,001	0,001	0,001
Passenger Cars	LPG	Conventional	0,000	0,000	0,000
Passenger Cars	2-Stroke	Conventional	0,002	0,002	0,002

Sector	Subsector	Tech	NH3u	NH3r	NH3h
Light Duty Vehicles	Gasoline <3,5t	Conventional	0,002	0,002	0,002
Light Duty Vehicles	Gasoline <3,5t	Euro I	0,070	0,100	0,100
Light Duty Vehicles	Gasoline <3,5t	Euro II	0,070	0,100	0,100
Light Duty Vehicles	Gasoline <3,5t	Euro III	0,070	0,100	0,100
Light Duty Vehicles	Diesel <3,5 t	Conventional	0,001	0,001	0,001
Light Duty Vehicles	Diesel <3,5 t	Euro I	0,001	0,001	0,001
Light Duty Vehicles	Diesel <3,5 t	Euro II	0,001	0,001	0,001
Light Duty Vehicles	Diesel <3,5 t	Euro III	0,001	0,001	0,001
Heavy Duty Vehicles	Gasoline >3,5 t	Conventional	0,002	0,002	0,002
Heavy Duty Vehicles	Diesel 3,5 - 7,5 t	Conventional	0,003	0,003	0,003
Heavy Duty Vehicles	Diesel 3,5 - 7,5 t	Euro I	0,003	0,003	0,003
Heavy Duty Vehicles	Diesel 3,5 - 7,5 t	Euro II	0,003	0,003	0,003
Heavy Duty Vehicles	Diesel 3,5 - 7,5 t	Euro III	0,003	0,003	0,003
Heavy Duty Vehicles	Diesel 7,5 - 16 t	Conventional	0,003	0,003	0,003
Heavy Duty Vehicles	Diesel 7,5 - 16 t	Euro I	0,003	0,003	0,003
Heavy Duty Vehicles	Diesel 7,5 - 16 t	Euro II	0,003	0,003	0,003
Heavy Duty Vehicles	Diesel 7,5 - 16 t	Euro III	0,003	0,003	0,003
Heavy Duty Vehicles	Diesel 16 - 32 t	Conventional	0,003	0,003	0,003
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro I	0,003	0,003	0,003
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro II	0,003	0,003	0,003
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro III	0,003	0,003	0,003
Heavy Duty Vehicles	Diesel >32t	Conventional	0,003	0,003	0,003
Heavy Duty Vehicles	Diesel >32t	Euro I	0,003	0,003	0,003
Heavy Duty Vehicles	Diesel >32t	Euro II	0,003	0,003	0,003
Heavy Duty Vehicles	Diesel >32t	Euro III	0,003	0,003	0,003
Buses	Urban Buses	Conventional	0,003	0,003	0,003
Buses	Urban Buses	Euro I	0,003	0,003	0,003
Buses	Urban Buses	Euro II	0,003	0,003	0,003
Buses	Urban Buses	Euro III	0,003	0,003	0,003
Buses	Coaches	Conventional	0,003	0,003	0,003
Buses	Coaches	Euro I	0,003	0,003	0,003
Buses	Coaches	Euro II	0,003	0,003	0,003
Buses	Coaches	Euro III	0,003	0,003	0,003
Mopeds	<50 cm^3	Conventional	0,001	0,001	0,000
Mopeds	<50 cm^3	97/24/EC I	0,001	0,001	0,000
Motorcycles	2-stroke >50 cm^3	Conventional	0,002	0,002	0,002
Motorcycles	4-stroke <250 cm^3	Conventional	0,002	0,002	0,002
Motorcycles	4-stroke <250 cm^3	97/24/EC	0,002	0,002	0,002
Motorcycles	4-stroke 250 - 750 cm^3	Conventional	0,002	0,002	0,002
Motorcycles	4-stroke 250 - 750 cm^3	97/24/EC	0,002	0,002	0,002
Motorcycles	4-stroke >750 cm^3	Conventional	0,002	0,002	0,002
Motorcycles	4-stroke >750 cm^3	97/24/EC	0,002	0,002	0,002

Annex 3.B.3 Fuel use factors (MJ/km) and emission factors (g/km)

Year	Sector	FCu (MJ)	FCr (MJ)	FCh (MJ)	CO2u	CO2r	CO2h	CH4u	CH4r	CH4h	N2Ou	N2Or	N2Oh	SO2u	SO2r	SO2h
1990	Passenger Cars	3,082	2,054	2,318	225	150	169	0,143	0,027	0,024	0,008	0,007	0,008	0,031	0,020	0,023
1991	Passenger Cars	3,121	2,036	2,297	228	149	168	0,157	0,026	0,024	0,011	0,008	0,010	0,030	0,019	0,023
1992	Passenger Cars	3,133	2,020	2,276	229	148	166	0,165	0,025	0,023	0,014	0,009	0,011	0,021	0,014	0,016
1993	Passenger Cars	3,161	2,003	2,255	231	146	165	0,181	0,025	0,023	0,017	0,009	0,013	0,012	0,008	0,009
1994	Passenger Cars	3,162	1,981	2,226	231	145	163	0,189	0,024	0,022	0,021	0,010	0,016	0,012	0,008	0,009
1995	Passenger Cars	3,213	1,960	2,202	235	143	161	0,208	0,023	0,021	0,025	0,011	0,018	0,013	0,008	0,009
1996	Passenger Cars	3,275	1,945	2,182	239	142	159	0,234	0,022	0,021	0,028	0,012	0,020	0,013	0,008	0,009
1997	Passenger Cars	3,225	1,912	2,142	236	140	157	0,215	0,020	0,019	0,032	0,013	0,023	0,013	0,008	0,009
1998	Passenger Cars	3,201	1,901	2,128	234	139	156	0,198	0,018	0,017	0,034	0,013	0,024	0,013	0,008	0,009
1999	Passenger Cars	3,218	1,886	2,110	235	138	154	0,194	0,016	0,015	0,037	0,014	0,026	0,010	0,006	0,007
2000	Passenger Cars	3,207	1,875	2,097	234	137	153	0,187	0,014	0,014	0,038	0,015	0,027	0,007	0,004	0,005
2001	Passenger Cars	3,241	1,865	2,085	237	136	152	0,188	0,013	0,013	0,040	0,015	0,028	0,007	0,004	0,005
2002	Passenger Cars	3,205	1,860	2,079	234	136	152	0,167	0,012	0,012	0,041	0,016	0,029	0,007	0,004	0,005
1990	Light Duty Vehicles	3,842	2,792	3,007	284	206	222	0,038	0,009	0,007	0,016	0,016	0,016	0,312	0,233	0,255
1991	Light Duty Vehicles	3,872	2,792	3,007	286	206	222	0,040	0,009	0,007	0,016	0,016	0,016	0,314	0,233	0,254
1992	Light Duty Vehicles	3,873	2,790	3,002	286	206	222	0,042	0,010	0,008	0,016	0,016	0,016	0,202	0,150	0,164
1993	Light Duty Vehicles	3,907	2,790	2,999	289	206	222	0,044	0,010	0,008	0,016	0,016	0,016	0,079	0,058	0,063
1994	Light Duty Vehicles	3,945	2,791	3,002	291	206	222	0,044	0,010	0,008	0,016	0,016	0,016	0,080	0,058	0,064
1995	Light Duty Vehicles	3,937	2,771	2,979	291	205	220	0,044	0,009	0,007	0,016	0,016	0,016	0,080	0,058	0,063
1996	Light Duty Vehicles	3,973	2,752	2,959	293	203	219	0,046	0,009	0,007	0,017	0,016	0,016	0,080	0,057	0,062
1997	Light Duty Vehicles	3,900	2,732	2,939	288	202	217	0,041	0,009	0,007	0,017	0,016	0,017	0,079	0,057	0,062
1998	Light Duty Vehicles	3,851	2,714	2,918	284	200	216	0,040	0,008	0,007	0,018	0,016	0,017	0,078	0,056	0,062
1999	Light Duty Vehicles	3,846	2,697	2,900	284	199	214	0,038	0,008	0,007	0,018	0,016	0,017	0,043	0,031	0,034
2000	Light Duty Vehicles	3,816	2,681	2,883	282	198	213	0,036	0,008	0,007	0,018	0,016	0,017	0,009	0,006	0,007
2001	Light Duty Vehicles	3,821	2,663	2,866	282	197	212	0,034	0,007	0,006	0,019	0,016	0,018	0,009	0,006	0,007
2002	Light Duty Vehicles	3,782	2,647	2,845	279	196	210	0,032	0,007	0,006	0,019	0,016	0,018	0,009	0,006	0,007

Year	Sector	FCu (MJ)	FCr (MJ)	FCh (MJ)	CO2u	CO2r	CO2h	CH4u	CH4r	CH4h	N2Ou	N2Or	N2Oh	SO2u	SO2r	SO2h
1990	Heavy Duty Vehicles	11,965	9,685	10,256	885	717	759	0,151	0,067	0,063	0,030	0,030	0,030	1,119	0,906	0,960
1991	Heavy Duty Vehicles	12,016	9,691	10,226	889	717	757	0,151	0,066	0,062	0,030	0,030	0,030	1,124	0,907	0,957
1992	Heavy Duty Vehicles	12,023	9,677	10,218	890	716	756	0,152	0,066	0,062	0,030	0,030	0,030	0,731	0,588	0,622
1993	Heavy Duty Vehicles	11,898	9,723	10,189	880	719	754	0,150	0,067	0,062	0,030	0,030	0,030	0,278	0,227	0,238
1994	Heavy Duty Vehicles	11,929	9,663	10,141	883	715	750	0,146	0,065	0,061	0,030	0,030	0,030	0,279	0,226	0,237
1995	Heavy Duty Vehicles	11,911	9,673	10,013	881	716	741	0,142	0,064	0,059	0,030	0,030	0,030	0,278	0,226	0,234
1996	Heavy Duty Vehicles	11,938	9,657	10,026	883	715	742	0,137	0,061	0,058	0,030	0,030	0,030	0,279	0,226	0,235
1997	Heavy Duty Vehicles	12,176	9,836	10,152	901	728	751	0,133	0,061	0,057	0,030	0,030	0,030	0,285	0,230	0,238
1998	Heavy Duty Vehicles	12,246	9,904	10,209	906	733	755	0,129	0,059	0,056	0,030	0,030	0,030	0,286	0,232	0,239
1999	Heavy Duty Vehicles	12,389	10,028	10,306	917	742	763	0,126	0,059	0,055	0,030	0,030	0,030	0,159	0,129	0,133
2000	Heavy Duty Vehicles	12,422	10,055	10,329	919	744	764	0,121	0,057	0,053	0,030	0,030	0,030	0,029	0,024	0,024
2001	Heavy Duty Vehicles	12,685	10,273	10,476	939	760	775	0,121	0,057	0,053	0,030	0,030	0,030	0,030	0,024	0,025
2002	Heavy Duty Vehicles	12,739	10,323	10,510	943	764	778	0,114	0,055	0,051	0,030	0,030	0,030	0,030	0,024	0,025
1990	2-wheelers	1,173	1,245	1,578	86	91	115	0,209	0,130	0,192	0,001	0,001	0,002	0,003	0,004	0,005
1991	2-wheelers	1,182	1,242	1,578	86	91	115	0,208	0,127	0,193	0,001	0,001	0,002	0,003	0,003	0,004
1992	2-wheelers	1,178	1,253	1,578	86	91	115	0,209	0,137	0,192	0,001	0,001	0,002	0,003	0,003	0,004
1993	2-wheelers	1,190	1,249	1,578	87	91	115	0,207	0,133	0,192	0,001	0,001	0,002	0,003	0,003	0,004
1994	2-wheelers	1,188	1,258	1,578	87	92	115	0,207	0,141	0,193	0,001	0,001	0,002	0,003	0,003	0,004
1995	2-wheelers	1,182	1,254	1,578	86	92	115	0,208	0,137	0,193	0,001	0,001	0,002	0,003	0,003	0,004
1996	2-wheelers	1,185	1,256	1,578	86	92	115	0,208	0,139	0,193	0,001	0,001	0,002	0,003	0,003	0,004
1997	2-wheelers	1,186	1,257	1,578	87	92	115	0,208	0,140	0,192	0,001	0,001	0,002	0,003	0,003	0,004
1998	2-wheelers	1,186	1,257	1,578	87	92	115	0,208	0,140	0,193	0,001	0,001	0,002	0,003	0,003	0,004
1999	2-wheelers	1,195	1,264	1,578	87	92	115	0,207	0,146	0,192	0,001	0,002	0,002	0,003	0,003	0,004
2000	2-wheelers	1,198	1,265	1,572	87	92	115	0,202	0,150	0,193	0,001	0,002	0,002	0,003	0,003	0,004
2001	2-wheelers	1,210	1,272	1,568	88	93	114	0,199	0,158	0,193	0,002	0,002	0,002	0,003	0,003	0,004
2002	2-wheelers	1,209	1,271	1,566	88	93	114	0,197	0,159	0,193	0,002	0,002	0,002	0,003	0,003	0,004

Year	Sector	NOxu	NOxr	NOxh	NMVOCu	NMVOCr	NMVOCh	COu	COr	COh	NH3u	NH3r	NH3h
1990	Passenger Cars	1,791	2,142	2,763	2,527	0,929	0,787	26,382	7,625	7,554	0,004	0,004	0,004
1991	Passenger Cars	1,718	2,014	2,609	2,520	0,864	0,732	26,666	7,061	7,065	0,008	0,011	0,011
1992	Passenger Cars	1,649	1,901	2,475	2,416	0,804	0,681	25,631	6,538	6,663	0,012	0,017	0,017
1993	Passenger Cars	1,595	1,798	2,356	2,402	0,746	0,633	25,790	6,025	6,323	0,016	0,023	0,023
1994	Passenger Cars	1,488	1,624	2,149	2,200	0,654	0,555	23,663	5,243	5,741	0,023	0,032	0,032
1995	Passenger Cars	1,430	1,495	1,993	2,157	0,584	0,497	23,607	4,701	5,507	0,027	0,039	0,039
1996	Passenger Cars	1,393	1,395	1,875	2,176	0,526	0,449	24,352	4,267	5,365	0,032	0,045	0,045
1997	Passenger Cars	1,283	1,240	1,694	1,835	0,435	0,376	20,485	3,464	4,975	0,037	0,053	0,053
1998	Passenger Cars	1,197	1,129	1,549	1,619	0,382	0,329	18,258	3,057	4,674	0,040	0,057	0,057
1999	Passenger Cars	1,102	0,995	1,369	1,477	0,322	0,277	17,050	2,617	4,306	0,043	0,062	0,062
2000	Passenger Cars	1,027	0,893	1,232	1,335	0,277	0,238	15,805	2,309	4,104	0,046	0,065	0,065
2001	Passenger Cars	0,958	0,796	1,107	1,261	0,234	0,203	15,723	2,064	4,048	0,048	0,069	0,069
2002	Passenger Cars	0,907	0,749	1,041	1,119	0,213	0,185	14,127	1,911	3,885	0,048	0,068	0,068
1990	Light Duty Vehicles	1,960	1,117	1,141	0,546	0,171	0,135	5,044	1,620	1,823	0,001	0,001	0,001
1991	Light Duty Vehicles	1,979	1,118	1,143	0,568	0,172	0,135	5,242	1,622	1,826	0,001	0,001	0,001
1992	Light Duty Vehicles	1,981	1,138	1,165	0,586	0,177	0,138	5,453	1,666	1,881	0,001	0,001	0,001
1993	Light Duty Vehicles	2,004	1,147	1,176	0,620	0,179	0,140	5,785	1,688	1,908	0,001	0,001	0,001
1994	Light Duty Vehicles	2,006	1,135	1,162	0,618	0,176	0,138	5,767	1,661	1,874	0,001	0,001	0,001
1995	Light Duty Vehicles	1,945	1,115	1,144	0,605	0,170	0,134	5,616	1,553	1,758	0,002	0,002	0,002
1996	Light Duty Vehicles	1,907	1,091	1,121	0,612	0,163	0,130	5,646	1,441	1,636	0,003	0,003	0,003
1997	Light Duty Vehicles	1,811	1,064	1,094	0,543	0,154	0,125	4,957	1,317	1,500	0,003	0,004	0,004
1998	Light Duty Vehicles	1,735	1,050	1,082	0,507	0,149	0,122	4,638	1,232	1,410	0,004	0,005	0,005
1999	Light Duty Vehicles	1,688	1,031	1,064	0,487	0,142	0,118	4,399	1,137	1,307	0,004	0,006	0,006
2000	Light Duty Vehicles	1,629	1,018	1,052	0,459	0,137	0,115	4,159	1,064	1,229	0,005	0,007	0,007
2001	Light Duty Vehicles	1,593	0,998	1,032	0,442	0,130	0,111	3,903	0,964	1,119	0,005	0,007	0,007
2002	Light Duty Vehicles	1,504	0,974	1,010	0,407	0,123	0,105	3,675	0,891	1,044	0,006	0,008	0,008

Year	Sector	NOxu	NOxr	NOxh	NMVOCu	NMVOCr	NMVOCh	COu	COr	COh	NH3u	NH3r	NH3h
1990	Heavy Duty Vehicles	12,379	9,166	8,502	1,527	1,007	0,792	3,707	2,411	1,857	0,003	0,003	0,003
1991	Heavy Duty Vehicles	12,423	9,174	8,460	1,532	1,007	0,792	3,687	2,414	1,862	0,003	0,003	0,003
1992	Heavy Duty Vehicles	12,435	9,145	8,456	1,532	1,011	0,792	3,700	2,413	1,866	0,003	0,003	0,003
1993	Heavy Duty Vehicles	12,272	9,212	8,433	1,538	1,008	0,792	3,707	2,420	1,872	0,003	0,003	0,003
1994	Heavy Duty Vehicles	11,939	8,820	8,092	1,475	0,986	0,775	3,588	2,323	1,814	0,003	0,003	0,003
1995	Heavy Duty Vehicles	11,490	8,527	7,722	1,439	0,964	0,761	3,411	2,225	1,757	0,003	0,003	0,003
1996	Heavy Duty Vehicles	11,123	8,241	7,455	1,396	0,938	0,745	3,260	2,156	1,704	0,003	0,003	0,003
1997	Heavy Duty Vehicles	10,798	8,035	7,206	1,331	0,903	0,721	3,070	2,044	1,632	0,003	0,003	0,003
1998	Heavy Duty Vehicles	10,374	7,747	6,917	1,283	0,876	0,700	2,941	1,970	1,586	0,003	0,003	0,003
1999	Heavy Duty Vehicles	10,019	7,524	6,684	1,234	0,849	0,680	2,795	1,885	1,535	0,003	0,003	0,003
2000	Heavy Duty Vehicles	9,598	7,227	6,410	1,193	0,826	0,663	2,686	1,824	1,500	0,003	0,003	0,003
2001	Heavy Duty Vehicles	9,526	7,161	6,252	1,148	0,803	0,645	2,625	1,770	1,467	0,003	0,003	0,003
2002	Heavy Duty Vehicles	8,842	6,686	5,823	1,071	0,757	0,611	2,455	1,671	1,398	0,003	0,003	0,003
1990	2-wheelers	0,064	0,164	0,340	6,532	4,283	2,011	16,842	19,852	27,917	0,001	0,001	0,002
1991	2-wheelers	0,068	0,161	0,340	6,249	4,379	2,011	17,073	19,753	27,917	0,001	0,001	0,002
1992	2-wheelers	0,066	0,171	0,340	6,372	4,042	2,011	16,972	20,099	27,917	0,001	0,001	0,002
1993	2-wheelers	0,071	0,167	0,340	6,033	4,187	2,011	17,250	19,950	27,917	0,001	0,001	0,002
1994	2-wheelers	0,070	0,175	0,340	6,097	3,880	2,011	17,197	20,267	27,917	0,001	0,001	0,002
1995	2-wheelers	0,068	0,171	0,340	6,271	4,023	2,011	17,055	20,119	27,917	0,001	0,001	0,002
1996	2-wheelers	0,069	0,173	0,340	6,184	3,960	2,011	17,126	20,184	27,917	0,001	0,001	0,002
1997	2-wheelers	0,069	0,174	0,340	6,153	3,931	2,011	17,152	20,214	27,917	0,001	0,001	0,002
1998	2-wheelers	0,069	0,174	0,340	6,145	3,924	2,011	17,158	20,221	27,917	0,001	0,001	0,002
1999	2-wheelers	0,073	0,180	0,340	5,895	3,704	2,011	17,363	20,448	27,917	0,001	0,002	0,002
2000	2-wheelers	0,077	0,186	0,342	5,549	3,417	1,980	17,021	20,004	27,414	0,001	0,002	0,002
2001	2-wheelers	0,084	0,196	0,345	5,073	3,064	1,933	16,990	19,880	26,948	0,002	0,002	0,002
2002	2-wheelers	0,086	0,198	0,348	4,875	2,899	1,877	16,784	19,690	26,937	0,002	0,002	0,002

Annex 3.B.4 Fuel use (GJ) and emissions (tons) per vehicle category and as totals

Year	Sector	FC (GJ)	CO2	CH4	N2O	SO2	NOx	NMVOC	CO	NH3
1990	Passenger Cars	69608254	5087105	2079	214	687	57332	71086	427990	110
1991	Passenger Cars	73816548	5394444	2334	280	709	57836	71423	443231	281
1992	Passenger Cars	77348442	5652313	2467	347	526	58614	70458	434504	464
1993	Passenger Cars	79376296	5800343	2719	407	307	57397	68127	438753	639
1994	Passenger Cars	82258416	6010935	2876	511	318	55069	63930	410796	940
1995	Passenger Cars	83450719	6098344	3038	587	329	52947	59334	396227	1178
1996	Passenger Cars	84286667	6159584	3288	651	335	50991	55425	394948	1374
1997	Passenger Cars	86483699	6320175	3139	761	344	48026	49139	347652	1694
1998	Passenger Cars	88522087	6469358	2975	833	356	45484	44559	320454	1894
1999	Passenger Cars	89167631	6517606	2903	896	292	41094	39478	297453	2054
2000	Passenger Cars	88595697	6476748	2769	938	203	37329	32628	274087	2159
2001	Passenger Cars	88434195	6465693	2751	981	202	33750	28933	267408	2273
2002	Passenger Cars	89468068	6542849	2503	1013	205	32435	26637	247451	2310
1990	Light Duty Vehicles	23115080	1707662	149	112	1906	10428	3091	21687	8
1991	Light Duty Vehicles	23957024	1769846	159	115	1974	10830	3248	23002	8
1992	Light Duty Vehicles	23479719	1734385	160	112	1248	10678	3305	23176	8
1993	Light Duty Vehicles	23450531	1732124	167	112	481	10731	3389	24109	8
1994	Light Duty Vehicles	24974574	1844855	167	120	516	11211	3480	24458	9
1995	Light Duty Vehicles	24505598	1810121	164	121	504	10790	3295	23171	16
1996	Light Duty Vehicles	25221292	1862973	170	127	519	10851	3235	23111	24
1997	Light Duty Vehicles	25453281	1880204	159	132	526	10671	2991	21012	31
1998	Light Duty Vehicles	24752576	1828342	151	132	509	10197	2750	19304	37
1999	Light Duty Vehicles	25068712	1851738	146	136	287	10138	2630	18457	43
2000	Light Duty Vehicles	25282013	1867429	141	139	59	10060	2415	17666	49
2001	Light Duty Vehicles	25520318	1885224	135	143	60	9976	2282	16600	52
2002	Light Duty Vehicles	26775092	1977649	134	153	62	10146	2239	16450	65

Year	Sector	FC (GJ)	CO2	CH4	N2O	SO2	NOx	NMVOC	CO	NH3
1990	Heavy Duty Vehicles	33933165	2511006	298	96	3174	32300	3614	8675	9
1991	Heavy Duty Vehicles	34424256	2547345	301	98	3220	32781	3671	8792	9
1992	Heavy Duty Vehicles	33656314	2490515	295	96	2046	32044	3600	8622	9
1993	Heavy Duty Vehicles	33365322	2468980	292	95	780	31668	3560	8537	9
1994	Heavy Duty Vehicles	35732489	2644149	295	103	836	32553	3654	8705	10
1995	Heavy Duty Vehicles	36314627	2687228	293	105	849	31921	3638	8483	10
1996	Heavy Duty Vehicles	37071644	2743246	290	107	867	31494	3613	8346	10
1997	Heavy Duty Vehicles	37390997	2766891	282	106	875	30309	3433	7827	10
1998	Heavy Duty Vehicles	38573775	2854414	281	109	902	29875	3403	7719	10
1999	Heavy Duty Vehicles	39439479	2918480	277	110	508	29210	3320	7452	10
2000	Heavy Duty Vehicles	38127592	2821398	259	106	89	27017	3110	6950	10
2001	Heavy Duty Vehicles	38708387	2864376	257	106	91	26531	2991	6725	10
2002	Heavy Duty Vehicles	37849451	2800810	237	103	89	24060	2737	6175	10
1990	2-wheelers	618260	45133	93	1	2	59	2984	9392	1
1991	2-wheelers	647664	47280	98	1	2	59	3092	9806	1
1992	2-wheelers	673027	49131	101	1	2	65	3136	10261	1
1993	2-wheelers	693419	50620	104	1	2	65	3175	10540	1
1994	2-wheelers	704846	51454	106	1	2	70	3139	10790	1
1995	2-wheelers	714032	52124	107	1	2	73	3210	10957	1
1996	2-wheelers	755112	55123	113	1	2	74	3420	11533	1
1997	2-wheelers	803775	58676	121	1	2	79	3632	12287	1
1998	2-wheelers	866101	63225	130	1	2	86	3905	13242	1
1999	2-wheelers	854128	62351	128	1	2	88	3655	13144	1
2000	2-wheelers	879655	64215	130	1	2	95	3472	13267	1
2001	2-wheelers	790185	57683	116	1	2	91	2820	11803	1
2002	2-wheelers	933578	68151	136	1	2	110	3202	13836	1
1990	Total	127274759	9350906	2620	423	5769	100118	80774	467745	128
1991	Total	132845492	9758915	2891	494	5905	101506	81436	484830	299
1992	Total	135157502	9926345	3024	556	3822	101402	80499	476563	482
1993	Total	136885568	10052066	3283	615	1571	99862	78250	481940	656
1994	Total	143670326	10551393	3444	735	1671	98904	74203	454750	959
1995	Total	144984976	10647817	3602	813	1684	95730	69476	438837	1204
1996	Total	147334715	10820927	3862	886	1723	93410	65693	437939	1408
1997	Total	150131752	11025946	3700	1000	1746	89086	59195	388778	1735
1998	Total	152714538	11215339	3536	1074	1769	85642	54617	360719	1943
1999	Total	154529949	11350175	3454	1143	1089	80531	49083	336505	2108
2000	Total	152884957	11229790	3299	1185	353	74501	41624	311969	2219
2001	Total	153453085	11272977	3259	1230	355	70348	37026	302537	2336
2002	Total	155026190	11389459	3010	1270	358	66749	34814	283912	2386

Annex 3.B.5 Emission factors and total emissions for 1990 and 2002 in CollectER format

Year	SNAP ID	Category	Fuel type	Mode	Fuel [GJ]	SO2 [g/GJ]	NOx [g/GJ]	NMVOC [g/GJ]	CH4 [g/GJ]	CO [g/GJ]	CO2 [kg/GJ]	NH3 [g/GJ]	N2O [g/GJ]	TSP [g/GJ]
1990	70101	Passenger cars	Diesel	Highway driving	716028	93,68	253,78	24,51	4,30	179,70	74	12,62	0,47	79,48
1990	70101	Passenger cars	Gasoline 2-stroke	Highway driving	1512	2,97	288,90	2357,34	10,03	3490,86	73	2,01	0,80	48,15
1990	70101	Passenger cars	Gasoline conventional	Highway driving	28730	2,25	1311,04	369,53	11,10	3612,94	73	2,13	0,85	12,33
1990	70101	Passenger cars	Gasoline catalyst	Highway driving	7394952	1,95	190,36	35,59	7,47	943,80	73	16,76	47,89	0,34
1990	70101	Passenger cars	LPG	Highway driving	183522	0,00	1151,70	187,09	10,06	3914,25	65	6,04	0,00	10,06
1990	70102	Passenger cars	Diesel	Rural driving	2039148	93,68	253,33	46,16	2,75	268,08	74	15,34	0,57	75,13
1990	70102	Passenger cars	Gasoline 2-stroke	Rural driving	4361	2,97	352,84	2476,82	13,84	2594,44	73	1,73	0,69	41,51
1990	70102	Passenger cars	Gasoline conventional	Rural driving	115355	2,24	1139,51	488,47	13,94	4110,62	73	2,40	0,96	14,24
1990	70102	Passenger cars	Gasoline catalyst	Rural driving	22799974	1,95	143,35	42,55	9,25	370,07	73	8,53	53,34	0,37
1990	70102	Passenger cars	LPG	Rural driving	570376	0,00	1248,46	305,18	16,91	1146,38	65	7,25	0,00	14,49
1990	70103	Passenger cars	Diesel	Urban driving	3046172	93,68	208,31	85,82	2,37	310,69	74	9,59	0,36	117,16
1990	70103	Passenger cars	Gasoline 2-stroke	Urban driving	6471	2,97	61,43	3122,63	30,71	4238,59	73	1,02	0,41	24,57
1990	70103	Passenger cars	Gasoline conventional	Urban driving	181888	2,25	633,42	894,14	50,15	9534,02	73	1,62	0,65	13,98
1990	70103	Passenger cars	Gasoline catalyst	Urban driving	31532452	1,95	163,59	299,31	68,50	3772,36	73	15,24	20,13	0,32
1990	70103	Passenger cars	LPG	Urban driving	987315	0,00	642,80	421,67	33,67	1249,98	65	4,56	0,00	12,16
1990	70201	Light duty vehicles	Diesel	Highway driving	2313348	93,68	270,67	31,16	1,62	344,14	74	5,52	0,32	104,48
1990	70201	Light duty vehicles	Gasoline conventional	Highway driving	254498	2,97	1369,26	170,29	10,11	2987,40	73	2,43	0,81	16,17
1990	70201	Light duty vehicles	Gasoline catalyst	Highway driving	0	0,00	0,00	0,00	0,00	0,00	73	0,00	0,00	0,00
1990	70202	Light duty vehicles	Diesel	Rural driving	8280955	93,68	299,25	35,71	1,78	358,42	74	6,04	0,36	107,73
1990	70202	Light duty vehicles	Gasoline conventional	Rural driving	1057020	2,97	1188,86	262,59	15,25	2316,18	73	2,29	0,76	15,25
1990	70202	Light duty vehicles	Gasoline catalyst	Rural driving	0	0,00	0,00	0,00	0,00	0,00	73	0,00	0,00	0,00
1990	70203	Light duty vehicles	Diesel	Urban driving	9666704	93,68	489,77	57,53	2,29	403,83	74	4,51	0,27	126,74
1990	70203	Light duty vehicles	Gasoline conventional	Urban driving	1542555	2,97	638,11	671,68	58,35	7008,46	73	1,37	0,46	9,12
1990	70203	Light duty vehicles	Gasoline catalyst	Urban driving	0	0,00	0,00	0,00	0,00	0,00	73	0,00	0,00	0,00
1990	70301	Heavy duty vehicles	Diesel	Highway driving	7558528	93,68	828,80	76,83	6,11	174,57	74	2,92	0,28	45,30
1990	70301	Heavy duty vehicles	Gasoline	Highway driving	6630	2,97	1037,77	474,61	9,69	7610,35	73	0,83	0,28	55,35
1990	70302	Heavy duty vehicles	Diesel	Rural driving	14175012	93,68	946,10	102,99	6,86	237,86	74	3,10	0,27	54,49
1990	70302	Heavy duty vehicles	Gasoline	Rural driving	19287	2,97	1141,55	820,40	16,74	8371,39	73	0,91	0,30	60,88
1990	70303	Heavy duty vehicles	Diesel	Urban driving	12151405	93,68	1035,68	126,62	12,65	297,36	74	2,51	0,25	61,38
1990	70303	Heavy duty vehicles	Gasoline	Urban driving	22301	2,97	456,62	696,09	14,21	7102,99	73	0,61	0,20	40,59
1990	704	Mopeds	Gasoline		270104	2,97	27,40	8057,18	162,00	13698,63	73	0,74	0,74	109,59
1990	70501	Motorcycles	Gasoline	Highway driving	68816	2,97	215,21	1274,28	121,98	17689,89	73	1,27	1,27	32,95
1990	70502	Motorcycles	Gasoline	Rural driving	128454	2,97	173,17	1528,62	146,07	16834,36	73	1,52	1,52	39,46
1990	70503	Motorcycles	Gasoline	Urban driving	150886	2,97	93,28	2018,58	147,26	15322,43	73	1,53	1,53	39,78

Year	SNAPID	Category	Fuel type	Mode	Fuel [GJ]	SO2 [g/GJ]	NOx [g/GJ]	NMVOC [g/GJ]	CH4 [g/GJ]	CO [g/GJ]	CO2 [kg/GJ]	NH3 [g/GJ]	N2O [g/GJ]	TSP [g/GJ]
1990	801	Military	Diesel		146162	93,68	778,10	83,81	6,66	250,19	74	4,04	0,28	69,87
1990	801	Military	Jet fuel	< 3000 ft	986	4,60	250,57	24,94	2,65	229,89	72	2,30		
1990	801	Military	Jet fuel	> 3000 ft	4913	4,60	250,57	24,94	2,65	229,89	72	2,30		
1990	801	Military	Gasoline		149678	2,28	871,06	1129,29	33,78	6687,29	73	2,24	1,63	
1990	801	Military	Aviation gasoline		1347105	4,57	859,00	1242,60	21,90	6972,00	73	2,00	1,60	
1990	802	Railways	Diesel		4010007	93,68	1225,13	79,94	3,07	223,21	74	2,04	0,20	50,26
1990	802	Railways	Kerosene		70	5,00	50,00	3,00	7,00	20,00	72	2,00		
1990	802	Railways	Gasoline		0	2,28	871,06	1129,29	33,78	6687,29	73	2,24	1,63	
1990	803	Inland waterways	Diesel		544970	93,68	1249,33	270,13	4,35	595,20	74	3,05	0,17	164,83
1990	803	Inland waterways	Gasoline		371237	2,28	64,34	10809,58	108,10	18485,08	73	0,52	0,10	
1990	80402	National sea traffic	Residual oil		3559806	1466,99	1393,64	56,92	1,76	180,93	78	4,89		139,36
1990	80402	National sea traffic	Diesel		2782388	93,68	1334,89	54,52	1,69	173,30	74	4,68		42,15
1990	80402	National sea traffic	Kerosene		452	4,60	50,00	3,00	7,00	20,00	72	2,00		
1990	80402	National sea traffic	LPG		1794		1249,00	384,90	20,30	443,00	65	2,00		
1990	80403	Fishing	Residual oil		285426	1466,99	1393,64	56,92	1,76	180,93	78	4,89		139,36
1990	80403	Fishing	Diesel		10051143	93,68	1334,89	54,52	1,69	173,30	74	4,68		42,15
1990	80403	Fishing	Kerosene		25787	4,60	50,00	3,00	7,00	20,00	72	2,00		
1990	80403	Fishing	Gasoline		9001	2,28	64,34	10809,58	108,10	18485,08	73	0,52	0,10	
1990	80403	Fishing	LPG		42320		1249,00	384,90	20,30	443,00	65	2,00		
1990	80404	International sea traffic	Residual oil		28543368	1711,49	2127,14	56,92	1,76	180,93	78	4,89		200,49
1990	80404	International sea traffic	Diesel		11632674	468,38	2037,47	54,52	1,69	173,30	74	4,68		42,15
1990	80501	Air traffic, other airports	Jet fuel	Dom. < 3000 ft	378795	2,30	310,41	16,54	1,76	100,94	72	6,35		
1990	80501	Air traffic, other airports	Aviation gasoline		104947	4,57	859,00	1242,60	21,90	6972,00	73	2,00	1,60	
1990	80502	Air traffic, other airports	Jet fuel	Int. < 3000 ft	136077	2,30	306,48	18,38	1,95	177,11	72	6,90		
1990	80502	Air traffic, other airports	Aviation gasoline		30660	4,57	859,00	1242,60	21,90	6972,00	73	2,00	1,60	
1990	80503	Air traffic, other airports	Jet fuel	Dom. > 3000 ft	910427	2,30	330,34	9,28	0,99	93,07	72	2,30		
1990	80504	Air traffic, other airports	Jet fuel	Int. > 3000 ft	1612988	2,30	242,81	6,20	0,66	54,25	72	2,30		
1990	806	Agriculture	Diesel		17292498	93,68	1273,14	190,59	4,43	424,13	74	3,10	0,18	128,88
1990	806	Agriculture	Gasoline		520115	2,28	244,33	1022,05	51,10	24741,09	73	1,80	0,12	
1990	807	Forestry	Diesel		5001	93,68	1255,79	238,29	4,37	526,70	74	3,06	0,17	150,34
1990	807	Forestry	Gasoline		60375	2,28	48,66	18095,47	180,95	33391,26	73	0,48	0,10	
1990	808	Industry	Diesel		9277501	93,68	1286,85	174,83	4,48	390,74	74	3,14	0,18	122,38
1990	808	Industry	Gasoline		142938	2,28	216,67	3096,74	119,76	44820,30	73	1,63	0,11	
1990	808	Industry	LPG		1251154	0,00	621,12	838,51	62,11	931,68	65	3,11	0,19	12,44
1990	809	Household and gardening	Gasoline		1187573	2,28	213,71	3726,00	116,17	42616,59	73	1,61	0,11	
1990	80501	Air traffic, Copenhagen airport	Jet fuel	Dom. < 3000 ft	441215	2,30	280,41	23,40	2,49	144,24	72	5,03		
1990	80501	Air traffic, Copenhagen airport	Aviation gasoline		8642	4,57	859,00	1242,60	21,90	6972,00	73	2,00	1,60	
1990	80502	Air traffic, Copenhagen airport	Jet fuel	Int. < 3000 ft	2037255	2,30	326,94	34,43	3,66	159,73	72	3,76		
1990	80502	Air traffic, Copenhagen airport	Aviation gasoline		5612	4,57	859,00	1242,60	21,90	6972,00	73	2,00	1,60	
1990	80503	Air traffic, Copenhagen airport	Jet fuel	Dom. > 3000 ft	1160709	2,30	315,28	8,51	0,90	79,30	72	2,30		
1990	80504	Air traffic, Copenhagen airport	Jet fuel	Int. > 3000 ft	20653862	2,30	291,18	8,79	0,93	36,07	72	2,30		

Year	SNAP ID	Category	Fuel type	Mode	Fuel [GJ]	SO2 [g/GJ]	NOx [g/GJ]	NMVOC [g/GJ]	CH4 [g/GJ]	CO [g/GJ]	CO2 [kg/GJ]	NH3 [g/GJ]	N2O [g/GJ]	TSP [g/GJ]	PM10 [g/GJ]	PM2.5 [g/GJ]
2002	70101	Passenger cars	Diesel	Highway driving	2104778	2,34	284,55	12,88	4,39	102,66	74	13,18	0,49	43,63	43,63	43,63
2002	70101	Passenger cars	Gasoline 2-stroke	Highway driving	116	2,28	288,90	2357,34	10,03	3490,86	73	2,01	0,80	48,15	48,15	48,15
2002	70101	Passenger cars	Gasoline conventional	Highway driving	834	2,28	1368,76	331,97	11,45	2545,90	73	2,20	0,88	10,28	10,28	10,28
2002	70101	Passenger cars	Gasoline catalyst	Highway driving	2889850	2,28	293,17	33,94	4,44	2045,65	73	17,19	49,12	0,34	0,34	0,34
2002	70101	Passenger cars	LPG	Highway driving	9902730	0,00	1151,70	187,09	10,06	3914,25	65	6,04	0,00	10,06	10,06	10,06
2002	70102	Passenger cars	Diesel	Rural driving	4463829	2,34	258,40	21,41	2,64	102,77	74	15,05	0,56	29,76	29,76	29,76
2002	70102	Passenger cars	Gasoline 2-stroke	Rural driving	235	2,28	352,84	2476,82	13,84	2594,44	73	1,73	0,69	41,51	41,51	41,51
2002	70102	Passenger cars	Gasoline conventional	Rural driving	2342	2,28	1163,54	450,58	14,17	3096,23	73	2,44	0,97	11,45	11,45	11,45
2002	70102	Passenger cars	Gasoline catalyst	Rural driving	6326306	2,28	208,85	34,99	4,95	610,36	73	8,78	54,85	0,38	0,38	0,38
2002	70102	Passenger cars	LPG	Rural driving	21472312	0,00	1248,46	305,18	16,91	1146,38	65	7,25	0,00	14,49	14,49	14,49
2002	70103	Passenger cars	Diesel	Urban driving	5116462	2,34	261,74	59,77	2,68	251,13	74	9,99	0,37	57,36	57,36	57,36
2002	70103	Passenger cars	Gasoline 2-stroke	Urban driving	295	2,28	61,43	3122,63	30,71	4238,59	73	1,02	0,41	24,57	24,57	24,57
2002	70103	Passenger cars	Gasoline conventional	Urban driving	3011	2,28	632,96	881,29	53,98	8271,10	73	1,59	0,64	11,08	11,08	11,08
2002	70103	Passenger cars	Gasoline catalyst	Urban driving	7353822	2,28	200,55	267,47	60,27	4168,00	73	15,92	21,03	0,33	0,33	0,33
2002	70103	Passenger cars	LPG	Urban driving	29831080	0,00	615,43	433,89	34,65	1341,58	65	4,39	0,00	11,72	11,72	11,72
2002	70201	Light duty vehicles	Diesel	Highway driving	3295673	2,34	326,74	32,40	1,69	232,00	74	5,95	0,35	62,06	62,06	62,06
2002	70201	Light duty vehicles	Gasoline conventional	Highway driving	147550	2,28	1369,26	170,29	10,11	2987,40	73	2,43	0,81	16,17	16,17	16,17
2002	70201	Light duty vehicles	Gasoline catalyst	Highway driving	273957	2,28	148,94	19,36	3,12	579,23	73	12,03	34,36	0,24	0,24	0,24
2002	70202	Light duty vehicles	Diesel	Rural driving	10040568	2,34	348,04	37,13	1,85	224,61	74	6,51	0,38	59,68	59,68	59,68
2002	70202	Light duty vehicles	Gasoline conventional	Rural driving	521554	2,28	1188,86	262,59	15,25	2316,18	73	2,29	0,76	15,25	15,25	15,25
2002	70202	Light duty vehicles	Gasoline catalyst	Rural driving	967300	2,28	131,04	26,25	3,57	433,64	73	5,19	32,44	0,23	0,23	0,23
2002	70203	Light duty vehicles	Diesel	Urban driving	9731291	2,34	413,46	63,87	2,54	264,22	74	4,70	0,28	76,47	76,47	76,47
2002	70203	Light duty vehicles	Gasoline conventional	Urban driving	630891	2,28	623,61	702,94	61,07	7468,02	73	1,32	0,44	8,83	8,83	8,83
2002	70203	Light duty vehicles	Gasoline catalyst	Urban driving	1167027	2,28	143,89	150,84	28,37	3359,41	73	9,97	13,17	0,17	0,17	0,17
2002	70301	Heavy duty vehicles	Diesel	Highway driving	10490395	2,34	553,54	57,73	4,83	126,21	74	2,85	0,28	25,57	25,57	25,57
2002	70301	Heavy duty vehicles	Gasoline	Highway driving	9584	2,28	1037,77	474,61	9,69	7610,35	73	0,83	0,28	55,35	55,35	55,35
2002	70302	Heavy duty vehicles	Diesel	Rural driving	15941119	2,34	647,07	72,38	5,27	151,80	74	2,90	0,26	30,88	30,88	30,88
2002	70302	Heavy duty vehicles	Gasoline	Rural driving	19501	2,28	1141,55	820,40	16,74	8371,39	73	0,91	0,30	60,88	60,88	60,88
2002	70303	Heavy duty vehicles	Diesel	Urban driving	11368635	2,34	694,55	82,97	8,91	180,63	74	2,35	0,24	35,51	35,51	35,51
2002	70303	Heavy duty vehicles	Gasoline	Urban driving	19915	2,28	456,62	696,09	14,21	7102,99	73	0,61	0,20	40,59	40,59	40,59
2002	704	Mopeds	Gasoline		244496	2,28	26,64	7308,88	149,01	12510,68	73	0,74	0,74	109,59	109,59	109,59
2002	70501	Motorcycles	Gasoline	Highway driving	112965	2,28	221,92	1198,73	123,25	17201,47	73	1,28	1,28	32,70	32,70	32,70
2002	70502	Motorcycles	Gasoline	Rural driving	262763	2,28	179,41	1444,32	147,60	16168,61	73	1,53	1,53	39,16	39,16	39,16
2002	70503	Motorcycles	Gasoline	Urban driving	313351	2,28	98,28	1919,76	149,16	14632,30	73	1,55	1,55	39,57	39,57	39,57

Year	SNAPID	Category	Fuel type	Mode	Fuel [GJ]	SO2 [g/GJ]	NOx [g/GJ]	NMVOC [g/GJ]	CH4 [g/GJ]	CO [g/GJ]	CO2 [kg/GJ]	NH3 [g/GJ]	N2O [g/GJ]	TSP [g/GJ]	PM10 [g/GJ]	PM2.5 [g/GJ]
2002	801	Military	Diesel		434684	2,34	492,12	58,33	4,41	183,98	74	5,23	0,31	44,52	44,52	44,52
2002	801	Military	Jet fuel	< 3000 ft	66	4,60	250,57	24,94	2,65	229,89	72	2,30	0,00	1,16	1,16	1,16
2002	801	Military	Jet fuel	> 3000 ft	8272	4,60	250,57	24,94	2,65	229,89	72	2,30	0,00	1,16	1,16	1,16
2002	801	Military	Gasoline		77781	2,28	376,42	370,81	32,62	3280,61	73	10,80	28,65	4,43	4,43	4,43
2002	801	Military	Aviation gasoline		700033	4,57	859,00	1242,60	21,90	6972,00	73	2,00	1,60	10,00	10,00	10,00
2002	802	Railways	Diesel		2844583	2,34	1190,04	86,91	3,34	223,26	74	2,04	0,20	43,93	43,93	43,93
2002	802	Railways	Kerosene		0	5,00	50,00	3,00	7,00	20,00	72	2,00	0,00	121,95	115,85	110,06
2002	802	Railways	Gasoline		0	2,28	397,09	400,36	35,56	3516,78	73	10,55	27,87	4,43	4,43	4,43
2002	803	Inland waterways	Diesel		1001571	23,42	1249,33	270,13	4,35	595,20	74	3,05	0,17	164,83	156,59	148,76
2002	803	Inland waterways	Gasoline		902453	2,28	64,34	10809,58	108,10	18485,08	73	0,52	0,10	23,25	23,25	23,25
2002	80402	National sea traffic	Residual oil		2064248	810,26	1393,60	56,90	1,76	180,90	78	4,90		139,40	132,43	125,81
2002	80402	National sea traffic	Diesel		3421700	93,68	1334,90	54,50	1,69	173,30	74	4,70	0,00	42,15	40,04	38,04
2002	80402	National sea traffic	Kerosene		696	4,60	50,00	3,00	7,00	20,00	72	2,00	2,00	97,56	92,68	88,05
2002	80402	National sea traffic	LPG		0	0,00	1249,00	384,90	20,30	443,00	65	2,00	0,00	12,44	12,44	12,44
2002	80403	Fishing	Residual oil		3821	810,26	1393,60	56,90	1,76	180,90	78	4,90		139,40	132,43	125,81
2002	80403	Fishing	Diesel		8244841	93,68	1334,90	54,50	1,69	173,30	74	4,70	0,00	42,15	40,04	38,04
2002	80403	Fishing	Kerosene		592	4,60	50,00	3,00	7,00	20,00	72	2,00		97,56	92,68	88,05
2002	80403	Fishing	Gasoline		3351	2,28	64,34	10809,60	108,10	18485,10	73	0,52	0,10	23,25	23,25	23,25
2002	80403	Fishing	LPG		20976	0,00	1249,00	384,90	20,30	443,00	65	2,00	0,00	12,44	12,44	12,44
2002	80404	International sea traffic	Residual oil		17546654	1681,38	2127,10	56,90	1,76	180,90	78	4,90		200,50	190,48	180,95
2002	80404	International sea traffic	Diesel		21579480	468,38	2037,50	54,50	1,69	173,30	74	4,70		42,15	40,04	38,04
2002	80501	Air traffic, other airports	Jet fuel	Dom. < 3000 ft	217050	2,30	310,16	22,58	2,40	132,06	72	10,87		1,16	1,16	1,16
2002	80501	Air traffic, other airports	Aviation gasoline		97530	4,57	859,00	1242,60	21,90	6972,00	73	2,00	1,60	10,00	10,00	10,00
2002	80502	Air traffic, other airports	Jet fuel	Int. < 3000 ft	233379	2,30	300,42	20,98	2,23	189,16	72	7,69		1,16	1,16	1,16
2002	80502	Air traffic, other airports	Aviation gasoline		7200	4,57	859,00	1242,60	21,90	6972,00	73	2,00	1,60	10,00	10,00	10,00
2002	80503	Air traffic, other airports	Jet fuel	Dom. > 3000 ft	520189	2,30	312,37	14,16	1,50	108,33	72	2,30		1,16	1,16	1,16
2002	80504	Air traffic, other airports	Jet fuel	Int. > 3000 ft	2205821	2,30	242,33	8,27	0,88	65,26	72	2,30		1,16	1,16	1,16
2002	806	Agriculture	Diesel		15994341	23,42	1240,45	186,29	4,43	424,08	74	3,10	0,18	124,99	118,74	112,87
2002	806	Agriculture	Gasoline		489194	2,28	244,33	1022,05	51,10	24741,09	73	1,80	0,12	23,25	23,25	23,25
2002	807	Forestry	Diesel		4625	23,42	1088,93	206,16	4,37	512,98	74	3,06	0,17	126,23	119,92	113,98
2002	807	Forestry	Gasoline		56786	2,28	48,66	18095,47	180,95	33391,26	73	0,48	0,10	23,25	23,25	23,25
2002	808	Industry	Diesel		8581034	23,42	1131,35	160,73	4,48	389,65	74	3,14	0,18	105,35	100,08	95,13
2002	808	Industry	Gasoline		134440	2,28	216,67	3096,74	119,76	44820,30	73	1,63	0,11	23,25	23,25	23,25
2002	808	Industry	LPG		1498955	0,00	621,12	838,51	62,11	931,68	65	3,11	0,19	12,44	12,44	12,44
2002	809	Household and gardening	Gasoline		1116970	2,28	213,71	3726,00	116,17	42616,59	73	1,61	0,11	23,25	23,25	23,25
2002	80501	Air traffic, Copenhagen airport	Jet fuel	Dom. < 3000 ft	272988	2,30	294,64	26,14	2,78	159,41	72	7,22		1,16	1,16	1,16
2002	80501	Air traffic, Copenhagen airport	Aviation gasoline		791	4,57	859,00	1242,60	21,90	6972,00	73	2,00	1,60	10,00	10,00	10,00
2002	80502	Air traffic, Copenhagen airport	Jet fuel	Int. < 3000 ft	2821218	2,30	330,82	35,49	3,77	191,08	72	3,96	0,00	1,16	1,16	1,16
2002	80502	Air traffic, Copenhagen airport	Aviation gasoline		1145	4,57	859,00	1242,60	21,90	6972,00	73	2,00	1,60	10,00	10,00	10,00
2002	80503	Air traffic, Copenhagen airport	Jet fuel	Dom. > 3000 ft	916659	2,30	305,20	12,24	1,30	59,71	72	2,30	0,00	1,16	1,16	1,16
2002	80504	Air traffic, Copenhagen airport	Jet fuel	Int. > 3000 ft	23250413	2,30	308,23	10,43	1,11	35,22	72	2,30	0,00	1,16	1,16	1,16

Year	Category	Mode	SNAP ID	SO2 [tons]	NOx [tons]	NMVOC [tons]	CH4 [tons]	CO [tons]	CO2 [ktons]	NH3 [tons]	N2O [tons]	TSP [tons]
1990	Passenger cars	Highway driving	70101	84	9922	2825	87	27126	608	28	15	150
1990	Passenger cars	Rural driving	70102	244	26625	11543	330	94784	1866	91	54	483
1990	Passenger cars	Urban driving	70103	359	20785	29322	1662	306081	2613	95	41	803
1990	Light duty vehicles	Highway driving	70201	217	975	115	6	1556	190	13	1	246
1990	Light duty vehicles	Rural driving	70202	779	3735	573	31	5416	690	52	4	908
1990	Light duty vehicles	Urban driving	70203	910	5719	1592	112	14715	828	46	3	1239
1990	Heavy duty vehicles	Highway driving	70301	708	6271	584	46	1370	560	22	2	343
1990	Heavy duty vehicles	Rural driving	70302	1328	13433	1476	98	3533	1050	44	4	774
1990	Heavy duty vehicles	Urban driving	70303	1138	12595	1554	154	3772	901	30	3	747
1990	Mopeds		704	1	7	2176	44	3700	20	0	0	30
1990	Motorcycles	Highway driving	70501	0	15	88	8	1217	5	0	0	2
1990	Motorcycles	Rural driving	70502	0	22	196	19	2162	9	0	0	5
1990	Motorcycles	Urban driving	70503	0	14	305	22	2312	11	0	0	6
1990	Evaporation		706	0	0	28425	0	0	0	0	0	0
1990	Military		801	21	494	57	5	422	119	4	0	10
1990	Railways		802	376	4913	321	12	895	297	8	1	202
1990	Inland waterways		803	52	705	4160	43	7187	67	2	0	90
1990	National sea traffic		80402	5483	8678	355	11	1127	484	30	0	613
1990	Fishing		80403	1360	13870	678	19	1979	771	49	0	463
1990	International sea traffic		80404	54300	84417	2259	70	7180	3087	194	0	6213
1990	Air traffic, Dom. < 3000 ft.		80501	2	339	158	4	894	67	5	0	0
1990	Air traffic, Int. < 3000 ft.		80502	5	739	118	9	602	159	9	0	0
1990	Air traffic, Dom. > 3000 ft.		80503	5	667	18	2	177	149	5	0	0
1990	Air traffic, Int. > 3000 ft.		80504	51	6406	192	20	832	1603	51	0	0
1990	Agriculture		806	1621	22143	3827	103	20203	1318	55	3	2229
1990	Forestry		807	1	9	1094	11	2019	5	0	0	1
1990	Industry		808	869	12747	3114	136	11197	778	33	2	1151
1990	Household and gardening		809	3	254	4425	138	50610	87	2	0	0

Year	Category	Mode	SNAP ID	SO2 [tons]	NOx [tons]	NMVOC [tons]	CH4 [tons]	CO [tons]	CO2 [ktons]	NH3 [tons]	N2O [tons]	TSP [tons]	PM10 [tons]	PM2.5 [tons]
2002	Passenger cars	Highway driving	70101	34	7458	1325	86	27834	1090	204	490	125	125	125
2002	Passenger cars	Rural driving	70102	74	13000	3703	208	33159	2360	271	1186	214	214	214
2002	Passenger cars	Urban driving	70103	97	11977	14775	2209	186458	3093	538	634	385	385	385
2002	Light duty vehicles	Highway driving	70201	9	1320	137	8	1364	275	23	11	207	207	207
2002	Light duty vehicles	Rural driving	70202	27	4241	535	30	3883	852	72	36	607	607	607
2002	Light duty vehicles	Urban driving	70203	27	4585	1241	96	11203	851	58	18	750	750	750
2002	Heavy duty vehicles	Highway driving	70301	25	5817	610	51	1397	777	30	3	269	269	269
2002	Heavy duty vehicles	Rural driving	70302	37	10337	1170	84	2583	1181	46	4	493	493	493
2002	Heavy duty vehicles	Urban driving	70303	27	7905	957	102	2195	843	27	3	404	404	404
2002	Mopeds		704	1	7	1787	36	3059	18	0	0	27	27	27
2002	Motorcycles	Highway driving	70501	0	25	135	14	1943	8	0	0	4	4	4
2002	Motorcycles	Rural driving	70502	1	47	380	39	4249	19	0	0	10	10	10
2002	Motorcycles	Urban driving	70503	1	31	602	47	4585	23	0	0	12	12	12
2002	Evaporation		706	0	0	7458	0	0	0	0	0	0	0	0
2002	Military		801	5	416	55	4	317	89	4	0	20	20	20
2002	Railways		802	7	3385	247	10	635	211	6	1	125	125	125
2002	Inland waterways		803	23	1192	11070	112	19051	140	3	0	172	165	158
2002	National sea traffic		80402	1993	7444	304	9	966	414	26	0	432	410	390
2002	Fishing		80403	775	11038	494	15	1501	612	39	0	348	331	315
2002	International sea traffic		80404	39610	81292	2174	67	6914	2966	187	0	4428	4206	3996
2002	Air traffic, Dom. < 3000 ft.		80501	2	232	134	3	758	42	5	0	2	2	2
2002	Air traffic, Int. < 3000 ft.		80502	7	1011	115	11	641	221	13	0	4	4	4
2002	Air traffic, Dom. > 3000 ft.		80503	3	442	19	2	111	103	3	0	2	2	2
2002	Air traffic, Int. > 3000 ft.		80504	59	7701	261	28	963	1833	59	0	30	30	30
2002	Agriculture		806	376	19960	3480	96	18886	1219	51	3	2011	1911	1817
2002	Forestry		807	0	8	1029	10	1899	4	0	0	2	2	2
2002	Industry		808	201	10668	3052	148	10766	742	32	2	926	881	838
2002	Household and gardening		809	3	239	4162	130	47601	82	2	0	26	26	26

Annex 3.B.6 Uncertainty estimate calculation schemes for CO_2, CH_4 and N_2O in transport

		Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t
			Input data Gg CO2	Input data Gg CO2	Input data %	Input data %	%	%
Civil Aviation	Aviation Gasoline	CO2	8,29	7,18	2	5	5,385	0,003
	Jet Kerosene	CO2	208,16	138,74	2	5	5,385	0,052
Road Transportation	Gasoline	CO2	4.914,00	6.020,54	2	5	5,385	2,271
	Diesel Oil	CO2	4.436,10	5.368,90	2	5	5,385	2,025
Railways	Diesel Oil	CO2	296,75	210,50	2	5	5,385	0,079
Navigation	Residual Oil	CO2	277,66	161,01	2	5	5,385	0,061
	Gas/Diesel Oil	CO2	246,26	320,04	2	5	5,385	0,121
Agriculture	Diesel Oil	CO2	1280	1184	20	5	20,616	1,709
	Gasoline	CO2	38	36	20	5	20,616	0,052
Forestry	Diesel Oil	CO2	0	0	20	5	20,616	0,000
	Gasoline	CO2	4	4	20	5	20,616	0,006
Industry	Diesel Oil	CO2	687	635	20	5	20,616	0,917
	Gasoline	CO2	10	10	20	5	20,616	0,015
	LPG	CO2	81	97	20	5	20,616	0,117
Household and gardening	Gasoline	CO2	87	82	20	5	20,616	0,125
	Total	CO2	12574,6037	14274,465				13,084
	Total uncertainties				**Overall uncertainty in the year (%):**			**3,617**

		Gas	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			%	%	%	%	%
Civil Aviation	Aviation Gasoline	CO2	-0,000178	0,0006	-0,0009	0,0016	0,0018
	Jet Kerosene	CO2	-0,007758	0,0110	-0,0388	0,0312	0,0498
Road Transportation	Gasoline	CO2	0,035033	0,4788	0,1752	1,3542	1,3655
	Diesel Oil	CO2	0,026399	0,4270	0,1320	1,2076	1,2148
Railways	Diesel Oil	CO2	-0,010047	0,0167	-0,0502	0,0473	0,0690
Navigation	Residual Oil	CO2	-0,012259	0,0128	-0,0613	0,0362	0,0712
	Gas/Diesel Oil	CO2	0,003219	0,0255	0,0161	0,0720	0,0738
Agriculture	Diesel Oil	CO2	-0,021374	0,0941	-0,1069	2,6622	2,6644
	Gasoline	CO2	-0,000588	0,0028	-0,0029	0,0803	0,0804
Forestry	Diesel Oil	CO2	-6,19E-06	0,0000	0,0000	0,0008	0,0008
	Gasoline	CO2	-6,82E-05	0,0003	-0,0003	0,0093	0,0093
Industry	Diesel Oil	CO2	-0,011473	0,0505	-0,0574	1,4283	1,4295
	Gasoline	CO2	-0,000162	0,0008	-0,0008	0,0235	0,0235
	LPG	CO2	0,000407	0,0065	0,0020	0,1829	0,1829
Household and gardening	Gasoline	CO2	-0,001342	0,0069	-0,0067	0,1950	0,1951
	Total	CO2					12,57911942
	Total uncertainties				**Trend uncertainty (%):**		**3,547**

		Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t
			Input data Gg CH4	Input data Gg CH4	Input data %	Input data %	%	%
Civil Aviation	Aviation Gasoline	CH4	0,00	0,00	2	100	100,020	0,063
	Jet Kerosene	CH4	0,00	0,00	2	100	100,020	0,095
Road Transportation	Gasoline	CH4	2,27	2,69	2	40	40,050	31,488
	Diesel Oil	CH4	0,35	0,32	2	40	40,050	3,741
Railways	Diesel Oil	CH4	0,01	0,01	2	100	100,020	0,278
Navigation	Residual Oil	CH4	0,01	0,00	2	100	100,020	0,106
	Gas/Diesel Oil	CH4	0,01	0,01	2	100	100,020	0,284
Agriculture	Diesel Oil	CH4	0	0	20	100	101,980	2,113
	Gasoline	CH4	0	0	20	100	101,980	0,745
Forestry	Diesel Oil	CH4	0	0	20	100	101,980	0,001
	Gasoline	CH4	0	0	20	100	101,980	0,306
Industry	Diesel Oil	CH4	0	0	20	100	101,980	1,146
	Gasoline	CH4	0	0	20	100	101,980	0,480
	LPG	CH4	0	0	20	100	101,980	2,775
Household and gardening	Gasoline	CH4	0	0	20	100	101,980	3,867
	Total	CH4	3,03965538	3,4216856				1035,006
	Total uncertainties					**Overall uncertainty i the year (%):**		**32,172**

		Gas	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			%	%	%	%	%
Civil Aviation	Aviation Gasoline	CH4	-0,000213	0,0007	-0,021308064	0,002003386	0,021402036
	Jet Kerosene	CH4	-0,000303	0,0011	-0,030295942	0,003026016	0,030446689
Road Transportation	Gasoline	CH4	0,045668	0,8850	1,826738205	2,50327431	3,098927999
	Diesel Oil	CH4	-0,025792	0,1051	-1,031661444	0,297400028	1,073672255
Railways	Diesel Oil	CH4	-0,001436	0,0031	-0,143592714	0,008838906	0,143864498
Navigation	Residual Oil	CH4	-0,001126	0,0012	-0,112564703	0,00338054	0,112615454
	Gas/Diesel Oil	CH4	0,000579	0,0032	0,057901801	0,009038035	0,05860294
Agriculture	Diesel Oil	CH4	-0,005061	0,0233	-0,506148753	0,659750951	0,831539462
	Gasoline	CH4	-0,001619	0,0082	-0,161870173	0,232619327	0,283396726
Forestry	Diesel Oil	CH4	-1,44E-06	0,0000	-0,000144413	0,000188191	0,000237216
	Gasoline	CH4	-0,000665	0,0034	-0,066538478	0,095615755	0,116489234
Industry	Diesel Oil	CH4	-0,002745	0,0126	-0,274505784	0,357769432	0,450946108
	Gasoline	CH4	-0,001043	0,0053	-0,104254515	0,149816732	0,182521388
	LPG	CH4	0,00185	0,0306	0,184988611	0,866329921	0,885860214
Household and gardening	Gasoline	CH4	-0,008399	0,0427	-0,8398684	1,207394781	1,470775675
	Total	CH4					14,76426267
	Total uncertainties				**Trend uncertainty (%):**		**3,842**

		Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t
			Input data Gg N2O	Input data Gg N2O	Input data %	Input data %	%	%
Civil Aviation	Aviation Gasoline	N2O	0,00	0,00	2	1000	1000,002	0,141
	Jet Kerosene	N2O	0,01	0,01	2	1000	1000,002	5,464
Road Transportation	Gasoline	N2O	0,15	0,89	2	50	50,040	31,902
	Diesel Oil	N2O	0,27	0,38	2	50	50,040	13,599
Railways	Diesel Oil	N2O	0,01	0,01	2	1000	1000,002	4,154
Navigation	Residual Oil	N2O	0,02	0,01	2	1000	1000,002	7,240
	Gas/Diesel Oil	N2O	0,01	0,02	2	1000	1000,002	13,479
Agriculture	Diesel Oil	N2O	0,05	0,05	20	1000	1000,200	35,532
	Gasoline	N2O	0,00	0,00	20	1000	1000,200	0,631
Forestry	Diesel Oil	N2O	0,00	0,00	20	1000	1000,200	0,010
	Gasoline	N2O	0,00	0,00	20	1000	1000,200	0,019
Industry	Diesel Oil	N2O	0,03	0,03	20	1000	1000,200	19,268
	Gasoline	N2O	0,00	0,00	20	1000	1000,200	0,156
	LPG	N2O	0,00	0,00	20	1000	1000,200	3,333
Household and gardening	Gasoline	N2O	0,00	0,00	20	1000	1000,200	1,284
	Total	N2O	0,56273641	1,3970775				3130,901

	Total uncertainties					**Overall uncertainty i the year (%):**		**55,954**

		Gas	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			%	%	%	%	%
Civil Aviation	Aviation Gasoline	N2O	-0,000651	0,0004	-0,651388547	0,000990162	0,651389299
	Jet Kerosene	N2O	-0,02784	0,0136	-27,83992431	0,038365003	27,83995074
Road Transportation	Gasoline	N2O	0,915346	1,5828	45,76729291	4,476727935	45,98571727
	Diesel Oil	N2O	-0,524311	0,6747	-26,21557134	1,908373673	26,28494
Railways	Diesel Oil	N2O	-0,025763	0,0103	-25,76340152	0,029167053	25,76341803
Navigation	Residual Oil	N2O	-0,058802	0,0180	-58,80239977	0,050840038	58,80242175
	Gas/Diesel Oil	N2O	-0,03135	0,0335	-31,35032428	0,094648418	31,35046716
Agriculture	Diesel Oil	N2O	-0,148395	0,0882	-148,3950456	2,49457977	148,4160116
	Gasoline	N2O	-0,002569	0,0016	-2,568697096	0,044313227	2,569079297
Forestry	Diesel Oil	N2O	-4,24E-05	0,0000	-0,042369482	0,00071157	0,042375456
	Gasoline	N2O	-7,89E-05	0,0000	-0,078922382	0,001361488	0,078934125
Industry	Diesel Oil	N2O	-0,080507	0,0478	-80,5066993	1,352759533	80,51806375
	Gasoline	N2O	-0,000637	0,0004	-0,636794447	0,01098536	0,636889195
	LPG	N2O	-0,008869	0,0083	-8,869207891	0,233976721	8,872293599
Household and gardening	Gasoline	N2O	-0,005225	0,0032	-5,224651785	0,090133309	5,225429197
	Total	N2O					37308,90934
	Total uncertainties				**Trend uncertainty (%):**		**193,155**

Annex 3 Other detailed methodological descriptions for individual source or sink categories (where relevant)

3C Industry

Annex 3.C

On Industrial Processes. CRF sector 2

Lime production

CRF source category 2.A Mineral Products, 2. Lime Production.

SNAP source category 040614. Lime (decarbonizing).

Source category description

This source includes CO_2 emissions from production of lime and bricks and represents as such a combined activity in the CRF tables. This Annex serves to explain the source.

The source is not a key source neither for the trend nor for the level key source analyses in this report.

The production of lime has a slightly falling trend in the time-series 1990-2002, while the production of bricks is slightly increasing. As a result the CO_2 emission for the combined activity in year 2002 is almost the same as in 1990, refer to the table below.

Methodology

The CO_2 emission from production of Lime is calculated according to the IPCC guidelines, Reference Manual p2.8, with the emission factor of 0.79 kg CO_2 / kg Lime. This emission factor is multiplied by activity data from production statistics published by Statistics Denmark, refer the Table below.

The emission factor from production of yellow bricks is calculated the following way. When limestone ($CaCO_3$) is heated it decomposes into lime (CaO) and CO_2. Using the molecular weights, implies that 44 kg of CO_2 is emitted for every 100 kg $CaCO_3$ decomposed. Since clay used to produce yellow bricks contains 18% of limestone, the emission factor is 0.18*0.44=0.079 kg CO_2 / kg yellow bricks. This emission factor is multiplied by activity data from production statistics published by Statistics Denmark. This Statistics accounts for the number of bricks produced, the average weight of a brick is estimated to 2 kg. Refer to the Table below for the data and the emissions calculated.

The activity data and the resulting emissions from production of lime and bricks are aggregated in the CRF, in Table 2(I).A-G sheet 1. The underlying data and the resulting aggregated data are given in the table below.

Table. Production of Lime and Bricks, CO_2 emission factors and CO_2 emissions.

Year	Lime		Yellow Bricks		Lime and Bricks		
	Production	CO2 emission	Production	CO2 emission	Production	CO2 emission	Combined emission factor
	(1)	(2)	(3)	(4)	(5)	(5)	(5)
	(t)	(Mg)	(t)	(Mg)	(kt)	(Gg)	(t/t)
1990	126706	99555	291348	23016	418,05	122,57	0,29
1991	86226	67749	291497	23028	377,72	90,78	0,24
1992	104526	82128	301908	23851	406,43	105,98	0,26
1993	106587	83747	278534	22004	385,12	105,75	0,27
1994	112480	88377	389803	30794	502,28	119,17	0,24
1995	100929	79301	365149	28847	466,08	108,15	0,23
1996	95028	74665	397206	31379	492,23	106,04	0,22
1997	102587	80604	419431	33135	522,02	113,74	0,22
1998	88922	69867	423254	33437	512,18	103,30	0,20
1999	95137	74751	405241	32014	500,38	106,76	0,21
2000	92002	72287	412082	32554	504,08	104,84	0,21
2001	96486	75810	351955	27804	448,44	103,61	0,23
2002	122641	96361	346633	27384	469,27	123,74	0,26

Notes:
(1) Statistics Denmark: Sales Statistics for manifactoring industries.
(2) Emission factor 0,786 kgCO2/kg; 1996 IPCC guidelines; reference manual p. 2.8
(3) Statistics Denmark: Sales Statistics for manifactoring industries, assuming that of the bricks produced and sold, 50% is yellow bricks each with and average weight of 2 kg.
(4) Emission factor 0,079 kgCO2/kg, further information in the text.
(5) Corresponding to the values in the CRF Table 2(I).A-Gs1, A.2. in this report for the respective years (apart from roundings).

Source specific planned improvements

The review team in their report on the April 15 2003 submission made a note on the implied emission factor in the CRF tables on this activity. We have considered reporting the two activities separately in the CRF. However, we find the activities so much related both being a decarbonizing process that we find a combination of the activities justified with the explanations given in this Annex.

Annex 3 Other detailed methodological descriptions for individual source or sink categories (where relevant)

3D Agriculture

Annex 3.D.1 – Table A.

Background data for CRF, table 4.A - Enteric Fermentation

Compounds	Animal category	Average daily feed intake	CH_4 conversion
		1990-2002	1990-2002
CH_4	Dairy cattle	note 1	6.0
	Non-dairy cattle	note 1	6.0
	Sheep	59.7	6.0
	Goats	54.9	5.0
	Horses	208.8	2.5
	Swine	note 1	0.6
	Poultry	NE	NE

Note 1 Feed intake

Animal category	Subcategory	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
		MJ/day per produced unit*												
Dairy cattle	Big race	285.8	285.8	285.8	285.8	302.4	302.4	302.4	302.4	304.1	304.1	304.1	304.1	305.8
Dairy cattle	Jersey	237.2	237.2	237.2	237.2	250.7	250.7	250.7	250.7	253.2	253.2	253.2	253.2	255.7
Non-dairy cattle	Bull >½ year. heavy breed	64.2	64.2	64.2	64.2	64.2	64.2	64.2	64.2	64.2	64.2	64.2	64.2	64.2
	Heifer >½ year. heavy breed	98.8	98.8	98.8	98.8	98.8	98.8	98.8	98.8	98.5	98.5	98.5	98.5	98.5
	Calves. bull. heavy breed	31.1	31.1	31.1	31.1	31.1	31.1	31.1	31.1	31.1	31.1	31.1	31.1	31.1
	Calves. heifer. heavy breed	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.5	9.5	9.5	9.4	9.4
Swine	Slaughtering pigs	10.8	10.8	10.8	10.8	9.7	9.7	9.7	9.7	9.5	9.5	9.5	9.5	9.5
	Piglets	1.7	1.7	1.7	1.7	2.0	2.0	2.0	2.0	2.1	2.1	2.1	2.1	2.1
	Sows	62.3	62.3	62.3	62.3	62.3	62.3	62.3	62.3	64.2	64.2	64.2	64.2	64.2

* The feed in take is given per produced unit. which mean it is not comparable with the default values in IPCC.

Background data for CRF - table 4.A - Enteric Fermentation – additional information

	Indicators	Dairy cattle	Non-dairy cattle
		1985-2002	1985-2002
	Weigth	575	325
Note 1	Fedding situation	85	54
Note 2	Milk yield	note 2	NO
	Work	NO	NO
	Pregnant	90	NO
Note 3	Digestibility of feed	71	78

Note 1	Feeding situation	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
						Percent of feeding in stable								
	Dairy cattle	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
	Bull-calves	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Bulls	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Heifer-calves	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Heifer	0.55	0.53	0.52	0.50	0.48	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
	Cattle for suckling	0.50	0.47	0.45	0.43	0.41	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39

Note 2	Milk yield	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
						kg milk/head/yr								
	No. of dairy cattle	17.07	16.95	17.23	17.97	17.90	18.16	18.83	19.18	19.50	19.87	20.02	20.32	20.62
	Milk yield per cow	6231	6187	6288	6560	6533	6628	6872	7001	7118	7252	7308	7416	7525

Note 3	Digestibility of feed	In stable (pct.)	On grass (pct.)
	Dairy cattle	71	78
	Bull-calves	79	79
	Bulls	75	78
	Heifer-calves	78	78
	Heifer	71	78
	Cattle for suckling	67	77

Annex 3.D.2 – Table B

Background data for CRF, table 4.A - Manure Management

Compounds	Animal category	Typical animal mass		VS daily excretion	Bo CH_4 producing potential
		1990-2002		1990-2002	1990-2002
		kg		kg DM/head/year	
CH4	Dairy cattle	575.0	note 1a	1600.0	0.24
	Non-dairy cattle	325.0	note 1b	300.0	0.17
	Sheep	70.0		86.0	0.19
	Goats	60.0		84.0	0.17
	Horses	600.0		520.0	0.33
	Swine	76.0	note 1c	22.0	0.45
	Poultry	2.0		0.3	0.32

Note 1a – VS daily excretion depending on stable type

Animal category	Stable type	Manure type	Methane convention factor - MCF	Distribution of stable type 2002	Vs daily excretion kg VS/prod. head/yr 2002	Distribution of stable type 1990	Vs daily excretion kg VS/prod. head/yr 1990
Dairy cattle	Tied-up with liquid and solid manure	Solid manure	1	0.12	1317	0.35	1317
		+Liquid	10	0.12	225	0.35	225
	Tied-up with slurry	Slurry	10	0.23	1473	0.44	1473
	Loose-holding with beds, slatted floor	Slurry	10	0.39	1473	0.13	1473
	Loose-holding with beds, slatted floor, scrapes	Slurry	10	0.04	1473	0.01	1473
	Loose-holding with beds, solid floor	Slurry	10	0.11	1473	0.04	1473
	Deep litter (all)	Deep litter	1	0.00	2958	0.00	2958
	Deep litter, slatted floor	Deep litter	1	0.07	2255	0.03	2255
		+Slurry	10	0.07	495	0.03	495
	Deep litter, slatted floor, scrapes	Deep litter	1	0.01	2255	0.00	2255
		+Slurry	10	0.01	495	0.00	495
	Deep litter, solid floor, scrapes	Deep litter	1	0.03	2255	0.01	2255
		+Slurry	10	0.03	495	0.01	495

	Average VS daily excretion				**1622**		**1539**

Note 1b – VS daily excretion depending on stable type

Animal category	Stable type	Manure type	Methane convention factor - MCF	Distribution of stable type 2002	Vs daily excretion kg VS/prod. head/yr 2002	Distribution of stable type 1990	Vs daily excretion kg VS/prod. head/yr 1990
Heifer							
> ½ year*	Tied-up with liquid and solid manure	Solid manure	1	0.07	215.6	0.19	255.1
		+Liquid	10	0.07	29.5	0.19	34.9
	Tied-up with slurry	Slurry	10	0.07	235.4	0.19	278.6
	Slatted floor-boxes	Slurry	10	0.23	191.4	0.40	226.5
	Loose-holding with beds, slatted floor	Slurry	10	0.19	235.4	0.04	278.6
	Deep litter (all)	Deep litter	1	0.00	446.4	0.03	528.3
	Deep litter, solid floor	Deep litter	1	0.28	394.4	0.09	466.7
	Deep litter, slatted floor	Deep litter	1	0.09	340.2	0.04	402.6
		+Slurry	10	0.09	76.7	0.04	90.7
	Deep litter, slatted floor, scrapes	Deep litter	1	0.02	340.2	0.01	402.6
		+Slurry	10	0.02	76.7	0.01	90.7
	Deep litter, solid floor, scrapes	Deep litter	1	0.05	340.2	0.01	402.6
		+Slurry	10	0.05	76.7	0.01	90.7
	Average VS daily excretion				**309.6**		**310.1**

* Heifer > ½ year is the largest subcategory

Note 1c – VS daily excretion depending on stable type

Animal category	Stable type	Manure type	Methane convention factor - MCF	Distribution of stable type 2002	Vs daily excretion kg VS/prod. head/yr 2002	Distribution of stable type 1990	Vs daily excretion kg VS/prod. head/yr 1990
Pigs for slaughtering	Full slatted floor	Slurry	10	0.56	22.0	0.51	22.0
	Partly slatted floor	Slurry	10	0.34	23.8	0.23	23.8
	Solid floor	Solid manure	1	0.04	15.5	0.22	15.5
		+Liquid	10	0.04	4.8	0.22	4.8
	Deep litter	Deep litter	1	0.01	42.1	0.04	42.1
	Partley slatted floor and partley deep litter	Deep litter	1	0.05	19.8	0.00	19.8
		+Slurry	10	0.05	11.0	0.00	11.0
	Average VS daily excretion				**23.2**		**22.8**

Annex 3 Other detailed methodological descriptions for individual source or sink categories (where relevant)

3E Waste

Annex 3.E

Methodology on CH4-emission from solid deposited waste are given.

The methodology is a IPCC Tier 2 approach and the model is unchanged since the submission of the NIR2003.

The composition of waste (Table 1) has considerable variation. The composition shown has been kept for all years (1990-2002) reported.

Table 1. Composition of landfilled waste

Materiale fractions in	Waste food	Card-board	Paper	Wet Card-board and paper	Plastics	Other Combu-stible	Glass	Metal	Other not Combu-stible	Sum
Domestic Waste	0,38	0,02	0,13	0,26	0,07	0,03	0,02	0,05	0,05	1,00
Bulky Waste		0,08	0,23		0,05	0,46	0,09	0,09	0,02	1,00
garden Waste						0,76			0,24	1,00
Commercial & office Waste	0,25	0,31	0,04	0,11	0,05	0,10	0,05	0,05	0,05	1,00
Industrial Waste	0,06	0,02	0,07	0,01	0,01	0,06	0,04	0,18	0,54	1,00
Building & constr. Waste						0,07			0,93	1,00
Sludge						0,29			0,71	1,00
Ash & slag									1,00	1,00

In Table 2 the resulting CH_4 emission factors for the various waste types are shown. The emission factors are based on the assumptions that 50% of the carbon in the landfill is emitted as a gas containing 45% of CH_4.

Table 2. CH4 emisssionfactors from waste in landfills

	Domestic Waste	Bulky Waste	Garden Waste	Com-mercial & office Waste	Industrial Waste	Building & cons-truction Waste	Sludge	Ash & slag
Carbon content in %	20	40	25	40	35	40	57	0
Emission factor in kg CH4 / ton	54,0	108,0	67,5	108,0	94,5	108,0	153,9	0,0

In Table 3 below the amounts of waste given are given. These data are given as in the official registration of amounts of municipal solid waste deposited at solid waste disposal sites as performed by Danish Environmental Protection Agency. These data for the amounts of waste is used to calculate a potential emission (Table 3) using only emission factors and the amounts of waste for the actual year. Using however, the IPCC Tier 2 method the emissions from waste landfilled the years before are taken into account. A further assumption here is that the half-life of the Carbon in the waste is 10 years, which means that half of Carbon in waste deposited in 10 years time will be converted to CH_4. The result of the calculation of the model is in the column Annual emission of Table 3. The annual emission has to be subtracted the amount of CH_4 collected by the landfill gas plants to result in The Annual net emission. The data for landfill gas plants are according to the Danish Energy Agency.

The total waste amount in Table 3 is taken as the sum of the different waste types. This total is equal to the activity data for the Annual Municipal Solid Waste at Solid Waste Disposal Sites of the CRF table 6.A.

The implied emission factor in the CRF tables reflects an aggregated emission factor for the model. So far this IEF has been increasing from 1990 to 2002 despite the decreasing amount of waste through the time-series. This is due to the time lag of emissions from the waste deposited calculated by the model.

Table 3. Amounts of Waste in landfills and their CH4 emisssions.

Year	Domestic Waste	Bulky Waste	Garden Waste	Commercial & office Waste	Industrial Waste	Building & construction Waste	Sludge	Ash & slag	Waste Total	Potential emission	Annual emission	Biogas collected	Annual net emission
	kt								kt	kt CH4	kt CH4	kt CH4	kt CH4
1990	198,9	250,7	85,2	109,3	822,4	951,4	222,1	535,0	3175,1	85,2	64,0	1,7	62,4
1991	198,7	259,0	70,7	120,0	824,3	804,3	193,3	562,0	3032,3	83,7	65,3	1,7	63,7
1992	198,4	267,3	56,1	130,7	826,2	657,2	164,6	589,0	2889,6	82,2	66,5	1,7	64,8
1993	198,2	275,7	41,6	141,3	828,1	510,1	135,8	616,0	2746,8	80,7	67,4	2,8	64,7
1994	198,0	284,0	27,0	152,0	830,0	363,0	107,0	643,0	2604,0	79,2	68,2	2,8	65,5
1995	190,0	286,0	17,0	128,0	779,0	321,0	101,0	135,0	1957,0	74,7	68,7	6,0	62,7
1996	132,0	275,0	6,0	135,0	822,0	317,0	117,0	703,0	2507,0	71,4	68,8	6,6	62,2
1997	83,0	248,0	6,0	170,0	707,0	264,0	130,0	475,0	2083,0	65,9	68,6	9,4	59,2
1998	98,0	234,0	20,0	161,0	746,0	266,0	124,0	210,0	1859,0	66,3	68,5	10,4	58,1
1999	117,0	239,0	3,0	164,0	582,0	224,0	126,0	12,0	1467,0	63,5	68,2	9,9	58,2
2000	85,0	264,0	7,0	152,0	611,0	269,0	94,0	0,0	1482,0	62,5	67,8	10,3	57,5
2001	50,0	180,0	3,0	150,0	583,0	260,0	64,0	10,0	1300,0	49,9	66,6	10,0	56,6
2002	37,0	161,0	4,0	137,0	520,0	229,0	48,0	38,0	1174,0	43,9	65,1	11,2	53,9

Annex 4 CO_2 reference approach and comparison with sectoral approach, and relevant information on the national energy balance

ANNEX 4

Please see Annex 3.A

Annex 5 Assessment of completeness and (potential) sources and sinks of greenhouse gas emissions and removals excluded

Annex 5 Assessment of completeness and (potential) sources and sinks of greenhouse gas emissions and removals excluded

The Danish greenhouse gas emission inventory due 15 April 2004 includes all sources identified by the Revised IPPC Guidelines except the following (se table A5.1):

- Waste: Wastewater handling systems are considered to produce only minor emissions of CO2, CH4 and N2O but it will be investigated further.

- Industrial processes: At present CO_2 emissions from use of limestone, dolomite and soda ash are included in the emissions from glass production. CO_2 emission from sugar production and production of expanded clay will be included in the next submission. CO_2 emissions from use of coke in iron foundries will be included in the next submission.

- Agriculture: The methane convension factor for poultry and fur farming is not estimated. There is no default value recommended in IPCC (table A-4 in GPG). The CH4 emission from manure storage in the field is not estimated. The CH4 emission from cultivation of organogenic soil is not estimated.

In response to review of previous submissions the use of notation key in the Danish CRF-tables is improved and extended.

Table A5.1 Completeness.

Sources and sinks not reported (NE)[1]				
GHG	Sector[2]	Source/sink category [2]	Explanation	
CO_2	Waste	Wastewater handling	Wastewater handling systems are considered to produce only negligible emissions.	
	2. Industrial Processes	Iron, steel and ferroalloys	Consumption of C in iron foundries will be investigated	
	2. Industrial Processes	Limestone, dolomite and soda ash use	CO2 emission from sugar production and production of expanded clay will be included in the next submission.	
CH_4	Waste	Wastewater handling	Wastewater handling systems are considered to produce only minor emissions, to be investigated	
	Agriculture, Enteric fermentation - table 4s1 + table 4.A	Poultry and fur farming	The methane convension factor for poultry and fur farming is not estimated. There is no default value recommended in IPCC (table A-4 in GPG)	
	Agricultural soils	Direct soil emissions	The CH4 emission from manure storage in the field is not estimated	
	Agricultural soils	Indirect emissions	The CH4 emission from cultivation of organogenic soil is not estimated	
N_2O	Waste	Wastewater handling	Wastewater handling systems are considered to produce only minor emissions, to be investigated	
HFCs				
PFCs				
SF_6				

Sources and sinks reported elsewhere (IE)[3]				
GHG	Source/sink category	Allocation as per IPCC Guidelines	Allocation used by the Party	Explanation
CO_2	Waste Incineration non biogenic	6.C	1.A1a	Waste Incineration plants are used for energy and heat production and are included in energy statistics
	1A2, Energy, Fuel combustion, Manufacturing industries and construction	1A2a-e	1A2f	Danish energy statistics states energy consumption of manufacturing industry as a whole. Thus all energy consumption of 1A2 is included in 1A2f.
CH_4	Waste Incineration non biogenic	6.C	1.A1a	Waste Incineration plants are used for energy and heat production and are included in energy statistics
	1A2, Energy, Fuel combustion, Manufacturing industries and construction	1A2a-e	1A2f	Danish energy statistics states energy consumption of manufacturing industry as a whole. Thus all energy consumption of 1A2 is included in 1A2f.
	Agricultural soils, animal production	4s2	4s1	CH4 emission caculated in 4s1 under B Manure Management includes emission from animal on grass
N_2O	Waste Incineration non biogenic	6.C	1.A1a	Waste Incineration plants are used for energy and heat production and are included in energy statistics
	1A2, Energy, Fuel combustion, Manufacturing industries and construction	1A2a-e	1A2f	Danish energy statistics states energy consumption of manufacturing industry as a whole. Thus all energy consumption of 1A2 is included in 1A2f.
HFCs				
PFCs				
SF_6				

[1] Please, clearly indicate sources and sinks which are considered in the IPCC Guidelines but are not considered in the submitted inventory. Explain the reason for excluding these sources and sinks, in order to avoid arbitrary interpretations. An entry should be made for each source/sink category for which the indicator "NE" is entered in the sectoral tables.

[2] Indicate omitted source/sink following the IPCC source/sink category structure (e.g. sector: Waste, source category: Wastewater Handling).

[3] Please clearly indicate sources and sinks in the submitted inventory that are allocated to a sector other than that indicated by the IPCC Guidelines. Show the sector indicated in the IPCC Guidelines and the sector to which the source or sink is allocated in the submitted inventory. Explain the reason for reporting these sources and sinks in a different sector. An entry should be made for each source/sink for which the indicator "IE" is used in the sectoral tables.

Annex 6 (6.1) Additional information to be considered as part of the NIR submission (where relevant) or other useful reference information

Annex 6.1. Total emissions for Denmark, Greenland and the Faroe Islands (CO2 equivalent (Gg))

GREENHOUSE GAS EMISSIONS	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
	CO_2 equivalent (Gg)												
Net CO_2 emissions/removals	51.162,04	61.654,08	55.792,43	57.230,94	61.827,23	59.201,14	72.607,37	63.169,71	58.080,68	55.356,47	53.554,96	52.368,27	51.718,92
CH_4	5.446,86	5.556,50	5.593,14	5.717,66	5.860,09	5.941,60	6.062,68	5.915,84	5.896,12	5.780,30	5.751,29	5.811,34	5.655,15
N_2O	10.638,05	10.518,09	10.067,37	9.843,30	9.710,63	9.603,27	9.338,40	9.213,70	9.098,63	8.799,97	8.575,34	8.354,57	8.007,75
HFCs	0,00	0,00	3,44	93,93	134,53	217,73	329,30	323,75	411,20	502,98	604,64	647,32	672,10
PFCs	0,00	0,00	0,00	0,00	0,05	0,50	1,66	4,12	9,10	12,48	17,89	22,13	22,17
SF_6	44,45	63,50	89,15	101,17	122,06	107,36	60,99	73,09	59,46	65,39	59,25	30,43	21,63
Total (with net CO_2 emissions/removals	**67.291,40**	**77.792,17**	**71.545,52**	**72.987,01**	**77.654,59**	**75.071,61**	**88.400,40**	**78.700,20**	**73.555,19**	**70.517,60**	**68.563,37**	**67.234,05**	**66.097,72**

Annex 6 (6.2) Additional information to be considered as part of the NIR submission (where relevant) or other useful reference information

Greenland/Faroe Islands

Annex 6.2 CO_2 emissions in Greenland and the Faroe Islands

In the Faroe Islands a major work was in 2002 to produce a revised and more comprehensive greenhouse gas inventory as required by the IPCC guidelines (Lastein et al., 2003). The work comprised emission estimates of CO_2, CH_4 and N_2O for the years 1990-2001. However, because of limited resources the inventory work was not continued to produce emission figures for 2002, and due to lack of emission data the 2001 total is repeated for 2002.

For Greenland only totals for CO_2 emissions from fossil fuels are reported. However, fossil fuels are expected to be the most important sources of greenhouse gases in this region. Figures for CO_2 emissions from 1990 to 2002 are given in the table below.

The significant increase in CO_2 emissions from 1998 to 2001 is mainly due to more fuel use in the fishery, public electricity and manufacturing industry sectors, while the CH_4 and N_2O emission increases (the Faroe Islands) are due to rising activity in the agricultural sector.

The possibilities for corresponding improvement in statistics and greenhouse gas inventories in both Greenland and the Faroe Islands will be investigated.

Table 1 Estimation of greenhouse gas emissions in Greenland and the Faroe Islands 1990 –2002.

	Greenland	**Faroe Islands**		
	Gg CO_2	**Gg CO_2**	**Mg CH_4**	**Mg N_2O**
1990	624	709	853	73
1991	609	682	885	78
1992	594	650	881	78
1993	0	536	875	73
1994	494	544	906	79
1995	523	541	909	81
1996	564	578	904	81
1997	575	559	935	86
1998	550	616	908	83
1999	585	645	920	87
2000	659	699	959	97
2001	617	791	973	101
2002	577	791	973	101

References

Lastein, L. & Winther, M. 2003: Emission of greenhouse gases and long-range transboundary air pollutants in the Faroe Islands 1990-2001. National Environmental Research Institute. - NERI Technical Report 477 (electronic): 62 pp. Available at: http://www.dmu.dk/1_viden/2_Publikationer/3_fagrapporter/rapporter/FR477.PDF

Annex 7 Tables 6.1 and 6.2 of the IPCC good practice guidance

Annex 7

IPCC Source category	Gas	Base year emission	Year t emission	Activity data uncer-tainty	Emission factor uncer-tainty	Combined uncer-tainty	Combined uncer-tainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty i trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		Gg CO2 eq	Gg CO2 eq	%	%	%	%	%	%	%	%	%
Stationary Combustion, Coal	CO2	24209	16708	1	5	5,099	1,344	-0,111	0,260	-0,556	0,368	0,667
Stationary Combustion, Petroleum coke	CO2	410	762	3	5	5,831	0,070	0,006	0,012	0,028	0,050	0,057
Stationary Combustion, Plastic waste	CO2	369	599	5	5	7,071	0,067	0,004	0,009	0,018	0,066	0,068
Stationary Combustion, Residual oil	CO2	2505	1923	2	2	2,828	0,086	-0,009	0,030	-0,017	0,085	0,086
Stationary Combustion, Gas oil	CO2	4564	2920	4	5	6,403	0,295	-0,025	0,045	-0,123	0,257	0,285
Stationary Combustion, Kerosene	CO2	366	18	4	5	6,403	0,002	-0,005	0,000	-0,027	0,002	0,027
Stationary Combustion, Orimulsion	CO2	0	1908	1	2	2,236	0,067	0,030	0,030	0,059	0,042	0,073
Stationary Combustion, Natural gas	CO2	4330	11090	3	1	3,162	0,553	0,106	0,173	0,106	0,732	0,740
Stationary Combustion, LPG	CO2	194	104	4	5	6,403	0,011	-0,001	0,002	-0,007	0,009	0,011
Stationary Combustion, Refinery gas	CO2	806	842	3	5	5,831	0,077	0,001	0,013	0,004	0,056	0,056
Stationary combustion plants, gas engines	CH4	2	400	2,2	40	40,060	0,253	0,006	0,006	0,248	0,019	0,248
Stationary combustion plants, other	CH4	117	133	2,2	100	100,024	0,210	0,000	0,002	0,028	0,006	0,029
Stationary combustion plants	N2O	397	383	2,2	1000	1000,002	6,037	0,000	0,006	-0,142	0,019	0,143
Transport, Civil aviation, Aviation Gasoline	CO2	8	7	2	5	5,385	0,001	0,000	0,000	0,000	0,000	0,000
Transport, Civil aviation, Jet Kerosene	CO2	208	139	2	5	5,385	0,012	-0,001	0,002	-0,005	0,006	0,008
Transport, Road transport, Gasoline	CO2	4914	6021	2	5	5,385	0,512	0,018	0,094	0,091	0,265	0,280
Transport, Road transport, Diesel Oil	CO2	4436	5369	2	5	5,385	0,456	0,015	0,084	0,077	0,236	0,249
Transport, Railways, Diesel Oil	CO2	297	210	2	5	5,385	0,018	-0,001	0,003	-0,006	0,009	0,011
Transport, Navigation, Residual Oil	CO2	278	161	2	5	5,385	0,014	-0,002	0,003	-0,009	0,007	0,011
Transport, Navigation, Gas/Diesel Oil	CO2	246	320	2	5	5,385	0,027	0,001	0,005	0,006	0,014	0,015
Transport, Agriculture, Diesel Oil	CO2	1280	1184	20	5	20,616	0,385	-0,001	0,018	-0,006	0,521	0,521
Transport, Agriculture, Gasoline	CO2	38	36	20	5	20,616	0,012	0,000	0,001	0,000	0,016	0,016
Transport, Forestry, Diesel Oil	CO2	0	0	20	5	20,616	0,000	0,000	0,000	0,000	0,000	0,000
Transport, Forestry, Gasoline	CO2	4	4	20	5	20,616	0,001	0,000	0,000	0,000	0,002	0,002
Transport, Industry, Diesel Oil	CO2	687	635	20	5	20,616	0,207	-0,001	0,010	-0,003	0,280	0,280
Transport, Industry, Gasoline	CO2	10	10	20	5	20,616	0,003	0,000	0,000	0,000	0,004	0,004
Transport, Industry, LPG	CO2	81	97	20	5	20,616	0,032	0,000	0,002	0,001	0,043	0,043
Transport, Household and gardening, Gasoline	CO2	87	82	20	5	20,616	0,027	0,000	0,001	0,000	0,036	0,036
Transport, Civil aviation, Aviation Gasoline	CH4	0	0	2	100	100,020	0,000	0,000	0,000	0,000	0,000	0,000
Transport, Civil aviation, Jet Kerosene	CH4	0	0	2	100	100,020	0,000	0,000	0,000	0,000	0,000	0,000

Transport, Road transport, Gasoline	CH4	48	56	2	40	40,050	0,036	0,000	0,001	0,006	0,002	0,006
Transport, Road transport, Diesel Oil	CH4	7	7	2	40	40,050	0,004	0,000	0,000	0,000	0,000	0,000
Transport, Railways, Diesel Oil	CH4	0	0	2	100	100,020	0,000	0,000	0,000	0,000	0,000	0,000
Transport, Navigation, Residual Oil	CH4	0	0	2	100	100,020	0,000	0,000	0,000	0,000	0,000	0,000
Transport, Navigation, Gas/Diesel Oil	CH4	0	0	2	100	100,020	0,000	0,000	0,000	0,000	0,000	0,000
Transport, Agriculture, Diesel Oil	CH4	2	1	20	100	101,980	0,002	0,000	0,000	0,000	0,001	0,001
Transport, Agriculture, Gasoline	CH4	1	1	20	100	101,980	0,001	0,000	0,000	0,000	0,000	0,000
Transport, Forestry, Diesel Oil	CH4	0	0	20	100	101,980	0,000	0,000	0,000	0,000	0,000	0,000
Transport, Forestry, Gasoline	CH4	0	0	20	100	101,980	0,000	0,000	0,000	0,000	0,000	0,000
Transport, Industry, Diesel Oil	CH4	1	1	20	100	101,980	0,001	0,000	0,000	0,000	0,000	0,000
Transport, Industry, Gasoline	CH4	0	0	20	100	101,980	0,001	0,000	0,000	0,000	0,000	0,000
Transport, Industry, LPG	CH4	2	2	20	100	101,980	0,003	0,000	0,000	0,001	0,001	0,001
Transport, Household and gardening, Gasoline	CH4	3	3	20	100	101,980	0,004	0,000	0,000	0,000	0,001	0,001
Transport, Civil aviation, Aviation Gasoline	N2O	0	0	2	1000	1000,002	0,001	0,000	0,000	0,000	0,000	0,000
Transport, Civil aviation, Jet Kerosene	N2O	3	2	2	1000	1000,002	0,037	0,000	0,000	-0,008	0,000	0,008
Transport, Road transport, Gasoline	N2O	47	276	2	50	50,040	0,218	0,004	0,004	0,179	0,012	0,179
Transport, Road transport, Diesel Oil	N2O	84	118	2	50	50,040	0,093	0,001	0,002	0,027	0,005	0,027
Transport, Railways, Diesel Oil	N2O	3	2	2	1000	1000,002	0,028	0,000	0,000	-0,011	0,000	0,011
Transport, Navigation, Residual Oil	N2O	5	3	2	1000	1000,002	0,049	0,000	0,000	-0,034	0,000	0,034
Transport, Navigation, Gas/Diesel Oil	N2O	5	6	2	1000	1000,002	0,092	0,000	0,000	0,021	0,000	0,021
Transport, Agriculture, Diesel Oil	N2O	17	15	20	1000	1000,200	0,243	0,000	0,000	-0,016	0,007	0,017
Transport, Agriculture, Gasoline	N2O	0	0	20	1000	1000,200	0,004	0,000	0,000	0,000	0,000	0,000
Transport, Forestry, Diesel Oil	N2O	0	0	20	1000	1000,200	0,000	0,000	0,000	0,000	0,000	0,000
Transport, Forestry, Gasoline	N2O	0	0	20	1000	1000,200	0,000	0,000	0,000	0,000	0,000	0,000
Transport, Industry, Diesel Oil	N2O	9	8	20	1000	1000,200	0,132	0,000	0,000	-0,009	0,004	0,009
Transport, Industry, Gasoline	N2O	0	0	20	1000	1000,200	0,001	0,000	0,000	0,000	0,000	0,000
Transport, Industry, LPG	N2O	1	1	20	1000	1000,200	0,023	0,000	0,000	0,004	0,001	0,004
Transport, Household and gardening, Gasoline	N2O	1	1	20	1000	1000,200	0,009	0,000	0,000	0,000	0,000	0,000
Energy, fugitive emissions, oil and natural gas	CO2	240	535	15	5	15,811	0,134	0,005	0,008	0,023	0,177	0,178
Energy, fugitive emissions, solid fuels	CH4	72	62	2	200	200,010	0,197	0,000	0,001	-0,028	0,003	0,028
Energy, fugitive emissions, oil and natural gas	CH4	21	70	15	50	52,202	0,057	0,001	0,001	0,038	0,023	0,045
Energy, fugitive emissions, oil and natural gas	N2O	1	3	15	50	52,202	0,002	0,000	0,000	0,001	0,001	0,002
Agriculture, enteric fermentation	CH4	3100	2798	2	20	20,100	0,887	-0,004	0,044	-0,081	0,123	0,147
Agriculture, manure management	CH4	742	966	10	30	31,623	0,482	0,004	0,015	0,109	0,213	0,239
Agriculture, manure management	N2O	686	605	10	500	500,100	4,777	-0,001	0,009	-0,559	0,133	0,574
Agriculture, Agricultural soils	N2O	8297	5765	20	500	500,400	45,521	-0,038	0,090	-18,808	2,538	18,978
Total		64242	63373				2135,657					362,333
Total uncertainties					**Overall uncertainty i the year (%):**		**46,213**			**Trend uncertainty (%):**		**19,035**

Annex 8 Other annexes – (Any other relevant information)

ANNEX 8

Not relevant for Denmark