National Environmental Research Institute
Ministry of the Environment · Denmark

Emission Inventories

Denmark's National Inventory Report 2006

Submitted under the United Nations Framework Convention on Climate Change, 1990-2004

NERI Technical Report No. 589

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Data sheet

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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 2006. The report contains information on Denmark's inventories for all years' from 1990 to 2004 for CO_2, CH_4, N_2O, HFCs, PFCs and SF_6, CO, NMVOC, SO_2.
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Executive summary

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

Annual report

This report is Denmark's National Inventory Report (NIR), for submission to the United Nations Framework Convention on Climate Change (UNFCCC), for 15 April 2006. The report contains information on Denmark's inventories for all years from 1990 to 2004. The structure of the report is in accordance with the UNFCCC guidelines on reporting and review. 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 transparency.

The annual emission inventory for Denmark from 1990 to 2004 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 total greenhouse gas emissions in CO_2 equivalents.

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

The NIR is available to the public on the National Environmental Research Institute's homepage:

http://www.dmu.dk/International/Publications/
(search for "National Inventory Report 2006")

and the CRF tables are available at the Eionet web site:
http://cdr.eionet.europa.eu/dk/Air_Emission_Inventories/Submission_UNFCCC/colrdy8sq

This report does not contain the full set of CRF Tables. Only the trend tables, Tables 10.1-5 of the CRF format, are included in Annex 9.

Concerning figures, please note that figures in the CRF tables (and Annex 9) are in the Danish notation which is "," (comma) for decimal sign and "." (Full stop) to divide thousands. In the report (except where tables are taken from the CRF as "pictures" as Annex 9) English notation is used: "." (Full stop) for decimal sign and (mostly) space for division of thousands. The English notation for division of thousand as "," (comma) is not used due to the risk to be misinterpreted in Danish.

Institute responsible

The National Environmental Research Institute (NERI), under the Danish Ministry of the 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 is also the body designated with overall responsibility for the national inventory under the Kyoto Protocol. The work concerning the annual greenhouse emissions inventory is carried out in cooperation with other Danish ministries, research institutes, organisations and companies.

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

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

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

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

Based on weight and a 100-year period, methane is thus 21 times more powerful a greenhouse gas than CO_2, and N_2O is 310 times more powerful than CO_2. Some of the other greenhouse gases (hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride) have considerably higher global warming potentials. For example, sulphur hexafluoride has a global warming potential of 23,900. The values for global warming potential used in this report are those prescribed by UNFCCC.

ES.2. Summary of national emission and removal trends

Greenhouse Gas Emissions

The greenhouse gas emissions are estimated according to the IPCC guidelines and are aggregated within seven main sectors. The greenhouse gases include CO_2, CH_4, N_2O, HFCs, PFCs and SF_6. Figure 2 shows the estimated total greenhouse gas emissions in CO_2 equivalents from 1990 to 2004. The emissions are not corrected for electricity trading 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 approximately 1%. Stationary combustion plants, transport and agriculture represent the largest sources. The net CO_2 removals by forestry and soil (Land Use Change and Forestry (LUCF)) represent approximately 3% of the total emissions in CO_2 equivalents in 2004. The national total greenhouse gas emission in CO_2 equivalents without LUCF has decreased by 1.5% from 1990 to 2004 and by 5.5% with LUCF.

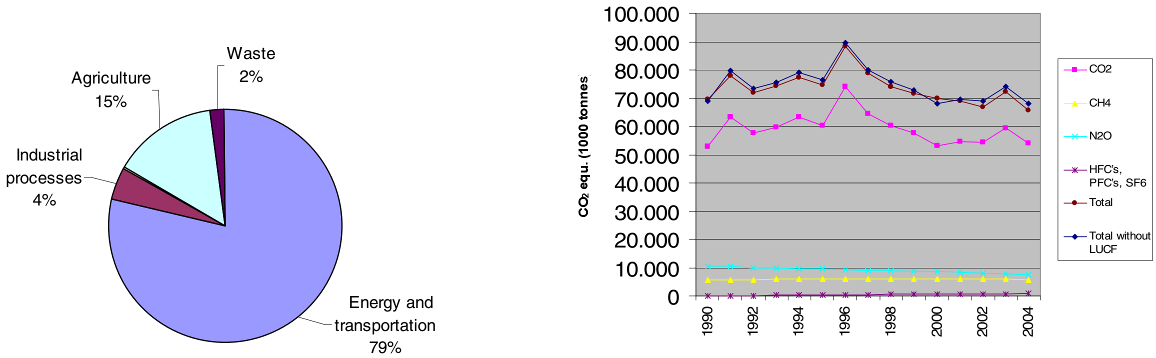


Figure ES.1. Left: Greenhouse gas emissions in CO_2 equivalents by main sector for 2004. Right: Time-series for 1990 to 2004.

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

Energy

The largest source of the emission of CO_2 is the energy sector, which includes the combustion of fossil fuels such as oil, coal and natural gas. Public power and district heating plants contribute with more than half of the emissions. Approximately 24% comes from the transport sector. The CO_2 emission decreased by approximately 9% from 2003 to 2004. A relatively large fluctuation in the emission time-series from 1990 to 2004 is due to inter-country electricity trade. Thus, high emissions in 1991, 1996 and 2003 reflect a large electricity export and the low emission in 1990 was due to a large import of electricity in that year. 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 24% 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 2003, the contributions to the total emissions of N_2O and CH_4were 83% and 65%, respectively. The main reason for a fall of approximately 31% in the emission of N_2O from 1990 to 2003 is legislative demand for an improved utilisation of nitrogen in feedstuff and in manure. This results in less nitrogen excreted per livestock unit produced and a considerable reduction in the use of fertilisers. From 1990, the emission of CH_4 from enteric fermentation has decreased due to decreasing numbers of cattle. However, the emission from manure management has increased due to changes in stable management systems towards an increase in slurry-based systems. Altogether, the emission of CH_4 for the agricultural sector has decreased by 7% from 1990 to 2004.

Industrial processes

The emissions from industrial processes – i.e. emissions from processes other than fuel combustion, amount to 4% of 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 2.3% of the national total – increased by 74% from 1990 to 2004. The second largest source is N_2O from the production of nitric acid. The N_2O emission from this production has decreased by 49% from 1990 to 2004. The production of nitric acid in Denmark stopped in mid-2004.

The emission of HFCs, PFCs and SF_6 has, since 1995 until 2004, increased by 145%, largely due to the increasing emission of HFCs. The use of HFCs, and especially HFC-134a, has increased several fold, so HFCs have become dominant F-gases, contributing 67% to the F-gas total in 1995, rising to 94% in 2004. HFC-134a is mainly used as a refrigerant. However, the use of HFC-134a is now stable. This is due to Danish legislation, which, in 2007, forbids new HFC-based refrigerant stationary systems. Running counter to this trend, however, is the increasing use of air conditioning systems among mobile systems.

Waste

Waste disposal is the third largest source of the CH_4 emission. The emission has decreased by 20% from 1990 to 2004, at which point the contribution from waste was 19% of the total CH_4 emission. This decrease is due to the 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. The CH_4 emission from wastewater handling amounts to around 5% of the total CH_4 emission.

ES.4. Other information

ES.4.1 Quality assurance and quality control

A plan for implementing Quality Assurance (QA) and Quality Control (QC) in greenhouse gas emission inventories is included in the report. The plan is in accordance with the guidelines provided by the UNFCCC (Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories and Guidelines for National Systems). ISO 9000 standards are also used as an important input for the plan (Sørensen et al., 2005).

In preparation of Denmark's annual emission inventory, several quality control (QC) procedures are already carried out, as described in Chapters 3-8. The QA/QC plan will improve these activities in the future.

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

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

ES.4.2. Completeness

The Danish greenhouse gas emission inventory, which was due 15 April 2006, includes all sources identified by the revised IPPC guidelines except the following:

- Agriculture: The methane conversion factor in relation to the enteric fermentation for poultry and fur farming is not estimated. There is no default value recommended by the IPCC. However, this emission is seen as non-significant compared with the total emission from enteric fermentation.

ES.4.3. Recalculations and improvements

Considerable improvements in the inventories and the reporting have been made in response to the latest UNFCCC review process, and as a result of an on-going working process.

The main improvements are:

Stationary Combustion
The N_2O emission factor for coal combusted in large power plants has been changed for 1990-2003.

Mobile sources
Inland waterways/agriculture/forestry/household-gardening
A complete revision of the 1985-2003 time-series of fuel use and emissions has been made using results from a specific Danish non-road research project.

Industry
Emissions of CO_2 from production of mineral wool and expanded clay products, refining of sugar, flue gas cleaning (wet process) in relation to waste incineration, combined heat and power plants, and power plants have been included. The indirect emission of CO_2, and

the emission of NMVOC from asphalt roofing and road-paving with asphalt have also been included.

Solvent
A survey based on new methodologies results in new NMVOC emission estimates. The changes are mainly caused by new information on the amounts of propane and butane used as propellants.

Agriculture
The changes with regard to the CH_4 emission are due to a recalculation of the emission factor for cattle. Recent research shows that the principal feedstuff used (sugar beets) results in a higher methane conversion rate than the default values.

Due to changes in the methodology for calculating the emission from organic soils in the LULUCF sector, the N_2O emission in the agricultural sector from histosols has been recalculated.

Waste
The emission estimates methodology for wastewater handling was introduced for the first time in the inventory submission in March-April 2005. Data in this methodology has been updated and revised for the current submission.

Cropland, grassland and wetlands
Mineral soils are, for the first time, incorporated in the inventory.

For the **National Total CO_2 Equivalent Emissions without Land-Use Change and Forestry**, the general impact of the improvements and recalculations performed is small and the changes for the whole time-series are between -0.89% and +0.08%. Therefore, the implications of the recalculations on the level and on the trend, 1990-2003, of this national total are small.

For the **National Total CO_2 Equivalent Emissions with Land-Use Change and Forestry**, the general impact of the **recalculations** is rather small, although the impact is larger than without LULUCF due to recalculations in the LULUCF sector. The differences are positive for all years. The differences vary between –2.51% and +0.54%. These differences refer to recalculated estimates, with major changes in the forestry sector for those years.

Sammenfatning

S.1. Baggrund for opgørelse af drivhusgasemissioner og klimaændringer

Årlig rapport
Denne rapport er Danmarks rapport om drivhusgasopgørelser sendt til FN's konvention om klimaændringer (UNFCCC) den 15. april 2006. Rapporten indeholder oplysninger om Danmarks opgørelser for fra 1990 til 2004. Rapporten er struktureret som angivet i IPCC's retningslinier for rapportering og evalueringer af drivhusgasopgørelser. For at sikre at opgørelserne er gennemskuelige indeholder rapporten detaljerede oplysninger om opgørelsesmetoder og baggrundsdata for alle årene fra basisåret og frem til det seneste rapporterede år.

Den årlige emissionsopgørelse for Danmark for årene 1990 til 2004 er rapporteret i det format (CRF) som Klimakonventionen foreskriver. CRF-tabellerne indeholder oplysninger om emissioner, aktivitetsdata og emissionsfaktorer for hvert år, emissionsudvikling for de enkelte drivhusgasser samt den totale drivhusgasemission i CO_2 ækvivalenter.

Følgende emner er beskrevet i rapporten: Udviklingen i drivhusgasemissionerne, de forskellige emissions-kategorier i CRF-fomatet, usikkerheder, rekalkulationer, planlagte forbedringer og procedure for kvalitetssikring og – kontrol.

Rapporten tilgængelige på DMU's hjemmeside:
http://www.dmu.dk/International/Publications/
(søg efter "National Inventory Report 2006")

og CRF tabellerne er tilgængelig på Eionet web site:
http://cdr.eionet.europa.eu/dk/Air_Emission_Inventories/Submission_UNFCCC/colrdy8sq

Ansvarligt institut
Danmarks Miljøundersøgelser (DMU) er ansvarlig for udarbejdelse af de danske drivhusgasemissioner og den årlige rapportering til UNFCCC og kontaktpunktet for Danmarks nationale system til drivhusgasopgørelser under Kyoto-protokollen. DMU deltager desuden i arbejdet i UNFCCC regi, hvor retningsliner for rapportering diskuteres og vedtages og i EU's moniteringsmekanisme for opgørelse af drivhusgasser, hvor retningslinier for rapportering til EU reguleres.

Arbejdet med de årlige opgørelser udføres i samarbejde med andre danske ministerier, forskningsinstitutioner, organisationer og private virksomheder.

Drivhusgasser
Til Klimakonventionen rapporteres følgende drivhusgasser:

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

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

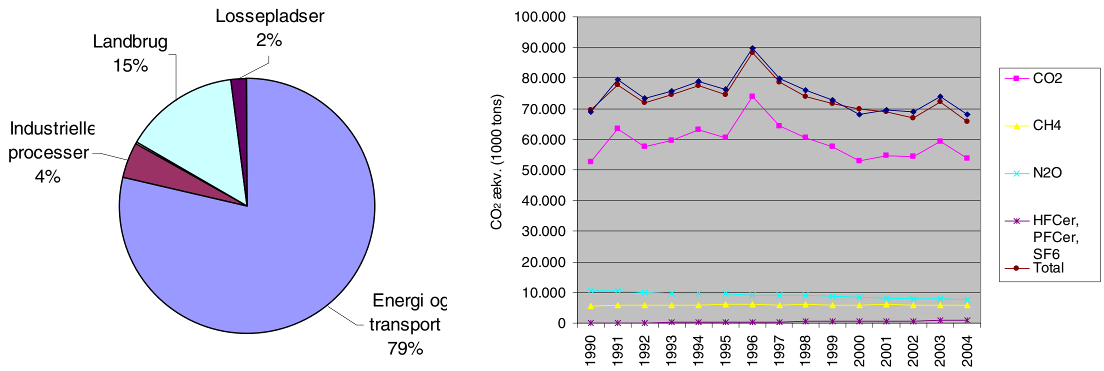
- Kuldioxid, CO_2: 1
- Metan, CH_4: 21
- Lattergas, N_2O: 310

Regnet efter vægt og over en 100-årig periode er metan således ca. 21 og lattergas ca. 310 gange så effektive drivhusgasser som kuldioxid. Nogle af de øvrige drivhusgasser (HFC, PFC, SF_6) har væsentlig højere GWP-værdier, som fx SF_6, der har en beregnet værdi på 23.900. I denne rapport er anvendt de GWP-værdier som UNFCCC har anbefalet.

S.2. Udviklingen i emissioner og optag

Drivhusgasemissioner

De danske emissionsopgørelser følger metoderne beskrevet i IPCC's[1] retningslinier og er aggregerede i 7 overordnede kategorier. Drivhusgasserne omfatter CO_2, CH_4, N_2O, HFC'er, PFC'er og SF_6. Figur s.1 viser de estimerede totale drivhusgasemissioner i CO_2-ækvivalenter for perioden 1990 til 2004. Emissionerne er ikke korrigerede for eludveksling med andre lande og temperatursvingninger fra år til år. CO_2 er den vigtigste drivhusgas efterfulgt af N_2O og CH_4, mens HFC'er, PFC'er og SF_6 kun udgør ca. 1% af de totale emissioner. Stationære forbrændingsanlæg, transport og landbrug er de største kilder. Netto-CO_2-optaget af skov og jorde (Land Use Change and Forestry) var ca. 5% af de totale emissioner i CO_2-ækvivalenter i 2004. De nationale totale drivhusgasemissioner i CO_2-ækvivalenter er faldet med 1,5% fra 1990 til 2004 hvis netto-bidraget fra skovenes og jordenes udledninger og optag af CO_2 ikke indregnes og med 5,5% hvis de indregnes.



Figur S.1: Danske drivhusgasemissioner i CO_2-ækvivalenter for hovedsektorer for 2004 og tidsserier for 1990-2004.

S.3. Oversigt over emissionskilder

Energi

Udledningen af CO_2 stammer altovervejende fra forbrænding af kul, olie og naturgas på kraftværker samt i beboelsesejendomme og industri. Kraft- og fjernvarmeværker bidrager med mere end halvdelen af emissionerne. Omkring 24% stammer fra transportsektoren. CO_2-emissionen faldt med omkring 9% fra 2003 til 2004 grundet faldende eksport af elektricitet og højere udendørstemperatur i 2004 sammenlignet med 2003. De relative store udsving i emissionerne fra år til år skyldes handel med elektricitet med andre lande, herunder særligt de nordiske. De store emissioner i 1991, 1994, 1996 og 2003 er et resultat af stor eleksport, mens den lave emission i 1990 skyldes stor import af elektricitet. Udledningen af metan fra energiproduktion har været stigende på grund øget anvendelse af gasmotorer, som har et stort metan-udslip i forhold til andre forbrændingsteknologier. Transportsektorens CO_2-emissioner er steget med ca. 24% siden 1990 hovedsagelig på grund af voksende vejtrafik.

Landbrug

Landbrugssektoren bidrager med 15% af de totale drivhusgasser i CO_2-ækvivalenter og er den vigtigste kilde hvad angår emissioner af N_2O og CH_4. I 2004 var bidragene til de totale emissioner af N_2O og CH_4 henholdsvis 83% og 65%. Fra 1990 ses et fald på 31% i N_2O-emissionen fra landbrug. Det skyldes mindre brug af handelsgødning og bedre udnyttelse af husdyrgødningen, hvilket resulterer i mindre emissioner pr. producerede dyreenhed. Emissionerne fra husdyrenes fordøjelsessystem er faldet fra 1990 til 2004 grundet et faldende antal kvæg. På den anden side har en stigende andel af gyllebaserede staldsystemer bevirket at emissionerne fra husdyrgødning er steget. I alt er CH_4 emissionerne fra landbrugssektoren faldet med 7% fra 1990 til 2004.

Industrielle processer

Emissionerne fra industrielle processer – hvilket vil sige andre processer end forbrændingsprocesser – udgør 4% af de totale danske drivhusgasemissioner. De vigtigste kilder er cementproduktion, salpetersyreproduktion, kølesystemer, opskumning af plast og kalcinering af kalksten. CO_2-emissionen fra cementproduktion - som er den største kilde - bidrager med 2,3% af de totale emissioner i 2003 og stigningen fra 1990 til 2004 var 74%. Den anden største kilde er lattergas fra produktion af salpetersyre. Produktionen af salpetersyre stoppede i midten af 2004, hvilket er medvirkende til at lattergasemissionen faldt med 57% fra 1990 til 2004.

Emissionerne af HFC'er, PFC'er og SF_6 er siden 1995 og indtil 2004 steget med 145% hovedsageligt på grund af stigende emissioner af HFC'erne. Anvendelsen af HFC'erne, og specielt HFC-134a, er steget kraftigt, hvilket har betydet at andelen af HFC'er af de totale F-gasser steg fra 67% i 1995 og til 94% i 2004. HFC'erne anvendes primært inden for køleindustrien. Anvendelsen er dog nu stagnerende, som et resultat af dansk lovgivning, der forbyder anvendelsen af nye HFC-baserede stationære kølesystemer fra 2007. I modsætning til denne udvikling ses et stigende brug af airconditionsystemer, hvoraf nogle er mobile.

Affald
Lossepladser er den tredjestørste kilde til CH_4 emissioner. Emissionen er faldet med 20% fra 1990 til 2004 hvor andelen var 19% af de totale CH_4 emissioner. Faldet skyldes stigende anvendelse af affald til produktion af elektricitet og varme. Da al affaldsforbrænding bruges til produktion af elektricitet og varme, er emissionerne inkluderet i IPCC-kategorien 1A1a, der omfatter kraft- og fjernvarmeværker. Emissionerne fra spildevandsanlæg udgør omkring 5% af de totale CH_4-emissioner.

S.4. Andre informationer

S.4.1 Kvalitetssikring og - kontrol

Rapporten indeholder en plan for implementering af kvalitetssikring og -kontrol af emissionsopgørelserne. Kvalitetsplanen bygger på IPCC's retningslinier og ISO 9000 standarderne (Sørensen et al., 2005).

Som beskrevet i rapportens kapitel 3-8 anvendes allerede procedure, der sikre opgørelsernes kvalitet. Kvalitetsplanen vil forbedre disse procedurer, når den er fuldt implementeret.

Hovedformålet med planen er at skabe rammer for dokumentering og rapportering af emissionerne, så opgørelserne bliver gennemskuelige, konsistente, sammenlignelige, komplette og nøjagtige. For at opfylde disse kriterier, er der foreslået en datastruktur der understøtter arbejdsgangen fra indsamling af data til sammenstilling, modellering og til sidst rapportering af data.

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

S. 4.2. Komplethed

De danske opgørelser af drivhusgasemissioner, som blev rapporteret den 15. april 2005 til UNFCCC, indeholder alle de kilder der er beskrevet i IPCC's retningsliner undtagen:

Landbrug: Metankonverteringsfaktoren for emissioner fra kyllingers og pelsdyrs fordøjelsessystemer er ikke bestemt, og der er findes ingen IPCC standardemissionsfaktor. Emissionerne fra disse dyrs fordøjelsessystemer anses dog for at være forsvindende i forhold til de totale emissioner fra fordøjelsessystemer.

S. 4.3. Rekalkulationer og forbedringer

Der er blevet fortaget omfattende forbedringer af opgørelserne og rapporteringen, som opfølgning på den seneste UNFCCC evaluering, og som en følge af de løbende forbedringer som DMU foretager.

De vigtigste forbedringer er:

Stationær forbrænding
N_2O-emissionsfaktoren for forbrænding af kul for kraftværker er ændret for 1990-2003.

Mobile kilder
Som følge af et dansk forskningsprojekt er brændselsforbrug og emissioner revideret for ikke-vejgående køretøjer for årene 1985-2003.

Industri
CO_2-emissioner fra produktion af mineraluld og ekspanderet ler samt raffinering af sukker og røggasrensning er nu inkluderet i opgørelserne. Indirekte CO_2-emissioner og NMVOC-emissioner fra brug af asfalt er også blevet inkluderet.

Solvent
NMVOC-emissioner fra brug af opløsningsmidler er ændret grundet nye oplysninger vedrørende mængde af propan og butan, der anvendes til som drivmiddel.

Landbrug
Ændrede CH_4-emissioner skyldes at emissionsfaktoren for kvæg er revideret. Nye undersøgelser viser at sukkerroer, der er hovedbestanddelen af foderet, resulterer i en højere metanomdannelseshastighed end tidligere antaget.

Affald
Emissioner fra spildevandsanlæg blev for første gang rapporteret i mart-april 2005. Data der anvendes til beregningerne er blevet opdateret og de estimerede estimater derfor ændret.

Landbrugsjord, græsarealer og vådområder

Emissioner fra mineraljorde er for første gang indarbejdet i emissionsopgørelserne.

Ændringer i de danske totale drivhusgasemissioner, uden medtagning af emissioner og optag fra jorde og skov, som følge af forbedringer og rekalkulationer er små i forhold til sidste års rapportering. Ændringerne for hele tidsserien 1990 til 2003 ligger mellem –0,89% og +0,08%.

Ændringer i de danske totale drivhusgasemissioner er større når emissioner og optag fra jorder og skov medtages. Det skyldes at emissioner og optag fra jorde nu medregnes. Ændringerne i forhold til sidste rapportering er dog stadig forholdsvis små og ligger for hele tidsserien 1990 til 2003 mellem –2,51% og +0,54%.

1 Introduction

1.1 Background information on greenhouse gas inventories and climate change

Annual report

This report is Denmark's National Inventory Report (NIR) for submission by 15 April 2006 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 2004. 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 transparency.

The annual emission inventories for Denmark, from 1990 to 2004, 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 the CRF-files are available on the Eionet web site:
http://cdr.eionet.europa.eu/dk/Air_Emission_Inventories/Submission_UNFCCC/colrdy8sq
while this report contains the CRF Tables 10.1 to 10.5, only (refer Annex 9).

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

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 2004. 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 relates only to Denmark.

The NIR is available to the public on the homepage of the Danish National Environmental Research Institute (NERI).
http://www.dmu.dk/International/Publications/
(search for "National Inventory Report 2006").

Greenhouse gases

The greenhouse gases reported under the Climate Convention are:

- Carbon dioxide CO_2

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

The main greenhouse gas responsible for the anthropogenic influence on the heat balance is CO_2. The atmospheric concentration of CO_2 has increased from 280 to 370 ppm (about 30%) since the pre-industrial era in the nineteenth century (IPCC, Third Assessment Report). The main cause is the use of fossil fuels, but changing land use, including forest clearance, has also been a significant factor. Concentrations of the greenhouse gases methane and N_2O, which are very much linked to agricultural production, have increased by 150% and 16%, respectively (IPCC, Third Assessment Report). Changes in the concentrations of greenhouse gases are not related in simple terms to the effect on the heat balance, however. The various gases absorb radiation at different wavelengths and with different efficiency. This must be considered in assessing the effects of changes in the concentrations of various gases. Furthermore, the lifetime of the gases in the atmosphere needs to be taken into account – the longer they remain in the atmosphere, the greater the overall effect. The global warming potential (GWP) for various gases has been defined as the warming effect over a given time of a given weight of a specific substance relative to the same weight of CO_2. The purpose of this measure is to be able to compare and integrate the effects of individual substances on the global climate. Typical lifetimes in the atmosphere of substances are very different, e.g. aproximaty for CH_4 and N_2O, 12 and 120 years respectively. So the time perspective clearly plays a decisive role. The lifetime chosen is typically 100 years. The effect of the various greenhouse gases can, then, be converted into the equivalent quantity of CO_2, i.e. the quantity of CO_2 giving the same effect in absorbing solar radiation. According to the IPCC and their Second Assessment Report, which UNFCCC has decided to use as reference, the global warming potentials for a 100-year time horizon are:

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

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

The 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 a sufficient number countries, including Denmark, for it to enter into force on 21 March 1994. One of the provisions of the treaty was to stabilise the greenhouse gas emissions from the industrialised nations by the end of 2000. At the first conference under the UN Climate Convention in March 1995, it was decided that the stabilisation goal was inadequate. At the third conference in December 1997 in Kyoto in Japan, a legally binding agreement was reached committing the industrialised countries to reduce the six greenhouse gases by 5.2% by 2008-2012 compared with 1990 levels. However, for the F-gases, the nations can choose freely between 1990 and 1995 as the base year. On May 16, 2002, the Danish parliament voted for the Danish ratification of the Kyoto Protocol. Denmark is, thus, under a legal commitment to meet the requirements of the Kyoto Protocol, when it came into force on 16 February 2005. 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 to be made by each state to the overall EU reduction level of 8%.

Under the Burden Sharing Agreement, Denmark must reduce emissions by an average of 21% in the period 2008-2012 compared with 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-equivalents. Furthermore, removal by sinks is included in the net emissions. Removal by sinks only includes sequestration due to afforestation since 1990. When reporting to the Climate Convention, the net CO_2 removal by forests existing in 1990 is 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, the EU has to submit similar datasets 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 co-operation 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.

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

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

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

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

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

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

Level	Name	Application	Path	Type	Input sources	Remarks
5	NFR-tables (UNECE/EMEP)	External report	I:\ROSPROJ\LUFT_EMI\2003_unece	MS Excel	NFR_Report_Automatisk.xls	NFR-format
5	CFR-tables (UNFCCC and EU)	External report	I:\ROSPROJ\LUFT_EMI\2003_EU	MS Excel	ReportER CRF-skabeloner CRF-Retteskabelon	CRF-format
4	CRF-Retteskabelon (correction templates)	Help tool	I:\ROSPROJ\LUFT_EMI\2003_EU\2003_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	

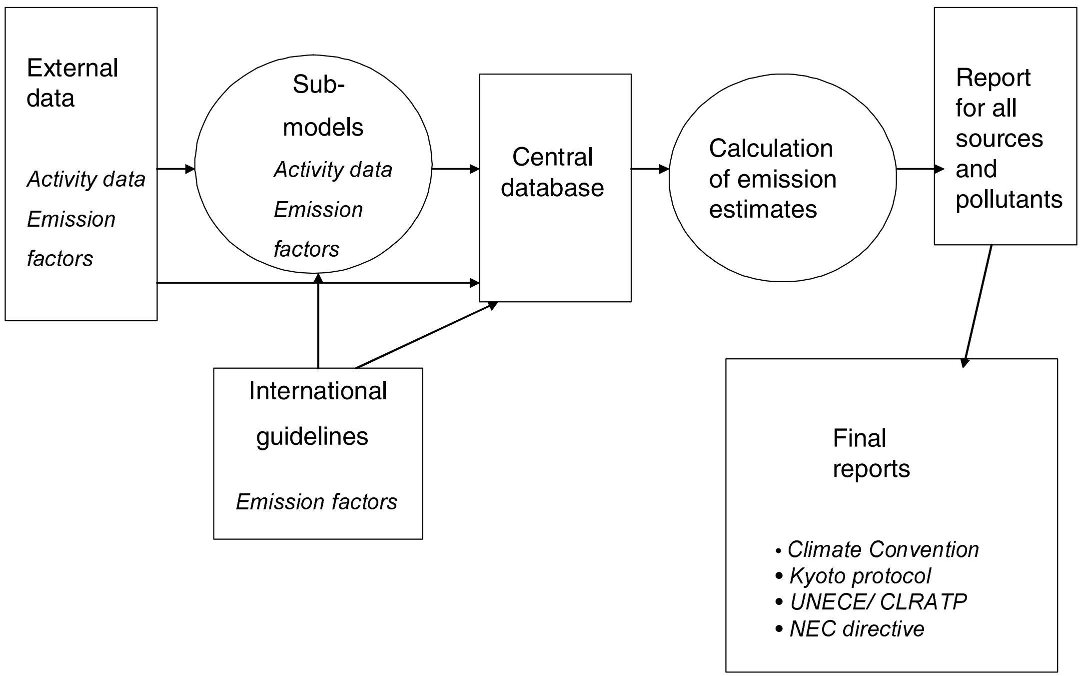


Figure 1.1. Schematic diagram of the process of inventory preparation.

1.4 Brief general description of methodologies and data sources used

Denmark's air emission inventories are based on the Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (IPCC, 1997), the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC, 2000) and the CORINAIR methodology. CORINAIR (COoRdination of INformation on AIR emissions) is a European air emission inventory programme for national sector-wise emission estimations, harmonised with the IPCC guidelines. To ensure estimates are as timely, consistent, transparent, accurate and comparable as possible, the inventory programme has developed calculation methodologies for most subsectors and software for storage and further data processing (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 largely 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 subsectors at the most detailed level is given in Illerup et al., 2000. The translation between CORINAIR and IPCC codes for sector classifications are listed in Illerup et al., 2000.

1.4.1 Stationary Combustion Plants

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

The Danish emission inventory for stationary combustion plants is based on the CORINAIR system described in 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, such as e.g. power plants and municipal waste incineration plants are registered individually as large point sources and emission data from the actual plants are used. This enables use of plant specific emission factors that refer to emission measurements stated in annual environmental reports, etc. At present, the emission factors for CO_2, CH_4 and N_2O are, however, not plant-specific, whereas emission factors for 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 2004, the CO_2 emission inventory based on the reference approach and the national approach, respectively, differ by 0.04%.

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

The specific methodologies regarding Fugitive Emissions from Fuels

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

Off-shore activities:

Emissions from offshore activities have been updated using the methodology described in the Emission Inventory Guidebook 3rd edition. The sources include emissions from the extraction of oil and gas, on-shore oil tanks, and onshore and offshore loading of ships. The emission factors are based on the figures given in the guidebook, except for the onshore oil tanks where national values are used.

Oil Refineries – Petroleum products processing:

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

Please refer to Chapter 3 for further information on fugitive emissions from fuels.

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

Natural gas transmission and distribution:

Inventories of the CH_4 emission from gas transmission and distribution is based on annual environmental reports from the Danish gas transmission company, Gastra (former DONG) and on a Danish inventory for the years 1999-2004, reported by the Danish gas sector (transmission and distribution companies).

1.4.2 Transport

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

An internal NERI model with a structure similar to the European COPERT III emission model is used to calculate the Danish annual emissions for road traffic. The emissions are calculated for operationally hot engines, during cold start and fuel evaporation. The model also includes the emission effect of catalyst wear. Input data for vehicle stock and mileage is obtained from the 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 2001-2004 estimates are made on a city-pair level, using flight data from the Danish Civil Aviation Agency (CAA-DK) and LTO and distance-related emission factors from the CORINAIR guidelines (Tier 2 approach). For previous years the background data consists of LTO/aircraft type statistics from Copenhagen Airport and total LTO numbers from CAA-DK. With appropriate assumptions, consistent time-series of emissions are produced back to 1990, which also include the findings from a Danish city-pair emission inventory in 1998.

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

The most thorough recalculations have changed the estimates for agriculture, forestry, industry, household/gardening and recreational craft. The recalculations influence the CH_4 emission factors and the emission estimates of CO_2, CH_4 and N_2O for the sectors Agriculture/forestry/fisheries (1A4c), Industry (1A2f), Residential (1A4b) and Navigation (1A3d).

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 uncertainties in 2004 for CO_2, CH_4 and N_2O are around 5, 35 and 64%, while the 1990-2004 emission trend uncertainties for the same three components are 5, 7 and 253%, respectively.

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

1.4.3 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") worked out by the company according to obligations under Danish law. These accounts are subject to audit. The emission factor is produced as a result of a weighting of the emission factors 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, hydrated lime, expanded clay products and bricks is the production statistics from the manufacturing industries, published by Statistics Denmark. The production of lime and yellow bricks gives rise to CO_2 emissions. The emission factors are based on stoichiometric relations, assumption on $CaCO_3$ content in clay as well as a default emission factor for expanded clay products.

Mineral Products: Limestone and dolomite use. CRF Table 2(I). A-G Sectoral Background Data for IindustrialProcesses. A.3.

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

Mineral Products: Asphalt roofing. CRF Table 2(I). A-G Sectoral Background Data for Industrial Processes. A.5.

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

Mineral Products: Road paving with asphalt. CRF Table 2(I). A-G Sectoral Background Data for Industrial Processes. A.6.

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

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 the production of glass and glass wool are obtained from the producers published in their environmental reports. Emission factors are based on stoichiometric relations between raw materials and CO_2 emissions.

Chemical Industry. Nitric Acid production: CRF Table 2(I).A-G Sectoral Background Data for Industrial processes. B.2.
There is one producer. To date, the data in the inventory relies on information from the producer. The producer reports emissions of NO_x and NH_3 as measured emissions and emissions of N_2O for 2003 as estimated emissions. The emission of N_2O in 2004 has been estimated by extrapolation as the nitric acid production was closed down in the middle of 2004.

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, 2006) is available in English as documentation of inventory data up to the year 2004. The methodology is implemented for the whole time-series 1990-2004, but full information on activities only exists since 1995 (1993).

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

1.4.4 Solvents

CRF Table 3.A-D. Sectorial background data for solvents and other product use
The approach for calculating the emissions of Non-Methane Volatile Organic Carbon (NMVOC) from industrial and household use in Denmark focuses on single chemicals rather than activities. This leads to a clearer picture of the influence from each specific chemical, which enables a more detailed differentiation on products and the

influence of product use on emissions. The procedure is to quantify the use of the chemicals and estimate the fraction of the chemicals that is emitted as a consequence of use.

Simple mass balances for calculating the use and emissions of chemicals are set up 1) use = production + import – export, 2) emission = use * emission factor. Production, import and export figures are extracted from Statistics Denmark, from which a list of 427 single chemicals, a few groups and products is generated. For each of these, a "use" amount in tonnes per year (from 1995 to 2004) is calculated. It is found that 44 different NMVOCs comprise over 95% of the total use and it is these 44 chemicals that are investigated further. The "use" amounts are distributed across industrial activities according to the Nordic SPIN (Substances in Preparations in Nordic Countries) database, where information on industrial use categories and products is available in a NACE coding system. The chemicals are also related to specific products. Emission factors are obtained from regulators or the industry.

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

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

1.4.5 Agriculture

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

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 emissions from the agricultural sector is based on methods described in the IPCC Guidelines (IPCC, 1996) and the Good Practice Guidance (IPCC, 2000). Activity data for livestock is on a one-year average basis from the agriculture statistics published by Statistics Denmark (2004). Data concerning the land use and crop yield is also from the agricultural statistics. Data concerning the feed consumption and nitrogen excretion is based on information from the Danish Institute of Agricultural Science. The CH_4 Implied Emission Factors for Enteric Fermentation and Manure Management are based on a Tier 2 approach for all animal categories. All livestock categories in the Danish emission inventory are based on an average of certain subgroups separated by differences in animal breed, age and weight class. The emission from enteric fermentation for poultry and fur farming is not estimated. There is no default value recommended in the IPCC guidelines (Table A-4 in Good Practice Guidance).

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 (Hutchings et al., 2001, Mikkelsen et al., 2005). National standards are used to estimate the amount of ammonia emission. When estimating the N_2O emission the IPCC standard value is used for all emission sources. The emission of CO_2 from Agricultural Soils is included in the LULUCF sector.

A model-based system is applied for the calculation of the emissions in Denmark. This model (DIEMA – Danish Integrated Emission Model for Agriculture) is used to estimate emission from both greenhouse gases and ammonia. A more detailed description is published, but only in Danish (Mikkelsen et al. 2005). An English edition is in preparation and the report is presently undergoing a review procedure in Sweden. The emission from the agricultural sector is mainly related to livestock production. DIEMA works on a detailed level and includes around 30 livestock categories, and each category is subdivided according to stable type and manure type. The emission is calculated from each subcategory and the emission is aggregated in accordance with the livestock category given in the CRF.

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

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

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

1.4.6 Forestry, Land Use and Land Use Change

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

As in previous submissions for forest land remaining forest land, only carbon (C) stock change in living biomass is reported. Change in C stocks is based on Equation 3.2.1 in the IPCC GPG, where C lost due to annual harvests is subtracted from C sequestered in growing biomass for the area of forest land remaining forest land. The data for forest area and growth rates are obtained from the latest Forestry Census conducted in 2000 and remain similar during the period 2000-2004. The data for the amount of wood annually harvested are obtained from Statistics Denmark. Wood volumes are converted to C stocks by a combination of country-specific values, literature values from the northwest European region and default values. There were no changes in methodology for the 2006 submission.

For cropland converted to forest land (afforestation), the reported change in C stock also concerned living biomass only. The change in C stock is estimated using a model based on country-specific increment tables for oak (representing broadleaves) and Norway spruce (representing conifers). The model calculates annual growth for annual cohorts of afforestation areas since 1990. Data on annual afforestation area is for the most part obtained from the Danish Forest and Nature Agency (subsidised private afforestation, municipal afforestation and afforestation by state forest districts). Afforestation by private landowners without subsidies was based on total afforested area recorded by the Forestry Census 2000 for the period 1990-99, with subtraction of the above categories of afforestation. Wood volumes estimated by the model are converted to C-stocks as for forest land remaining forest land. There is as yet no harvesting conducted in the young afforested stands. No changes in methodology or recalculations were done for the 2006 submission.

CO_2 emissions from cropland and grassland are based on census data from Statistics Denmark as regards size of area and crop yield combined with GIS-analysis on land use. The emission from mineral soils for both cropland and grassland is estimated with a three-pooled dynamical soil C model (C-TOOL). C-TOOL was initialised in 1980. The model is run for each county in Denmark. Emissions from organic soils are based on IPCC Tier 1b. The area with organic soils is based on soil maps combined with field-specific crop data. National models have been developed for the horticultural area based on area statistics from Statistic Denmark. Sinks in hedgerows are based on a national developed model. The area with hedgerows is based on hedgerows established with financial support from the Danish Government. Emissions from liming are based on annual sales data collected by the Danish Agricultural Advisory Centre, combined with the acid neutralisation capacity for each lot produced. The acid neutralisation capacity is estimated by the Danish Plant Directorate.

1.4.7 The specific methodologies regarding Waste

CRF Table 6 Sectoral Report for Waste Table 6.A.C Sectoral Background Data for Waste.

For 6.A Solid Waste Disposal on Land, only managed waste disposal is of importance and registered. The data used for the amounts of municipal solid waste deposited at solid waste disposal sites is according to the official registration performed by the Danish Environmental Protection Agency (DEPA). The data is registered in the ISAG database, where the latest yearly report is DEPA, 2006 (see the reference list in Chapter 8 for the link to the report). CH_4 emissions from solid waste disposal sites are calculated with a model suited to 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.

For 6.B Waste Water Handling, country-specific methodologies for calculating the emissions of CH_4 and N_2O at wastewater treatment plants (WWTPs) were prepared and implemented for the 2005 submissions. Some adjustments to data in this methodology have been made for this submision.

The methodology for CH_4 is developed following the IPCC Guidelines and the IPCC Good Practice Guidance. The data available for the volume of wastewater is registered by DEPA. The wastewater flow to WWTPs and the resulting sludge consists of a municipal and industrial part. From the registration performed by DEPA, no data exists to allow for a separation of the domestic/municipal contribution from the industrial contribution. A significant fraction of the industrial wastewater is treated at centralised municipal WWTPs. In addition, it is not possible to separate the contribution to methane emission from sludge versus wastewater. The methodology is based on information on the amount of organic degradable matter in the influent wastewater and the fraction which is treated by anaerobic wastewater treatment processes. The amount of CH_4 not emitted, the CH_4 recovered or combusted, has been calculated based on yearly reported national final sludge disposal data from DEPA. No emissions originating from on-site industrial treatment processes have been included.

For the methodology for N_2O emissions, both anaerobic and aerobic conditions have been considered. The methodology has been divided into two parts, i.e. direct and indirect emissions. The direct emission originates from wastewater treatment processes at the WWTPs and a minor indirect emission contribution originates from the effluent's content of nitrogen compounds. The direct emission from wastewater treatment processes is calculated according to the equation:

$$E_{N_2O,WWTP,direct} = N_{pop} \cdot F_{connected} \cdot EF_{N_2O,WWTP,direct}$$

where N_{pop} is the size of the Danish population, $F_{connected}$ is the fraction of the Danish population connected to the municipal sewer system (90%) and $EF_{N2O.WWTP.direct}$ is the emission factors. The latter has been adjusted by a correction factor, accounting for an increasing influent of nitrogen-containing wastewater from industry from 1990 to 1998, after which the industrial contribution reached a constant level. The methodology for calculation of the indirect N_2O emission includes emissions from human sewage based on annual per capita protein intake, improved by including the fraction of non-consumption protein in domestic wastewater. Emission of N_2O originating from effluent-recipient nitrogen discharges from the following point sources has been included: industry discharges, rainwater conditioned effluents, effluent from scattered houses, effluent from mariculture and fish farming and effluent from municipal and private WWTPs. Data on nitrogen effluent contributions has been obtained from national statistics.

6.C Waste Incineration. All waste incinerated is used for energy and heat production. This production is included in the energy statistics, hence emissions are included in *CRF Table 1A.1a Public Electricity and Heat Production*. Only very small emissions due to gasification of waste are included here.

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

1.5 Brief description of key source categories

A key source analysis for year 2004 has been carried out in accordance with the IPCC Good Practice Guidance. The analyses, as regards the basic source categorisation, have been kept unchanged since the analyses for the submissions in 2002, 2003, 2004 and 2005. The source categorisation used results in a total of 71 sources, of which 18 are identified as key sources due to both level and trend key source analysis. The energy sector and CO_2 emissions from stationairy combustion contribute to those 18 key sources with 6 key sources, of which CO_2 from coal contributes most with 24.7% of the national total. The category, CO_2 emissions from mobile combustion and road transportation, is also a key source and the second highest contributor, with 17.7%. CO_2 from natural gas is the third largest contributor with 16.4%. In the agricultural sector, there are 4 trend and level key sources, of which 3 are among the 7 highest contributors to the national total. These three sources are direct N_2O emissions from agriculture soils, indirect N_2O emissions from nitrogen used in agriculture and CH_4 from enteric fermentation, contributing 4.3, 4.1 and 4.0%, respectively, to the national total in 2004. The fourth agricultural key source is CH_4 from manure management contributing 1.5%. N_2O from manure management is a key source to level only and contributes 0.8%. Finally, the industrial sector contributes with 3 level and trend key sources: CO_2 from cement production (contributes 2.3%), N_2O from the nitric acid production (0.8%) and emissions from substitutes for ODS, F-gases (1.1%). The waste sector includes one key source, which is CH_4 from solid waste disposal on land, contributing 1.6% to the national total. 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 section outlines a plan for implementing a Quality Control (QC) and Quality Assurance (QA) for greenhouse gas emission inventories performed by the Danish National Environmental Research Institute (Sørensen et al., 2005). The plan is in accordance with the guidelines provided by the UNFCCC (IPCC, 1997), and the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC, 2000). The ISO 9000 standards are also used as important input for the plan.

In the preparation of Denmark's annual emission inventory, several quality control (QC) procedures are already carried out, as described in Chapters 3-8. The QA/QC plan will improve these activities in the future.

1.6.2 Concepts of quality work

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

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

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

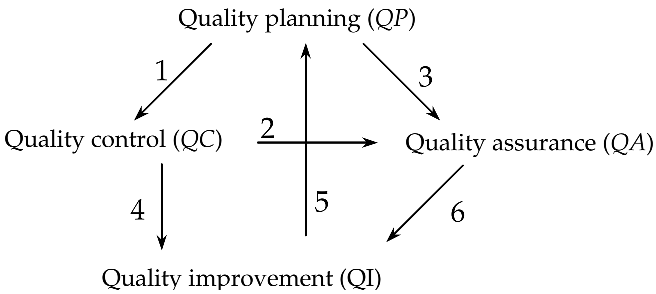


Figure 1.2 Interrelation between the activities with regard to quality. The arrows are explained in the text below this figure.

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

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

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

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

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

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

1.6.3 Definition of quality

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

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

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

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

1.6.4 Definition of Critical Control Points (*CCP*)

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

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

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

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

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

Change (IPCC) guidelines and good practice guidance.

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

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

Accuracy is a relative measure of the exactness of an emission or removal estimate. Estimates should be accurate and the sense that they are systematically neither over nor under true emissions or removals, as far as can be judged, and that uncertainties are reduced as far as practicable. Appropriate methodologies should be used in accordance with the *IPCC good practice guidance*, to promote data accuracy in inventories.

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

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

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

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

1.6.5 Process oriented QC

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

The data flow needs to support the QC/QA in order to facilitate a cost-effective procedure. The flow of data has to take place in a transparent way by making the transformation of data detectable. It should be easy to find the original background data for any calculation and to trace the sequence of calculations from the raw data to the final emission result. Computer programming for automated calculations and checking will enhance the accuracy and 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 means to secure accuracy. Realistic uncertainty estimates are necessary for securing accuracy, but they can be difficult to produce due to the uncertainty related to the uncertainty estimates themselves. It is, therefore, important to include the uncertainty calculation procedures into the data structure as far as possible. The QC/QA needs to be supported as far as possible by the data structure; otherwise the procedures can easily become troublesome and subject to frustration.

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

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

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

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

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

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

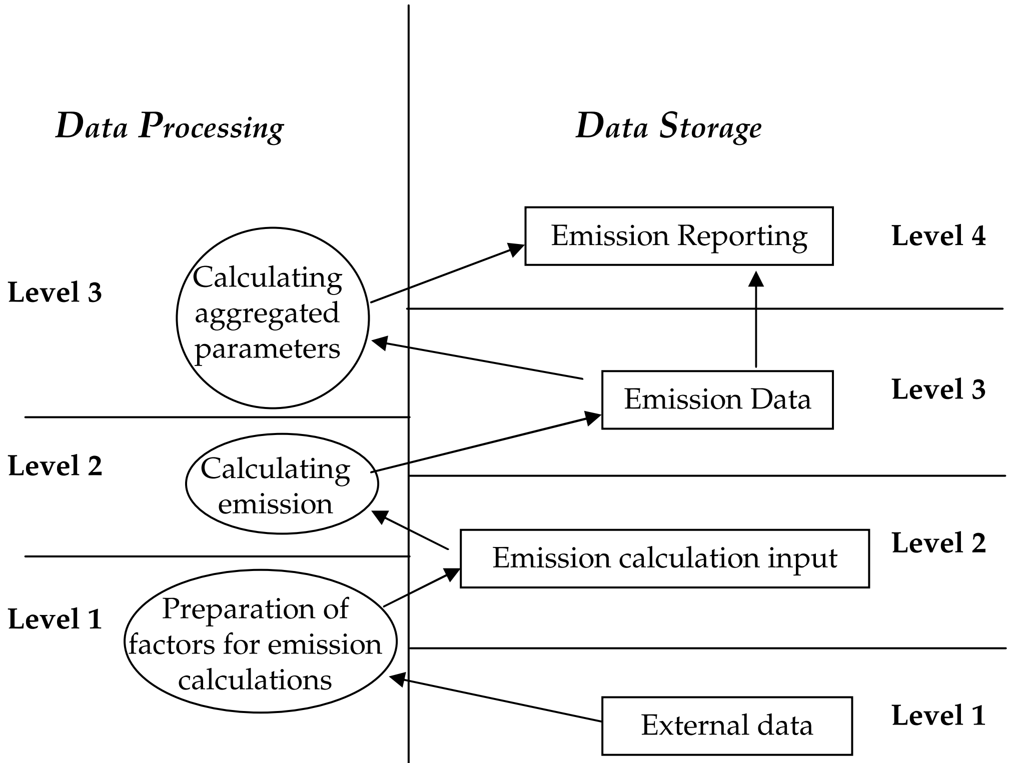


Figure 1.3 The general data structure for the emission inventory.

Key levels are defined in the data structure as:

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

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

this level.

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

Data storage Level 4, Final reports for all subcategories
The complete emission inventory is reported to UNFCCC at this level by summing up the results from every subcategory.

Data processing Level 1 compilation of external data
Preparation of input data for the emission inventory based on the external data sources. Some external data may be used directly as input to the data processing at level 2, while other data needs to be interpreted using more or less complicated models, which takes place at this level. The interpretation of activity data is to be seen in connection with availability of emission factors and vice versa. These models are compiled and processed as an integrated part of the inventory preparation.

Data processing Level 2 Calculation of inventory figures
The emission for every subcategory is calculated, including the uncertainty for all sectors and activities. The summation of all contributions from sub-sources makes up the inventory.

Data processing Level 3 Calculation aggregated parameters
Some aggregated parameters need to be reported as part of the final reporting. This will not involve complicated calculations but important figures, e.g. implied emission factors at a higher aggregated level to be compared in time-series and with other countries.

1.6.6 Definition of Point of Measurements (*PM*)

The *CCP*s have to be based on clear measurable factors, otherwise the *QP* will end up being just a loose declaration of intent. Thus, in the following, a series of *Points for Measuring* (*PM*) is identified as building blocks for a solid *QC*. Table 8.1 in Good Practice Guidance is a listing of such *PM*s. However, the listing in Table 1.1 below is an extended and modified listing, in comparison to Table 8.1. in the Good Practice Guidance supporting all the *CCP*s. The *PM*s will be routinely checked in the QC reporting and, when external reviews take place, the reviewers will be asked to assess the fulfilment of the *PM*s using a checklist system. The list of *PM*s is continually evaluated and modified to offer the best possible support for the *CCP*s. The actual list used in Spring 2006 is seen in Table 1.2.

Table 1.2 The list of *PM*s as used in Spring 2006.

Level	CCP	Id	Description
Data Storage level 1	1. Accuracy	DS.1.1.1	General level of uncertainty for every dataset including the reasoning for the specific values

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

	7.Transparency	DP.1.7.1	The calculation principle and equations used must be described
		DP.1.7.2	The theoretical reasoning for all methods must be described
		DP.1.7.3	Explicit listing of assumptions behind all methods
		DP.1.7.4	Clear reference to dataset at Data Storage level 1
		DP.1.7.5	A manual log to collect information about recalculations
Data Storage level 2	2.Comparability	DS.2.2.1	Comparison with other countries that are closely related to Denmark and explanation of the largest discrepancies
	5.Correctness	DS.2.5.1	Documentation of a correct connection between all data types at level 2 to data at level 1
		DS.2.5.2	Check if a correct data import to level 2 has been made
	6.Robustness	DS.2.6.1	All persons in the inventory work must be able to handle and understand all data at level 2.
	7.Transparency	DS.2.7.1	The time trend for every single parameter must be graphically available and easy to map
		DS.2.7.2	A clear Id must be given in the dataset having reference to level 1.
Data Processing level 2	1. Accuracy	DP.2.1.1	Documentation of the methodological approach for the uncertainty analysis
		DP.2.1.2	Quantification of uncertainty
	2.Comparability	DP.2.2.1	The inventory calculation has to follow the international guidelines suggested by UNFCCC and IPCC
	6.Robustness	DP.2.6.1	Any calculation at level 4 must be anchored to two responsible persons who can replace each other in the technical issue of performing the calculations.
	7.Transparency	DP.2.7.1	Reporting of the calculation principle and equations used
		DP.2.7.2	Reporting of the theoretical reasoning for all methods
		DP.2.7.3	Reporting of assumptions behind all methods
		DP.2.7.4	The reasoning for the choice of methodology for uncertainty analysis needs to be written explicitly.
Data Storage level 3	1. Accuracy	DS.3.1.1	Quantification of uncertainty
	5.Correctness	DS.3.5.1	Comparison with inventories of the previous years on the level of the categories of the CRF as well as on SNAP source categories. Any major changes are checked, verified, etc.
		DS.3.5.2	Total emissions, when aggregated to CRF source categories, are compared with totals based on SNAP source categories (control of data transfer).
		DS.3.5.3	Checking of time-series of the CRF and SNAP source categories as they are found in the Corinair databases. Considerable trends and changes are checked and explained.
	7.Transparency	DS.3.7.1	Documentation of a correct connection between all data types at DS3 to data at level DS2
Data Processing level 3	7.Transparency	DP.3.7.1	In the calculation sheets, there must be clear Id to Data Storage level 3 data
Data Storage level 4	1. Accuracy	DS.4.1.1	Questionnaire to external experts: The performance of the PMs that relate to accuracy.

	2.Comparability	DS.4.2.1	Description of similarities and differences in relation to other countries' inventories for the methodological approach.
	3.Completeness	DS.4.3.1	Questionnaire to external experts: The performance of the PMs that relate to completeness.
		DS.4.3.2	National and international verification including explanation of the discrepancies.
	4.Consistency	DS.4.4.1	The inventory reporting must follow the international guidelines suggested by UNFCCC and IPCC.
	7.Transparency	DS.4.7.1	External review for evaluation of the communication performance.

1.6.7 Plan for the quality work

The IPCC uses the concept of a tiered approach, i.e. a stepwise approach, where complexity, advancement and comprehensiveness increase. Generally, more detailed and advanced methods are recommended in order to give guidance to countries which have more detailed datasets and more capacity, as well as to countries with less available data and manpower. The tiered approach helps to focus attention on the areas of the inventories that are relatively weak, rather than investing effort in irrelevant areas. Furthermore, the IPCC guidelines recommend using higher tier methods for key sources in particular. Therefore, the identification of key sources is crucial for planning quality work. However, there exist several issues regarding the listing of priority sources: (1) The contribution to the total emission figure (key source listing); (2) The contribution to the total uncertainty; (3) Most critical sources in relation to implementation of new methodologies and thus highest risk for miscalculations. All the points listed are necessary for different aspects of producing high quality work. In 2006, these listings will be used to secure implementation of the full quality scheme for the most relevant sources. Verification in relation to other countries is undertaken for priority sources during the first part of 2006.

1.6.8 Implementation of the QA/QC plan

The PMs listed in Table 1.2 are described for each sector in the QA/QC sections of Chapters 3-8, where a status with regard to implementation is also given. Some of the PMs are the same for all sectors and a common description for these PMs is given in Section 1.6.10, below. During the first half of 2006, the focus will be on level 1 for both data storage and data processing as this is the most labour-intensive part. The quality system will be evaluated and adjustments made during Autumn 2006.

1.6.9 Archiving of data and documentations

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

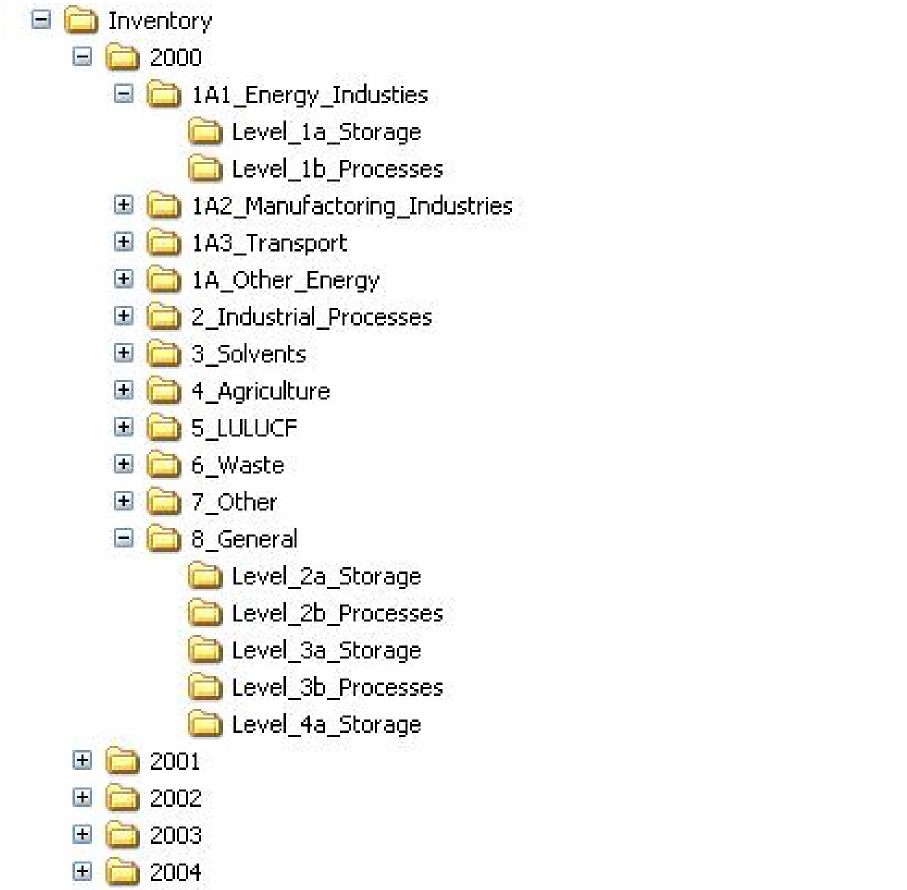


Figure 1.4 Schematic diagram of the folder structure in the inventory file system.

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

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

1.6.10 Common QA/QC PMs.

The following PMs are common for all the sectors:

Data storage Level 1

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

For the energy sector, two persons have detailed insight in data gathering, while this is only partly achieved for the other sectors. The plan is to fulfil this PM in 2007.

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

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

Data processing Level 1

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

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

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

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

Data storage Level 2

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

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

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

This PM is fulfilled for all sectors except agriculture and land use change and forestry. The PM is supported by the inventory file system. Refer to Section 1.6.9.

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

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

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

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

Data Processing Level 2

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

Refer to Section 1.7 in the Danish NIR.

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

Refer to Section 1.7 in the Danish NIR and the QA/QC sections in the sector chapters.

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

The emission calculations follow the international guidelines.

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

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

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

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

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

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

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

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

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

Refer to Section 1.7 in the Danish NIR and the QA/QC sections in the sector chapters.

Data storage Level 3

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

Refer to Section 1.7 in the Danish NIR and the QA/QC sections in the sector chapters.

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

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

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

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

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

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

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

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

Data Processing Level 3

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

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

Data Storage Level 4

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

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

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

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

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

When emissions are compared with non-dependent parameters, similarities with regard to geography, climate, industry structure and level of economic development may be necessary for obtaining comparable emission density indicators (Thomsen and Fauser, 2006).

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

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

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

Refer to DS 4.2.1

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

The inventory reporting is in accordance with the UNFCCC guidelines on reporting and review (UNFCCC, 2002). The present report includes detailed and complete information on the inventories for all years from the base year to the year of the current annual inventory submission, in order to ensure the transparency of the inventory. The annual emission inventory for Denmark is reported in the Common Reporting Format (CRF) as requested in the reporting guidelines. The CRF-spreadsheets contain data on emissions, activity data and implied emission factors for each year. Emission trends are given for each greenhouse gas and for total greenhouse gas emissions in CO_2 equivalents. The complete sets of CRF-files are available on the NERI homepage (www.dmu.dk).

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

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

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 the IPCC Good Practice Guidance (GPG) (IPCC 2000). Uncertainty estimates for the following sectors are included in the current year: stationary combustion plants, mobile combustion, fugitive emissions from fuels, industry, solid waste and wastewater treatment and agriculture. The aim is to include solvents in 2006 or 2007. The sources included in the uncertainty estimate cover 99.9% of the total Danish greenhouse gas emission (CO_2 eq., without CO_2 from LUCF).

The uncertainties for the activity rates and emission factors are shown in Table 1.4.

The estimated uncertainties for total GHG and for CO_2, CH_4, N_2O and F-gases are shown in Table 1.3. The base year for F-gases is 1995 and for all other sources the base year is 1990. The total Danish GHG emission is estimated with an uncertainty of ±5.2% and the trend in GHG emission since 1990 has been estimated to be -1.5%[2] ± 2.1%-age points. The GHG uncertainty estimates do not take into account the uncertainty of the GWP factors.

The uncertainty on N_2O from stationary combustion plants, N_2O emission from agricultural soils and CH_4 emission from manure management are the predominant sources of uncertainty for the Danish GHG inventory.

The uncertainty of the GHG emission from combustion (sector 1A) is 5.6% and the trend uncertainty is +1.9% ±2%-age points.

Table 1.3 Uncertainty

1)	Uncertainty [%]	Trend [%]	Uncertainty in trend [%-age points]
CO_2	2.3	+2.3	±1.9
CH_4	23	+4.2	±10.4
N_2O	40	-28	±10.9
F-gases	48	+147	±58
GHG	5.2	-1.5	±2.1

The uncertainty estimates include stationary combustion plants, mobile combustion, fugitive emissions from fuels, industry, solid waste and wastewater treatment and agriculture.

[2] Including only emission sources for which the uncertainty has been estimated. LULUFC is not included.

Table 1.4 Uncertainty rates for each emission source

IPCC Source category	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty
		Gg CO2 eq	Gg CO2 eq	%	%
Stationary Combustion, Coal	CO2	24077	17337	1	5
Stationary Combustion, BKB	CO2	11	0	3	5
Stationary Combustion, Coke	CO2	138	123	3	5
Stationary Combustion, Petroleum coke	CO2	410	817	3	5
Stationary Combustion, Plastic waste	CO2	349	676	5	5
Stationary Combustion, Residual oil	CO2	2505	1832	2	2
Stationary Combustion, Gas oil	CO2	4564	2712	4	5
Stationary Combustion, Kerosene	CO2	366	15	4	5
Stationary Combustion, Orimulsion	CO2	0	1	1	2
Stationary Combustion, Natural gas	CO2	4330	11143	3	1
Stationary Combustion, LPG	CO2	164	108	4	5
Stationary Combustion, Refinery gas	CO2	806	904	3	5
Stationary combustion plants, gas engines	CH4	6	386	2,2	40
Stationary combustion plants, other	CH4	115	136	2,2	100
Stationary combustion plants	N2O	240	268	2,2	1000
Transport, Road transport	CO2	9241	12024	2	5
Transport, Military	CO2	119	239	2	5
Transport, Railways	CO2	297	216	2	5
Transport, Navigation (small boats)	CO2	71	104	42	5
Transport, Navigation (large vessels)	CO2	484	387	2	5
Transport, Fisheries	CO2	771	473	2	5
Transport, Agriculture	CO2	1272	1017	26	5
Transport, Forestry	CO2	36	17	32	5
Transport, Industry (mobile)	CO2	842	912	36	5
Transport, Residential	CO2	138	298	36	5
Transport, Civil aviation	CO2	243	128	10	5
Transport, Road transport	CH4	52	53	2	40
Transport, Military	CH4	0	0	2	100
Transport, Railways	CH4	0	0	2	100
Transport, Navigation (small boats)	CH4	0	1	42	100
Transport, Navigation (large vessels)	CH4	0	0	2	100
Transport, Fisheries	CH4	0	0	2	100
Transport, Agriculture	CH4	2	1	26	100
Transport, Forestry	CH4	0	0	32	100
Transport, Industry (mobile)	CH4	1	1	36	100
Transport, Residential	CH4	4	6	36	100
Transport, Civil aviation	CH4	0	0	10	100
Transport, Road transport	N2O	125	421	2	50
Transport, Military	N2O	1	4	2	1000
Transport, Railways	N2O	3	2	2	1000
Transport, Navigation (small boats)	N2O	1	1	42	1000
Transport, Navigation (large vessels)	N2O	9	8	2	1000
Transport, Fisheries	N2O	15	9	2	1000
Transport, Agriculture	N2O	15	13	26	1000
Transport, Forestry	N2O	0	0	32	1000
Transport, Industry (mobile)	N2O	11	12	36	1000
Transport, Residential	N2O	1	1	36	1000
Transport, Civil aviation	N2O	3	2	10	1000
Energy, fugitive emissions, oil and natural gas	CO2	263	608	15	5
Energy, fugitive emissions, oil and natural gas	CH4	40	102	15	50
Energy, fugitive emissions, oil and natural gas	N2O	1	3	15	50
6 A. Solid Waste Disposal on Land	CH4	1334	1074	10	63
6 B. Wastewater Handling	CH4	126	265	20	35
6 B. Wastewater Handling	N2O	88	53	10	30
2A1 Cement production	CO2	882	1539	1	2
2A2 Lime production	CO2	152	110	5	5
2A3 Limestone and dolomite use	CO2	18	64	5	5
2A5 Asphalt roofing	CO2	0	0	5	25
2A6 Road paving with asphalt	CO2	2	2	5	25
2A7 Glass and Glass wool	CO2	17	13	5	2
2B5 Catalysts/Fertilizers, Pesticides and Sulphuric acid	CO2	1	3	5	5
2C1 Iron and steel production	CO2	28	0	5	5
2B2 Nitric acid production	N2O	1043	531	2	25
2F Consumption of HFC	HFC	218	749	10	50
2F Consumption of PFC	PFC	1	16	10	50
2F Consumption of SF6	SF6	105	33	10	50
4A Enteric Fermentation	CH4	3110	2711	10	8
4B Manure Management	CH4	743	1030	10	100
4B Manure Management	N2O	685	560	10	100
4D Agricultural Soils	N2O	8308	5699	7,6	19,5

1.8 General assessment of the completeness

The Danish greenhouse gas emission inventory which was due for submission 15 April 2006 includes all sources identified by the Revised IPPC Guidelines except the following:

- Agriculture: The methane conversion factor in relation to the enteric fermentation for poultry and fur farming is not estimated. There is no default value recommended by IPCC (Table A-4 in GPG). However, this emission is seen as non-significant compared with the total emission from enteric fermentation.

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2 Trends in Greenhouse Gas Emissions

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

Greenhouse Gas Emissions

The greenhouse gas emissions are estimated according to the IPCC guidelines and are aggregated into seven main sectors. The greenhouse gases include CO_2, CH_4, N_2O, HFCs, PFCs and SF_6. Figure 2.1 shows the estimated total greenhouse gas emissions in CO_2 equivalents from 1990 to 2004. 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 approximately 1%. Stationary combustion plants, transport and agriculture represent the largest sources. The net CO_2 removal by forestry and soil (Land Use Change and Forestry (LUCF)) is in the region of 3% of the total emission in CO_2 equivalents in 2004. The national total greenhouse gas emission in CO_2 equivalents without LUCF has decreased by 1.5% from 1990 to 2004 and by 5.5% with LUCF.

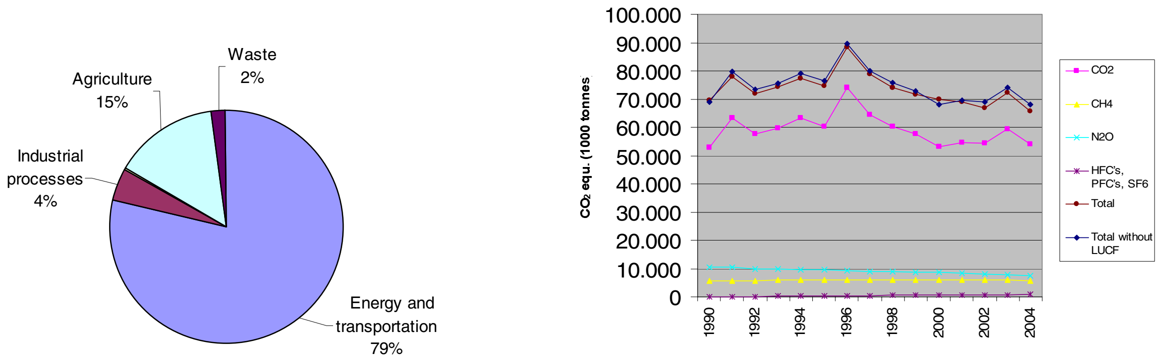


Figure 2.1 Greenhouse gas emissions in CO_2 equivalents distributed on main sectors for 2004. Left: Time-series for 1990 to 2004.

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 (Figure 2.2). Public power and district heating plants contribute with almost half of the emissions. About 24% come from the transport sector. The CO_2 emission decreased by approximately 9% from 2003 to 2004. The reason for this decrease was mainly due to decreasing export of electricity. Also higher outdoor temperature in 2004 compared with 2003 contributed to the decrease. If the CO_2 emission is adjusted for climatic variations and electricity trade with other countries the CO_2 emission from combustion of fossil fuels has decreased by 16% 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 34%. 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 recent years, the main part of the CO_2 emission comes from oil combustion. In 2004, the actual CO_2 emission was about 2% higher than the emission in 1990.

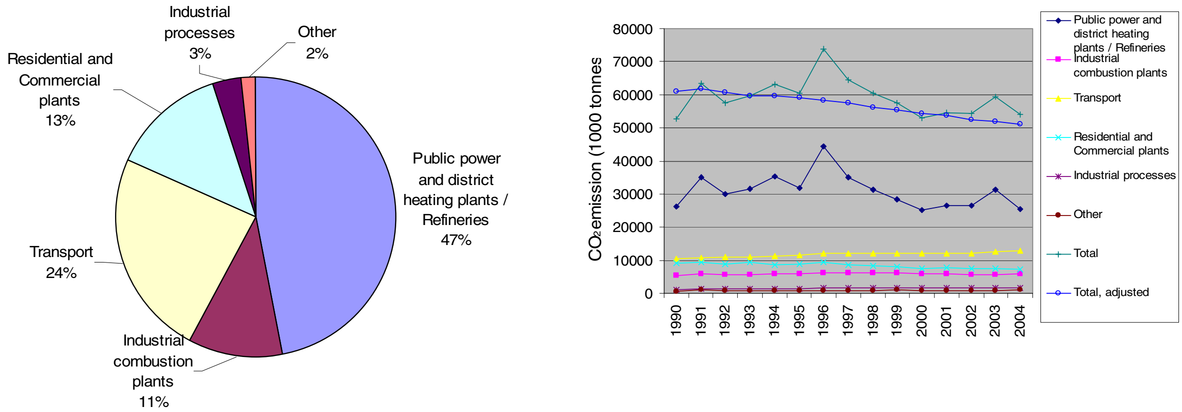


Figure 2.2 CO_2 emissions. Distribution according to the main sectors (2004) and time-series for 1990 to 2004.

Nitrous oxide

Agriculture is the most important N_2O emission source (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 approximately 25% from 1990 to 2004 is legislation to improve the utilisation of nitrogen in manure. The legislation has resulted in less nitrogen excreted per unit of livestock produced and a considerable reduction in the use of fertilisers. The basis for the N_2O emission is then reduced. Approximately 10% of the emisison of N_2O comes from combustion of fossil fuels, and transport accounts for around 6%. The N_2O emission from transport has increased during the nineties because of the increase in the use of catalyst cars. Emissions of N_2O from nitric acid production amount to approximately 7% of the total N_2O emission.

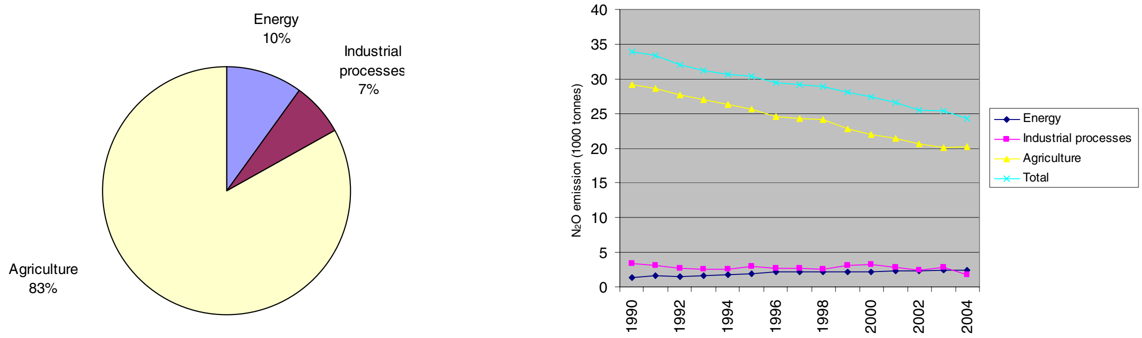


Figure 2.3 N_2O emissions. Distribution according to the main sectors (2004) and time-series for 1990 to 2004.

Methane

The largest sources of anthropogenic CH_4 emissions are agricultural activities, managed waste disposal on land, public power and district heating plants (Figure 2.4). 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 the increasing use of gas engines in the decentralised cogeneration plant sector. Approximately 3% of the natural gas in the gas engines is not combusted. From 1990, the emission of CH_4 from enteric fermentation has decreased due to the decrease in the number of cattle. However, the emission from manure management has increased due to a change in traditional stable systems towards an increase in slurry-based stable systems. Altogether, the emission of CH_4 for the agriculture sector has decreased by approximately 7% from 1990 to 2004. The emission of CH_4 from waste disposal has decreased slightly due to increases in the incineration of waste.

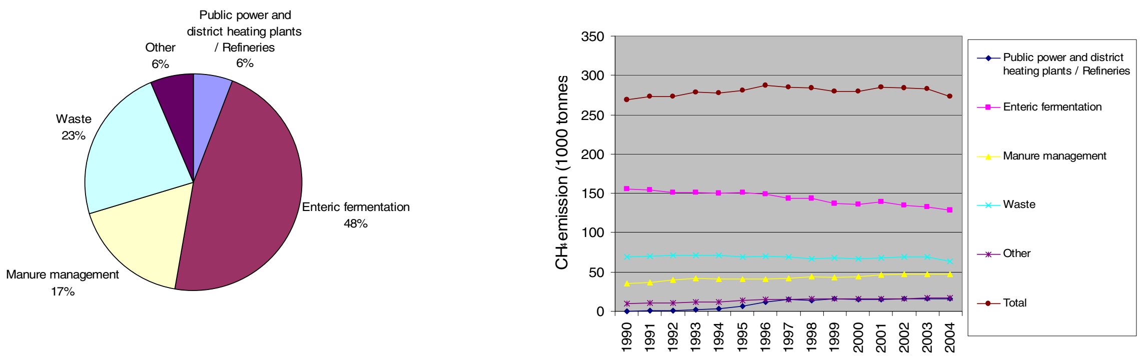


Figure 2.4 CH_4 emissions. Distribution according to the main sectors (2004) and time-series for 1990 to 2004.

HFCs, PFCs and SF_6

This part of the Danish inventory only comprises data for all substances from 1995. From 1995 to 2000, there has been a continuous and substantial increase in the contribution from the range of F-gases as a whole, calculated as the sum of emissions in CO_2 equivalents (Figure 2.5). This increase is simultaneous with the increase in the emission of HFCs. For the time-series 2000-2004, the increase has been much lower than for the years 1995 to 2000. SF_6 contributed considerably in earlier years, with 52% in 1993. Environmental awareness and regulation of this gas under Danish law has reduced its use in industry, with the result that the contribution in 2004 was approximately 4%. The use of HFCs, and especially HFC-134a as a major contributor to HFCs, has increased several fold. HFCs have, therefore, become dominant F-gases, comprising 48% in 1993, but 94% in 2004. HFC-134a is mainly used as a refrigerant. However, the use of HFC-134a as a refrigerant, as well as the use of other HFCs as refrigerants, is stable or falling. This is due to Danish legislation, which, in 2007, forbids new HFC-based refrigerant stationary systems. On the other hand, the use of air conditioning in mobile systems is on the increase.

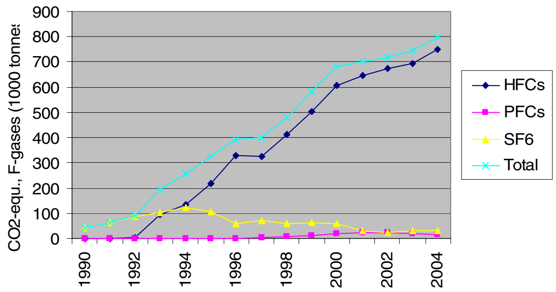


Figure 2.5 F-gas emissions. Time-series for 1990 to 2004.

2.3 Description and interpretation of emission trends by source

Energy

The emission of CO_2 from public power and district heating plants has decreased by approximately 8% from 1990 to 2004. The relatively large fluctuation in the emission is due to inter-country electricity trade. Thus, the high emissions in 1991, 1996 and 2003 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 the increasing use of gas engines in decentralised cogeneration plants. The CO_2 emission from the transport sector increased by 24% 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 2004, the contribution of N_2O and $CH_4$to the total emission was 80% and 65%, respectively. The N_2O emission decreased by 31% and the CH_4 emission by 7% from 1990 to 2004.

Industrial processes

The emissions from industrial process, i.e. emissions from processes other than fuel combustion, amount to 4% of the total emission 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 3% of the national total – increased by 75%

from 1990 to 2004. The second largest source is N_2O from the production of nitric acid. The N_2O emission from this production decreased by 57% from 1990 to 2004. The production of nitric acid in Denmark stopped mid-2004.

Waste

Waste disposal is the third largest source of the CH_4 emission. The emission has decreased by 20% from 1990 to 2004, at which point the contribution from waste was 19% of the total CH_4 emission. The decrease is due to the 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. The CH_4 emission from wastewater handling amounts to about 5% of the total CH_4 emissions.

Forest

The annual C-stock change for forest land remaining forest land in 2004 is slightly higher compared with that of 2003, as the amount of wood harvested was slightly lower in 2004 than in 2003. The C sequestration in afforested stands increased again in 2003 and will continue to do so over the coming decades due to i) increasing growth rates as afforested stands grow older and ii) an increase in the total area under afforestation.

Cropland, grassland and wetlands

Inclusion of emission estimates from mineral soils and a redistribution of soil types (excluding forestry) in the inventory results in an increased emission in the base year (1990) of 400 Gg CO_2 equivalents. This is largely due to the inclusion of mineral soils. In 2004, the net emission is estimated to 1170 Gg CO_2 equivalents, a 70% reduction. This is largely due to a reduction in liming (300 Gg CO_2-eqv.), a reduced cropland area with organic soils, establishment of shelter-belts on cropland and the effect of field burning on the amount of organic carbon in mineral soils. Re-establishment of wetlands on cropland is responsible for the increase in the carbon stock in wetlands and for part of the reduction in cropland and grassland. The trend between 1990 and 2004 is assumed to describe the Danish emission from the mentioned sources satisfactorily. However, the emission estimates from mineral soils is very variable across the years due to variations in yield level and annual temperatures which affect the degradation rate in the applied Tier 3 mode.

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

NO_X

The largest sources of emissions of NO_X are other mobile sources followed by road transport and combustion in energy industries (mainly public power and district heating plants). The transport sector is the sector contributing the most to the emission of NO_X and, in 2004, 39% of the Danish emissions of NO_X stems from road transport, national navigation, railways and civil aviation. Also emissions from national fishing and off-road vehicles contribute significantly to the

NO_x emission. For non-industrial combustion plants, the main sources are combustion of 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 2004. In the same period, the total emission decreased by 38%. The reduction is due to the increasing use of catalyst cars and installation of low-NO_x burners and denitrifying units in power and district heating plants.

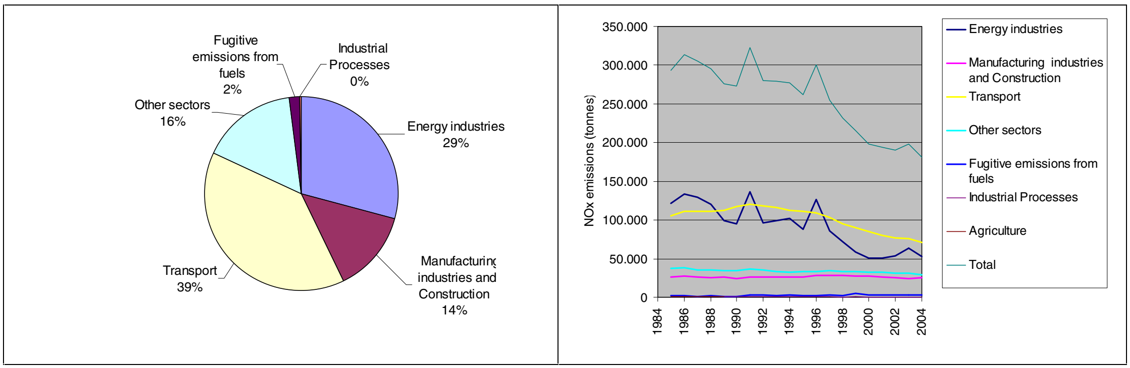


Figure 2.6 NO_x emissions. Distribution according to the main sectors (2004) and time-series for 1990 to 2004.

CO

Transport is responsible for 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 the burning of agricultural waste on fields. The emission decreased further by 23% from 1990 to 2004, largely because of decreasing emissions from road transportation.

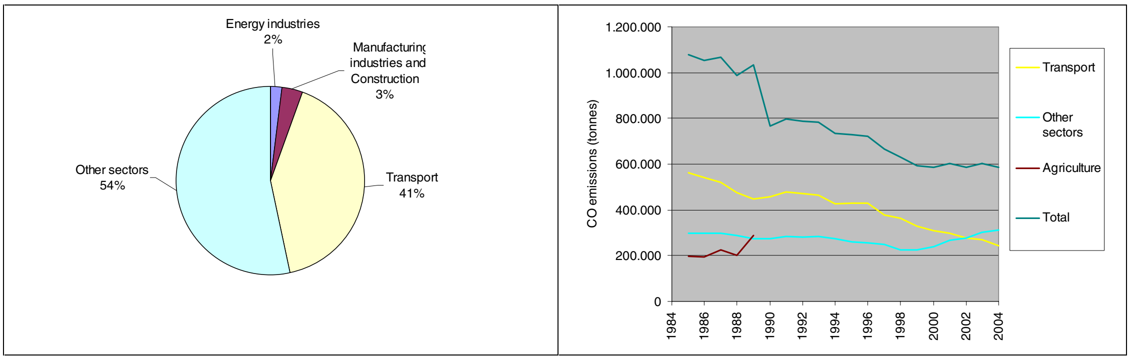


Figure 2.7 CO emissions. Distribution according to the main sectors (2004) and time-series for 1990 to 2004.

NMVOC

The emissions of NMVOC originate from many different sources and can be divided into two main groups: incomplete combustion and evaporation. Road vehicles and other mobile sources such as national navigation vessels and off-road machinery are the main sources of NMVOC emissions from incomplete combustion processes. Road transportation vehicles are still the main contributors, even though the emissions have declined since the introduction of catalyst cars in 1990. The evaporative emissions mainly originate from the use of solvents. The emissions from the energy industries have increased during the nineties due to the increasing use of stationary gas engines, which have much higher emissions of NMVOC than conventional boilers. The total anthropogenic emissions have decreased by 35% from 1985 to 2004, largely due to the increased use of catalyst cars and reduced emissions from use of solvents.

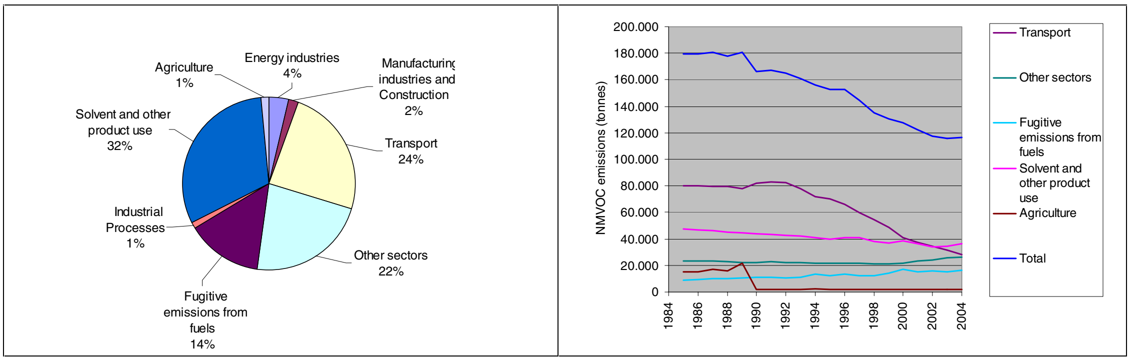


Figure 2.8 NMVOC emissions. Distribution according to the main sectors (2004) and time-series for 1990 to 2004.

SO_2

The main part of the SO_2 emission originates from combustion of fossil fuels, i.e. mainly coal and oil, in public power and district heating plants. From 1980 to 2004, the total emission decreased by 95%. The large reduction is largely due to installation of desulphurisation plant and use of fuels with lower content of sulphur in public power and district heating plants. Despite the large reduction of the SO_2 emissions, these plants make up 42% 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 sulphur content.

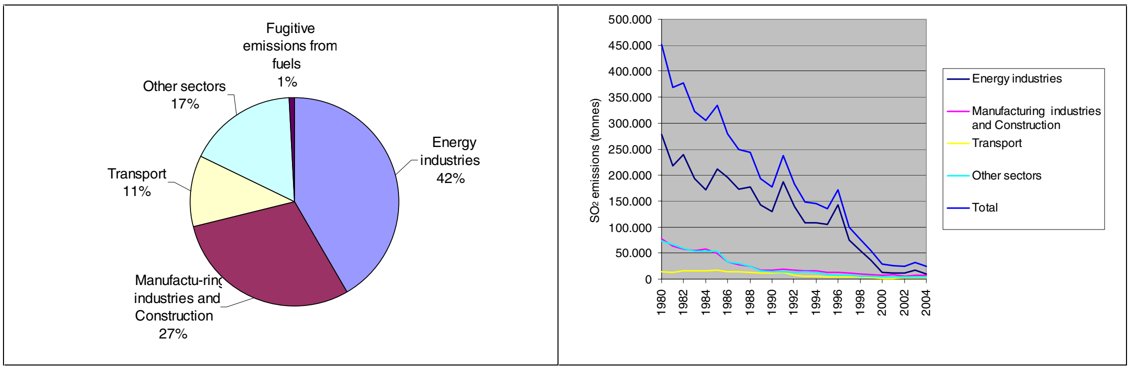


Figure 2.9 SO_2 emissions. Distribution according to the main sectors (2004) and time-series for 1990 to 2004.

3 Energy (CRF sector 1)

3.1 Overview of the sector

The energy sector has been reported in four main chapters:

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

Though industrial combustion is part of stationary combustion, detailed documentation for some of the specific industries is discussed in the industry chapters. Table 3.1 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	NERI documentation
1	**Energy**	**Stationary combustion, Transport, Fugitive, Industry**
1A	**Fuel Combustion Activities**	**Stationary combustion, Transport, Industry**
1A1	Energy Industries	Stationary combustion
1A1a	Electricity and Heat Production	Stationary combustion
1A1b	Petroleum Refining	Stationary combustion
1A1c	Solid Fuel Transf./Other Energy Industries	Stationary combustion
1A2	Fuel Combustion Activities/Industry (ISIC)	Stationary combustion, Transport, Industry
1A2a	Iron and Steel	Stationary combustion, Industry
1A2b	Non-Ferrous Metals	Stationary combustion, Industry
1A2c	Chemicals	Stationary combustion, Industry
1A2d	Pulp, Paper and Print	Stationary combustion, Industry
1A2e	Food Processing, Beverages and Tobacco	Stationary combustion, Industry
1A2f	Other (please specify)	Stationary combustion, Transport, Industry
1A3	Transport	Transport
1A3a	Civil Aviation	Transport
1A3b	Road Transportation	Transport
1A3c	Railways	Transport
1A3d	Navigation	Transport
1A3e	Other (please specify)	Transport
1A4	Other Sectors	Stationary combustion, Transport
1A4a	Commercial/Institutional	Stationary combustion
1A4b	Residential	Stationary combustion, Transport
1A4c	Agriculture/Forestry/Fishing	Stationary combustion, Transport
1A5	Other (please specify)	Stationary combustion, Transport
1A5a	Stationary	Stationary combustion
1A5b	Mobile	Transport
1B	**Fugitive Emissions from Fuels**	**Fugitive**
1B1	Solid Fuels	Fugitive
1B1a	Coal Mining	Fugitive
1B1a1	Underground Mines	Fugitive
1B1a2	Surface Mines	Fugitive
1B1b	Solid Fuel Transformation	Fugitive
1B1c	Other (please specify)	Fugitive
1B2	Oil and Natural Gas	Fugitive
1B2a	Oil	Fugitive
1B2a2	Production	Fugitive
1B2a3	Transport	Fugitive
1B2a4	Refining/Storage	Fugitive
1B2a5	Distribution of oil products	Fugitive
1B2a6	Other	Fugitive
1B2b	Natural Gas	Fugitive
1B2b1	Production/processing	Fugitive
1B2b2	Transmission/distribution	Fugitive
1B2c	Venting and Flaring	Fugitive
1B2c1	Venting and Flaring Oil	Fugitive
1B2c2	Venting and Flaring Gas	Fugitive
1B2d	Other	Fugitive

Summary tables for the energy sector are shown below.

Table 3.2 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	2003	2004
	(Gg)														
1. Energy	**51.474**	**61.984**	**56.075**	**58.207**	**61.674**	**58.880**	**72.285**	**62.615**	**58.555**	**55.759**	**51.265**	**52.847**	**52.457**	**57.772**	**52.094**
A. Fuel Combustion (Sectoral Approach)	51.211	61.466	55.540	57.739	61.206	58.515	71.885	62.050	58.133	54.862	50.671	52.213	51.921	57.222	51.485
1. Energy Industries	26.173	35.113	30.082	31.627	35.352	31.934	44.321	35.084	31.381	28.231	25.115	26.400	26.553	31.402	25.388
2. Manufacturing Industries and Construction	5.423	5.848	5.677	5.584	5.805	5.974	6.137	6.132	6.114	6.166	5.946	6.018	5.700	5.698	5.841
3. Transport	10.336	10.811	10.940	10.961	11.254	11.639	11.907	12.041	12.065	12.134	12.004	11.992	12.170	12.605	12.859
4. Other Sectors	9.159	9.407	8.700	9.330	8.543	8.716	9.345	8.622	8.368	8.148	7.496	7.707	7.409	7.426	7.159
5. Other	119	287	141	237	252	252	176	171	204	182	111	97	89	92	239
B. Fugitive Emissions from Fuels	263	518	534	468	468	365	400	565	422	898	594	633	535	550	608
1. Solid Fuels	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2. Oil and Natural Gas	263	518	534	468	468	365	400	565	422	898	594	633	535	550	608

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	2003	2004
	(Gg)														
1. Energy	**10,56**	**12,03**	**12,67**	**15,17**	**18,51**	**25,05**	**29,94**	**29,96**	**31,37**	**31,52**	**31,16**	**32,66**	**32,46**	**32,49**	**32,70**
A. Fuel Combustion (Sectoral Approach)	8,67	9,75	10,50	12,78	16,02	22,11	27,12	26,84	28,25	27,95	27,35	28,85	28,52	28,47	27,86
1. Energy Industries	1,11	1,53	1,83	3,38	6,37	11,51	14,96	14,51	15,70	15,63	14,84	16,07	16,00	15,71	15,37
2. Manufacturing Industries and Construction	0,71	0,74	0,71	0,73	0,74	0,84	1,27	1,27	1,35	1,35	1,54	1,60	1,47	1,47	1,51
3. Transport	2,51	2,79	2,96	3,13	3,24	3,55	3,87	3,70	3,69	3,45	3,29	3,22	2,96	2,88	2,57
4. Other Sectors	4,35	4,67	4,99	5,52	5,67	6,20	7,01	7,36	7,49	7,51	7,67	7,96	8,08	8,41	8,40
5. Other	0,00	0,02	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,00	0,00	0,01
B. Fugitive Emissions from Fuels	1,89	2,28	2,17	2,39	2,49	2,94	2,83	3,12	3,12	3,56	3,81	3,82	3,94	4,02	4,84
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	0,00	0,00
2. Oil and Natural Gas	1,89	2,28	2,17	2,39	2,49	2,94	2,83	3,12	3,12	3,56	3,81	3,82	3,94	4,02	4,84

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	2003	2004
	(Gg)														
1. Energy	**1,37**	**1,57**	**1,56**	**1,63**	**1,76**	**1,86**	**2,13**	**2,14**	**2,16**	**2,22**	**2,20**	**2,25**	**2,31**	**2,40**	**2,40**
A. Fuel Combustion (Sectoral Approach)	1,37	1,56	1,55	1,63	1,75	1,86	2,12	2,13	2,16	2,20	2,19	2,24	2,30	2,39	2,39
1. Energy Industries	0,38	0,47	0,43	0,45	0,49	0,50	0,65	0,57	0,53	0,52	0,48	0,51	0,52	0,55	0,50
2. Manufacturing Industries and Construction	0,18	0,19	0,18	0,18	0,18	0,18	0,19	0,19	0,19	0,19	0,19	0,19	0,18	0,18	0,19
3. Transport	0,45	0,53	0,59	0,64	0,74	0,84	0,93	1,03	1,11	1,17	1,21	1,23	1,29	1,34	1,40
4. Other Sectors	0,35	0,36	0,34	0,35	0,33	0,33	0,35	0,33	0,32	0,31	0,30	0,31	0,30	0,31	0,29
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	0,00	0,01
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	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	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	0,01	0,01

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

Fuel consumption and emissions from stationary combustion plants in CRF sectors 1A1, 1A2 and 1A4 are all included in this chapter. Further details on the inventories for stationary combustion are 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) according the CORINAIR system. The emission inventories are prepared from a complete emission database, based on the SNAP sectors. Aggregation to the IPCC sector codes is based on a correspondence list between SNAP and IPCC 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 emissions from transport subsectors. The emission source *1A2* includes emissions from some off-road machinery in the industries. 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 and fuel consumption data presented in tables and figures in Chapter 3.2 only includes emissions originating from stationary combustion plants of a given IPCC sector. The IPCC sector codes have been applied unchanged, but some sector names have been changed to reflect the stationary combustion element of the source.

3.2.1.2 Fuel consumption

In 2004, the total fuel consumption for stationary combustion plants was 564 PJ of which 466 PJ was fossil fuels.

Fuel consumption distributed acording to the stationary combustion subsectors is shown in Figure 3.1 and Figure 3.2. The majority - 60% - of all fuels is combusted in the sector, *Public electricity and heat production.* Other sectors with high fuel consumption are *Residential* and *Industry*.

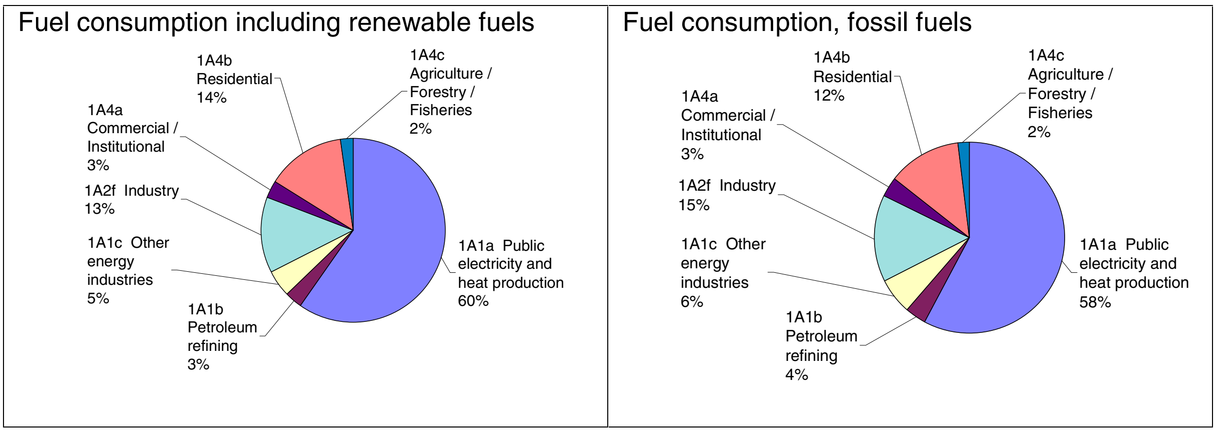


Figure 3.1 Fuel consumption rate of stationary combustion, 2004 (based on DEA 2005a)

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.

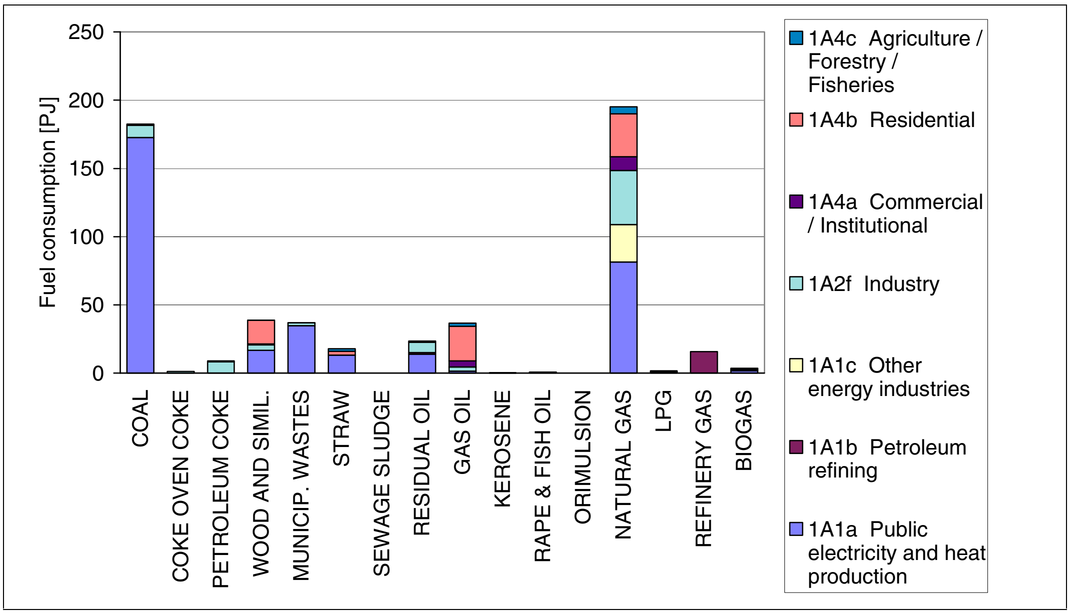


Figure 3.2 Fuel consumption of stationary combustion plants 2004 (based on DEA 2005a)

Fuel consumption time-series for stationary combustion plants are presented in Figure 3.3. The total fuel consumption increased by 13% from 1990 to 2004, while the fossil fuel consumption only increased by 4.2%. The consumption of natural gas and renewable fuels has increased since 1990, whereas the consumption of coal has decreased.

The fuel consumption rate fluctuates considerably, largely 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.

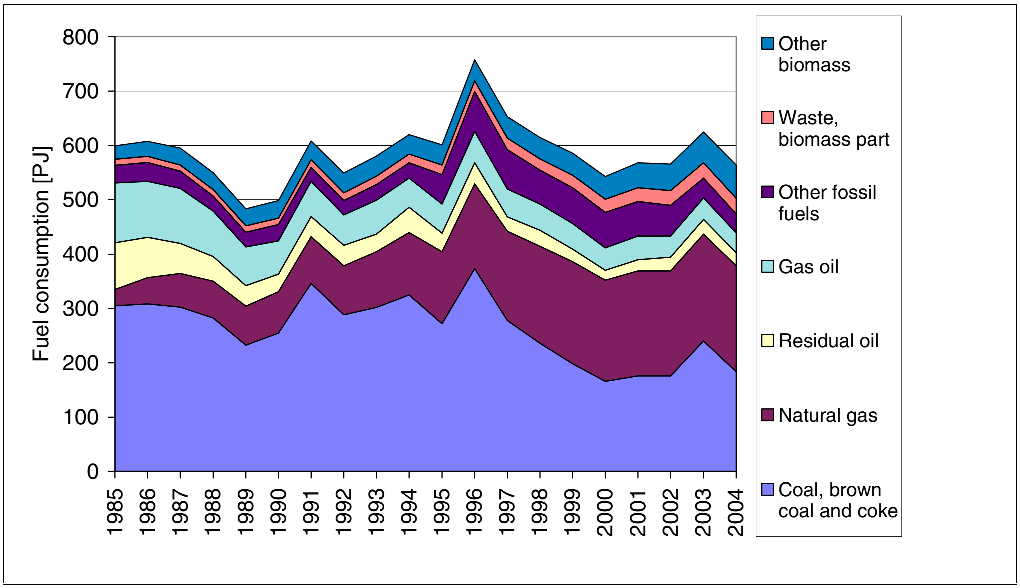


Figure 3.3 Fuel consumption time-series, stationary combustion (based on DEA 2005a)

3.2.1.3 Emissions

The GHG emissions from stationary combustion are listed in Table 3.5. The emission from stationary combustion accounts for 54% of the total Danish GHG emission.

The CO_2 emission from stationary combustion plants accounts for 66% of the total Danish CO_2 emission (not including land-use change and forestry). The CH_4 emission from stationary combustion accounts for 9% of the total Danish CH_4 emission and the N_2O emission from stationary combustion accounts for 4% of the total Danish N_2O emission. The total Danish emissions are calculated in the old CRF format. Due to structural changes in the new CRF, there is not total compliance with the old CRF. However, this might not affect the percentages given.

Table 3.5 Greenhouse gas emission for the year 2004 [1)].

	CO_2	CH_4	N_2O
		Gg CO_2 equivalent	
1A1 Fuel consumption, Energy industries	25388	323	154
1A2 Fuel consumption, Manufacturing Industries and Construction[1)]	4929	31	47
1A4 Fuel consumption, Other sectors [1)]	5354	169	67
Total emission from stationary combustion plants	**35670**	**522**	**268**
Total Danish emission (gross)	53938	5779	7587
		%	
Emission share for stationary combustion	66	9	4

1) Only stationary combustion sources of the sector is included

CO_2 is the most important GHG pollutant and accounts for 97.7% of the GHG emission (CO_2 eqv.).

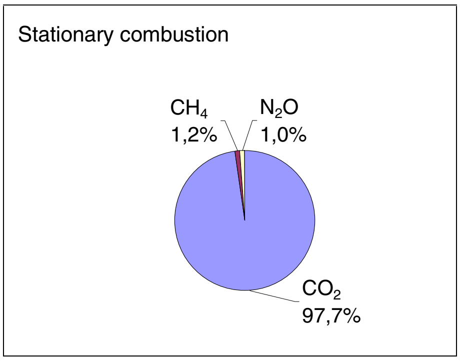


Figure 3.4 GHG emission (CO_2 equivalent) from stationary combustion plants

Figure 3.5 depicts the time-series of GHG emission (CO_2 eqv.) from stationary combustion and it can be seen that the GHG emission development follows the CO_2 emission development very closely. Both the CO_2 and the total GHG emission are lower in 2004 than in 1990 – CO_2 by 5% and GHG by 4%. However, fluctuations in the GHG emission level are large.

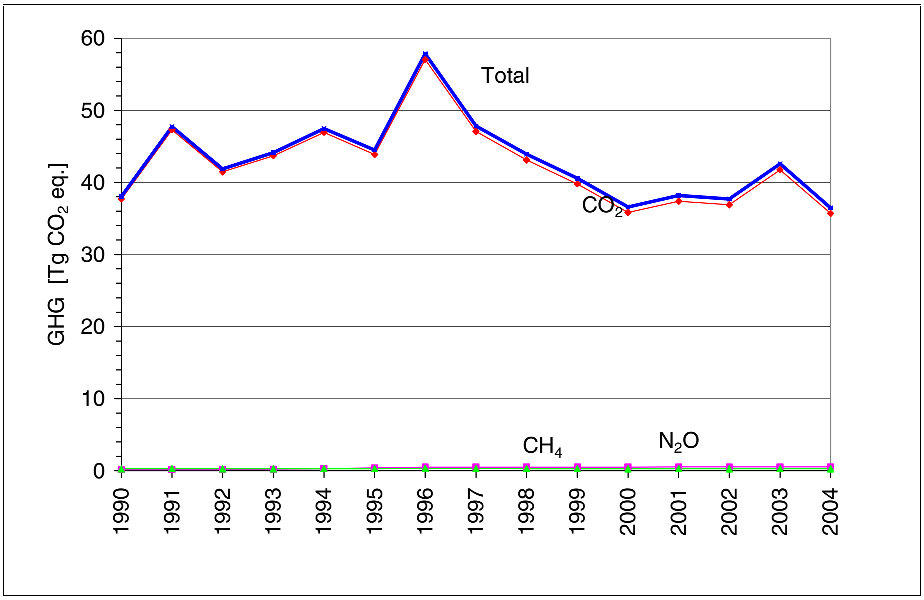


Figure 3.5 GHG emission time-series for stationary combustion

The fluctuations in the time-series are largely a result of electricity import/export activity, but also of outdoor temperature variations from year to year. These fluctuations are shown in Figure 3.6. The fluctuations follow the fluctuations in fuel consumption.

In 1990, the Danish electricity import was large causing relatively low fuel consumption, whereas the fuel consumption was high in 1996 due to a large electricity export. In 2004 the net electricity export was 10340 TJ which is lower than in 2003. The electricity export in 2004 was a result of low rainfall in Norway and Sweden causing insufficient hydropower production in both countries at this time.

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 illustrated 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 23% since 1990, and the CO_2 emission by 24%.

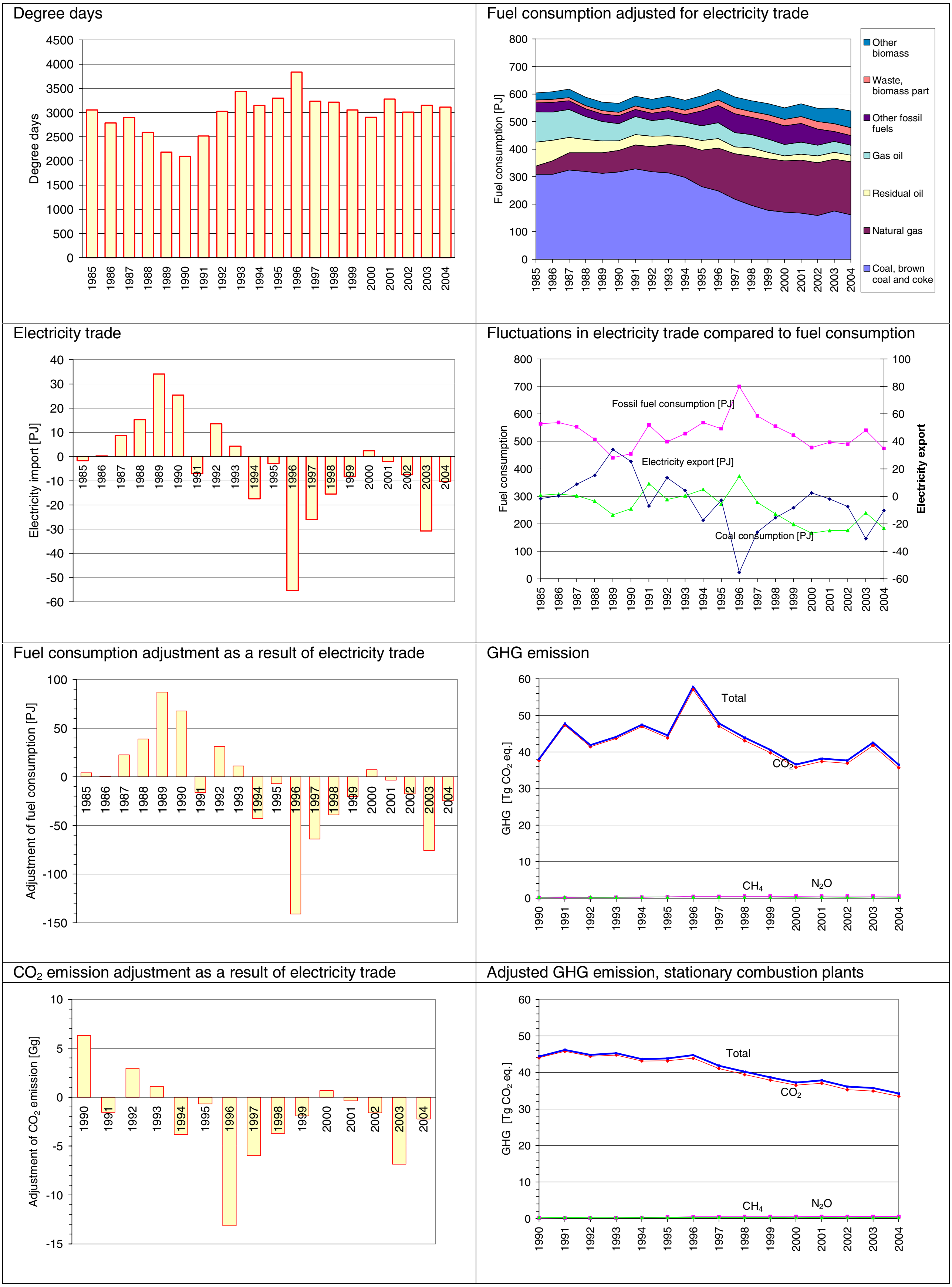


Figure 3.6 GHG emission time-series for stationary combustion and adjustment for electricity import/export and temperature variations (DEA 2005b)

3.2.1.3.1 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 66% of the total Danish CO_2 emission. Table 3.6 lists the CO_2 emission inventory for stationary combustion plants for 2004. Figure 3.7 reveals that *Electricity and heat production* accounts for 63% of the CO_2 emission from stationary combustion. This share is somewhat higher than the fossil fuel consumption share for this sector, which is 60% (Figure 3.1). Other large CO_2 emission sources are industrial plants and residential plants. These are the sectors, which also account for a considerable share of fuel consumption.

Table 3.6 CO_2 emission from stationary combustion plants 2004[1)]

CO_2	2004	
1A1a Public electricity and heat production	22832	Gg
1A1b Petroleum refining	988	Gg
1A1c Other energy industries	1567	Gg
1A2 Industry	4929	Gg
1A4a Commercial / Institutional	956	Gg
1A4b Residential	3768	Gg
1A4c Agriculture / Forestry / Fisheries	631	Gg
Total	**35670**	**Gg**

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

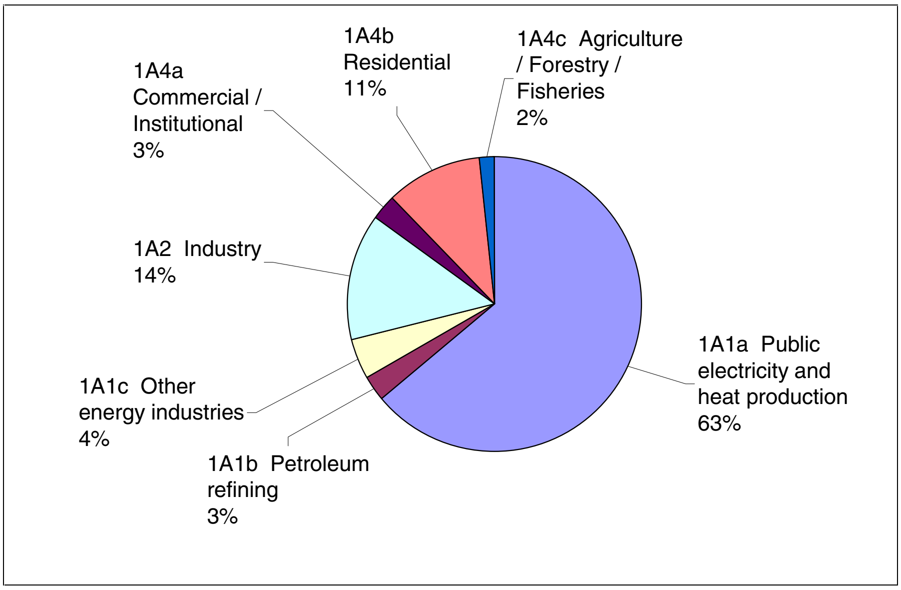


Figure 3.7 CO_2 emission sources, stationary combustion plants, 2004

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 listed in Table 3.7. The most important subsector is power plant boilers >300MW.

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

SNAP source	SNAP name	2004	
0101	Public power	0	Gg
010101	Combustion plants ≥ 300MW (boilers)	17508	Gg
010102	Combustion plants ≥ 50MW and < 300 MW (boilers)	910	Gg
010103	Combustion plants <50 MW (boilers)	203	Gg
010104	Gas turbines	2402	Gg
010105	Stationary engines	1528	Gg
0102	District heating plants	-	Gg
010201	Combustion plants ≥ 300MW (boilers)	7	Gg
010202	Combustion plants ≥ 50MW and < 300 MW (boilers)	58	Gg
010203	Combustion plants <50 MW (boilers)	188	Gg
010204	Gas turbines	-	Gg
010205	Stationary engines	27	Gg

The 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 2004, the CO_2 emission from biomass combustion was 9647 Gg.

Time-series for CO_2 emissions are provided in Figure 3.8. Despite an increase in fuel consumption of 13% since 1990, CO_2 emission from stationary combustion has decreased by 5.4% due to the change in the type of fuels used.

The fluctuations of CO_2 emission are discussed in Chapter 3.2.1.3.

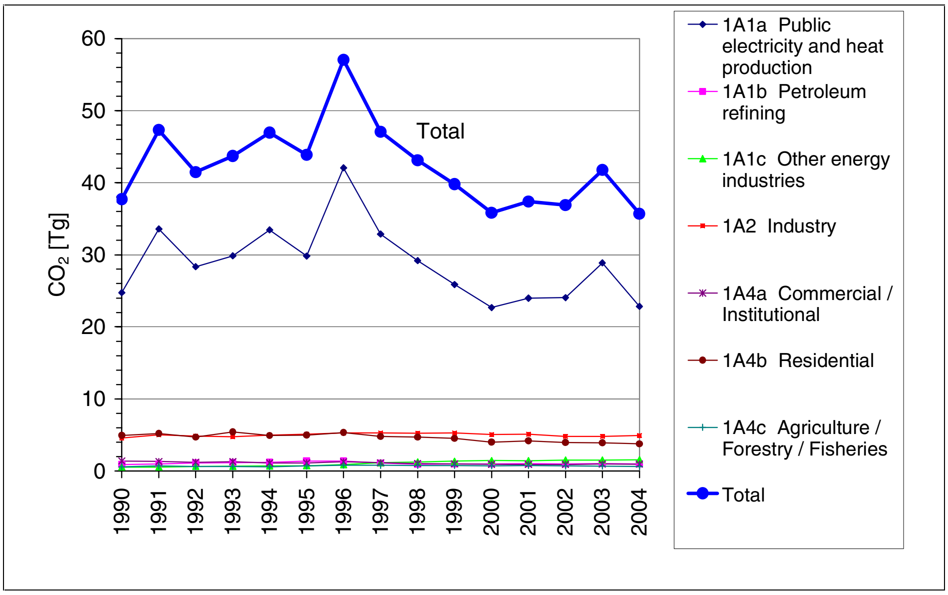


Figure 3.8 CO_2 emission time-series for stationary combustion plants

3.2.1.3.2 CH_4

CH_4 emission from stationary combustion plants accounts for 9% of the total Danish CH_4 emission. Table 3.8 lists the CH_4 emission inventory for stationary combustion plants in 2004. Figure 3.9 reveals that *Electricity and heat production* accounts for 62% of the CH_4 emission from stationary combustion, this being closely aligned with the fuel consumption share.

Table 3.8 CH_4 emission from stationary combustion plants 2004 [1)]

CH_4	2004	
1A1a Public electricity and heat production	15294	Mg
1A1b Petroleum refining	2	Mg
1A1c Other energy industries	69	Mg
1A2 Industry	1464	Mg
1A4a Commercial / Institutional	906	Mg
1A4b Residential	5057	Mg
1A4c Agriculture / Forestry / Fisheries	2071	Mg
Total	24863	Mg

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

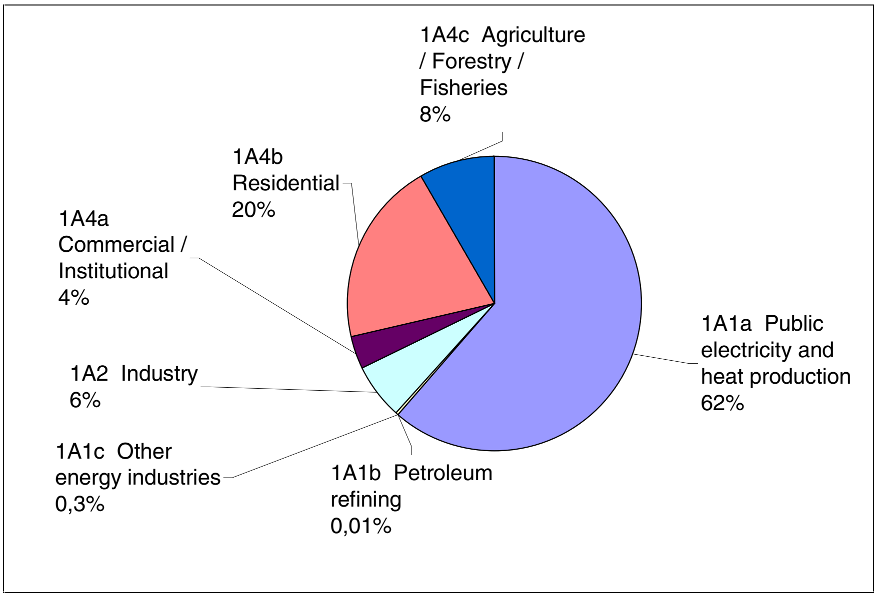


Figure 3.9 CH_4 emission sources, stationary combustion plants, 2004

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. Lean-burn gas engines have an especially high emission factor as discussed in Chapter 3.2.2.4. A considerable number of lean-burn gas engines are in operation in Denmark and these plants account for 74% 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.

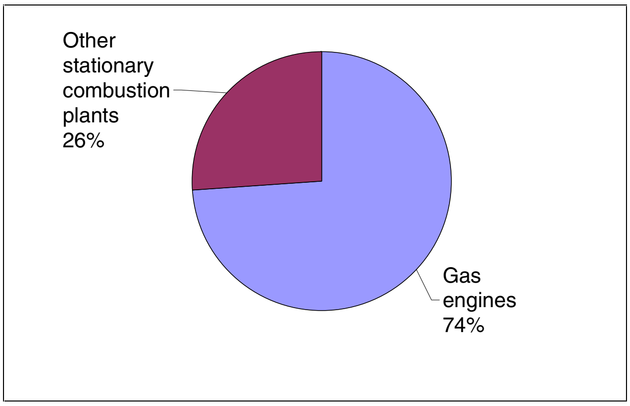


Figure 3.10 Gas engine CH_4 emission share, 2004.

The CH_4 emission from stationary combustion increased by a factor of 4.3 since 1990 (Figure 3.11). This results from the considerable number of lean-burn gas engines installed in 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 the CRF sectors *1A1*, *1A2* and *1A4*. Figure 3.12 provides time-series for the fuel consumption rate in gas engines and the corresponding increase in CH_4 emission.

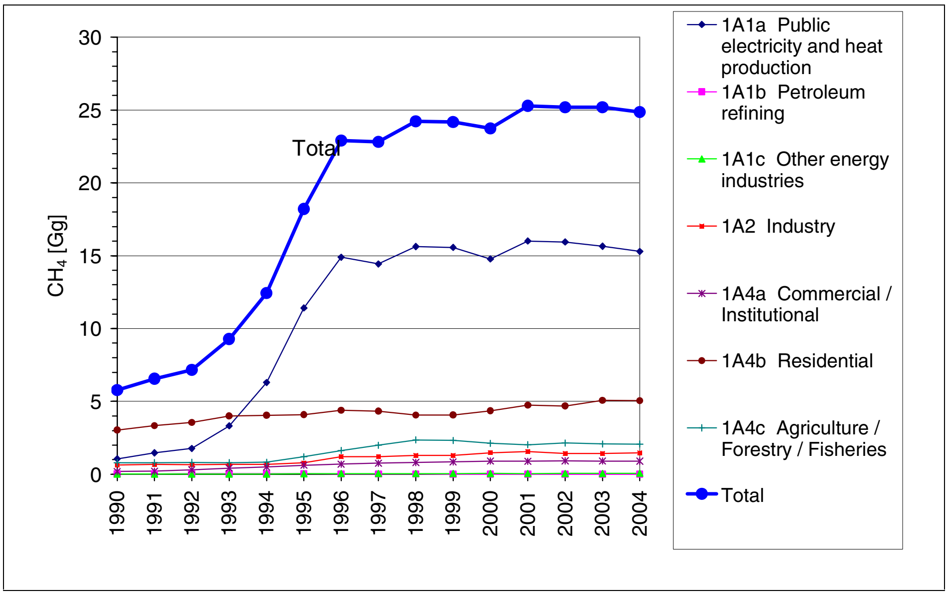


Figure 3.11 CH_4 emission time-series for stationary combustion plants

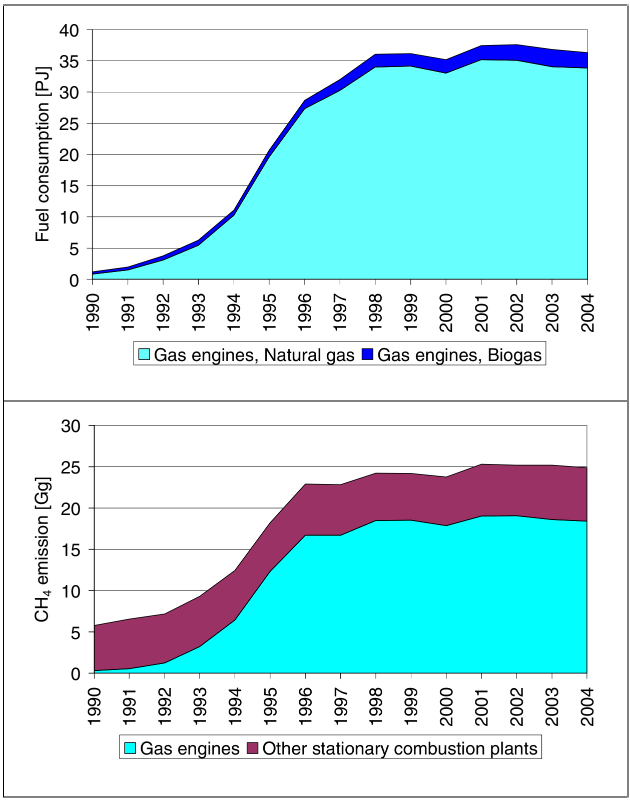


Figure 3.12 Fuel consumption and CH_4 emission from gas engines, time-series.

3.2.1.3.3 N_2O

The N_2O emission from stationary combustion plants accounts for 4% of the total Danish N_2O emission. Table 3.9 lists the N_2O emission inventory for stationary combustion plants in the year 2004. Since the last reporting, the emission factor for coal powered plants has been changed due to research by one of the major power plant operators in Denmark. Therefore, the emission for public power has been significantly reduced. The emission factor is updated for the entire time-series. Figure 3.13 reveals that *Electricity and heat production* accounts for 47% 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 2004 [1)]

N_2O	2004	
1A1a Public electricity and heat production	403	Mg
1A1b Petroleum refining	35	Mg
1A1c Other energy industries	60	Mg
1A2 Industry	150	Mg
1A4a Commercial / Institutional	25	Mg
1A4b Residential	167	Mg
1A4c Agriculture / Forestry / Fisheries	25	Mg
Total	**864**	Mg

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

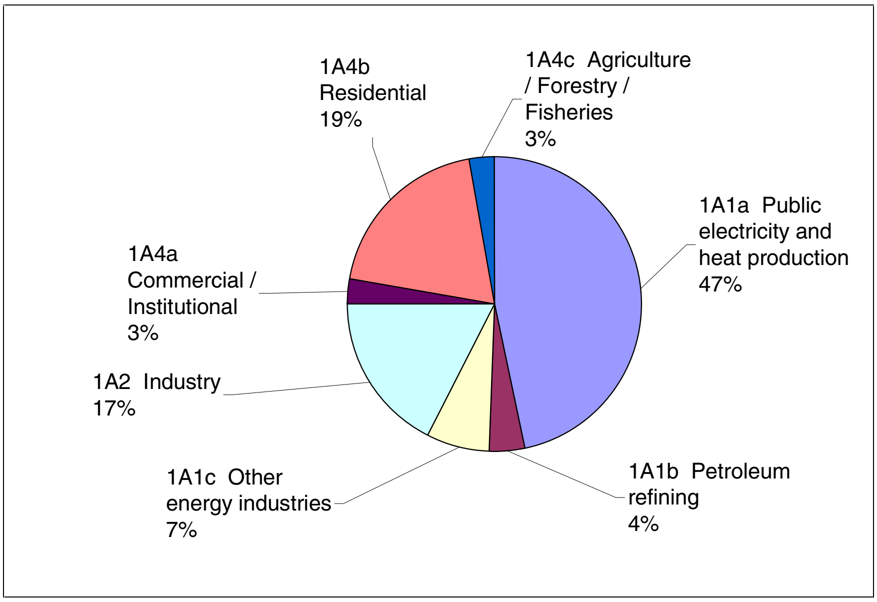


Figure 3.13 N_2O emission sources, stationary combustion plants, 2004

Figure 3.14 shows the time-series for the N_2O emission. The N_2O emission from stationary combustion increased by 10% from 1990 to 2004, but, again, fluctuations in emission level due to electricity import/export are considerable.

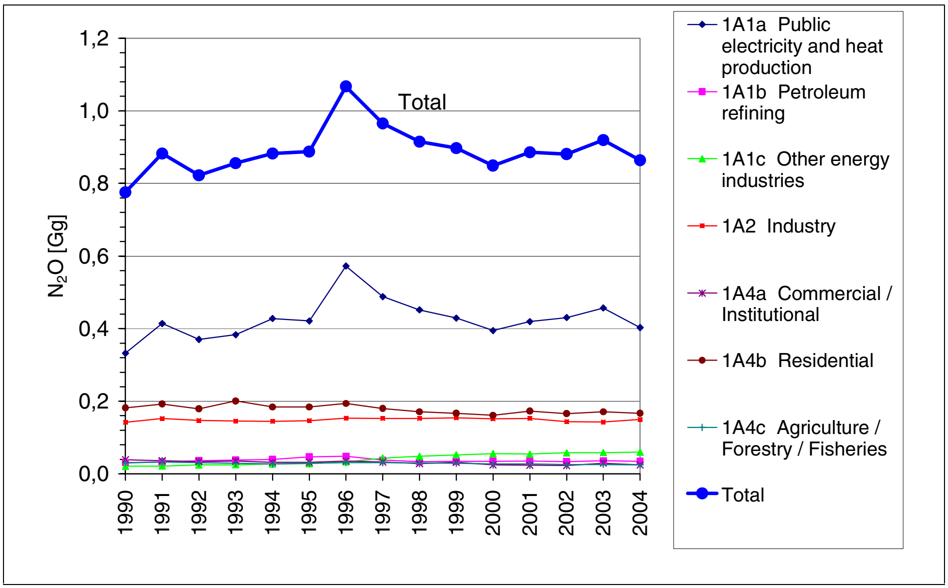


Figure 3.14 N_2O emission time-series for stationary combustion plants

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 2003 are presented in Table 3.10. Further details are shown in Annex 3A. SO_2 from stationary combustion plants accounts for 83% of the total Danish SO_2 emission. NO_x, CO and NMVOC account for 41%, 35% and 17%, respectively, of the total Danish emissions for these substances.

Table 3.10 SO_2, NO_X, NMVOC and CO emission from stationary combustion plants 2004

Pollutant	NO_X Gg	CO Gg	NMVOC Gg	SO_2 Gg
1A1 Fuel consumption, Energy industries	52.7	12.1	4.1	10.2
1A2 Fuel consumption, Manufacturing industries and Construction (Stationary combustion)	14.3	12.9	0.7	6.9
1A4 Fuel consumption, Other sectors (Stationary combustion)	7.3	180.3	14.7	3.2
Total emission from stationary combustion plants	**74.2**	**205.4**	**19.5**	**20.3**
Total Danish emission	181.3	587.3	116.5	24.4
		%		
Emission share for stationary combustion	41	35	17	83

1) Only emissions from stationary combustion plants in the sectors are included

3.2.2 Methodological issues

The Danish emission inventory is based on the CORINAIR (COoRdination of INformation on AIR emissions) system, which is a European programme 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 2004). Emission data are stored in an Access database, from which data are transferred to the reporting formats.

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

3.2.2.1 Large point sources

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

In the inventory for the year 2004, 75 stationary combustion plants are specified as large point sources. These point sources include:

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

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

- All centralised power plants, including smaller units.
- All units with a capacity above 25 MW_e
- All district heating plants with an installed effect of 50 MW or above and a significant fuel consumption

- All waste incineration plants included in the Danish law with regard to the preparation of "green accounts" "*Bekendtgørelse om visse listevirksomheders pligt til at udarbejde grønt regnskab*".
- Industrial plants
  - with an installed effect of 50 MW or above and significant fuel consumption.
  - with a significant process-related emission.

The fuel consumption of stationary combustion plants registered as large point sources is 361 PJ (2004). This corresponds to 64% of the overall fuel consumption for stationary combustion.

Further details regarding the large point sources are provided in Annex 3A. The number of large point sources registered in the databases increased from 1990 to 2004.

The emissions from a point source are based either on plant-specific emission data or, if plant specific data are not available, on fuel consumption data and the general Danish emission factors.

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 legislatory requirements
- Emission data reported by Elsam and E2, the two major electricity suppliers
- Emission data reported from industrial plants.

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

If plant-specific emission factors are not available, general area source emission factors are used. Emissions of the greenhouse gases (CO_2, CH_4 and N_2O) from the large point sources are all based on area source 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 such as residential boilers, small district heating plants, small CHP plants and some industrial boilers are defined as area sources. Emissions from area sources are based on fuel consumption data and emission factors. Further information on emission factors is provided below.

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 (DEA). The DEA aggregates fuel consumption rates to SNAP sector categories (DEA 2005a). Some fuel types in the official Danish energy statistics are added to obtain a less detailed fuel aggregation level, see Annex 3A. The calorific values on which the energy statistics are based are also included in the annex.

The fuel consumption of the IPCC sector *1A2 Manufacturing industries and construction* (corresponding to SNAP sector *03 Combustion in manufacturing industries)* is not disaggregated into specific industries in the NERI emission database. Disaggregation into specific industries is estimated for the reporting to the Climate Convention. The disaggregation of fuel consumption and emissions from the industrial sector are discussed in Chapter 3.2.2.5.

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

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

The DEA compiles a database for the fuel consumption of each district heating and power-producing plant based on data reported by plant operators. The fuel consumption of large point sources specified in the Danish emission database refers to the DEA database (DEA 2005c).

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, to date, but the non-energy use of fuels is, however, included in the reference approach for Climate Convention reporting. The Danish energy statistics include three fuels used for non-energy purposes: bitumen, white spirit and lube oil. The fuels used for non-energy purposes add up to less than 2% of the total fuel consumption in Denmark.

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 is presented in Chapter 3.2.1.2.

3.2.2.4 Emission factors

For each fuel and SNAP category (sector and e.g. type of plant), a set of general area source emission factors has been determined. The emission factors are either nationally referenced or based on the international guidebooks EMEP/Corinair Guidebook (EMEP/Corinair

2004) 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 2004 are presented in Table 3.11. For municipal waste and natural gas, time-series have been estimated. For all other fuels the same emission factor is applied for 1990-2004.

In reporting to the Climate Convention, the CO_2 emission is aggregated to five fuel types: Solid fuel, Liquid fuel, Gas, Biomass and Other fuels. The correspondence list between the NERI fuel categories and the IPCC fuel categories is also provided in Table 3.11. The emission factors are further discussed in Annex 3A.

The CO_2 emission from incineration of municipal waste (94.5 + 17.6 kg/GJ) is divided into 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 (which is reported as a memo item). In the IPCC reporting, the CO_2 emission from combustion of the plastic content of the waste is reported in the fuel category, *Other fuels*. However, this split is not applied in either fuel consumption or other emissions, as it is only relevant for CO_2. Thus, the full consumption of municipal waste is included in the fuel category, *Biomass,* and the full amount of non-CO_2 emissions from municipal waste combustion is also included in the *Biomass*-category.

The CO_2 emission factors have been confirmed by the two major power plant operators, both directly (Christiansen, 1996 and Andersen, 1996) and indirectly, by the large power plants' applying the NERI emission factors in their annual environmental reports and by the acceptance of the NERI factors in Danish legislation.

The current Danish legislation concerning CO_2 emission from power plants in 2003 and 2004 (Law no. 376 1999) is based on standard CO_2 emission factors for each fuel. Thus, so far power plant operators have not been encouraged to estimate CO_2 emission factors based on their own fuel analysis. In future legislation (Law no. 493 2004), operators of large power plants are obliged to verify the applied emission factors, which will lead to the availability of improved emission factors for national emission inventories in future. The plants will report CO_2 emissions for 2005 according to this legislation.

Table 3.11 CO_2 emission factors 2004

Fuel	Emission factor Biomass	Emission factor Fossil fuel	Unit	Reference type	IPCC fuel Category
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	74		kg/GJ	Country specific	Biomass
Orimulsion		80	kg/GJ	Country specific	Liquid
Natural gas		57.12	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 2004 are presented in Table 3.12. In general, the same emission factors have been applied for 1990-2004. However, time-series have been estimated for both natural gas fuelled engines and biogas fuelled engines. The emission factors and references are further discussed in Annex 3A.

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). Most other emission factors refer to the EMEP/Corinair Guidebook (EMEP/Corinair 2004).

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 in 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 the 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 1990-2004

Fuel	ipcc_id	SNAP_id	Emission factor [g/GJ]	Reference
COAL	1A1a	010101, 010102, 010103	1,5	EMEP/Corinair 2004
COAL	1A1a, 1A2f, 1A4b, 1A4c	010202, 010203, 0301, 0202, 0203	15	EMEP/Corinair 2004
BROWN COAL BRI.	all	all	15	EMEP/Corinair 2004, assuming same emission factor as for coal
COKE OVEN COKE	all	all	15	EMEP/Corinair 2004, assuming same emission factor as for coal
PETROLEUM COKE	all	all	15	EMEP/Corinair 2004
WOOD AND SIMIL.	1A1a	010102, 010103, 010104	2	Nielsen & Illerup 2003
WOOD AND SIMIL.	1A4a, 1A4b, 1A4c	0201, 0202, 0203	200	EMEP/Corinair 2004
WOOD AND SIMIL.	1A1a, 1A2f	010105, 010202, 010203, 0301, 030102, 030103	32	EMEP/Corinair 2004
MUNICIP. WASTES	1A1a	010102, 010103, 010104, 010105	0,59	Nielsen & Illerup 2003
MUNICIP. WASTES	1A1a, 1A2f, 1A4a	all other	6	EMEP/Corinair 2004
STRAW	1A1a	010102, 010103	0,5	Nielsen & Illerup 2003
STRAW	1A1a, 1A2f, 1A4c	010202, 010203, 020302, 030105	32	EMEP/Corinair 2004
STRAW	1A4b, 1A4c	0202, 0203	200	EMEP/Corinair 2004
RESIDUAL OIL	all	all	3	EMEP/Corinair 2004
GAS OIL	all	all	1,5	EMEP/Corinair 2004
KEROSENE	all	all	7	EMEP/Corinair 2004
FISH & RAPE OIL	all	all	1,5	EMEP/Corinair 2004, assuming same emission factor as gas oil
ORIMULSION	1A1a	010101	3	EMEP/Corinair 2004, 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, 1Ac, 1A2f, 1A4a, 1A4c	Gas turbines: 010104, 010504, 030104, 020104, 020303	1,5	Nielsen & Illerup 2003
NATURAL GAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4b, 1A4c	Gas engines: 010105, 010205, 010505, 030105, 020105, 020204, 020304	1) 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 2004
REFINERY GAS	1A1b	010304	1,5	EMEP/Corinair 2004
BIOGAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4c	Gas engines: 010105, 010505, 030105, 020105, 020304	1) 323	Nielsen & Illerup 2003
BIOGAS	1A1a, 1A2f, 1A4a, 1A4c	all other	4	EMEP/Corinair 2004

1) 2003 emission factor. Time-series is shown in Annex 3A

N_2O

The N_2O emission factors applied for the 2004 inventory are listed in Table 3.13. The same emission factors have been applied in the period 1990-2003.

Emission factors for gas engines, gas turbines and CHP plants combusting wood, straw or municipal waste all refer to emission measurements carried out in Danish plants (Nielsen & Illerup 2003). For coal-powered plants in the public power sector, research conducted by Elsam has led to a new emission factor being implemented for the entire time-series. Other emission factors refer to the EMEP/Corinair Guidebook (EMEP/Corinair 2004).

Table 3.13 N_2O emission factors 1990-2004

Fuel	ipcc_id	SNAP_id	Emission factor [g/GJ]	Reference
COAL	1A1a	0101**	0,8	Elsam 2005
COAL	1A1a, 1A1c, 1A2f, 1A4a, 1A4b, 1A4c	All except 0101**	3	EMEP/Corinair 2004
BROWN COAL BRI.	all	all	3	EMEP/Corinair 2004
COKE OVEN COKE	all	all	3	EMEP/Corinair 2004
PETROLEUM COKE	all	all	3	EMEP/Corinair 2004
WOOD AND SIMIL.	1A1a	010102, 010103, 010104	0,8	Nielsen & Illerup 2003
WOOD AND SIMIL.	1A1a	010105, 010202, 010203	4	EMEP/Corinair 2004
WOOD AND SIMIL.	1A2f, 1A4a, 1A4b, 1A4c	all	4	EMEP/Corinair 2004
MUNICIP. WASTES	1A1a	010102, 010103, 010104, 010105	1,2	Nielsen & Illerup 2003
MUNICIP. WASTES	1A1a	010203	4	EMEP/Corinair 2004
MUNICIP. WASTES	1A2f, 1A4a	030102, 0201, 020103	4	EMEP/Corinair 2004
STRAW	1A1a	010102, 010103	1,4	Nielsen & Illerup 2003
STRAW	1A1a	010202, 010203	4	EMEP/Corinair 2004
STRAW	1A2f, 1A4b, 1A4c	all	4	EMEP/Corinair 2004
RESIDUAL OIL	all	all	2	EMEP/Corinair 2004
GAS OIL	all	all	2	EMEP/Corinair 2004
KEROSENE	all	all	2	EMEP/Corinair 2004
FISH & RAPE OIL	all	all	2	EMEP/Corinair 2004, assuming same emission factor as gas oil
ORIMULSION	1A1a	010101	2	EMEP/Corinair 2004, assuming same emission factor as residual oil
NATURAL GAS	1A1a	0101, 010101, 010102, 010103, 010202, 010203	1	EMEP/Corinair 2004
NATURAL GAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4c	Gas turbines: 010104, 010504, 030104, 020104, 020303	2,2	Nielsen & Illerup 2003
NATURAL GAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4b, 1A4c	Gas engines: 010105, 010205, 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 2004
LPG	all	all	2	EMEP/Corinair 2004
REFINERY GAS	all	all	2,2	EMEP/Corinair 2004
BIOGAS	1A1a	010102, 010103, 010203	2	EMEP/Corinair 2004
BIOGAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4c	Gas engines: 010105, 010505, 030105, 020105, 020304	0,5	Nielsen & Illerup 2003
BIOGAS	1A2f, 1A4a, 1A4c	0301, 030102, 0201, 020103, 0203	2	EMEP/Corinair 2004

SO_2, NO_x, NMVOC and CO

Emission factors for SO_2, NO_X, NMVOC and CO including time-series and references are listed in Annex 3A.

The emission factors refer to:

- The EMEP/Corinair Guidebook (EMEP/Corinair 2004)
- The IPCC Guidelines, Reference Manual (IPCC 1996)
- Danish legislation:
  - Miljøstyrelsen 2001 (Danish Environmental Protection Agency)
  - Miljøstyrelsen 1990 (Danish Environmental Protection Agency)
  - Miljøstyrelsen 1998 (Danish Environmental Protection Agency)
- Danish research reports including:
  - An emission measurement programme for decentralised CHP plants (Nielsen & Illerup 2003)
  - Research and emission measurements programmes for biomass fuels:
    - Nikolaisen et al., 1998
    - Jensen & Nielsen, 1990
    - Dyrnum et al., 1990
    - Hansen et al., 1994
    - Serup et al., 1999

- ° Research and environmental data from the gas sector:
- – Gruijthuijsen & Jensen 2000
- – Danish Gas Technology Centre 2001
- Calculations based on plant-specific emissions from a considerable number of power plants (Nielsen 2004).
- Calculations based on plant-specific emission data from a considerable number of municipal waste incineration plants. These data refer to annual environmental reports published by plant operators.
- Sulphur-content data from oil companies and the Danish gas transmission company.
- Additional personal communication.

Emission factor time-series have been estimated for a considerable number of the emission factors. These are provided in Annex 3A.

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.

3.2.2.5 Disaggregation to specific industrial subsectors

The national statistics on which the emission inventories are based do not include a direct disaggregation to specific industrial subsectors. However, separate national statistics from Statistics Denmark include a disaggregation to industrial subsectors. This part of the energy statistics is also included in the official energy statistics from the Danish Energy Authority.

Every other year, Statistics Denmark collects fuel consumption data for all industrial companies of a considerable size. The deviation between the total fuel consumption from the Danish Energy Authority and the data collected by Statistics Denmark is rather small. Thus, the disaggregation to industrial subsectors available from Statistics Denmark can be applied for estimating disaggregation keys for fuel consumption and emissions.

Three aspects of industrial fuel consumption are considered:

- Fuel consumption for transport. This part of the fuel consumption is not disaggregated to subsectors.

- Fuel consumption in power or district heating plants. Disaggregation of fuel and emissions is plant specific.

- Fuel consumption for other purposes. The total fuel comsumption and the total emissions are disaggregated to subsectors.

All pollutants included in the Climate Convention reporting have been disaggregated to industrial subsectors.

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 with regard to the total emission inventory as well as uncertainty with regard to trends. The GHG emission from stationary combustion plants has been estimated with an uncertainty interval of ±7.8% and the decrease in the GHG emission since 1990 has been estimated to be 4.3% ± 2%-age-points.

3.2.3.1 Methodology

Greenhouse gases

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

- CO_2 emission from each of the applied fuel categories
- 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. Disaggregation is applied, because, in Denmark, the CH_4 emission from gas engines is much larger than the emission from other stationary combustion plants and the CH_4 emission factor for gas engines is estimated with a much smaller uncertainty level than for other stationary combustion plants.

Most of the applied uncertainty estimates 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.

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, BKB	CO_2	3 [1)]	5 [1)]
Stationary Combustion, Coke oven coke	CO_2	3 [1)]	5 [1)]
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 Good Practice Guidance (default value)
2) Kristensen (2001)
3) Jensen & Lindroth (2002)
4) NERI assumption

Other pollutants

With regard to other pollutants, IPCC methodologies for uncertainty estimates have been adopted for the LRTAP Convention reporting activities (Pulles & Aardenne 2001). The Danish uncertainty estimates are based on the simple Tier-1 approach.

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 2001. 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 uncertainty estimates for stationary combustion emission inventories are shown in Table 3.16. Detailed calculation sheets are provided in Annex 3A.

The uncertainty interval for GHG is estimated to be ±7.8% and the uncertainty for the trend in GHG emission is ±2%-age points. The main sources of uncertainty for GHG emission are the N_2O emission (all plants) and the CO_2 emission from coal combustion. The main source of uncertainty in the trend in GHG emission is the CO_2 emission from the combustion of coal and natural gas.

The total emission uncertainty is 7% for SO_2, 16% for NO_X, 39% for NMVOC and 44% for CO.

Table 3.16 Danish uncertainty estimates, 2004

Pollutant	Uncertainty Total emission [%]	Trend 1990-2004 [%]	Uncertainty Trend [%-age points]
GHG	7.8	-4.3	± 2.0
CO_2	2.7	-5.4	± 1.7
CH_4	39	331	± 316
N_2O	1000	11.4	± 3.5
SO_2	7	-87.1	±0.6
NO_X	16	-36	±2
NMVOC	39	54	±13
CO	44	19	±4.1

3.2.4 Source specific QA/QC and verification

The elaboration of a formal QA/QC plan started in 2004. A first version is now available, Sørensen et al., 2005.

The quality manual describes the concepts of quality work and definitions of sufficient quality, critical control points and a list of Points for Measuring (PMs). Please see the general chapter on QA/QC.

The QC is not yet fully implemented.

Data storage level 1

Table 3.17 List of external data sources for stationary combustion

Dataset	Description	AD or Emf.	Reference	Contact(s)	Data agreement/ Comment
Energiproducenttællingen.xls	Dataset for all electricity and heat producing plants.	Activity data	The Danish Energy Authority (DEA)	Anders B. Hansen & Peter Dal	Data agreement in place
Gas consumption for gas engines and gas turbines 1990-1994		Activity data	DEA	Anders B. Hansen & Peter Dal	No data agreement. Historical data
Basic data (Grunddata.xls)	Dataset used for IPCC reference approach	Activity data	DEA	Anders B. Hansen & Peter Dal	Not necessary. Published as part of national energy statistics
Energy statistics	The Danish energy statistics on SNAP level	Activity data	DEA	Anders B. Hansen & Peter Dal	Data agreement in place
SO_2 & NO_x data, plants>25 MW_e		Emissions	DEA	Marianne Nielsen	No data agreement in place
Emission factors	Emission factors stems from a large number of sources	Emission factors	See chapter regarding emission factors		
HM and PM from public power plants	Emissions from the two large power plant operators in DK Elsam & E2	Emissions	Elsam Energi E2	Helle M. Iversen & Egon Raun Hansen. Helle Herk-Hansen & Henrik Lous	No formal data agreement in place
Environmental reports	Emissions from plants defined as large point sources	Emissions	Various plants		No data agreement necessary. Plants are under obligation by law.
Additional data	Fuel consumption and emissions from large industrial plants	AD & emissions	Aalborg Portland Statoil Shell	Henrik M. Thomsen Peder Nielsen Lis R. Rasmussen	No formal data agreement in place

Data Storage level 1	1. Accuracy	DS.1.1.1	General level of uncertainty for every dataset including the reasoning for the specific values

Since the DEA are responsible for the official Danish energy statistics as well as reporting to the IEA, NERI regards the data as being complete and in accordance with the official Danish energy statistics and IEA reporting. The uncertainties connected with estimating fuel consumption do not, therefore, influence the accordance between IEA data, the energy statistics and the dataset on SNAP level utilised by NERI. For the remainder of the datasets, it is assumed that the level of uncertainty is relatively small. For further comments regarding uncertainties see Chapter 7.

Data Storage level 1	1. Accuracy	DS.1.1.2	Quantification of the uncertainty level of every single data value, including the reasoning behind the specific values.

The uncertainty for external data is not quantified. The uncertainties of activity data and emission factors are quantified see Chapter 7.

Data Storage level 1	2.Comparability	DS.1.2.1	Comparability of the data values with similar data from other countries, which are comparable with Denmark, and evaluation of discrepancy.

On the external data, the comparability has not been checked. However, at CRF level, a project has been carried out comparing the Danish inventories with those of other countries.

Data Storage level 1	3.Completeness	DS.1.3.1	Documentation showing that all possible national data sources are included, by setting down the reasoning behind the selection of datasets

See the above table for an overview of external datasets.

Danish Energy Authority

Statistics on fuel consumption from district heating and power plants

This statistics takes the form of a spreadsheet from the DEA listing fuel consumption of all plants included as large point sources in the emission inventory. The statistics on fuel consumption from district heating and power plants are regarded as complete and with no significant uncertainty since the plants are bound by law to report their fuel consumption and other information.

Gas consumption for gas engines and gas turbines 1990-1994

For the years 1990-1994, the DEA has estimated consumption of natural gas and biogas in gas engines and gas turbines. NERI assesses that the estimation by the DEA is the best available data.

Basic data

These data takes the form of a spreadsheet from DEA used for the CO_2 emission calculation in accordance with the IPCC reference approach. It is published annually on the DEA's webpage; therefore, a formal data delivery agreement is not deemed necessary.

Energy statistics on SNAP level

The DEA reports fuel consumption statistics on the SNAP level based on a correspondence table developed in co-operation with NERI. Both traded and non-traded fuels are included in the Danish energy statistics. Thus, for example, estimation of the annual consumption of non-traded wood is included. Petroleum coke, purchased abroad and combusted in Danish residential plants (border trade), is added to the apparent consumption of petroleum coke and the emissions are included in the inventory.

Emissions from non-energy use of fuels have not been included in the Danish inventory, to date, but the non-energy use of fuels is, however, included in the reference approach for Climate Convention reporting.

SO_2 and NO_x emission data from electricity producing plants > 25MWe
Plants larger than 25 MW_e are obligated to report SO_2 and NO_x emission data to the DEA annually. Data are on block level and are classified. The data on plant level are part of the plants' annual environmental reports. NERI's QC of the data consists of a comparison with data from previous years and with data from the plants' annual environmental reports.

Emission factors from a wide range of sources
For specific references, see chapter regarding emission factors.

Data for emission of heavy metals and particles from central power plants, Elsam and Energi E2
The two major Danish power plant operators assess heavy metal emissions from their plants using model calculations based on fuel data and type of flue-gas cleaning. NERI's QC of the data consists of a comparison with data from previous years and with data from the plants' annual environmental reports.

Annual environmental reports from plants defined as large point sources
A large number of plants are obligated by law to publish an environmental report annually with information on emissions, among other things. NERI compares data with those from previous years and large discrepancies are checked.

Supplementing data from large industrial combustion plants
Fuel consumption and emission data from a few large industrial combustion plants are obtained directly from the plants concerned. NERI compares data with those from previous years and large discrepancies are checked.

Data Storage level 1	4.Consistency	DS.1.4.1	The origin of external data has to be preserved whenever possible without explicit arguments (referring to other PMs)

It is ensured that all external data are archived at NERI. Subsequent data processing takes place in other spreadsheets or databases. The datasets are archived annually in order to ensure that the basic data for a given report are always available in their original form.

Data Storage level 1	6.Robustness	DS.1.6.1	Explicit agreements between the external institution holding the data and NERI about the condition of delivery

For stationary combustion, a data delivery agreement is made with the DEA. Most of the other external data sources are available due to legislatory requirements. See Table 3.17.

Data Storage level 1	7.Transparency	DS.1.7.1	Summary of each dataset, including the reasoning behind selection of the specific dataset

See DS 1.3.1

Data Storage level 1	7.Transparency	DS.1.7.3	References for citation for any external dataset have to be available for any single number in any dataset.

See Table 3.17 for general references. Much documentation already exists. However, some of the information used is classified and, therefore, not publicly available.

Data Storage level 1	7.Transparency	DS.1.7.4	Listing of external contacts for every dataset

See Table 3.17

Data Processing Level 1

Data Processing level 1	1. Accuracy	DP.1.1.1	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to type of variability (Distribution as: normal, log normal or other type of variability)

The uncertainty assessment of activity data and emission factors is discussed in the chapter concerning uncertainties.

Data Processing level 1	1. Accuracy	DP.1.1.2	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to scale of variability (size of variation intervals)

The uncertainty assessment of activity data and emission factors is discussed in the chapter concerning uncertainties.

Data Processing level 1	1. Accuracy	DP.1.1.3	Evaluation of the methodological approach using international guidelines

The methodological approach is consistent with international guidelines.

Data Processing level 1	1. Accuracy	DP.1.1.4	Verification of calculation results using guideline values

Calculated emission factors are compared with guideline emission factors to ensure that they are reasonable.

Data Processing level 1	2.Comparability	DP.1.2.1	The inventory calculation has to follow the international guidelines suggested by UNFCCC and IPCC.

The calculations follow the principle in international guidelines.

Data Processing level 1	3.Completeness	DP.1.3.1	Assessment of the most important quantitative knowledge which is lacking.

Regarding the distribution of energy consumption for industrial sources, a more detailed and frequently updated data material would be preferred. There is ongoing work to increase the accuracy and completeness of this sector. It is not assessed that this has any influence on the estimates for the emission of greenhouse gases.

Data Processing level 1	3.Completeness	DP.1.3.2	Assessment of the most important cases where access is lacking with regard to critical data sources that could improve quantitative knowledge.

There is no problem with regard to access to critical data sources.

Data Processing level 1	4.Consistency	DP.1.4.1	In order to keep consistency at a high level,, an explicit description of the activities needs to accompany any change in the calculation procedure

A change in calculating procedure would entail that an updated description would be elaborated.

Data Processing level 1	5.Correctness	DP.1.5.1	Demonstration at least once, by independent calculation, the correctness of every data manipulation

During data processing, it is checked that calculations are being carried out correctly. However, documentation for this needs to be elaborated.

Data Processing level 1	5.Correctness	DP.1.5.2	Verification of calculation results using time-series

A time-series for activity data on SNAP level, as well as emission factors, is used to identify possible errors in the calculation procedure.

Data Processing level 1	5.Correctness	DP.1.5.3	Verification of calculation results using other measures

The IPCC reference approach validates the fuel consumption rates and CO_2 emissions of fuel combustion. Fuel consumption rates and CO_2 emissions differ by less than 1.55% (1990-2004). The reference approach is further discussed below.

Data Processing level 1	5.Correctness	DP.1.5.4	Shows one-to-one correctness between external data sources and the databases at Data Storage level 2

There is a direct line between the external datasets, the calculation process and the input data used to Data storage level 2. During the calculation process, numerous controls are in place to ensure correctness, e.g. sum checks of the various stages in the calculation procedure.

Data Processing level 1	7.Transparency	DP.1.7.1	The calculation principle and equations used must be described.
Data Processing level 1	7.Transparency	DP.1.7.2	The theoretical reasoning for all methods must be described.
Data Processing level 1	7.Transparency	DP.1.7.3	Explicit listing of assumptions behind all methods.

Where appropriate this is included in the present report with annexes.

Data Processing level 1	7.Transparency	DP.1.7.4	Clear reference to dataset at Data Storage level 1

There is a clear line between external data and the data processing.

Data Processing level 1	7.Transparency	DP.1.7.5	A manual log to collect information about recalculations

At present a manual log table is not in place on this level, however this feature will be implemented in the future. A manual log table is incorporated in the national emission database, Data Storage level 2.

Data Storage level 2	5.Correctness	DS.2.5.1	Documentation of a correct connection between all data types at level 2 to data at level 1

To ensure a correct connection between data on level 2 to data on level 1, different controls are in place, e.g. control of sums and random tests.

Data Storage level 2	5.Correctness	DS.2.5.2	Check if a correct data import to level 2 has been made.

Data import is checked by use of sum control and random testing. The same procedure is applied every year in order to minimise the risk of data import errors.

Other QC procedures

- The emission from each large point source is compared with the emission reported the previous year.
- Some automated checks have been prepared for the emission databases:
  - Checking units for fuel rate, emission factor and plant-specific emissions
  - Checking emission factors for large point sources. Emission factors for pollutants that are not plant-specific should be the same as those defined for area sources.
  - Additional checks on database consistency
- Most emission factor references are now incorporated in the emission database, itself.
- Annual environmental reports are kept for subsequent control of plant-specific emission data.
- QC checks of the country-specific emission factors have not been performed, but most factors are based on 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 an environmental management system. Danish Gas Technology Centre and Force both run accredited laboratories for emission measurements.

Suggested QA/QC plan for stationary combustion

The following points make up the list of QA/QC tasks to be carried out directly in relation to the stationary combustion part of the Danish emission inventories. The time plan for the individual tasks has not yet been made.

Data storage level 1

- A fully comprehensive list of references for emission factors and activity data.
- A comparison with external data from other countries in order to evaluate discrepancies.

Data processing level 1

- Documentation list of model and independent calculations to test every single mathematical relation.

The second national external review of the inventories for stationary combustion was performed in 2005 by Bo Sander, Elsam Engineering. The review was performed after the reporting in 2005 and, thus, the improvements suggested by Bo Sander have only partly been included in the inventory presented in this report. In coming years, the recommendations made by Bo Sander are expected to be fully implemented in the inventory reports.

3.2.5 Source specific recalculations

Improvements and recalculations since the 2005 emission inventory include:

- Update of fuel rates according to the latest energy statistics. The update includes the years 1980-2003.
- A contract between NERI and the DEA specifying the content of the data supply for the emission inventory and deadlines has been signed. This contract also specifies that NERI will have access to the plant-specific CO_2 data that will be collected by the DEA from 2006.
- The emission factor for N_2O for coal-powered plants in SNAP categories 0101xx has been updated, based on new research.
- White spirit has been relocated to its own category instead of using the fuel category *Other oil* in the IPCC reference approach.
- The criteria for including a plant as a point source have been defined and included in the current report.

3.2.6 Source specific planned improvements

Some planned improvements to the emission inventories are discussed below.

1) Improved documentation for CO_2 emission factors

The CO_2 emission factors applied for the Danish inventories are considered accurate, but documentation will be improved in future inventories. The documentation will be improved when the large plants start reporting CO_2 emissions based on plant-specific CO_2 emission factors (2006).

2) Improved documentation for other emission factors

The reporting of, and references for, the applied emission factors have been improved in the current year and will be further developed in future inventories.

3) QA/QC and validation

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

4) Uncertainty estimates

Uncertainty estimates are largely based on default uncertainty levels for activity rates and emission factors. More country-specific uncertainty estimates will be incorporated in future inventories.

5) Response to review

During review, the ERT expressed concerns regarding the constancy of most fossil fuel carbon EFs. Due to new CO_2 emission laws in Denmark, where large point sources are obligated to measure CO_2 emissions, it should be possible in the future to estimate EFs for different fossil fuels annually.

The ERT noted that fuel- or country-specific oxidation factors should be applied for both the reference and sectoral approach. However, the research on which our country-specific emission factors are based does not specify an oxidation factor; therefore, an oxidation factor has not been utilised and full oxidation is assumed. Regarding the reference approach, the use of default oxidation factors will be taken into consideration for future reporting.

The ERT inquired about the industry responsible for the energy consumption in Sector 1Ac. The energy use in Sector 1A1c is mainly natural gas consumption in gas turbines in the off-shore industry which relates to oil and gas extraction. The point source in this sector is a gas processing plant.

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

The emission inventory basis for mobile sources is fuel use information from the Danish energy statistics. In addition, background data for road transport (fleet and mileage), air traffic (aircraft type, flight numbers, origin and destination airports) and non-road machinery (engine no., engine size, load factor and annual working hours) are used to make the emission estimates sufficiently detailed. Emission data mainly comes from the EMEP/CORINAIR Emission Inventory Guidebook. However, for railways, specific Danish measurements are used.

In the Danish emissions database, all activity rates and emissions are defined in SNAP sector categories (Selected Nomenclature for Air Pollution) according to the CORINAIR system. The emission inventories are prepared from a complete emission database based on the SNAP sectors. The aggregation to the sector codes used for both the UNFCCC and UNECE Conventions is based on a correspondence list between SNAP and IPCC classification codes (CRF), shown in the table below (mobile sources only).

SNAP – CRF 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

Military transport activities (land and air) refer to the CRF sector Other (1A5), while the Transport-Navigation sector (1A3d) comprises national sea transport (ship movements between two Danish ports) and small boats and pleasure crafts. The working machinery and materiel in industry is grouped in Industry-Other (1A2f), while agricultural and forestry machinery is accounted for in the Agriculture/forestry/fisheries (1A4c) sector together with fishing activities.

3.3.1 Source category description

The following description of source categories explains the development in fuel consumption and emissions for road transport and other mobile sources.

3.3.1.1 Fuel consumption

Table 3.18 Fuel use (PJ) for domestic transport in 2004 in CRF sectors

CRF ID	Fuel use (PJ)
Industry-Other (1A2f)	12
Civil Aviation (1A3a)	2
Road (1A3b)	164
Railways (1A3c)	3
Navigation (1A3d)	7
Residential (1A4b)	4
Ag./for./fish. (1A4c)	20
Military (1A5)	3
Total	215

Table 3.18 shows the fuel use for domestic transport based on DEA statistics for 2004 in CRF sectors. The fuel use figures in time-series 1990-2004 are given in Annex 3.B.13 (CRF format) and are shown for 1990 and 2004 in Annex 3.B.12 (CollectER format). Road transport has a major share of the fuel consumption for domestic transport. In 2004 this sector's fuel use share is 76%, while the fuel use shares for Agriculture/forestry/fisheries and Industry-Other are 9 and 6%, respectively. For the remaining sectors the total fuel use share is 9%.

From 1985 to 2004, diesel and gasoline fuel use has increased by 32% and 29%, respectively, and in 2004 the fuel use shares for diesel and gasoline were 58% and 39%, respectively (Figures 3.15 and 3.16). Other fuels only have a 3% share of the domestic transport total. Almost all gasoline is used in road transportation vehicles. Gardening machinery and private boats and pleasure crafts are merely small consumers. Regarding diesel, there is considerable fuel use in most of the domestic transport categories, whereas a more limited use of residual oil and jet fuel is apparent in the fisheries/navigation sectors and by aviation (civil and military flights), respectively.

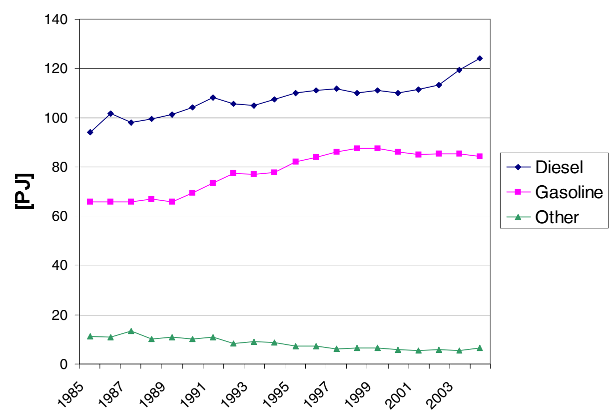


Figure 3.15 Fuel consumption per fuel type for domestic transport 1985-2004

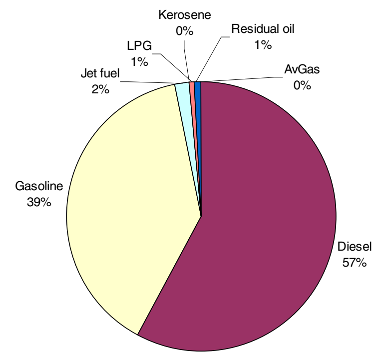


Figure 3.16 Fuel use share per fuel type for domestic transport in 2004

Road transport

As shown in Figure 3.17, the energy use for road transport increased until 2000, where a small fuel use decline can be noted. From 2002 onwards, fuel consumption increases. The fuel use development is due to a slight decrease in the use of gasoline fuels from 1999 onwards combined with a steady growth in the use of diesel. Within subsectors, passenger cars represent the most fuel-consuming vehicle category, followed by heavy-duty vehicles, light duty vehicles and 2-wheelers, in decreasing order (Figure 3.18).

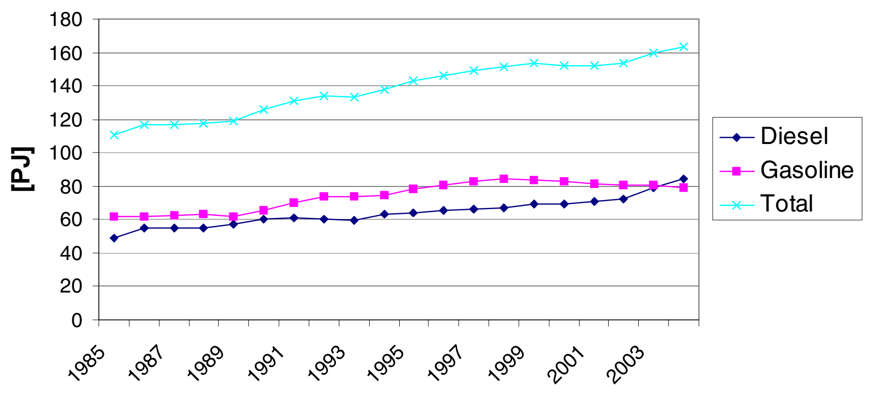


Figure 3.17 Fuel consumption per fuel type and as totals for road transport 1985-2004

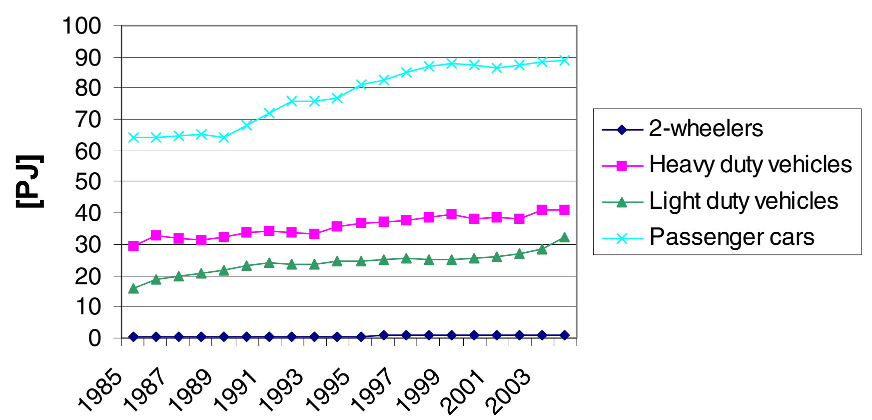


Figure 3.18 Total fuel consumption per vehicle type for road transport 1985-2004

As shown in Figure 3.19, fuel consumption for gasoline passenger cars dominates the overall gasoline consumption trend. The development in diesel fuel consumption in recent years (Figure 3.20) is characterised by increasing fuel use for diesel passenger cars and light duty vehicles, while the fuel use for trucks and buses (heavy-duty vehicles), since 1999, has fluctuated. The sudden increase in fuel consumption for heavy-duty vehicles in 2003 is, however, significant.

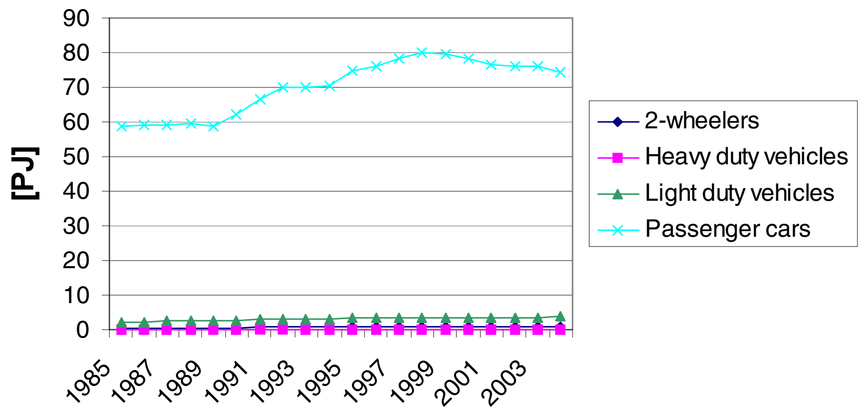


Figure 3.19 Gasoline fuel consumption per vehicle type for road transport 1985-2004

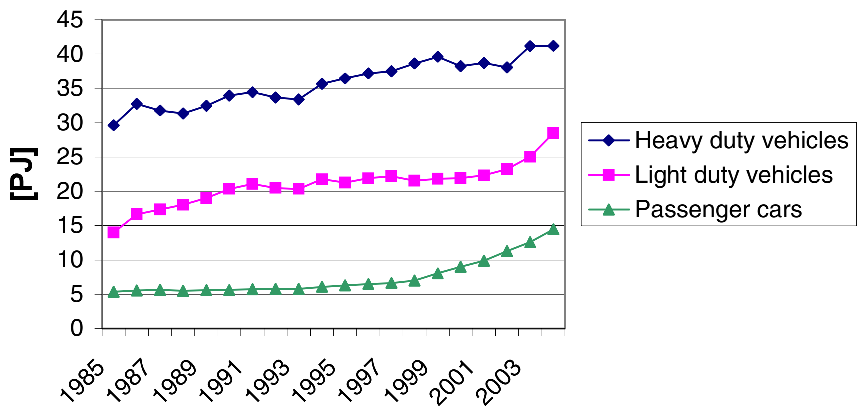


Figure 3.20 Diesel fuel consumption per vehicle type for road transport 1985-2004

In 2004, fuel consumption shares for gasoline passenger cars, heavy-duty vehicles, diesel light duty vehicles, diesel passenger cars and gasoline light duty vehicles were 46, 25, 17, 9 and 2%, respectively (Figure 3.21).

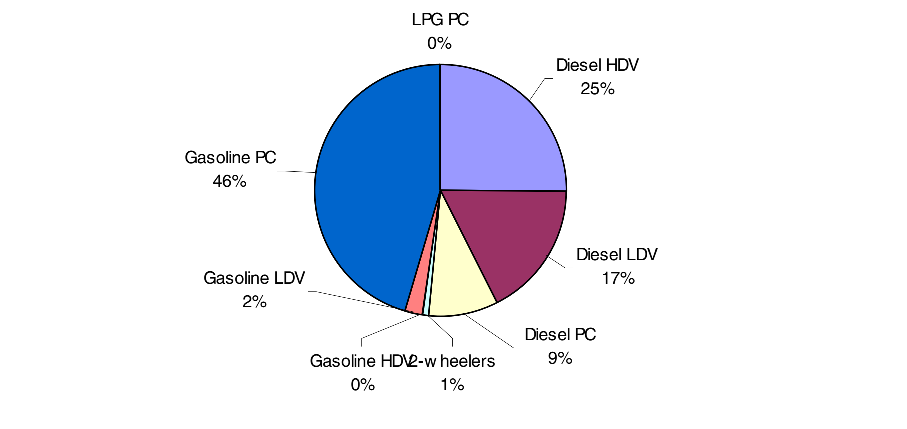


Figure 3.21 Fuel use share (PJ) per vehicle type for road transport in 2004

Other mobile sources

It must be noted that the fuel use figures behind the Danish inventory for mobile equipment in the agriculture, forestry, industry, household and gardening (residential), and inland waterways (part of navigation) sectors, are less certain than for other mobile sectors. For these types of machinery, the DEA statistical figures do not directly provide fuel use information, and fuel use totals are subsequently estimated from activity data and fuel use factors.

As seen in Figure 3.22, classified according to CRF the most important sectors are Agriculture/forestry/fisheries (1A4c), Industry-other (mobile machinery part of 1A2f) and Navigation (1A3d). Minor fuel consuming sectors are Civil Aviation (1A3a), Railways (1A3c), Other (military mobile fuel use: 1A5) and Residential (1A4b).

The 1985-2004 time-series are shown per fuel type in Figures 3.23-3.25 for diesel, gasoline and jet fuel, respectively.

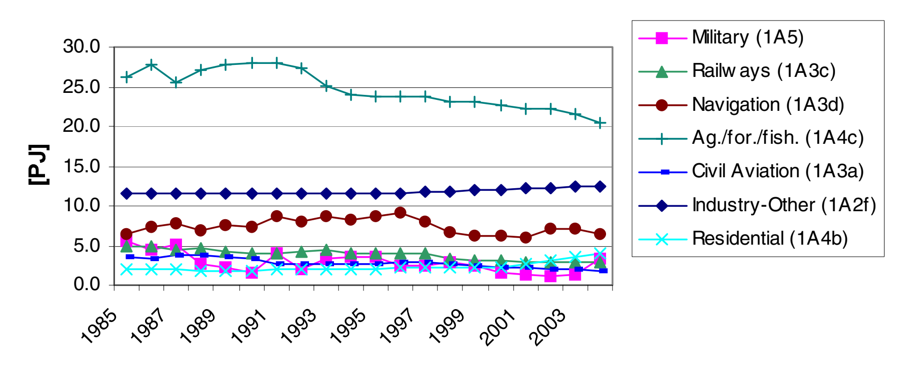


Figure 3.22 Total fuel use in CRF sectors for other mobile sources 1985-2004

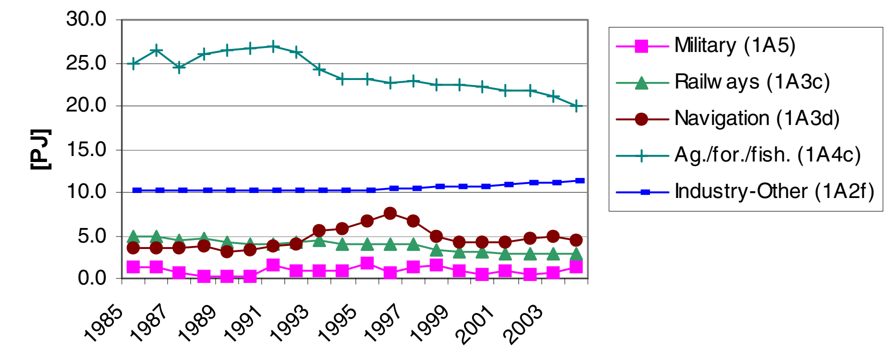


Figure 3.23 Diesel fuel use in CRF sectors for other mobile sources 1985-2004

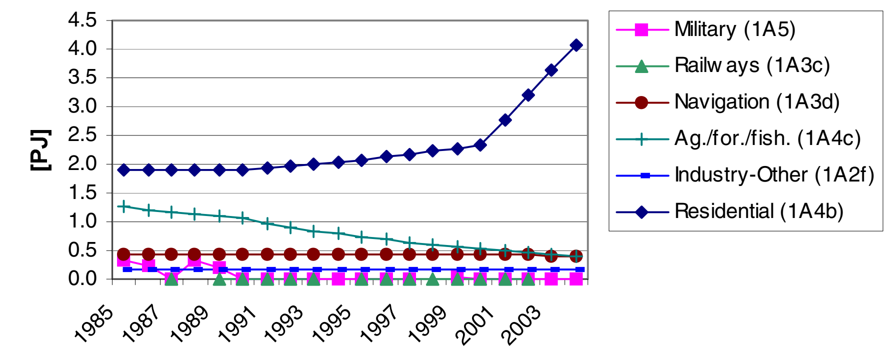


Figure 3.24 Gasoline fuel use in CRF sectors for other mobile sources 1985-2004

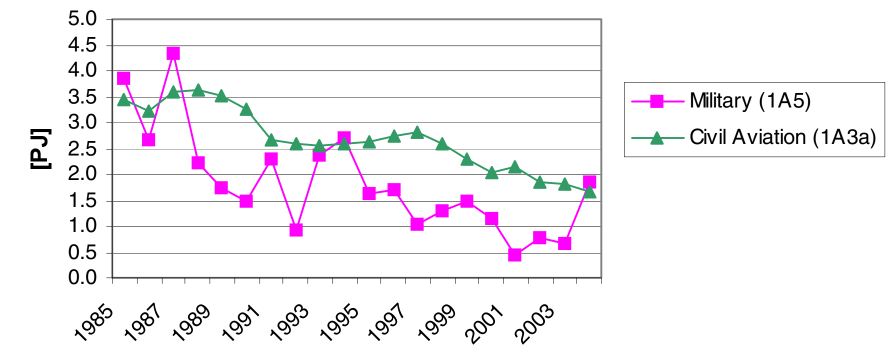


Figure 3.25 Jet fuel use in CRF sectors for other mobile sources 1985-2004

In the Agriculture/forestry/fisheries sector, diesel fuel use by agricultural machines accounts for two thirds of the total fuel consumption. The apparent decline is the result of fluctuations in the diesel fuel use for fishery and the steady fuel use decrease for agricultural machines, most marked from the beginning of the 1990s.

The Navigation sector comprises national sea transport (fuel use between two Danish ports) and recreational craft. For the latter category, fuel use has increased significantly from 1985 to 2004 due to the rising number of gasoline- and diesel-fuelled private boats. For national sea transport, diesel fuel use shows some fluctuations over the same time period. However, for 1997 and 1998, a sudden decline in fuel use is apparent. The most important explanation here is the closing of ferry service routes in connection with the opening of the Great Belt Bridge in 1997.

The largest gasoline fuel use is found for household and gardening machinery in the Residential (1A4b) sector, and, especially from 2001 onwards, a significant fuel use increase is apparent due to considerable growth in the machinery stock. The decline in gasoline fuel use for Agriculture/forestry/fisheries (1A4c) is due to the gradual phasing out of gasoline-fuelled agricultural tractors.

The considerable variations from one year to another in military jet fuel use are due to planning and budgetary reasons, and the passing demand for flying activities. Consequently, for some years, a certain amount of jet fuel stock-building might disturb the real picture of aircraft fuel use. Civil aviation has decreased since the building of the Great Belt Bridge, both in terms of number of flights and total jet fuel use. For railways, the gradual shift towards electrification explains the lowering trend in diesel fuel use and the emissions for this transport sector. The fuel used (and associated emissions) to produce electricity is accounted for in the stationary source part of the Danish inventories.

Bunkers

The residual oil and diesel oil fuel use fluctuations reflect the quantity of fuel sold in Denmark to international ferries, international warships, other ships with foreign destinations, transport to Greenland and the Faroe Islands, tank vessels and foreign fishing boats. For jet petrol, the sudden fuel use drop in 2002 is explained by the recession in the air traffic sector due to the events of September 11, 2001 and structural changes in the aviation business.

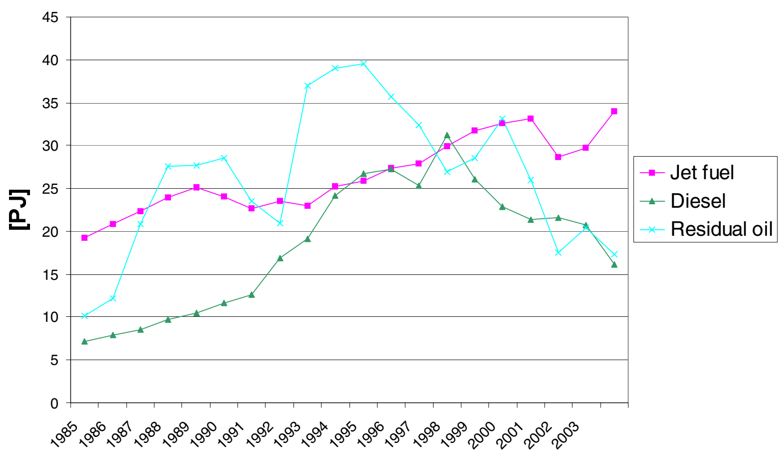


Figure 3.26 Bunker fuel use 1985-2004

3.3.1.2 Emissions of CO_2, CH_4 and N_2O

In Table 3.19 the CO_2, CH_4 and N_2O emissions for road transport and other mobile sources are shown for 2004 in CRF sectors. The emission figures in time-series 1985-2004 are given in Annex 3:B.13 (CRF format) and are shown for 1990 and 2004 in Annex 3.B.12 (CollectER format).

From 1985 to 2004 the road transport emissions of CO_2, CH_4 and N_2O have increased by 48, 8 and 301%, respectively, whereas the 1990-2004 emission increases are 30, 3 and 237%, respectively (from Figures 3.27-3.29). From 1985 and 1990, to 2004 the other mobile CO_2 emissions have decreased by 15 and 11%, respectively (from Figures 3.31-3.33).

Table 3.19 Emissions of CO_2, CH_4 and N_2O in 2004 for road transport and other mobile sources

CRF Sector	CH_4 [tons]	N_2O [tons]	CO_2 [ktons]
Industry-Other (1A2f)	46	39	912
Civil Aviation (1A3a)	6	8	128
Railways (1A3c)	8	6	216
Navigation (1A3d)	34	28	490
Residential (1A4b)	290	5	298
Ag./for./fish. (1A4c)	78	73	1507
Military (1A5)	11	12	239
Total other mobile	473	170	3791
Road (1A3b)	2526	1357	12024
Total mobile	2999	1527	15815

Road transport

CO_2 emissions are directly fuel-use dependent and, in this way, the development in the emission reflects the trend in fuel use. As shown in Figure 3.27, the most important emission source for road transport is passenger cars, followed by heavy-duty vehicles, light-duty vehicles and 2-wheelers in decreasing order. In 2004, the respective emission shares were 54, 25, 20 and 1%, respectively (Figure 3.30).

The majority of CH_4 emissions from road transport come from gasoline passenger cars (Figure 3.28.). The emission increase from 1990 to 1996 for this vehicle category is a result of the somewhat higher emission factors for EURO I gasoline cars (introduced in 1990) than for conventional gasoline cars. The emission drop from 1997 onwards is explained by the penetration of EURO II and III catalyst cars (1997 and 2001) into the Danish fleet. The newer technology stages have lower CH_4 emission factors than conventional gasoline vehicles. The 2004 emission shares for CH_4 were 80, 9, 6 and 5% for passenger cars, heavy-duty vehicles, 2-wheelers and light-duty vehicles, respectively (Figure 3.30).

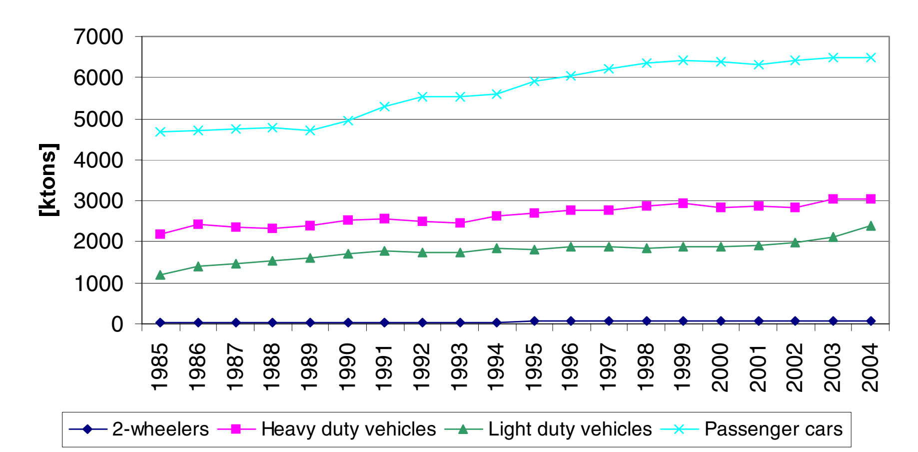


Figure 3.27 CO_2 emissions (k-tonnes) per vehicle type for road transport 1985-2004

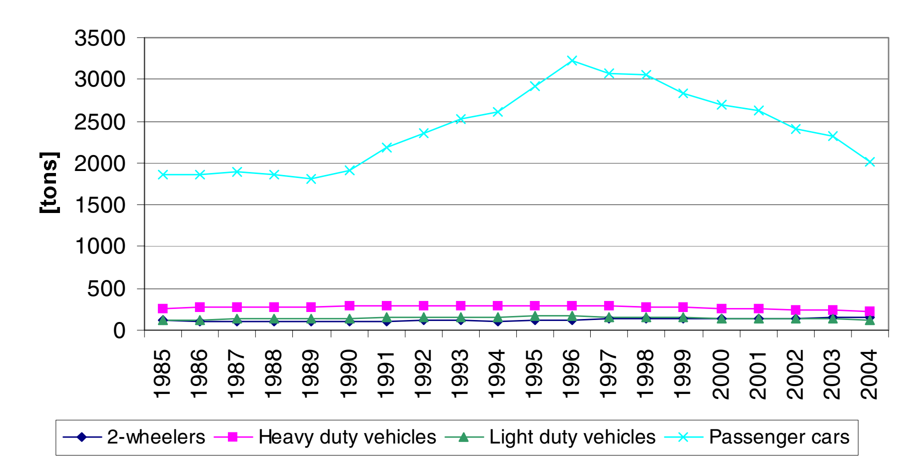


Figure 3.28 CH_4 emissions (tonnes) per vehicle type for road transport 1985-2004

An undesirable environmental side effect of the introduction of catalyst cars is the increase in the emissions of N_2O from 1990 onwards (Figure 3.29). However, the total contributions from road transport N_2O and CH_4 emissions are still small compared with the contribution from the agricultural sector. In 2004, emission shares for passenger cars, light and heavy-duty vehicles were 78, 14 and 8%, of the total road transport N_2O, respectively (Figure 3.30).

Referring to the second IPCC assessment report (IPCC, 1995), 1 g CH_4 and 1 g N_2O has the greenhouse effect of 21 and 310 g CO_2, respectively. In spite of the relatively large CH_4 and N_2O global warming potentials, the largest contribution to the total CO_2 emission equivalents for road transport comes from CO_2, and the CO_2 emission equivalent shares per vehicle category are almost the same as CO_2 shares.

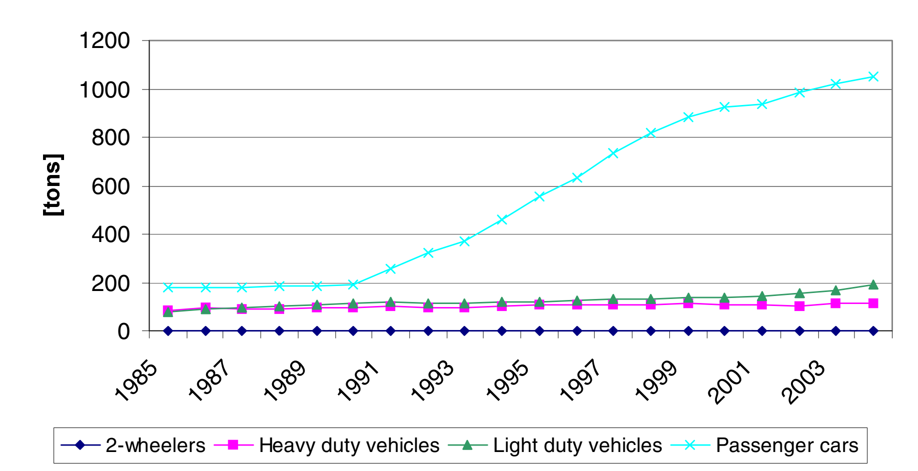


Figure 3.29 N_2O emissions (tonnes) per vehicle type for road transport 1985-2004

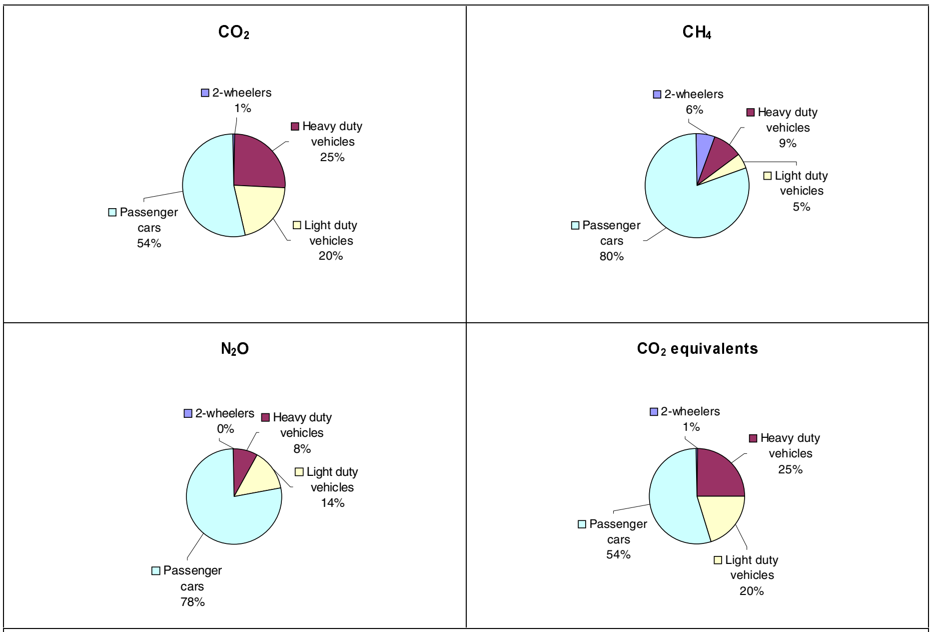


Figure 3.30 CO_2, CH_4 and N_2O emission shares and GHG equivalent emission distribution for road transport in 2004

Other mobile sources

For other mobile sources, the highest CO_2 emissions in 2004 come from Agriculture/forestry/fisheries (1A4c), Industry-other (1A2f), Navigation (1A3d), with shares of 40, 24 and 13%, respectively (Figure 3.34). The 1985-2004 emission trend is directly related to the fuel-use development in the same time-period. Minor CO_2 emission contributors are sectors such as Residential (1A4b), Railways (1A3c), Military (1A5) and Civil Aviation (1A3a). In 2004, the CO_2 emission shares for these sectors were 8, 6, 6 and 3%, respectively (Figure 3.34).

For CH_4, far the most important sector is Residential (1A4b), see Figure 3.34. The emission share of 62% in 2004 is due to a relatively large gasoline fuel use for gardening machinery. The 2004 emission shares for Agriculture/forestry/fisheries (1A4c), Industry (1A2f) and Navigation (1A3d) are 16, 10 and 7%, respectively, whereas the remaining sectors have emission shares of 2% or less.

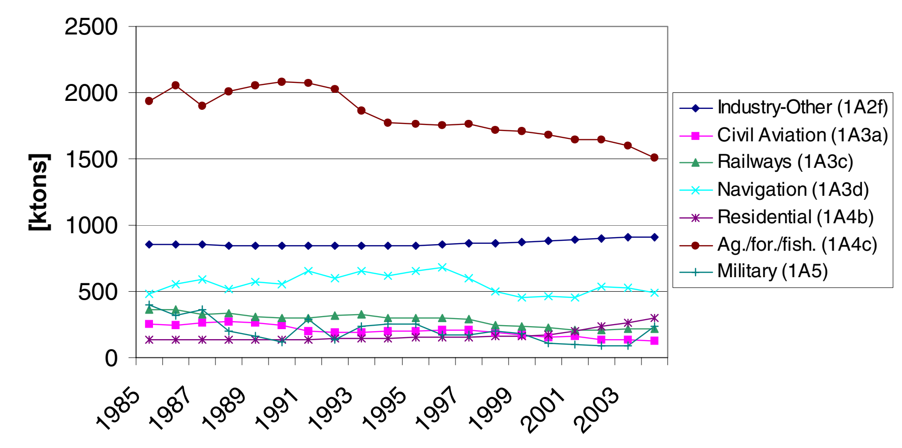


Figure 3.31 CO_2 emissions (k-tonnes) in CRF sectors for other mobile sources 1985-2004

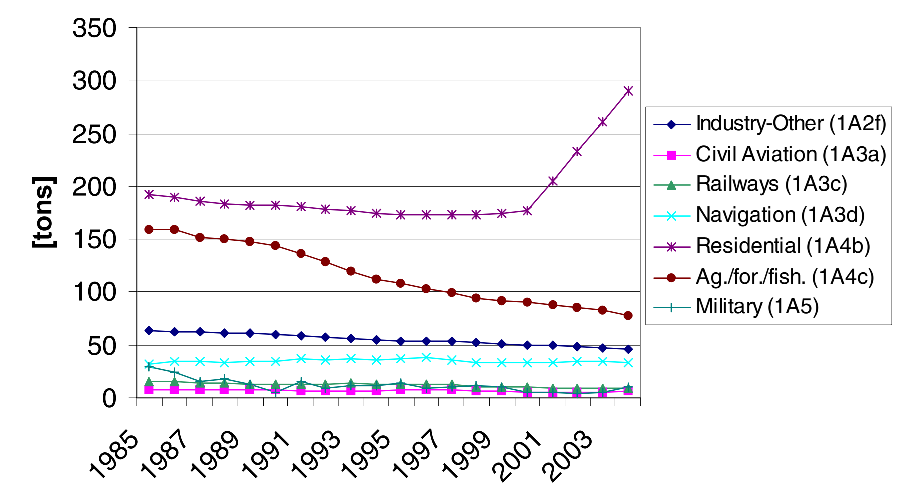


Figure 3.32 CH_4 emissions (tonnes) in CRF sectors for other mobile sources 1985-2004

For N_2O, the emission trend in subsectors is the same as for fuel use and CO_2 emissions (Figure 3.33).

As for road transport, CO_2 alone contributes with by far the most CO_2 emission equivalents in the case of other mobile sources, and the sectoral CO_2 emission equivalent shares are almost the same as those for CO_2, itself (Figure 3.34).

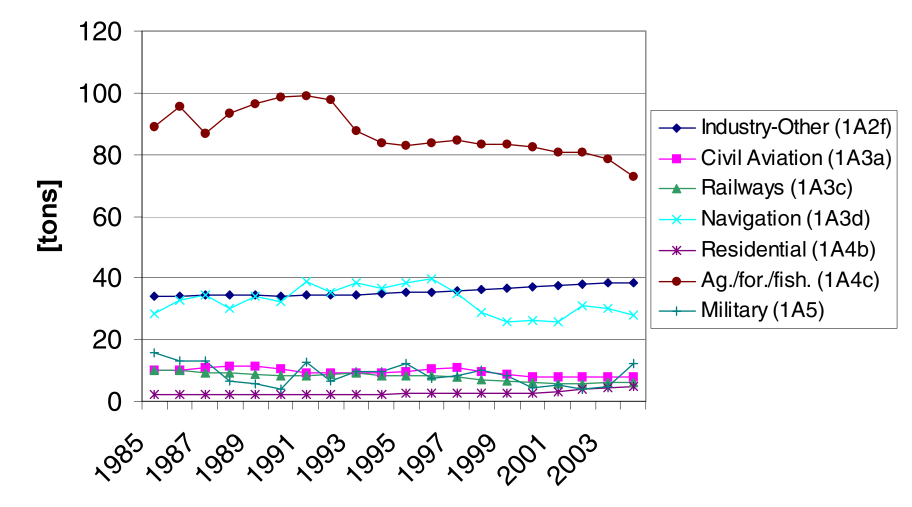


Figure 3.33 N_2O emissions (tonnes) in CRF sectors for other mobile sources 1985-2004

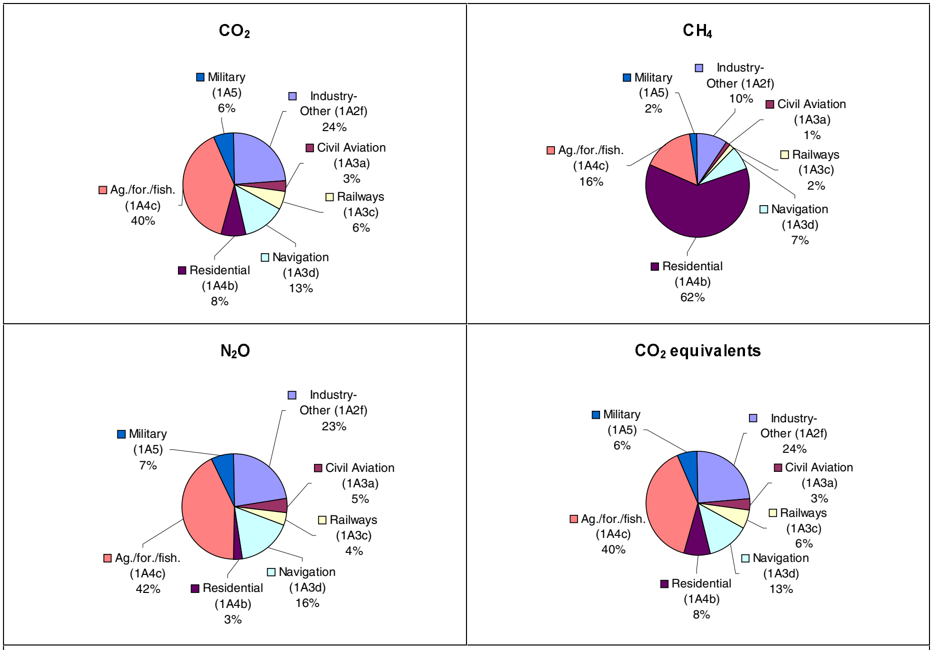


Figure 3.34 CO_2, CH_4 and N_2O emission shares and GHG equivalent emission distribution for other mobile sources in 2004

3.3.1.3 Emissions of SO_2, NO_x, NMVOC and CO

In Table 4, the SO_2, NO_X, NMVOC and CO emissions for road transport and other mobile sources are shown for 2004 in CRF sectors. The emission figures in the time-series 1985-2004 are given in Annex 3.B.13 (CRF format) and are shown for 1990 and 2004 in Annex 3.B.12 (CollectER format).

From 1985 to 2004, the road transport emissions of NMVOC, CO and NO_X emissions have decreased by 66, 58 and 34%, respectively (Figures 21-24). The highest CO, NO_X and NMVOC emissions occur in 1991, after which the emissions drop by 50, 43 and 67%, respectively, until 2004.

For other mobile sources, the emissions of NO_X decreased by 14% from 1985 to 2004 and for SO_2 the emission drop is as much as 73%. In the same period, the emissions of NMVOC have declined by 10%, whereas the 1985 and 2004 CO emission totals are the same (Figures 3.40-3.43).

Table 3.20 Emissions of SO_2, NO_X, NMVOC and CO in 2004 for road transport and other mobile sources

CRF ID	SO_2 [tons]	NO_X [tons]	NMVOC [tons]	CO [tons]
Industry-Other (1A2f)	263	10744	1676	7600
Civil Aviation (1A3a)	41	552	158	857
Railways (1A3c)	7	3478	217	599
Navigation (1A3d)	2259	7990	1474	7767
Residential (1A4b)	9	317	8731	114073
Ag./for./fish. (1A4c)	951	20501	2528	17445
Military (1A5)	46	1079	129	718
Total other mobile	3576	44661	14913	149058
Road (1A3b)	378	59085	26477	232650
Total mobile	3955	103746	41390	381709

Road transport

The step-wise lowering of the sulphur content in diesel fuel has given rise to a substantial decrease in the road transport emissions of SO_2 (Figure 3.35). In 1999, the sulphur content was reduced from 500 ppm to the present level of 50 ppm (the same as for gasoline). Since Danish diesel and gasoline fuels have the same sulphur percentages, at present, the 2004 shares for SO_2 emissions and fuel use for passenger cars, heavy-duty vehicles, light-duty vehicles and 2-wheelers are the same in each case: 53, 26, 20 and 1%, respectively (Figure 3.39).

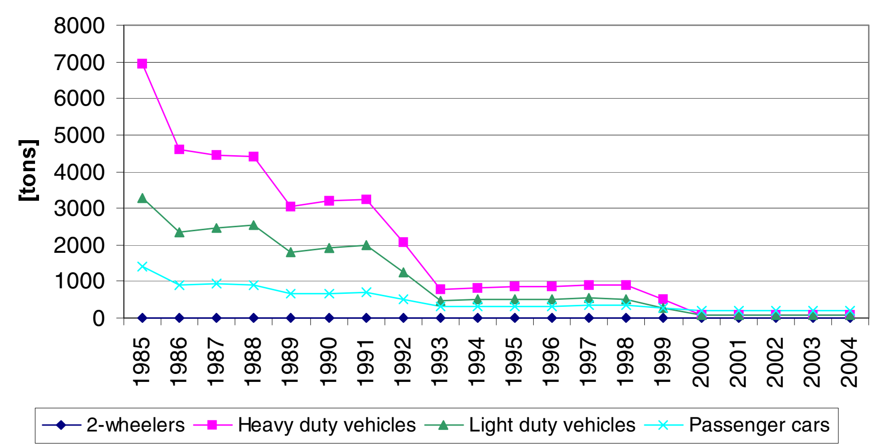


Figure 3.35 SO_2 emissions (k-tonnes) per vehicle type for road transport 1985-2004

Historically, the emission totals of NO_X, and especially NMVOC and CO, have been dominated by the contributions coming from private cars, as shown in Figures 3.36-3.38. However, the emissions from this vehicle type have shown a steady decreasing tendency since the introduction of private catalyst cars in 1990 (EURO I) and the introduction of even more emission-efficient EURO II and III private cars (introduced in 1997 and 2001, respectively). In general, the total emission reductions of NO_x, NMVOC and CO are fortified by the introduction of new, gradually stricter, EURO emission standards for all other vehicle classes. However, the significant increase in the consumption of diesel causes the NO_x emissions to increase for light-duty vehicles in 2004 and for heavy-duty vehicles in 2003.

In 2004, the emission shares for passenger cars, heavy-duty vehicles, light-duty vehicles and 2-wheelers were 43, 38, 19 and 0%, respectively, for NO_x; 70, 10, 8 and 12%, respectively, for NMVOC; and 87, 2, 6 and 5%, respectively, for CO (Figure 3.39).

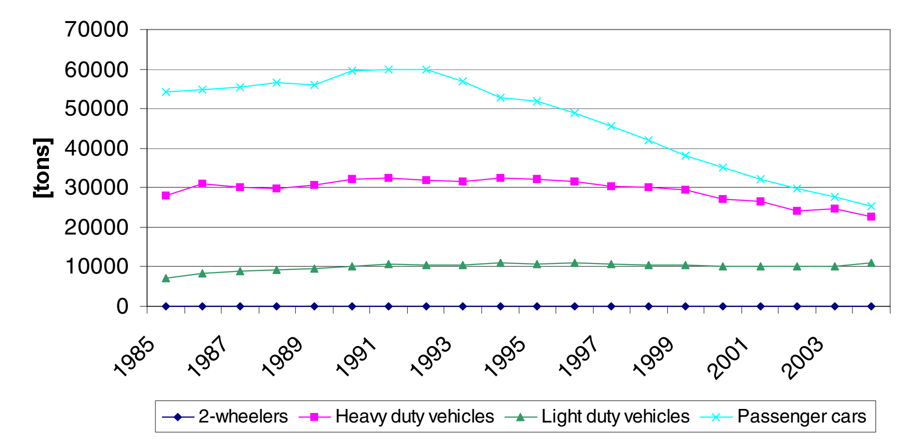


Figure 3.36 NO_x emissions (tonnes) per vehicle type for road transport 1985-2004

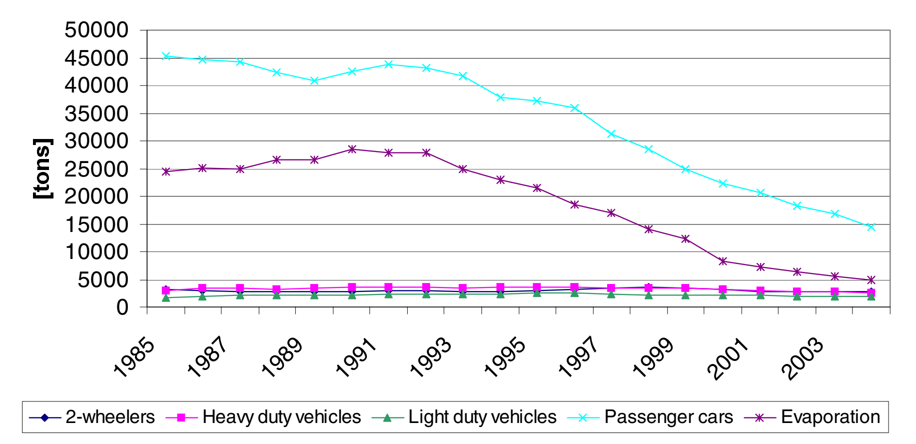


Figure 3.37 NMVOC emissions (tonnes) per vehicle type for road transport 1985-2004

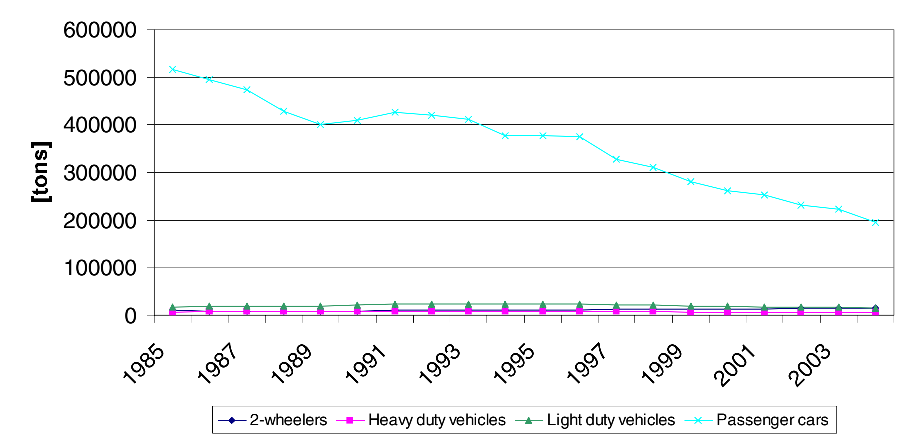


Figure 3.38 CO emissions (tonnes) per vehicle type for road transport 1985-2004

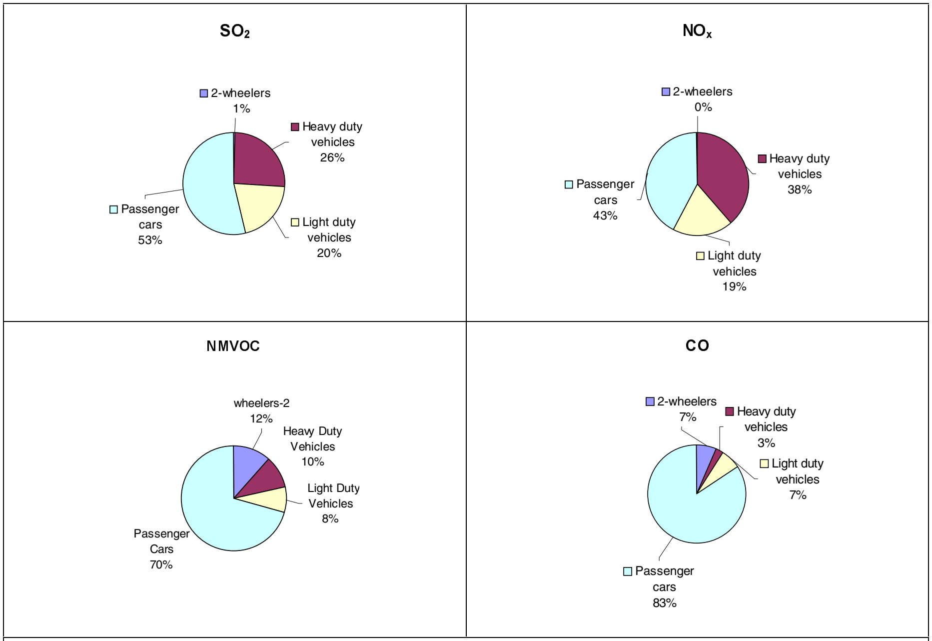


Figure 3.39 SO_2, NO_X, NMVOC and CO emission shares per vehicle type for road transport in 2004

Other mobile sources

SO_2 emissions decrease significantly from 1985 to 1996, as shown in Figure 3.40. The lowering is due to the reduction in sulphur content for marine diesel fuel in Navigation (1A3d) and diesel used by, among others, Railways (1A3c) and non-road machinery in Agriculture/forestry/fisheries (1A4c) and Industry (1A2f).

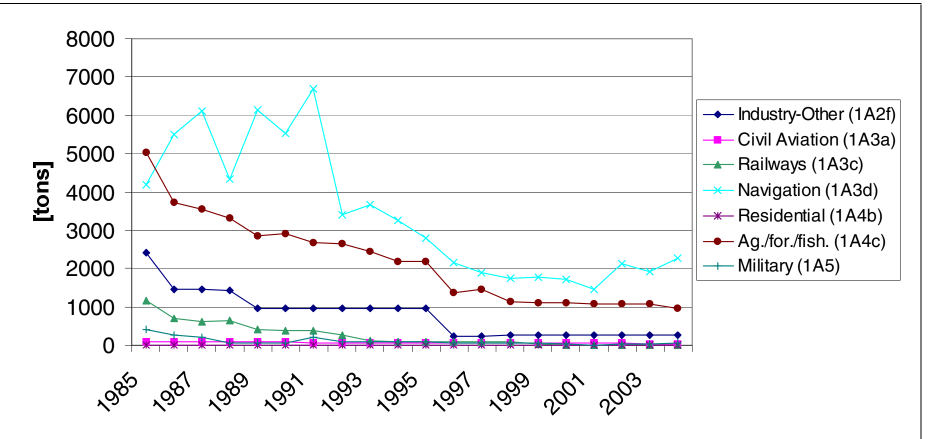


Figure 3.40 SO_2 emissions (k-tonnes) in CRF sectors for other mobile sources 1985-2004

In general, the emissions of NO_x, NMVOC and CO from diesel-fuelled working equipment and machinery in agriculture, forestry and industry have decreased slightly since the end of the 1990s due to the implementation of a two-stage EU emission directive.

NO_x emissions mainly come from diesel machinery, and the most important sources are Agriculture/forestry/fisheries (1A4c), Industry (1A2f), Navigation (1A3d) and Railways (1A3c), as shown in Figure 3.41. The 2004 emission shares are 46, 24, 18 and 8%, respectively (Figure 3.44). Minor emissions come from the sectors, Civil Aviation (1A3a), Military (1A5) and Residential (1A4b).

The NO_x emission trend for Agriculture/forestry/fisheries is determined by fuel use (and hence emission) fluctuations for fishery, and the development of fuel use and emission factors for diesel-fuelled agricultural machines. For the latter, total fuel use is generally decreasing (most markedly from the beginning of the 1990s), and there have been somewhat higher NO_x emission factors for 1991-stage I machinery, and an improved emission performance for stage I and II machinery since the late 1990s.

The emission development for industry NO_x is the product of a slight fuel-use increase from 1985 to 2004 and a development in emission factors as explained for agricultural machinery. The development in fuel use for national sea transport explains the emission trend for navigation. The most influential parameter is the shut down of ferry services in connection with the opening of the Great Belt Bridge in 1997. For railways, the gradual shift towards electrification explains the declining trend in diesel fuel use and NO_x emissions for this transport sector.

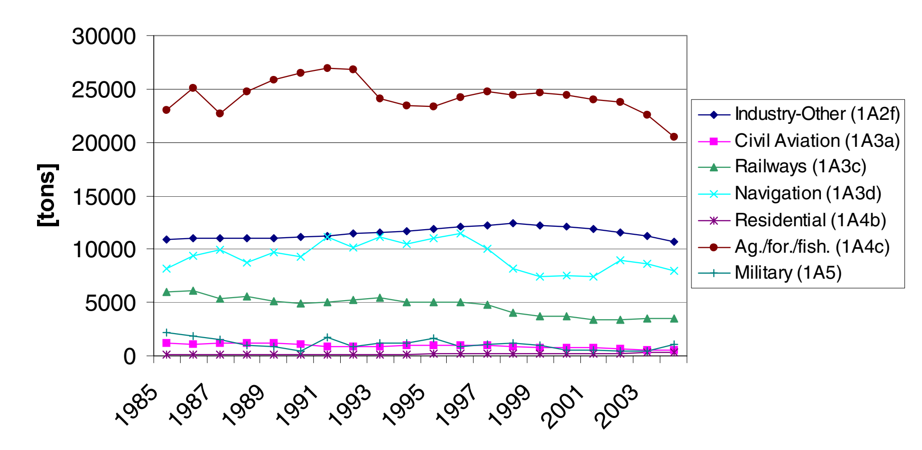


Figure 3.41 NO_x emissions (tonnes) in CRF sectors for other mobile sources 1985-2004

The 1985-2004 time-series of NMVOC and CO emissions are shown in Figures 3.42 and 3.43 for other mobile sources. The 2004 sector emission shares are shown in Figure 3.44. For NMVOC, the most important sectors are Residential (1A4b), Agriculture/forestry/fisheries (1A4c), Industry (1A2f) and Navigation (1A3d), with 2004 emission shares of 59, 17, 11 and 10%, respectively. The same four sectors also contribute with most of the CO emissions in the same consecutive order; the emission shares are 77, 12, 5 and 5%, respectively. Minor NMVOC and CO emissions come from Railways (1A3c), Civil Aviation (1A3a) and Military (1A5).

For NMVOC and CO, the significant emission increases for the residential sector after 2000 are due to the increased number of gasoline working machines. Improved NMVOC emission factors for diesel machinery in agriculture and gasoline equipment in forestry (chain saws) are the most important explanations for the NMVOC emission decline in the Agriculture/forestry/fisheries sector. This explanation also applies for the industrial sector, which is dominated by diesel-fuelled machinery. From 1997 onwards, the NMVOC emissions from Navigation decrease due to the gradually phase-out of the 2-stroke engine technology for recreational craft. The main reason for the significant 1985-2004 CO emission decrease for Agriculture/forestry/fisheries is the phasing out of gasoline tractors.

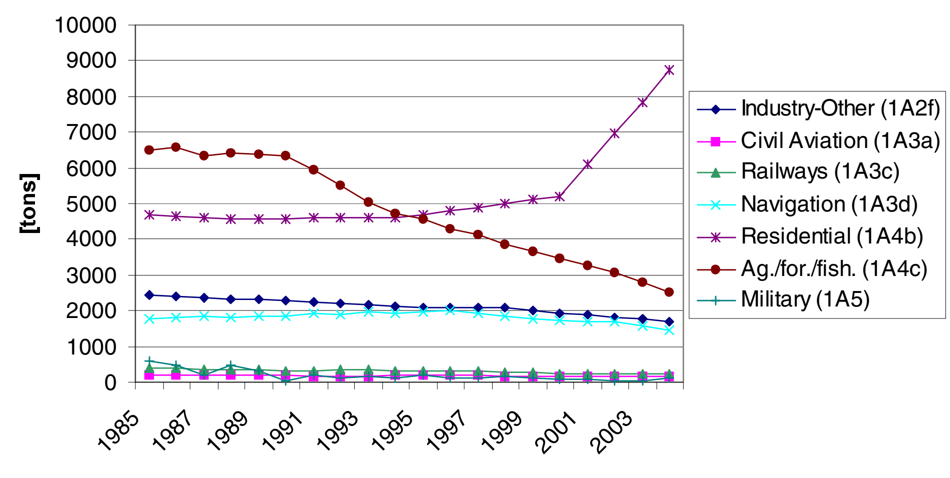


Figure 3.42 NMVOC emissions (tonnes) in CRF sectors for other mobile sources 1985-2004

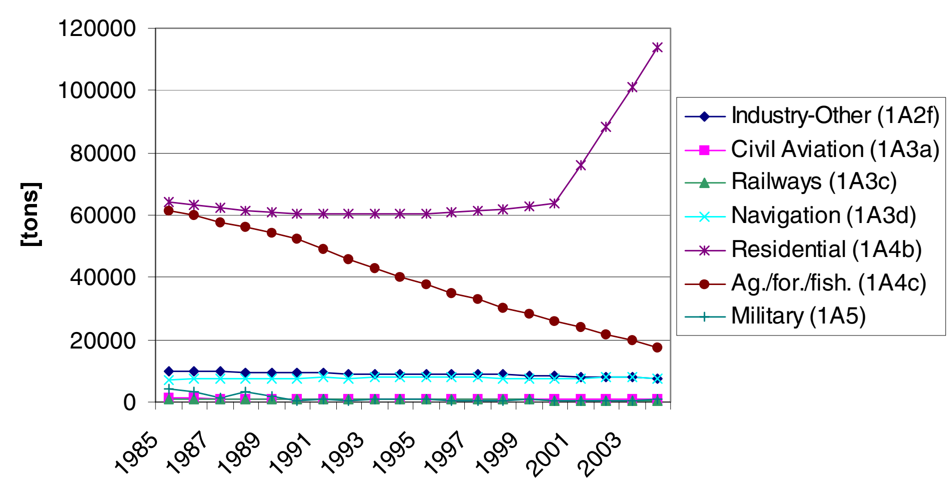


Figure 3.43 CO emissions (tonnes) in CRF sectors for other mobile sources 1985-2004

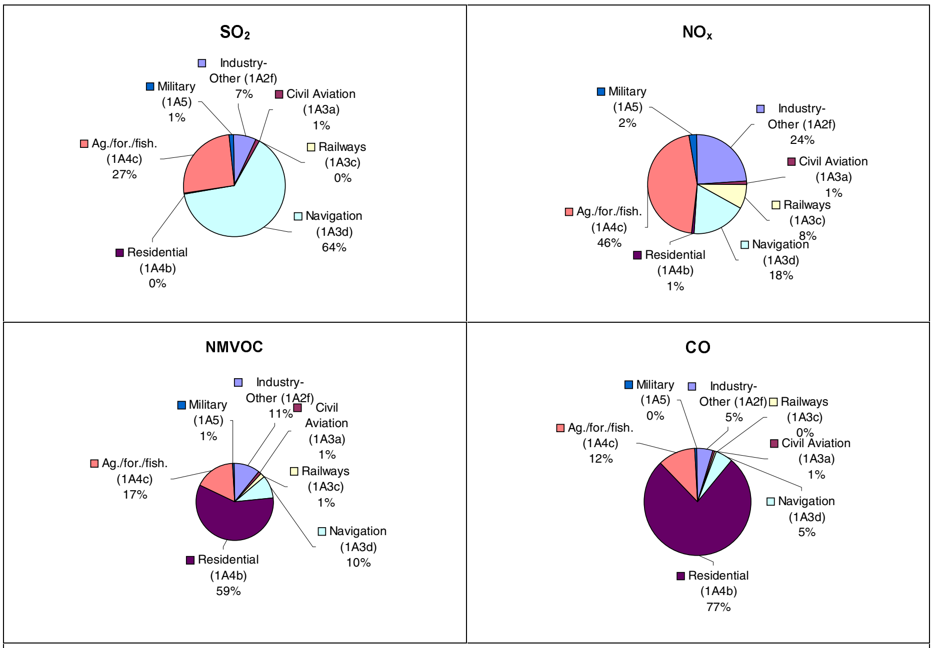


Figure 3.44 SO_2, NO_X, NMVOC and CO emission shares for other mobile sources in 2004

Bunkers

The most important emissions from bunker fuel use (fuel use for international transport) are SO_2, NO_X and CO_2 (and TSP, not shown). However, compared with the Danish national emission total (all sources), the greenhouse gas emissions from bunkers are small. The bunker emission totals are shown in Table 3.21 for 2004, split into sea transport and civil aviation. All emission figures in the 1985-2004 time-series are given in Annex 3.B.13 (CRF format). In Annex 3.B.12, the emissions are also given in CollectER format for the years 1990 and 2004.

Table 3.21 Emissions in 2004 for international transport and national totals

CRF sector	SO_2 [tonnes]	NO_X [tonnes]	NMVOC [tonnes]	CH_4 [tonnes]	CO [tonnes]	CO_2 [k-tonnes]	N_2O [tonnes]
Navigation int. (1A3d)	34821	69705	1865	58	5928	2545	161
Civil Aviation int. (1A3a)	781	10439	448	47	1848	2447	85
International total	35603	80144	2312	104	7776	4992	245

The differences in emissions between navigation and civil aviation are much larger than the differences in fuel use (and derived CO_2 emissions), and display a poor emission performance for international sea transport. In broad terms, the emission trends shown in Figure 3.45 are similar to the fuel-use development. Minor differences occur for navigation (SO_2, NO_X and CO_2) due to varying amounts of marine diesel and residual oil, and for civil aviation (NO_X) due to yearly variations in LTO/aircraft type (earlier than 2001) and city-pair statistics (2001 onwards).

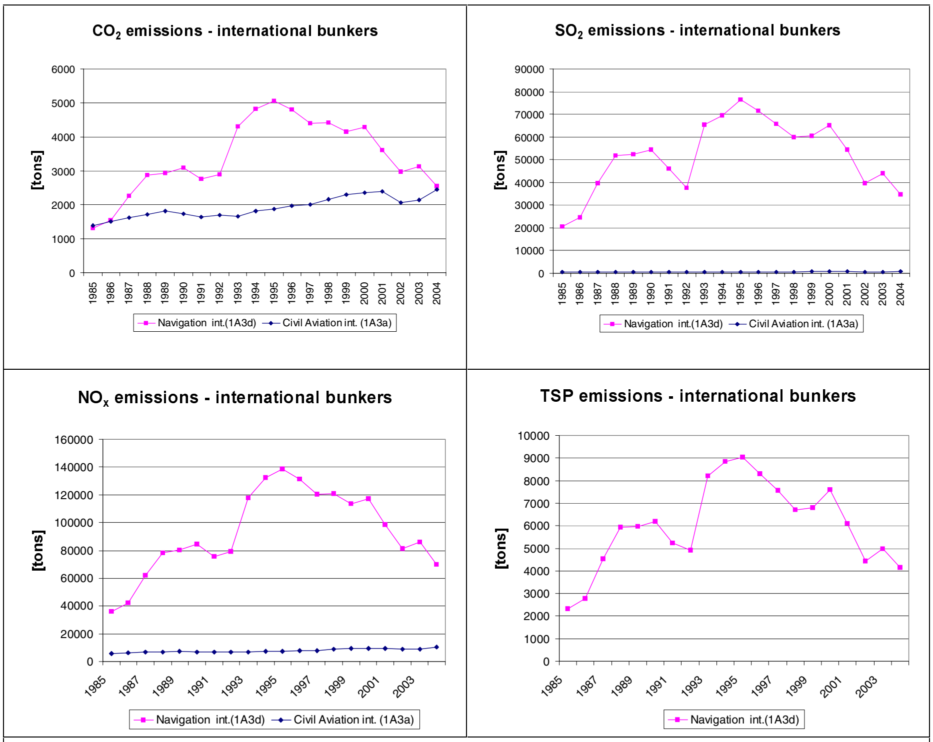


Figure 3.45 CO_2, SO_2, NO_X and TSP emissions for international transport 1985-2004

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 detailed methodology is used to make annual estimates of the Danish emissions, as described in the EMEP/CORINAIR Emission Inventory Guidebook (EMEP/CORINAIR, 2003). The actual calculations are made with a model developed by NERI, using the European COPERT III model methodology. The latter model approach is explained by Ntziachristos et al. (2000). In COPERT III, fuel use and emission simulations can be made for operationally hot engines, taking into account gradually stricter emission standards and emission degradation due to catalyst wear. Furthermore, the emission effects of cold-start and evaporation are simulated.

Vehicle fleet and mileage data

Corresponding to the COPERT fleet classification, all present and future vehicles in the Danish fleet are grouped into vehicle classes, sub-classes and layers. The layer classification is a further division of vehicle sub-classes into groups of vehicles with the same average fuel use and emission behaviour, according to EU emission legislation levels. Table 3.22 gives an overview of the different model classes and sub-classes, and the layer level with implementation years are shown in Annex 3.B.1.

Table 3.22 Model vehicle classes and sub-classes, trip speeds and mileage split

Vehicle classes	Fuel type	Engine size/weight	Trip speed [km/h] Urban	Rural	Highway	Mileage split [%] 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 on the vehicle stock and annual mileage is obtained from the Danish Road Directorate (Ekman, 2005). This covers data for the number of vehicles and annual mileage per first registration year for all vehicle sub-classes, and mileage split between urban, rural and highway driving, and the respective average speeds. Additional data for the moped fleet and motorcycle fleet disaggregation information is given by The National Motorcycle Association (Markamp, 2005).

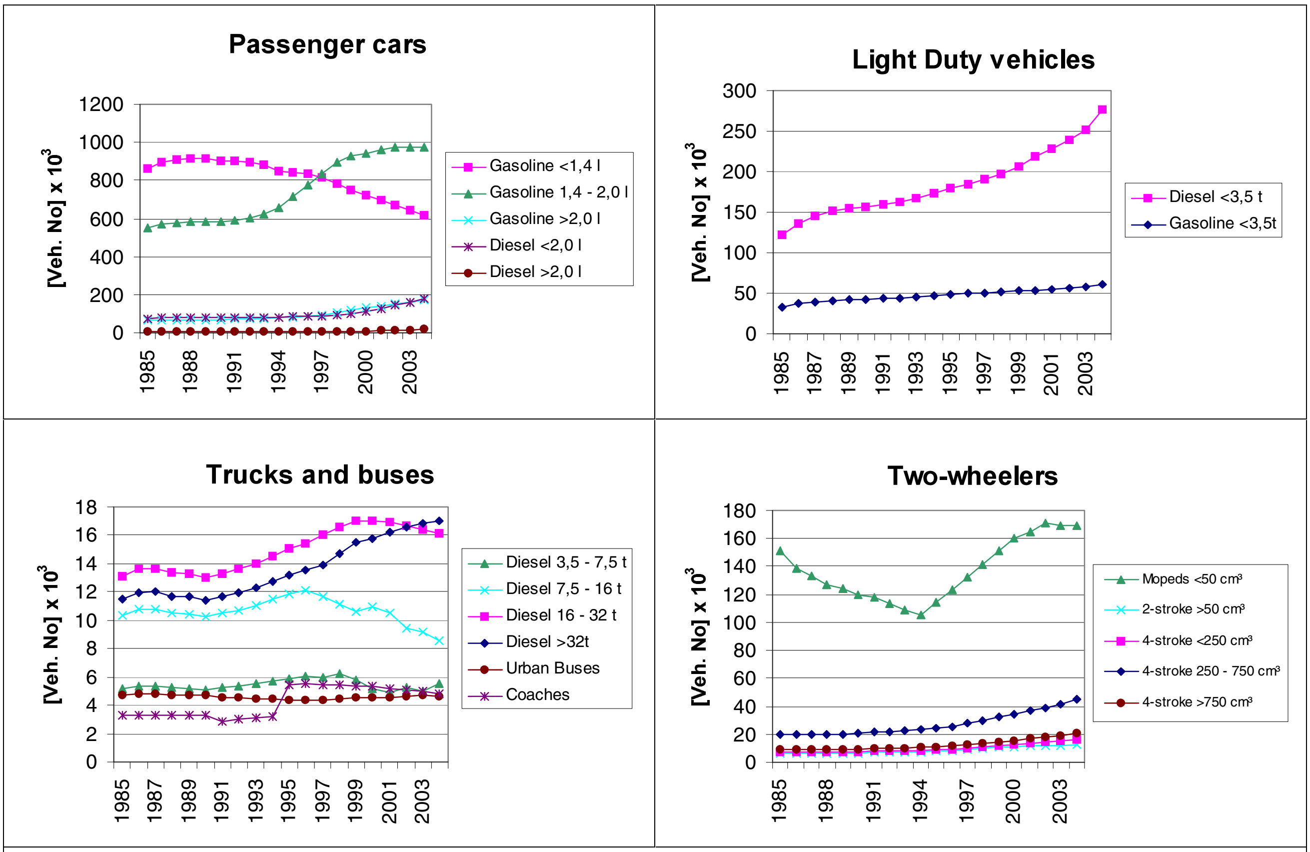


Figure 3.46 Number of vehicles in sub-classes in 1985-2004

The vehicle numbers per sub-class are shown in Figure 3.46. The engine size differention is associated with some uncertainty. The increase in the total number of passenger cars is mostly due to a growth in the number of gasoline cars with engine sizes between 1.4 and 2 litres (from 1990-2002) and an increase in the number of gasoline cars (>2 litres) and diesel cars (< 2 litres). In the later years, there has been a decrease in the number of cars with an engine size smaller than 1.4 litres.

There has been a considerable growth in the number of diesel light-duty vehicles from 1985 to 2004. The two largest truck sizes have also increased in numbers during the 1990s. From 2000 onwards, this growth has continued for trucks larger than 32 tonnes, whereas the number of trucks with gross vehicle weights between 16 and 32 tonnes has decreased slightly.

The number of urban buses has been almost constant between 1985 and 2004. The sudden change in the level of coach numbers from 1994 to 1995 is due to uncertain fleet data.

The reason for the significant growth in the number of mopeds from 1994 to 2002 is the introduction of the so-called Moped 45 vehicle type. For motorcycles, the number of vehicles has grown in general throughout the entire 1985-2004 period. The increase is, however, most visible from the mid-1990s and onwards.

The vehicle numbers are summed up in layers for each year (Figure 3.47) by using the correspondence between layers and first year of registration:

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

Where N = number of vehicles, j = layer, y = year, i = first year of registration.

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

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

Vehicle numbers and weighted annual mileages per layer are shown in Annex 3.B.1 and 3.B.2 for 1985-2004. The trends in vehicle numbers per layer are also shown in Figure 3.47. The latter figure shows how vehicles complying with the gradually stricter EU emission levels (EURO I, II, III etc.) have been introduced into the Danish motor fleet.

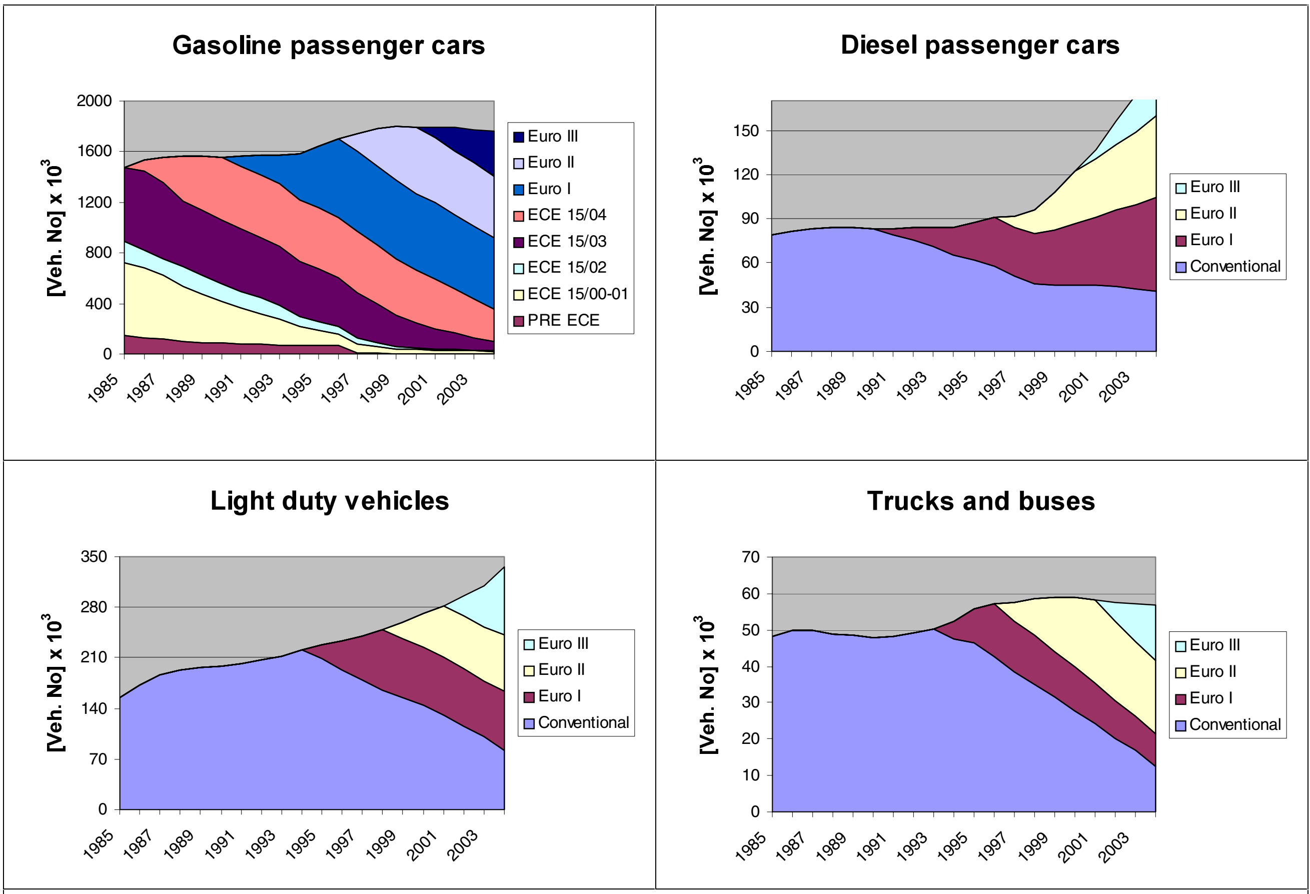


Figure 3.47 Layer distribution of vehicle numbers per vehicle type in 1985-2003

Emission legislation

No specific emission legislation exists for CO_2. An EU strategy has, however, been formulated to improve the fuel efficiency for new vehicles being sold in the EU. The goal is to bring down the average CO_2 emissions to 120 g/km in 2010. The means by which the CO_2 target should be met are:

- An agreement with the car manufacturers in Europe, Japan and Korea that new private cars sold in the EU in 2008/2009 on average have CO_2 emissions of 140 g/km or less.
- Energy labelling information from EU member states to car buyers.
- The use of fiscal instruments to promote fuel efficient cars

The test cycle used in the EU for measuring fuel is the NEDC (New European Driving Cycle) and is used also for emissions testing. The NEDC cycle consists of two parts, the first part being a 4-time repetition (driving length: 4 km) of the ECE test cycle. The latter test cycle is the so-called urban driving cycle (average speed: 19 km/h). The second part of the test is the run-through of the EUDC (Extra Urban Driving Cycle) test driving segment, simulating the fuel use under rural and highway driving conditions. The driving length of EUDC is 7 km at an average speed of 63 km/h. More information regarding the fuel measurement procedure can be found in the EU Directive 80/1268/EØF.

For NO_x, VOC, CO and TSP, the emissions from road transport vehicles have to comply with the different EU directives listed in Table 3.23. Even though the directives do not regulate the emissions of CH_4 and N_2O, the VOC emission limits influence the emissions of CH_4, the latter emissions forming part of total VOC. The specific emission limits are shown in Annex 3.B.3.

Table 3.23 Overview of the existing EU emission directives for road transport vehicles

Vehicle category	Emission layer	EU directive	First reg. year	
			start	end
Private cars (gasoline)	PRE ECE		0	1969
	ECE 15/00-01	70/220 - 74/290	1970	1978
	ECE 15/02	77/102	1979	1980
	ECE 15/03	78/665	1981	1985
	ECE 15/04	83/351	1986	1990
	Euro I	91/441	1991	1996
	Euro II	94/12	1997	2000
	Euro III	98/69	2001	2005
	Euro IV	98/69	2006	9999
Private cars (diesel and LPG)		Conventional	0	1990
	Euro I	91/441	1991	1996
	Euro II	94/12	1997	2000
	Euro III	98/69	2001	2005
	Euro IV	98/69	2006	2010
	Euro V		2011	9999
Light duty veh. (gasoline and diesel)		Conventional	0	1994
	Euro I	93/59	1995	1998
	Euro II	96/69	1999	2001
	Euro III	98/69	2002	2006
	Euro IV	98/69	2007	9999
	Euro V		2012	9999
Heavy duty vehicles		Conventional	0	1993
	Euro I	91/542	1994	1996
	Euro II	91/542	1997	2001
	Euro III	1999/96	2002	2006
	Euro IV	1999/96	2007	2009
	Euro V	1999/96	2010	9999
Mopeds		Conventional	0	1999
	Euro I	97/24	2000	2002
	Euro II	97/24	2003	9999
Motor cycles		Conventional	0	1999
	Euro I	97/24	2000	2003
	Euro II	2002/51	2004	2006
	Euro III	2002/51	2007	9999

For passenger cars and light-duty vehicles, the emission approval tests are made on a chassis dynamometer, and for Euro I-IV vehicles the EU NEDC test cycle is used (see Nørgaard and Hansen, 2004). The emission directives distinguish between three vehicle classes: passenger cars and light-duty vehicles (<1305 kg), light-duty vehicles (1305-1760 kg) and light-duty vehicles (>1760 kg).

In practice, the emissions from vehicles in traffic are different from the legislation limit values and, therefore, the latter figures are considered to be too inaccurate for total emission calculations. A major constraint is that the emission approval test conditions reflect only to a small degree the large variety of emission influencing factors in the real traffic situation, such as cumulated mileage driven, engine and exhaust after treatment maintenance levels and driving behaviour.

Therefore, in order to represent the Danish fleet and to support average national emission estimates, emission factors must be chosen which derive from numerous emissions measurements, using a broad range of real world driving patterns and a sufficient number of test vehicles. It is similar important to have separate fuel use and emission data for cold-start emission calculations and gasoline evaporation (hydrocarbons).

For heavy-duty vehicles (trucks and buses), the emission limits are given in g/kWh and the measurements are carried out for engines in a test bench, using the EU ESC (European Stationary Cycle) and ETC (European Transient Cycle) test cycles, depending on the Euro norm and exhaust gas after-treatment system installed. A description of the test cycles is given by Nørgaard and Hansen, 2004). Measurement results in g/kWh from emission approval tests cannot be directly used for inventory work. Instead, emission factors used for national estimates must be transformed into g/km, and derived from a sufficient number of measurements which represent the different vehicle size classes, Euro engine levels and real world variations in driving behaviour.

Fuel use and emission factors

Trip-speed dependent basis factors for fuel use and emissions are taken from the COPERT model using trip speeds as shown in Table 3.22. The factors are listed in Annex 3.B.4. For EU emission levels not represented by actual data, the emission factors are scaled according to the reduction factors given in Annex 3.B.5. For further explanation, see Ntziachristos et al. (2000) or Illerup et al. (2003).

The fuel use and emission factors used in the Danish inventory come from the COPERT III model. The scientific basis for COPERT III is fuel use and emission information from various European measurement programmes, transformed into trip-speed dependent fuel use and emission factors for all vehicle categories and layers. For passenger cars and light-duty vehicles, real measurement results are behind the emission factors for Euro I vehicles and those earlier, whereas the experimental basis for heavy-duty vehicles is computer simulated emission factors for pre-Euro I engines. In both cases, the emission factors for later engine technologies are produced by using reduction factors. The latter factors are determined by assessing the EU emission limits and the relevant emission approval test conditions, for each vehicle type and Euro class.

Deterioration factors

For three-way catalyst cars the emissions of NO_x, NMVOC and CO gradually increase due to catalyst wear and are, therefore, modified as a function of total mileage by the so-called deterioration factors. Even though the emission curves may be serrated for the individual vehicles, on average, the emissions from catalyst cars stabilise after a given cut-off mileage is reached due to OBD (On Board Diagnostics) and the Danish inspection and maintenance programme.

For each forecast year, the deterioration factors are calculated 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 corresponding 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”:

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

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

where UDF is the urban deterioration factor, U_A and U_B the urban deterioration coefficients, MTC = total cumulated mileage and U_{MAX} urban cut-off mileage.

In the case of trip speeds below 19 km/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 vehicle numbers and annual mileage levels 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 use for hot engines

Emissions and fuel-use results for operationally hot engines are calculated for each year and for layer and road type. The procedure is to combine fuel use and emission factors (and deterioration factors for catalyst vehicles), number of vehicles, annual mileage levels and the relvant road-type shares given in Table 3.22. 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 and k = road type.

For catalyst vehicles the calculation becomes:

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

Extra emissions and fuel use for cold engines

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

The cold:hot ratios depend on the average trip length and the monthly ambient temperature distribution. The Danish temperatures for 2004, 2000-2003, 1990-1999 and 1980-1989 are given in Cappelen et al. (2005) and Cappelen (2004, 2000 and 2003). The cold:hot ratios are equivalent for gasoline fuelled conventional passenger cars and vans and for diesel passenger cars and vans, respectively, see Ntziachristos et al. (2000). For conventional gasoline and all diesel vehicles the extra emissions become:

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

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

For catalyst cars, the cold:hot ratio is also trip speed dependent. The ratio is, however, unaffected by catalyst wear. The Euro I cold:hot ratio is used for all future catalyst technologies. However, in order to comply with gradually stricter emission standards, the catalyst light-off temperature must be reached in even shorter periods of time for future EURO standards. Correspondingly, the β-factor for gasoline vehicles is reduced step-wise for Euro II vehicles and their successors.

For catalyst vehicles the cold extra emissions are found from:

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

where β_{red} = the β reduction factor.

Evaporative emissions from gasoline vehicles

For each year, evaporative emissions of hydrocarbons are simulated in the forecast model as hot and warm running losses, hot and warm soak loss and diurnal emissions. All emission types depend on 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 while the vehicle is running. The distinction between hot and warm running loss emissions depends on engine temperature. In the model, hot and warm running losses occur for hot and cold engines, respectively. The emissions are calculated as annual mileage (broken down into cold and hot mileage totals using the β-factor) times the respective emission factors. For vehicles equipped with evaporation control (catalyst cars), the emission factors are only one tenth of the uncontrolled factors used for conventional gasoline vehicles.

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

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

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

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

where S^C is the soak emission, l_{trip} = the average trip length, and HS and WS are the hot and warm soak emission factors, respectively. Since all catalyst vehicles are assumed to be carbon canister controlled, no soak emissions are estimated for this vehicle type. Average maximum and minimum temperatures 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 loss and diurnal emissions.

Fuel use balance

The calculated fuel use in COPERT III must equal the statistical fuel sale totals from the Danish Energy Authority (DEA, 2005), according to the UNFCCC and UNECE emissions reporting format. The standard approach to achieve a fuel balance in annual emission inventories is to multiply annual mileage by 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.

Table 3.24 DEA:COPERT III fuel use ratios and mileage adjustment factors for the Danish 2004 road transport emission inventories.

		2004
Fuel ratio	DEA:COPERT III	0.93
	DEA:COPERT III	1.61
Mileage factor	DEA:COPERT III	0.93
	DEA:COPERT III	1.84

In Table 3.24, the COPERT III:DEA gasoline and diesel fuel use ratios are shown for fuel sales and fuel consumption in 2004. The figures for

1985-2004 are shown in Annex 3.B.8. The latter figures relate to the traffic on Danish roads. As previously mentioned, fuel sale figures underpin the national emission estimates, due to convention definitions.

For gasoline vehicles, all mileage numbers are equally scaled in order to obtain gasoline fuel equilibrium and, hence, the gasoline mileage factor used is the reciprocal value of the COPERT III:DEA gasoline fuel use ratio.

For diesel, the fuel balance is arrived at 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. Consequently, the diesel mileage factor used is slightly higher than the reciprocal value of the COPERT III:DEA diesel fuel use ratio.

From Table 3.24, it appears that the inventory fuel balances for gasoline and diesel would be improved if the DEA statistical figures for fuel consumption were used instead of fuel sale figures. The fuel difference for diesel is, however, still significant. This inaccuracy is due to a combination of uncertainties related to COPERT III fuel use factors; allocation of vehicle numbers in sub-categories; annual mileage; trip speeds; and mileage splits for urban, rural and highway driving conditions.

For future inventories the intention is to use improved fleet and mileage data from the Danish vehicle inspection programme (performed by the Danish motor vehicle inspection office). The update of road traffic fleet and mileage data will be made as soon as this information is provided from the Danish Ministry of Transport and Energy in a COPERT model input format. In addition, a new version of the COPERT model – COPERT IV – will be available in 2006. The scientific basis for the new model version is the work on emission models and measurements carried out under the EU 5th framework programme.

The final fuel use and emission factors are shown in Annex 3.B.6 for 1990-2004. The total fuel use and emissions are shown in Annex 3.B.7, per vehicle category and as grand totals, for 1990-2004 (and CRF format in Annex 3.B.13). In Annex 3.B.12, fuel-use and emission factors as well as total emissions are given in CollectER format for 1990 and 2004.

In Table 3.25, the aggregated emission factors for CO_2, CH_4 and N_2O are shown per fuel type for the Danish road transport.

Table 3.25 Fuel-specific emission factors for CO_2, CH_4 and N_2O for road transport in Denmark

SNAP ID	Category	Fuel type	Mode	Emission factors[3]		
				CH_4 [g/GJ]	CO_2 [kg/GJ]	N_2O [g/GJ]
70101	Passenger cars	Diesel	Highway driving	4.31	74	13.24
70101	Passenger cars	Gasoline 2-stroke	Highway driving	10.03	73	2.01
70101	Passenger cars	Gasoline conventional	Highway driving	11.45	73	2.20
70101	Passenger cars	Gasoline catalyst	Highway driving	3.58	73	16.92
70101	Passenger cars	LPG	Highway driving	10.06	65	6.04
70102	Passenger cars	Diesel	Rural driving	2.58	74	15.02
70102	Passenger cars	Gasoline 2-stroke	Rural driving	13.84	73	1.73
70102	Passenger cars	Gasoline conventional	Rural driving	14.16	73	2.43
70102	Passenger cars	Gasoline catalyst	Rural driving	4.14	73	8.58
70102	Passenger cars	LPG	Rural driving	16.91	65	7.25
70103	Passenger cars	Diesel	Urban driving	2.52	74	10.14
70103	Passenger cars	Gasoline 2-stroke	Urban driving	43.97	73	0.82
70103	Passenger cars	Gasoline conventional	Urban driving	52.55	73	1.61
70103	Passenger cars	Gasoline catalyst	Urban driving	48.77	73	15.33
70103	Passenger cars	LPG	Urban driving	33.68	65	4.44
70201	Light-duty vehicles	Diesel	Highway driving	1.59	74	6.06
70201	Light-duty vehicles	Gasoline conventional	Highway driving	10.11	73	2.43
70201	Light-duty vehicles	Gasoline catalyst	Highway driving	2.51	73	12.03
70202	Light-duty vehicles	Diesel	Rural driving	1.74	74	6.63
70202	Light-duty vehicles	Gasoline conventional	Rural driving	15.25	73	2.29
70202	Light-duty vehicles	Gasoline catalyst	Rural driving	2.87	73	5.19
70203	Light-duty vehicles	Diesel	Urban driving	2.27	74	4.81
70203	Light-duty vehicles	Gasoline conventional	Urban driving	59.59	73	1.34
70203	Light-duty vehicles	Gasoline catalyst	Urban driving	22.88	73	10.07
70301	Heavy-duty vehicles	Diesel	Highway driving	4.31	74	2.85
70301	Heavy-duty vehicles	Gasoline	Highway driving	9.69	73	0.83
70302	Heavy-duty vehicles	Diesel	Rural driving	4.71	74	2.89
70302	Heavy-duty vehicles	Gasoline	Rural driving	16.74	73	0.91
70303	Heavy-duty vehicles	Diesel	Urban driving	7.93	74	2.35
70303	Heavy-duty vehicles	Gasoline	Urban driving	14.21	73	0.61
704	Mopeds	Gasoline		158.08	73	0.91
70501	Motorcycles	Gasoline	Highway driving	119.98	73	1.27
70502	Motorcycles	Gasoline	Rural driving	143.85	73	1.52
70503	Motorcycles	Gasoline	Urban driving	144.82	73	1.53

3.3.2.2 Methodologies and references for other mobile sources

Other mobile sources are divided into several subsectors: sea transport, fishery, air traffic, railways, military, and working machinery and materiel in the industry, forestry, agriculture and household and gardening sectors. The emission calculations are made using the detailed method as described in the EMEP/CORINAIR Emission Inventory Guidebook (EMEP/CORINAIR, 2003) for air traffic and off-road working machinery and equipment, while for the remaining sectors the simple method is used.

[3] References. CO_2: Country specific: CH_4 and N_2O: COPERT III

Activity data

Air traffic

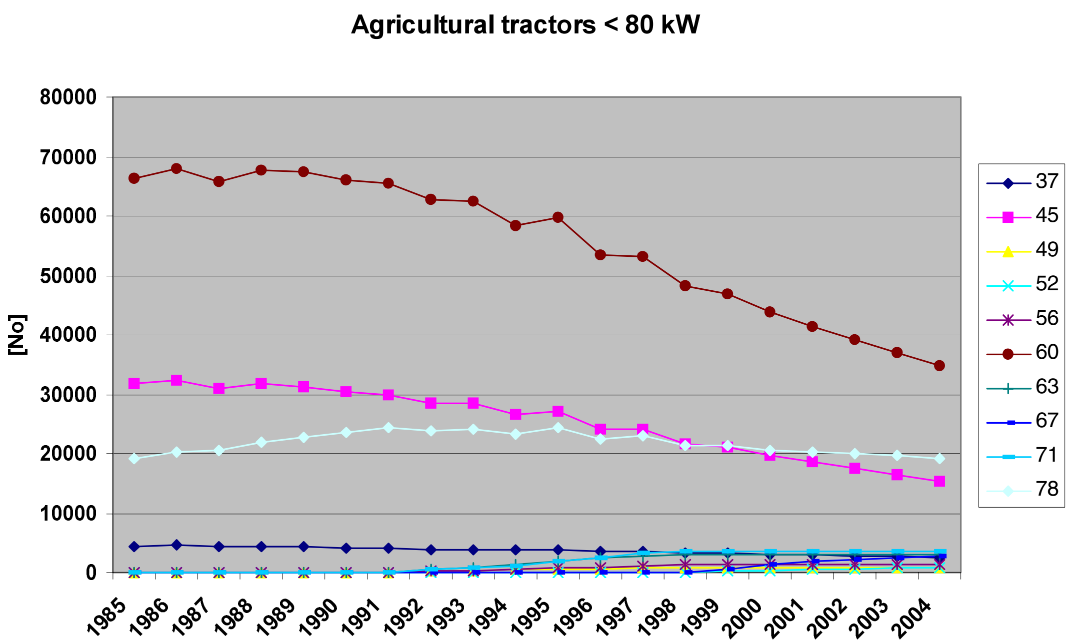
The activity data for air traffic consists of air traffic statistics provided by the Danish Civil Aviation Agency (CAA-DK) and Copenhagen Airport. For 2001 onwards, per flight records are provided by CAA-DK as data for aircraft type, and origin and destination airports. For inventory years prior to 2001, detailed LTO/aircraft type statistics are obtained from Copenhagen Airport (for this airport only), while information of total take-off numbers for other Danish airports is provided by CAA-DK. Fuel statistics for jet fuel use and aviation gasoline are obtained from the Danish energy statistics (DEA, 2005).

Prior to emission calculations, the aircraft types are grouped into a smaller number of representative aircraft groups, for which fuel use and emission data exist in the EMEP/CORINAIR databank. In this procedure, actual aircraft types are classified according to their overall aircraft type (jets, turbo props, helicopters and piston engines). Secondly, information on the aircraft MTOM (Maximum Take Off Mass) and number of engines are used to append a representative aircraft to the aircraft type in question. A more thorough explanation is given in Winther (2001a, b).

Non-road working machinery and equipment

Non-road working machinery and equipment are used in agriculture, forestry and industry, for household/gardening purposes and in inland waterways (recreational craft). A new Danish research project has provided new information on the number of different types of machines, their repective load factors, engine sizes and annual working hours (Winther et al., 2006). The stock development from 1985-2004 for the most important types of machinery are shown in Figures 3.48-3.55 below. The stock data are also listed in Annex 3.B.8, together with figures for load factors, engine sizes and annual working hours. As regards stock data for the remaining machinery types, please refer to (Winther et al., 2006).

For agriculture, the total number of agricultural tractors and harvesters per year are shown in the Figures 3.48-3.49, respectively. The Figures clearly show a decrease in the number of small machines, these being replaced by machines in the large engine-size ranges.



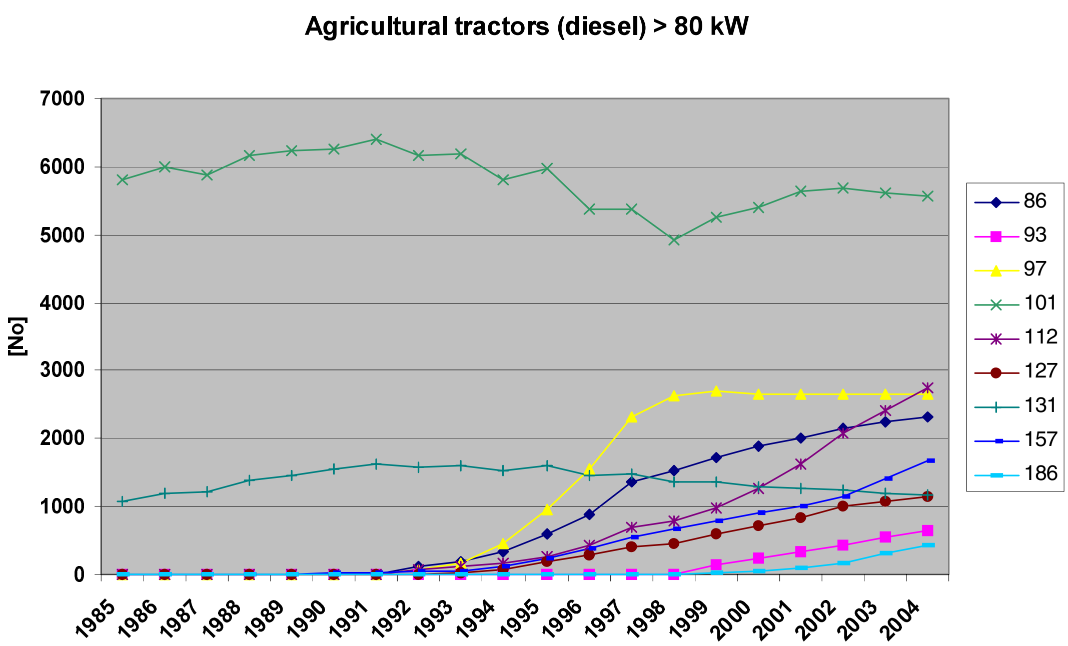


Figure 3.48 Total numbers in kW classes for tractors from 1985 to 2004

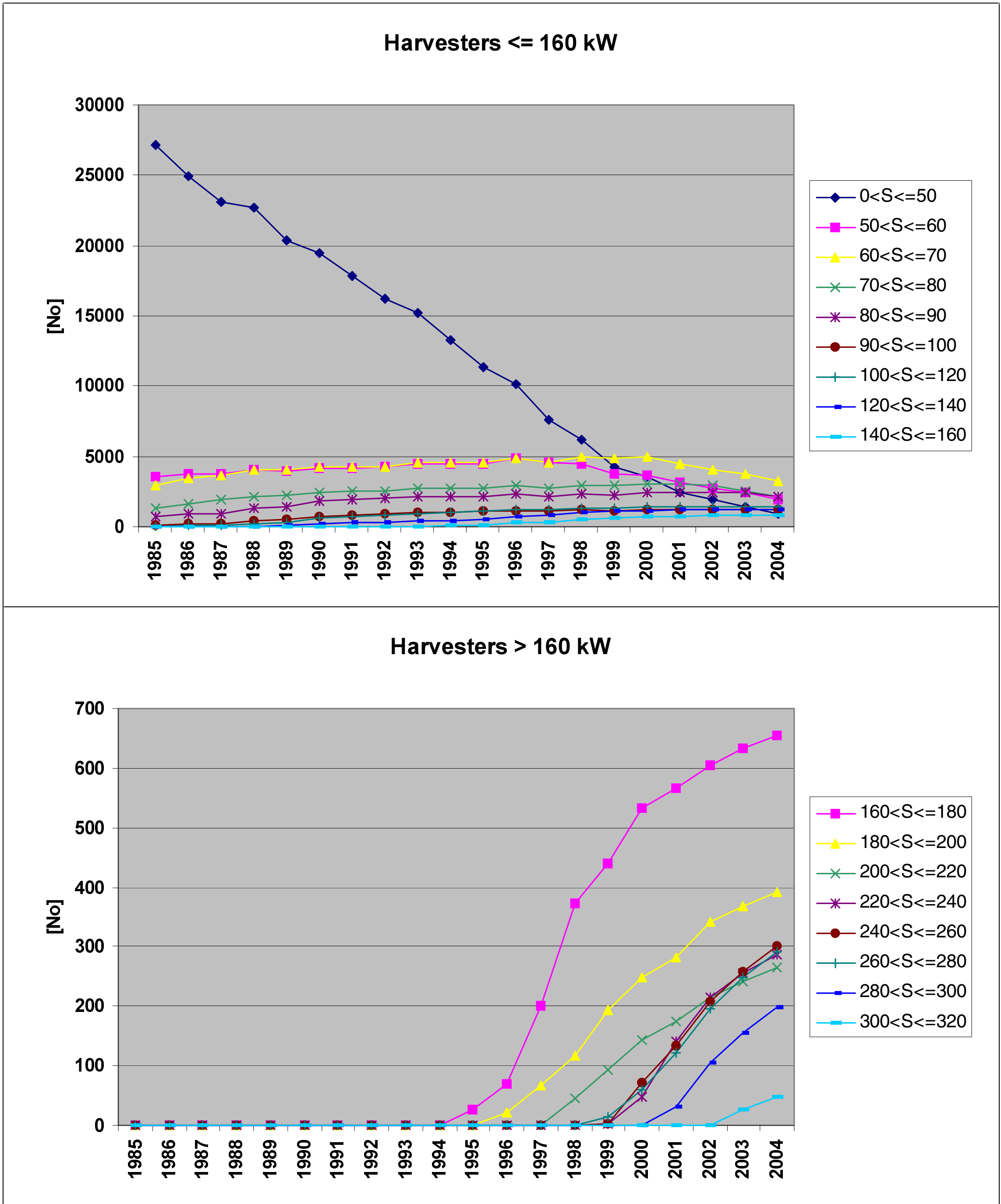


Figure 3.49 Total numbers in kW classes for harvesters from 1985 to 2004

The tractor and harvester developments towards fewer vehicles and larger engines, shown in Figure 3.50, are very clear. From 1985 to 2004, tractor and harvester numbers decrease by around 20% and 50%, respectively, whereas the average increase in engine size for tractors is 16%, and more than 100% for harvesters, in the same time period.

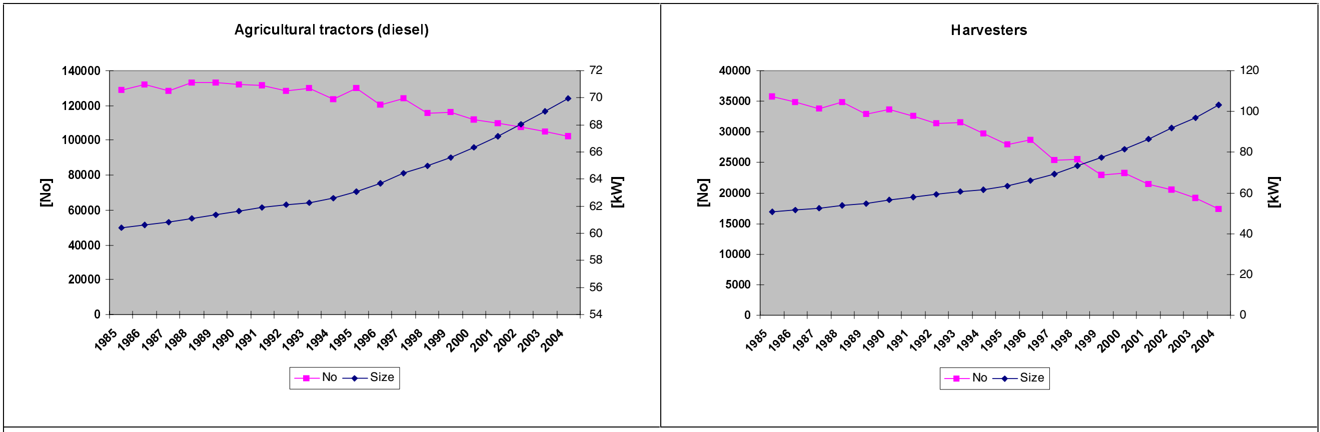
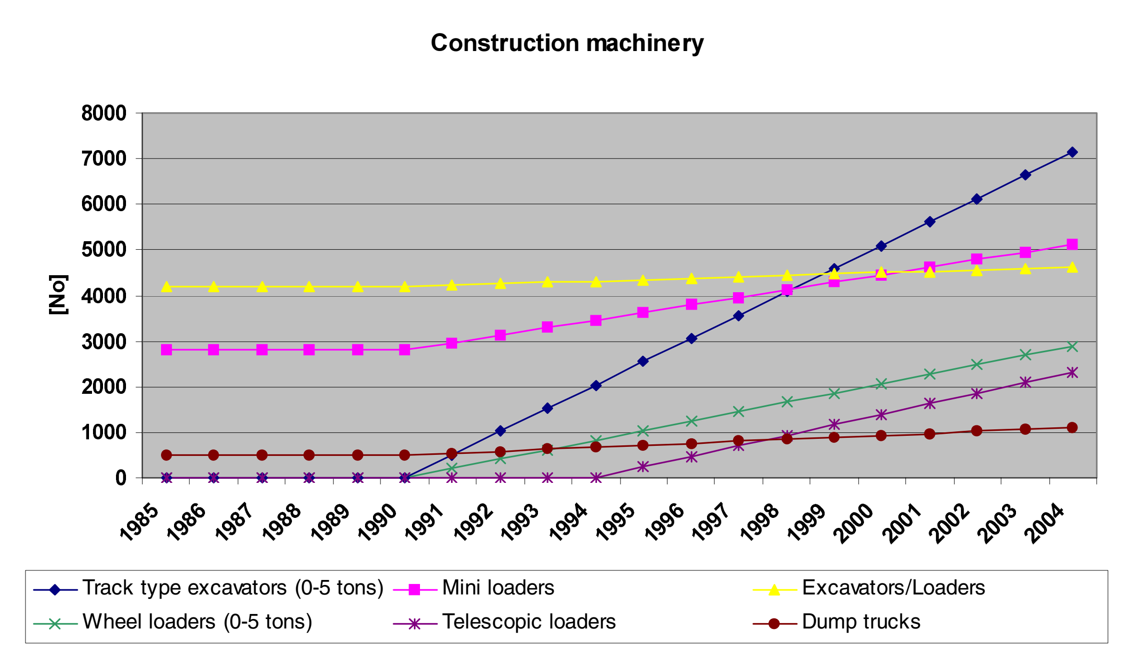


Figure 3.50 Total numbers and average engine size for tractors and harvesters (1985 to 2004)

The most important machinery types for industrial use are different types of construction machinery and fork lifts. The Figures 3.51 and 3.52 show the 1985-2004 stock development for specific types of construction machinery and diesel fork lifts. Due to lack of data, the construction machinery stock for 1990 is used also for 1985-1989. For most of the machinery types there is an increase in machinery numbers from 1990 onwards, due to increased construction activities. It is assumed that track type excavators/ wheel type loaders (0-5 tonnes), and telescopic loaders first enter into use in 1991 and 1995, respectively.



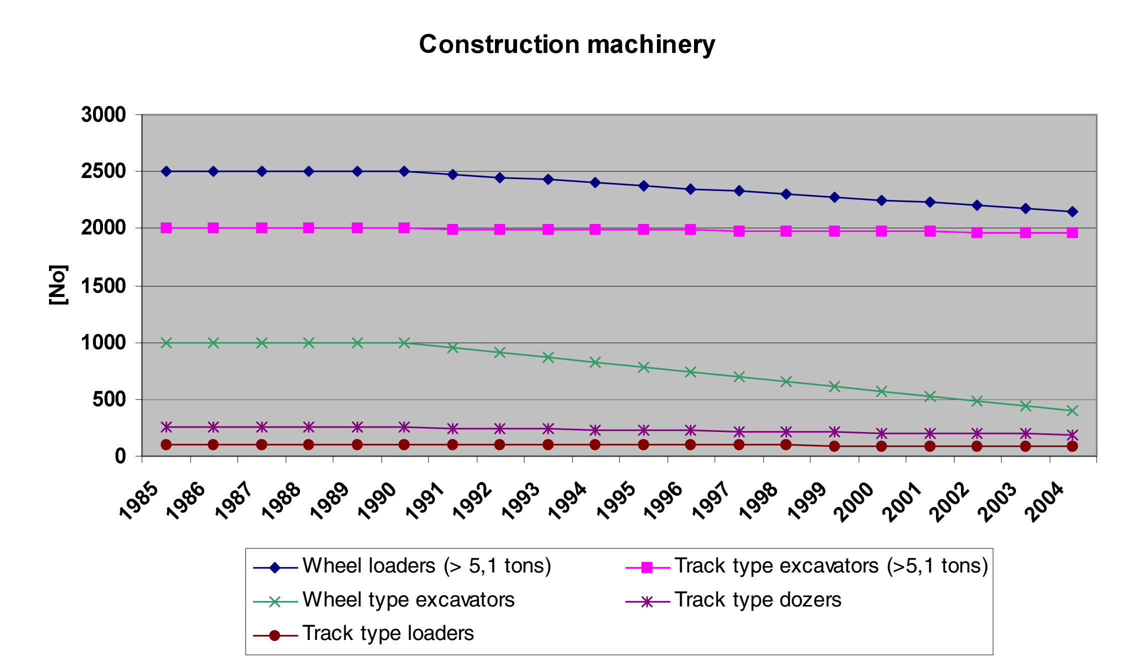


Figure 3.51 1985-2004 stock development for specific types of construction machinery

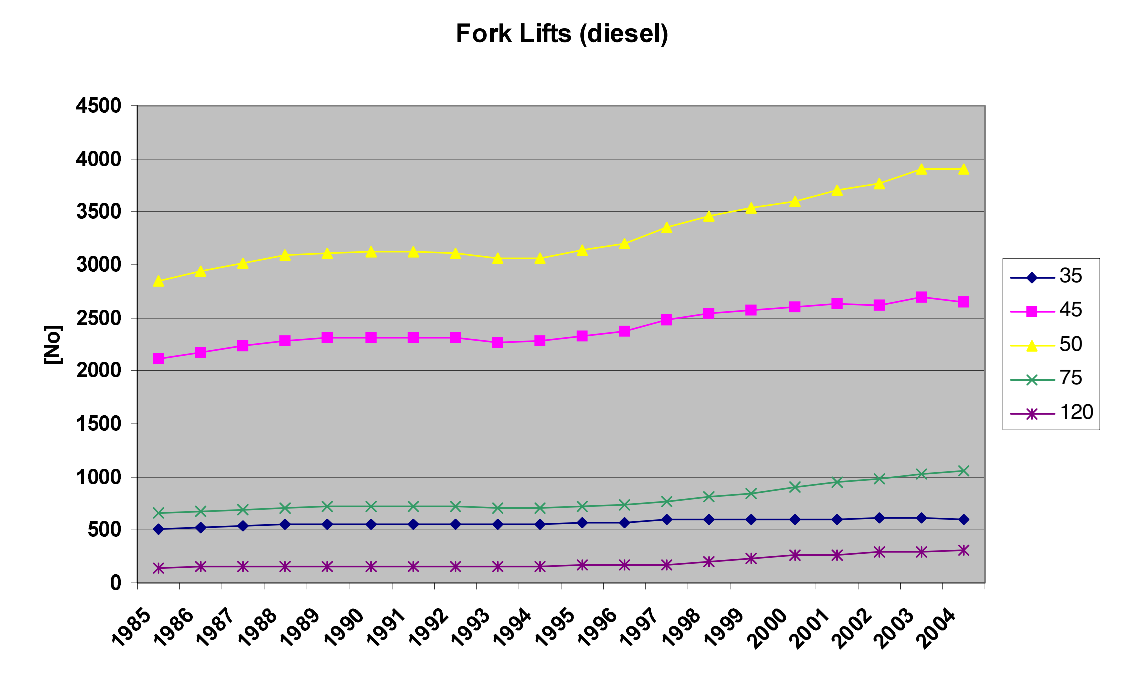


Figure 3.52 Total numbers of diesel fork lifts in kW classes from 1985 to 2004

The emission level shares for tractors, harvesters, construction machinery and diesel fork lifts are shown in Figure 3.53, and present an overview of the penetration of the different pre-Euro engine classes, and engine stages complying with the gradually stricter EU stage I and II emission limits. The average lifetimes of 30, 25, 20 and 10 years for tractors, harvesters, fork lifts and construction machinery, respectively, influence the individual engine technology turn-over speeds.

The EU emission directive Stage I and II implementation years relate to engine size, and for all four machinery groups the emission level shares for the specific size segments will differ slightly from the picture shown in Figure 3.53. Due to scarce data for construction machinery, the emission level penetration rates are assumed to be linear and the general technology turnover pattern is as shown in Figure 3.53.

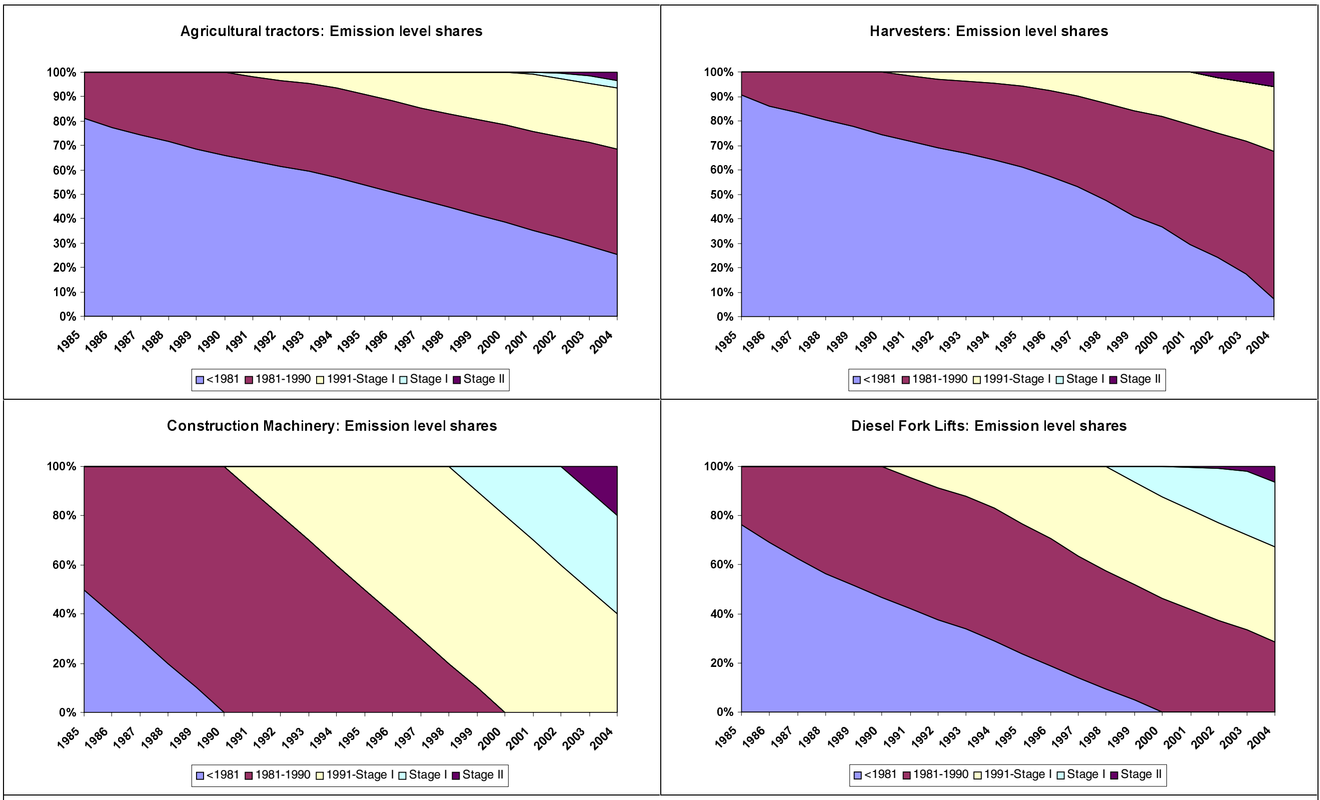


Figure 3.53 Emission level shares for tractors, harvesters, construction machinery and diesel fork lifts (1985 to 2004)

The 1985-2004 stock development for the most important household and gardening machinery types is shown in Figure 3.54. For lawn movers and cultivators, the machinery stock remains the same for all years, whereas the stock figures for riders, chain saws, shrub clearers, trimmers and hedge cutters increase from 1990 onwards. The yearly stock increases, in most cases, become larger after 2000. The lifetimes for gasoline machinery are short and, therefore, there new emission levels (not shown) penetrate rapidly.

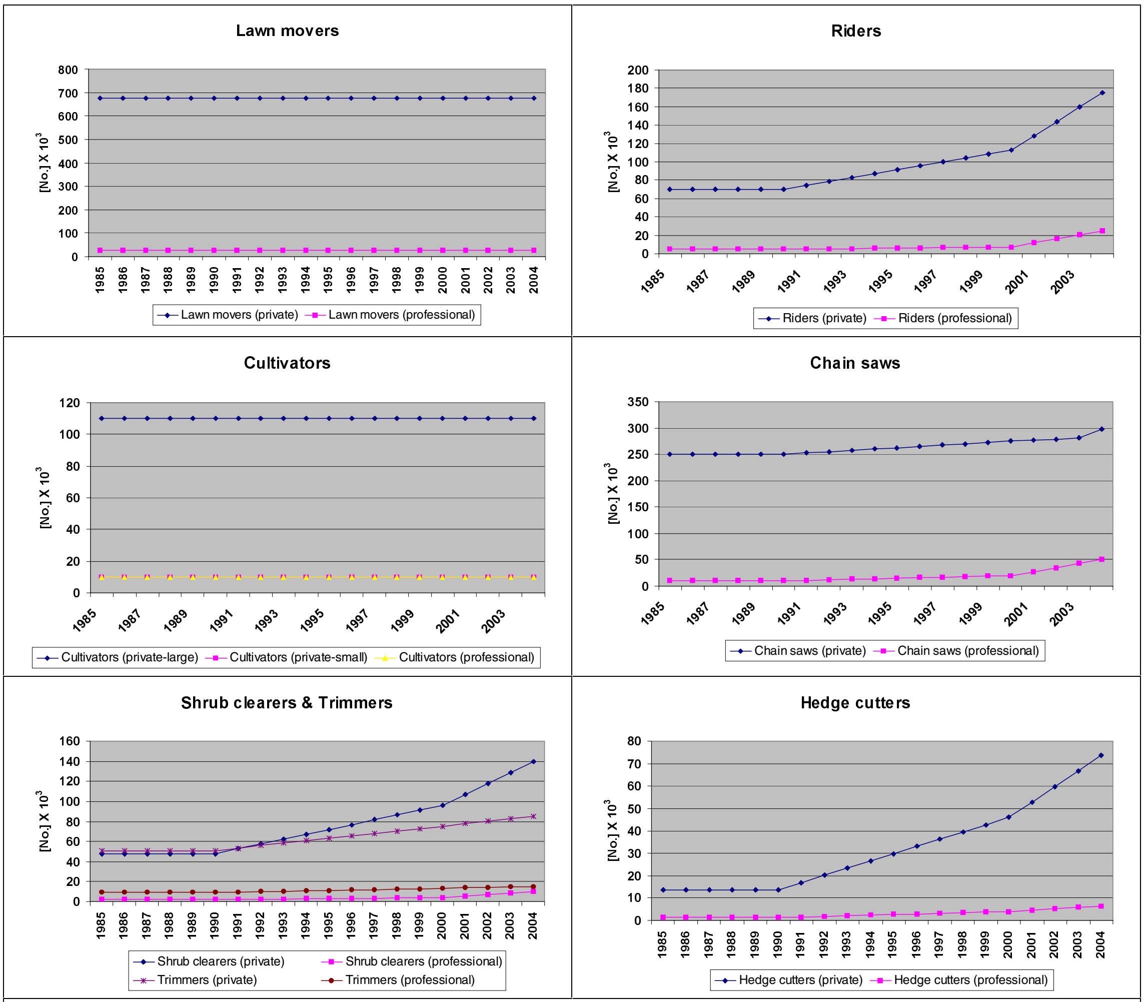


Figure 3.54 Stock development 1985-2004 for the most important household and gardening machinery types

Figure 3.55 shows the development in numbers of different recreational craft from 1985-2004. For diesel boats, increases in stock and engine size are expected during the whole period, except for the number of motor boats (< 27 ft.) and the engine sizes for sailing boats (<26 ft.), where the figures remain unchanged. A decrease in the total stock of sailing boats (<26 ft.) by 21% and increases in the total stock of yawls/cabin boats and other boats (<20 ft.) by around 25% are expected. Due to a lack of information specific to Denmark, the shifting rate from 2-stroke to 4-stroke gasoline engines is based on a German non-road study (IFEU, 2004).

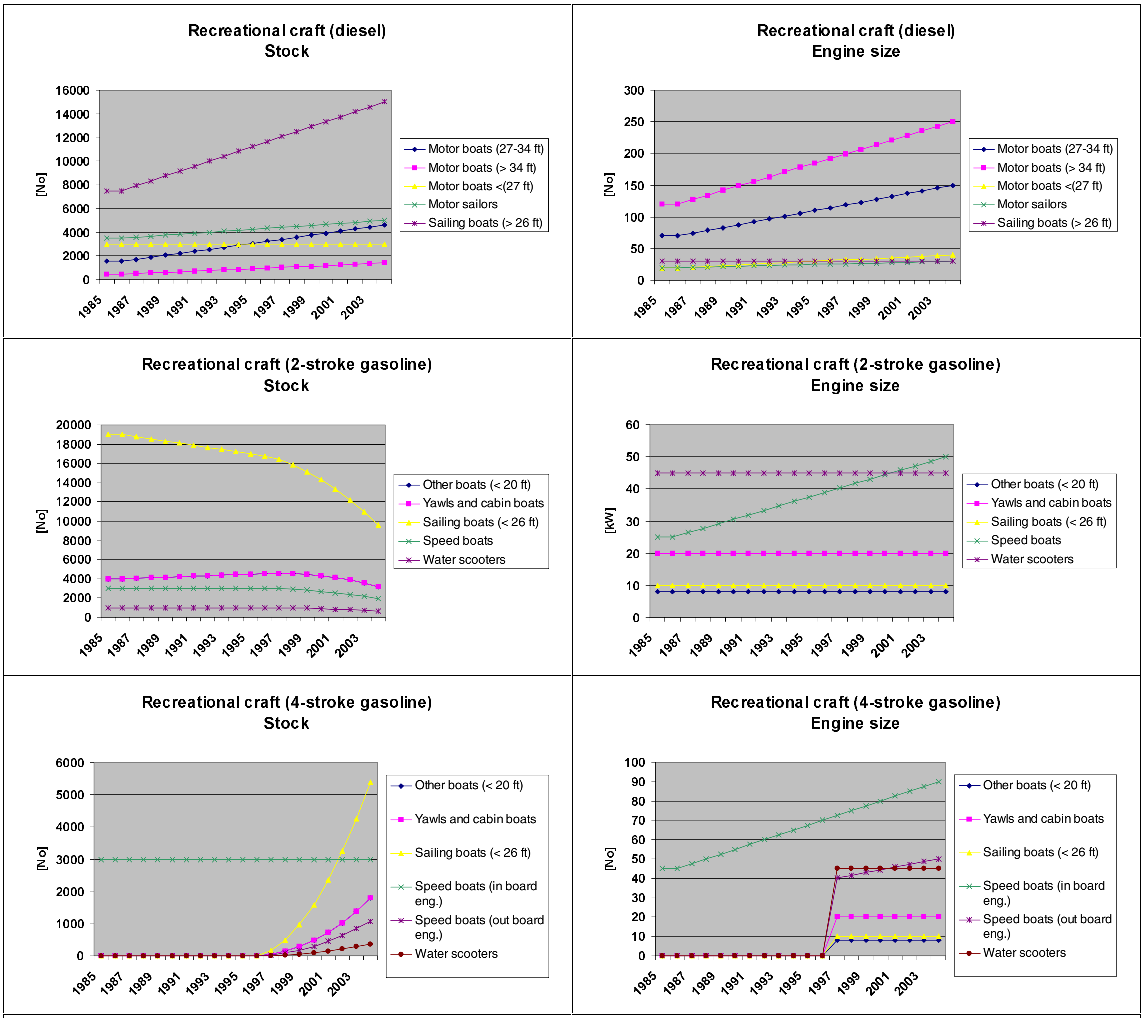


Figure 3.55 1985-2004 Stock and engine size development for recreational craft

Other sectors

The activity data for military, railways, sea transport and fishery consists of fuel use information from DEA (2003). For sea transport, the basis is fuel sold in Danish ports and, depending on the destination of the vessels in question the traffic, is defined as either national or international, as prescribed by the IPCC guidelines.

For all sectors, fuel-use figures are given in Annex 3.B.12 for the years 1990 and 2003 in CollectER format.

Emission legislation

For the engines used by other mobile sources, no legislative limits exist for specific fuel use. And no legistlative limits exist for the emissions of CO_2 which are directly fuel dependent. The engines, however, do have to comply with the emission legislation limits agreed by the EU and, except for ships, the VOC emission limits influence the emissions of CH_4, these forming part of total VOC.

For non-road working machinery and equipment, and recreational craft and railway locomotives/motor cars, the emission directives list specific emission limit values (g/kWh) for CO, VOC, NO_x (or VOC + NO_x) and TSP, depending on engine size (kW for diesel, ccm for gasoline) and date of implementation (referring to engine market date).

For diesel, the directives 97/68 and 2004/26 relate to non-road machinery other than agricultural and forestry tractors, and the directives have different implementation dates for machinery operating under transient and constant loads. The latter directive also comprises emission limits for railway machinery. For tractors the relevant directives are 2000/25 and 2005/13. For gasoline, the directive 2002/88 distinguishes between hand-held (SH) and not hand-held (NS) types of machinery.

For engine type approval, the emissions (and fuel use) are measured using various test cycles (ISO 8178). Each test cycle consists of a number of measurement points for specific engine loads during constant operation. The specific test cycle used depends on the machinery type in question and the test cycles are described in more details in the directives.

Table 3.26 Overview of EU emission directives relevant for diesel fuelled non-road machinery

Stage/Engine size [kW]	CO	VOC	NO_x	$VOC+NO_x$	PM	Diesel machinery			Tractors	
							Implement. date		EU	Implement.
			[g/kWh]			EU Directive	Transient	Constant	directive	date
Stage I										
37<=P<75	6.5	1.3	9.2	-	0.85	97/68	1/4 1999	-	2000/25	1/7 2001
Stage II										
130<=P<560	3.5	1	6	-	0.2	97/68	1/1 2002	1/1 2007	2000/25	1/7 2002
75<=P<130	5	1	6	-	0.3		1/1 2003	1/1 2007		1/7 2003
37<=P<75	5	1.3	7	-	0.4		1/1 2004	1/1 2007		1/1 2004
18<=P<37	5.5	1.5	8	-	0.8		1/1 2001	1/1 2007		1/1 2002
Stage IIIA										
130<=P<560	3.5	-	-	4	0.2	2004/26	1/1 2006	1/1 2011	2005/13	1/1 2006
75<=P<130	5	-	-	4	0.3		1/1 2007	1/1 2011		1/1 2007
37<=P<75	5	-	-	4.7	0.4		1/1 2008	1/1 2012		1/1 2008
19<=P<37	5.5	-	-	7.5	0.6		1/1 2007	1/1 2011		1/1 2007
Stage IIIB										
130<=P<560	3.5	0.19	2	-	0.025	2004/26	1/1 2011	-	2005/13	1/1 2011
75<=P<130	5	0.19	3.3	-	0.025		1/1 2012	-		1/1 2012
56<=P<75	5	0.19	3.3	-	0.025		1/1 2012	-		1/1 2012
37<=P<56	5	-	-	4.7	0.025		1/1 2013	-		1/1 2013
Stage IV										
130<=P<560	3.5	0.19	0.4	-	0.025	2004/26	1/1 2014		2005/13	1/1 2014
56<=P<130	5	0.19	0.4	-	0.025		1/10 2014			1/10 2014

Table 3.27 Overview of the EU Emission Directive 2002/88 for gasoline fuelled non-road machinery

	Category	Engine size [ccm]	CO [g/kWh]	HC [g/kWh]	NO_x [g/kWh]	HC+NO_x [g/kWh]	Implementation date
	Stage I						
Hand held	SH1	S<20	805	295	5.36	-	1/2 2005
	SH2	20=<S<50	805	241	5.36	-	1/2 2005
	SH3	50=<S	603	161	5.36	-	1/2 2005
Not hand held	SN3	100=<S<225	519	-	-	16.1	1/2 2005
	SN4	225=<S	519	-	-	13.4	1/2 2005
	Stage II						
Hand held	SH1	S<20	805	-	-	50	1/2 2008
	SH2	20=<S<50	805	-	-	50	1/2 2008
	SH3	50=<S	603	-	-	72	1/2 2009
Not hand held	SN1	S<66	610	-	-	50	1/2 2005
	SN2	66=<S<100	610	-	-	40	1/2 2005
	SN3	100=<S<225	610	-	-	16.1	1/2 2008
	SN4	225=<S	610	-	-	12.1	1/2 2007

For recreational craft, Directive 2003/44 comprises the emission legislation limits for diesel engines, and for 2-stroke and 4-stroke gasoline engines, respectively. The CO and VOC emission limits depend on engine size (kW) and the inserted parameters presented in the calculation formulas in Table 3.28. For NO_x, a constant limit value is given for each of the three engine types. For TSP, the constant emission limit regards diesel engines only.

Table 3.28 Overview of the EU Emission Directive 2003/44 for recreational craft

Engine type	Impl. date	CO=A+B/P^n			HC=A+B/P^n			NO_x	TSP
		A	B	n	A	B	n		
2-stroke gasoline	1/1 2007	150.0	600.0	1.0	30.0	100.0	0.75	10.0	-
4-stroke gasoline	1/1 2006	150.0	600.0	1.0	6.0	50.0	0.75	15.0	-
Diesel	1/1 2006	5.0	0.0	0	1.5	2.0	0.5	9.8	1.0

Tabel 3.29 Overview of the EU Emission Directive 2004/26 for railway locomotives and motorcars

	Engine size [kW]		CO [g/kWh]	HC [g/kWh]	Nox [g/kWh]	HC+Nox [g/kWh]	PM [g/kWh]	Implementation date
Locomotives	Stage IIIA							
	130<=P<560	RL A	3.5	-	-	4	0.2	1/1 2007
	560<P	RH A	3.5	0.5	6	-	0.2	1/1 2009
	2000<=P and piston displacement >= 5 l/cyl.	RH A	3.5	0.4	7.4	-	0.2	1/1 2009
	Stage IIIB	RB	3.5	-	-	4	0.025	1/1 2012
Motor cars	Stage IIIA							
	130<P	RC A	3.5	-	-	4	0.2	1/1 2006
	Stage IIIB							
	130<P	RC B	3.5	0.19	2	-	0.025	1/1 2012

Aircraft engine emissions of NO_x, CO, VOC and smoke are regulated by ICAO (International Civil Aviation Organization). The legislation is relevant for aircraft engines with a rated engine thrust larger than 26.7 kN. A further description of the emission legislation and emission limits is given in ICAO Annex 16 (1993).

Emission factors

The CO_2 emission factors are country-specific and come from the DEA. The N_2O emission factors are taken from the EMEP/CORINAIR guidebook (CORINAIR, 2003). For military ground material, aggregated CH_4 emission factors for gasoline and diesel are derived from the road traffic emission simulations. The CH_4 emission factors for railways are derived from specific Danish VOC measurements from the Danish State Railways (Næraa, 2005) and a NMVOC/CH_4 split, based on own judgment.

For agriculture, forestry, industry, household gardening and inland waterways, the VOC emission factors are derived from various European measurement programmes; see IFEU (2004) and Winther et al. (2006). The NMVOC/CH_4 split is taken from USEPA (2004). The CH_4 emission factors for the remaining sectors come from the EMEP/CORINAIR guidebook, see CORINAIR (2003). For all sectors, emission factors for the years 1990 and 2004 are given in CollectER format in Annex 3.B.12.

Table 3.30 shows the aggregated emission factors for CO_2, CH_4 and N_2O in 2004 used to calculate the emissions from other mobile sources in Denmark.

Table 3.30 Fuel-specific emission factors for CO_2, CH_4 and N_2O for other mobile sources in Denmark

SNAP ID	CRF ID	Category	Fuel type	Mode	Emission factors[4]		
					CH_4 [g/GJ]	CO_2 [kg/GJ]	N_2O [g/GJ]
801	1A5	Military	Diesel		3.88	74	5.45
801	1A5	Military	Jet fuel	< 3000 ft	2.65	72	2.30
801	1A5	Military	Jet fuel	> 3000 ft	2.65	72	2.30
801	1A5	Military	Gasoline		27.72	73	11.32
801	1A5	Military	Aviation gasoline		21.90	73	2.00
802	1A3c	Railways	Diesel		2.86	74	2.04
803	1A3d	Inland waterways	Diesel		2.76	74	2.97
803	1A3d	Inland waterways	Gasoline		54.65	73	1.07
80402	1A3d	National sea traffic	Residual oil		1.76	78	4.90
80402	1A3d	National sea traffic	Diesel		1.69	74	4.70
80402	1A3d	National sea traffic	Kerosene		7.00	72	2.00
80402	1A3d	National sea traffic	LPG		20.30	65	2.00
80403	1A4c	Fishing	Residual oil		1.76	78	4.90
80403	1A4c	Fishing	Diesel		1.69	74	4.70
80403	1A4c	Fishing	Kerosene		7.00	72	2.00
80403	1A4c	Fishing	Gasoline		108.10	73	0.52
80403	1A4c	Fishing	LPG		20.30	65	2.00
80404	Memo item	International sea traffic	Residual oil		1.76	78	4.90
80404	Memo item	International sea traffic	Diesel		1.69	74	4.70
80501	1A3a	Air traffic, other airports	Jet fuel	Dom. < 3000 ft	3.12	72	21.05
80501	1A3a	Air traffic, other airports	Aviation gasoline		21.90	73	2.00
80502	Memo item	Air traffic, other airports	Jet fuel	Int. < 3000 ft	1.55	72	8.47
80502	Memo item	Air traffic, other airports	Aviation gasoline		21.90	73	2.00
80503	1A3a	Air traffic, other airports	Jet fuel	Dom. > 3000 ft	2.23	72	2.30
80504	Memo item	Air traffic, other airports	Jet fuel	Int. > 3000 ft	0.62	72	2.30
806	1A4c	Agriculture	Diesel		1.63	74	3.12
806	1A4c	Agriculture	Gasoline		129.17	73	1.54
807	1A4c	Forestry	Diesel		1.06	74	3.20
807	1A4c	Forestry	Gasoline		52.96	73	0.41
808	1A2f	Industry	Diesel		1.85	74	3.08
808	1A2f	Industry	Gasoline		101.67	73	1.39
808	1A2f	Industry	LPG		7.69	65	3.50
809	1A4b	Household and gardening	Gasoline		71.19	73	1.17
80501	1A3a	Air traffic, Copenhagen airport	Jet fuel	Dom. < 3000 ft	4.16	72	11.22
80501	1A3a	Air traffic, Copenhagen airport	Aviation gasoline		21.90	73	2.00
80502	Memo item	Air traffic, Copenhagen airport	Jet fuel	Int. < 3000 ft	4.05	72	4.13
80502	Memo item	Air traffic, Copenhagen airport	Aviation gasoline		21.90	73	2.00
80503	1A3a	Air traffic, Copenhagen airport	Jet fuel	Dom. > 3000 ft	2.02	72	2.30
80504	Memo item	Air traffic, Copenhagen airport	Jet fuel	Int. > 3000 ft	1.17	72	2.30

Calculation method

Air traffic

For aviation, the estimates are made separately for landing and take-off (LTOs < 3000 ft), and cruising (> 3000 ft). From 2001, the estimates are made on a city-pair level by combining activity data and emission factors and subsequently grouping the emission results intodomestic

[4] References. CO_2: Country-specific. N_2O: EMEP/CORINAIR. CH_4: Railways: DSB/NERI; Agriculture/Forestry/Industry/Household-Gardening: IFEU/USEPA; remaining sectors: EMEP/CORINAIR.

and international totals. The overall fuel precision in the model is around 0.8, derived as the fuel ratio of model estimates to statistical sales. The fuel difference is accounted for by adjusting the cruise fuel consumption and emissions in the model, according to the domestic and international cruise fuel shares.

Prior to 2001, the calculation scheme involved firstly estimatation of each year's fuel use and emissions for LTO. Secondly, the total cruise fuel use was found, year for year, as the statistical fuel use total minus the calculated fuel use for LTO. Lastly, the cruise fuel use was split into a domestic and an international part, by using the results from a Danish city-pair emission inventory in 1998 (Winther, 2001a). For more details of the latter fuel allocation procedure, see Winther (2001b).

A more thorough documentation of the emission calculations for civil aviation will be given in the sector report for the 2003 inventory.

Non-road working machinery and recreational craft

Prior to adjustments for deterioration effects and transient engine operations, the fuel use and emissions in year X, for a given machinery type, engine size and engine age, are calculated as:

$$E_{Basis}(X)_{i,j,k} = N_{i,j,k} \cdot HRS_{i,j,k} \cdot P \cdot LF_i \cdot EF_{y,z} \quad (13)$$

where E_{Basis} = fuel use/emissions in the basic situation, N = number of engines, HRS = annual working hours, P = average rated engine size in kW, LF = load factor, EF = fuel use/emission factor in g/kWh, i = machinery type, j = engine size, k = engine age, y = engine-size class and z = emission level. The basic fuel use and emission factors are shown in Annex 3.B.9.

The deterioration factor for a given machinery type, engine size and engine age in year X depends on the engine-size class (only for gasoline), y, and the emission level, z. The deterioration factors for diesel and gasoline 2-stroke engines are found from:

$$DF_{i,j,k}(X) = \frac{K_{i,j,k}}{LT_i} \cdot DF_{y,z} \quad (14)$$

where DF = deterioration factor, K = engine age, LT = lifetime, i = machinery type, j = engine size, k = engine age, y = engine-size class and z = emission level.

For gasoline 4-stroke engines the deterioration factors are calculated as:

$$DF_{i,j,k}(X) = \sqrt{\frac{K_{i,j,k}}{LT_i}} \cdot DF_{y,z} \quad (15)$$

The deterioration factors inserted in (14) and (15) are shown in Annex 3.B.9. No deterioration is assumed for fuel use (all fuel types) or for LPG engine emissions and, hence, DF = 1 in these situations.

The transient factor for a given machinery type, engine size and engine age in year X, relies only on emission level and load factor, and is denominated as:

$$TF_{i,j,k}(X) = TF_z \quad (16)$$

Where i = machinery type, j = engine size, k = engine age and z = emission level.

The transient factors inserted in (16) are shown in Annex 3.B.9. No transient corrections are made for gasoline and LPG engines and,hence, $TF_z = 1$ for these fuel types.

The final calculation of fuel use and emissions in year X for a given machinery type, engine size and engine age, is the product of the expressions 13-16:

$$E(X)_{i,j,k} = E_{Basis}(X)_{i,j,k} \cdot TF(X)_{i,j,k} \cdot (1 + DF(X)_{i,j,k}) \quad (17)$$

The evaporative hydrocarbon emissions from fuelling are calculated as:

$$E_{Evap,fueling,i} = FC_i \cdot EF_{Evap,fueling} \quad (18)$$

Where $E_{Evap,fueling}$, = hydrocarbon emissions from fuelling, i = machinery type, FC = fuel consumption in kg, $EF_{Evap,fueling}$ = emission factor in g NMVOC/kg fuel.

For tank evaporation, the hydrocarbon emissions are found from:

$$E_{Evap,\tan k,i} = N_i \cdot EF_{Evap,\tan k,i} \quad (19)$$

Where $E_{Evap,tank,i}$ = hydrocarbon emissions from tank evaporation, N = number of engines, i = machinery type and $EF_{Evap,fueling}$ = emission factor in g NMVOC/year.

Other sectors
For military, railways, national sea traffic and fishing, the emissions are estimated with the simple method using fuel-related emission factors and fuel use from the DEA:

$$E = FC \cdot EF \quad (20)$$

where E = emission, FC = fuel consumption and EF = emission factor. The calculated emissions for other mobile sources are shown in CollectER format in Annex 3.B.12 for the years 1990 and 2003 and as time-series 1985-2003 in Annex 3.B.13 (CRF format).

DEA subsector totals and NERI non road estimates
For diesel and LPG, the non-road fuel use estimated by NERI is partly covered by the fuel-use amounts in the following DEA sectors: agriculture and forestry, market gardening, and building and construction. The remaining quantity of non-road diesel and LPG is taken from the DEA industry sector.

For gasoline, the DEA residential sector, together with the DEA sectors mentioned for diesel and LPG, contribute to the non-road fuel use total. In addition, a certain amount of fuel from road transport is needed to reach the fuel-use goal.

The amount of diesel and LPG in DEA industry not being used by non-road machinery is included in the sectors, "Combustion in manufacturing industry" (0301) and "Non-industrial combustion plants" (0203) in the Danish emission inventory.

For recreational crafts, the calculated fuel-use totals are subsequently subtracted from the DEA fishery (diesel) and road transport (gasoline) sectors.

Bunkers

The distinction between domestic and international emissions from aviation and navigation should be in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. For the national emission inventory, this, in principle, means that fuel sold (and associated emissions) for flights/sea transportation starting from a seaport/airport in the Kingdom of Denmark, with destinations inside or outside the Kingdom of Denmark, are regarded as domestic or international, respectively.

Aviation

For aviation, the emissions associated with flights inside the Kingdom of Denmark are counted as domestic. The flights from Denmark to Greenland and the Faroe Islands are classified as domestic flights in the inventory background data. In Greenland and in the Faroe Islands, the jet fuel sold is treated as domestic. This decision becomes reasonable when considering that almost no fuel is bunkered in Greenland/the Faroe Islands by flights other than those going to Denmark.

Navigation

In DEA statistics, the domestic fuel total consists of fuel sold to Danish ferries and other ships sailing between two Danish ports. The DEA international fuel total consists of the fuel sold in Denmark to international ferries, international warships, other ships with foreign destinations, transport to Greenland and the Faroe Islands, tank vessels and foreign fishing boats.

In Greenland, all marine fuel sales are treated as domestic. In the Faroe Islands, the fuel sold in Faroese ports for Faroese fishing vessels and other Faroese ships is treated as domestic. The fuel sold to Faroese ships bunkering outside Faroese waters and the fuel sold to foreign ships in Faroese ports or outside Faroese waters is classified as international (Lastein and Winther, 2003).

To comply with the IPCC classification rules, the fuel used by vessels sailing to Greenland and the Faroe Islands should be a part of the domestic total. To improve the fuel data quality for Greenland and the Faroe Islands, the fuel sales should be grouped according to vessel destination and IPCC classification, subsequently.

In conclusion, the domestic/international fuel split (and associated emissions) for navigation is not determined with the same degree of precision as for aviation. It is considered, however, that the potential of incorrectly allocated fuel quantities is only a small part of the total fuel sold for navigational purposes in the Kingdom of Denmark.

3.3.3 Uncertainties and time-series consistency

Uncertainty estimates for greenhouse gases are made for road transport and other mobile sources using the guidelines formulated in the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC, 2000). For road transport, railways and a part of navigation (large vessels), these guidelines provide uncertainty factors for activity data that are used in the Danish situation. For other sectors, the factors reflect specific national knowledge (Winther et al., 2006). These sectors are (SNAP categories): Inland Waterways (a part of 1A3d: Navigation), Agriculture and Forestry (parts of 1A4c: Agriculture/forestry/fisheries), Industry (mobile part of (1A2f: Industry-other) and Residential (1A4b).

The activity data uncertainty factor for civil aviation is based on own judgement.

The uncertainty estimates should be regarded as preliminary, only, and may be subject to changes in future inventory documentation. The calculations are shown in Annex 3.B.14 for all emission components.

Table 3.31 Uncertainties for activity data, emission factors and total emissions in 2004 and as a trend

Category	Activity data	CO_2	CH_4	N_2O
	%	%	%	%
Road transport	2	5	40	50
Military	2	5	100	1000
Railways	2	5	100	1000
Navigation (small boats)	42	5	100	1000
Navigation (large vessels)	2	5	100	1000
Fisheries	2	5	100	1000
Agriculture	26	5	100	1000
Forestry	32	5	100	1000
Industry (mobile)	36	5	100	1000
Residential	36	5	100	1000
Civil aviation	10	5	100	1000
Overall uncertainty in 2004		5	35	64
Trend uncertainty		5	7	253

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

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

3.3.4 Quality assurance/quality control (QA/QC)

The intention is to publish a sector report for road transport and other mobile sources annually. Due to constraints on time resources, the last sector report prepared concerned the 2002 inventory. The recommendation of the sector report reviewers was to include some text for each transport mode, explaining the existing emission legislation and the associated emission test procedures. In addition, more documentation of background data and trends was recommended to be given in cases where Tier 2 estimates are made. Apart from civil aviation, these recommendations have been taken onboard in the present NIR report.

The QA/QC descriptions of the Danish emission inventories for transport follow the general QA/QC description for NERI in Section 1.6, based on the prescriptions given in the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC, 2000).

An overview diagram of the Danish emission inventory system is presented in Figure 1.2 (Data storage and processing levels), and the exact definitions of Critical Control Points (CCP) and Points of Measurements (PM) are given in Section 1.6. The status for the PMs relevant for the mobile sector are given in the following text and the result of this investigation indicates a need for future QA/QC activities in order to fulfil the QA/QC requirements from the IPCC GPG.

Data storage level 1

Data Storage level 1	3.Completeness	DS.1.3.1	Documentation showing that all possible national data sources are included by setting down the reasoning behind the selection of datasets.

The following external data sources are used in the mobile part of the Danish emission inventories for activity data and supplementary information:

- Danish Energy Authority: Official Danish energy statistics
- Danish Road Directorate: Road traffic vehicle fleet and mileage data
- Civil Aviation Agency of Denmark: Flight statistics
- Non-road machinery: Information from statistical sources, research organisations, different professional organisations and machinery manufacturers.

- Danish Meteorological Institute (DMI): Temperature data

- The National Motorcycle Association: 2-wheeler data

The emission factors come from various sources:

- Danish Energy Authority: CO_2 emission factors and lower heating values (all fuel types)
- COPERT III: Road transport (all exhaust components, except CO_2 and SO_2)
- Danish State Railways: Diesel locomotives (NO_x, VOC, CO and TSP)
- EMEP/CORINAIR guidebook: Navigation, civil aviation and supplementary
- Non road machinery: References given in NERI reports.

Table 3.32 to follow contains Id, File/Directory/Report name, Description, Reference and Contacts. As regards File/Directory/Report name, this field refers to a file name for Id when all external data (time-series for the existing inventory) are stored in one file. In other cases, a computer directory name is given when the external data used are stored in several files, e.g. each file contains one inventory years's external data or each file contains time-series of external data for sub-categories of machinery. A third situation occurs when the external data are published in publically available reports; here the aim is to obtain electronic copies for internal archiving.

Table 3.32 Overview table of external data for transport

Id no	File/Directory/Report name	Description	Activity data or emission factor	Reference	Contacts	Data agreement
T1	Transport energy[1]	Dataset for all transport energy use	Activity data	The Danish Energy Authority (DEA)	Anders B. Hansen & Peter Dal	Yes
T2	Fleet and mileage data[1]	Road transport fleet and mileage data	Activity data	The Danish Road Directorate	Bo Ekman	Pending
T3	Flight statistics[2]	Data records for all flights	Activity data	Civil Aviation Agency of Denmark	Henrik Gravesen	In place
T4	Non road machinery[2]	Stock and operational data for non-road machinery	Activity data	Non road Documentation report	Morten Winther	No
T5	Temperature data[3]	Monthly avg of daily max/min temperatures	Other data	Danish Meteorological Institute	Danish Meteorological Institute	No
T6	Fleet and mileage data[1]	Stock data for mopeds and motorcycles	Activity data	The National Motorcycle Association	Henrik Markamp	No
T7	CO_2 emission factors[1]	DEA CO_2 emission factors (all fuel types)	Emission factor	The Danish Energy Authority (DEA)	Anders B. Hansen & Peter Dal	No
T8	COPERT III emission factors[3]	Road transport emission factors	Emission factor	Laboratory of applied thermodynamics Aristotle University Thessaloniki	Leonidas Ntziachristos	No
T9	Railways emission factors[1]	Emission factors for diesel locomotives	Emission factor	Danish State Railways	Rikke Næraa	Yes
T10	EMEP/CORINAIR guidebook[3]	Emission factors for navigation, civil aviation and supplementary	Emission factor	European Environment Agency	European Environment Agency	No
T11	Non road emission factors[3]	Emission factors for agriculture, forestry, industry and household/gardening	Emission factor	Non road Documentation report	Morten Winther	No

[1)] File name; [2)] Directory in the NERI data library structure; [3)] Reports available on the internet

Danish Energy Authority (energy statistics)

The official Danish energy statistics are provided by the Danish Energy Authority (DEA) and are regarded as complete on a national level. For most transport sectors, the DEA subsector classifications fit the SNAP classifications used by NERI. For non-road machinery, this is however not the case, since DEA do not distinguish between mobile and stationary fuel use in the subsectors relevant for non-road mobile fuel consumption.

Here, NERI calculates a bottom-up non-road fuel use estimate and for diesel (land based machinery only) and LPG, the residual fuel quantities are allocated to stationary consumption. For gasoline (land-based machinery) the relevant fuel use quantities for the DEA are smaller than the NERI estimates, and the amount of fuel use missing is subtracted from the DEA road transport total to account for all fuel sold. For recreational craft, no specific DEA category exists and, in this case, the gasoline and diesel fuel use is taken from road transport and fisheries, respectively.

The NERI non-road fuel modifications, thus, give DEA-SNAP differences for road transport and fisheries.

A special note must be made for the DEA civil aviation statistical figures. The domestic/international fuel use division derives from bottom-up fuel use calculations made by NERI.

Danish Road Directorate
Figures for fleet numbers and mileage data are provided by the Danish Road Directorate. Being a sector institution under the Ministry of Transport and Energy, it is a basic task for the Danish Road Directorate to possess comprehensive information on Danish road traffic. The fleet figures are based on data from the Car Register, kept by Statistics Denmark and are, therefore, regarded as very precise. In some cases, stock data are split into vehicle subcategories (COPERT III format), based on expert judgement. Annual mileage information comes from the Danish Road Directorate's own traffic measurement points, questionnaires and statistical methods subsequently used to disaggregate total traffic volumes into vehicle subcategories and ages.

Civil Aviation Agency of Denmark
The Civil Aviation Agency of Denmark (CAA-DK) monitors all aircraft movements in Danish airspace and, in this connection, possesses data records for all take-offs and landings at Danish airports. The dataset from 2001 onwards, among others consisting of aircraft type and origin and destination airports for all flights leaving major Danish airports, are, therefore, regarded as very complete. For inventory years before 2001, the most accurate data contain CAA-DK total movements from major Danish airports and detailed aircraft type distributions for aircraft using Copenhagen Airport, provided by the airport itself.

Non-road machinery (stock and operational data)
A research project for non-road machinery in Denmark has been recently carried out (Winther et al., 2006) and a great deal of new stock and operational data has been obtained via this project. The source for the agricultural machinery stock of tractors and harvesters is Statistics Denmark. Sales figures for tractors, harvesters and construction machinery, together with operational data and supplementary information, are obtained from The Association of Danish Agricultural Machinery Dealers. IFAG (The Association of Producers and Distributors of Fork Lifts in Denmark) provides fork-lift sale figures, whereas total stock numbers for gasoline equipment are obtained from machinery manufacturers with large Danish market shares, with figures validated through discussions with KVL. Stock information disaggregated into vessel types for recreational craft was obtained from the Danish Sailing Association. A certain part of the operational data comes from previous Danish non-road research projects (Dansk Teknologisk Institut, 1992 and 1993; Bak et al., 2003)

No statistical register exists for non-road machinery types and this affects the accuracy of stock and operational data. For tractors and harvesters, Statistics Denmark provide total stock data based on information from questionnaires and the registers of crop subsidy applications kept by the Ministry of Agriculture. In combination with new sales figures per engine size, the best available stock data are obtained, and using the sources for construction machinery and fork lift sale figures are regarded as the only realistic approach for consolidated stock information for these machinery types. Use of this source-type also applies in the case of machinery types (gasoline equipment, recreational craft) where data is even scarcer. For non-road machinery, in general, it is uncertain if the kind of data obtained by Winther et al. (2006) can be provided annually in the future.

Danish Meteorological Institute
The monthly average max/min temperature for Denmark comes from DMI. This source is self explanatory in terms of meteorological data. Data are publically available for each year on the internet.

The National Motorcycle Association

Road transport: 2-wheeler stock information (The National Motorcycle Association). Given that no consistent national data are available for mopeds in terms of fleet numbers and distributions according to new sales per year, The National Motorcycle Association is considered to be the professional organisation, where most expert knowledge is available. The relevant annual information is given as personal communication, a method which can be repeated in the future.

Danish Energy Authority (CO_2 emission factors and lower heating values)
The CO_2 emission factors and lower heating values (LHV) are fuel-specific constants. The country-specific values from the DEA are used for all inventory years.

COPERT III
COPERT III provides factors for fuel use and for all exhaust emission components which are included in the national inventory. For several reasons, COPERT III is regarded as the most appropriate source of road traffic fuel use and emission factors. First of all, very few Danish emission measurements exist, so data are too scarce to support emission calculations on a national level. Secondly, the fuel-use and emission information behind the COPERT model are derived from many European measurement programmes and the formulation of fuel-use and emission factors for all single vehicle categories has been made by a group of road traffic emission experts. A large degree of internal consistency is, therefore, achieved. Finally, the COPERT model is regularly updated with new experimental findings from European research programmes and, apart from updated fuel-use and emission factors, the use of COPERT III by many European countries ensures a large degree of cross-national consistency in reported emission results.

Danish State Railways
Aggregated emission factors of NO_x, VOC, CO and TSP for diesel locomotives are provided annually by the Danish State Railways. Taking into account available time resources for subsector emission calculations, the use of data from Danish State Railways is sensible. This operator accounts for around 90% of all diesel fuel used by railway locomotives in Denmark and the remaining diesel fuel is used by various private railways companies. Setting up contacts with the private transport operators is considered to be a rather time consuming experience taking time away from inventory work in areas of greater emission importance.

EMEP/CORINAIR guidebook
Fuel-use and emission data from the EMEP/CORINAIR guidebook is the prime and basic source for the aviation and navigation part of the Danish emission inventories. For aviation, the guidebook contains the most comprehensive list of representative aircraft types available for city-pair fuel-use and emission calculations. The data have been evaluated specifically for detailed national inventory use by a group of experts representing civil aviation administration, air traffic management, emission modellers and inventory workers. The thorough guidebook documentation and selection of fuel-use and emission factors also applies in the case of navigation and, for this transport sector, emission factors are also available in the EMEP/CORINAIR guidebook, in support of the simple calculation method used currently in the Danish inventory.

In addition, the EMEP/CORINAIR guidebook is the source of non-exhaust TSP, PM_{10} and $PM_{2.5}$ emission factors for road transport, and the primary source of emission factors for some emission components – typically N_2O, NH_3, heavy metals and PAH – for other mobile sources.

Non-road machinery (fuel use and emission factors)
The references for non-road machinery fuel-use and emission factors are listed in Winther et al. (2006). The fuel-use and emission data is regarded as the most comprehensive data collection on a European level, having been thoroughly evaluated by German emission measurement and non-road experts within the framework of a German non-road inventory project.

Data Storage level 1	1. Accuracy	DS.1.1.1	General level of uncertainty for every dataset, including the reasoning for the specific values

The uncertainty involved in the DEA fuel-use information (except civil aviation) and the CAA-DK flight statistics is negligible, as such, and this is also true for DMI temperature data. For civil aviation, some uncertainty prevails, since the domestic fuel-use figures originate from a division of total jet-fuel sales figures into domestic and international fuel quantities, derived from bottom-up calculations. A part of the fuel-use uncertainties for non-road machines is due to the varying levels of stock and operational data uncertainties, as explained in DS 1.3.1. The road transport fleet totals from the Danish

Road Directorate and The National Motorcycle Association in the main vehicle categories are accurate. Uncertainties, however, are introduced when the stock data are split into vehicle subcategories. The mileage figures from the Danish Road Directorate are generally less certain and uncertainties tend to increase for disaggregated mileage figures on subcategory levels.

As regards emission factors, the CO_2 factors (and LHVs) from the DEA are considered to be very precise, since they relate only to fuel. For the remaining emission factor sources, the SO_2 (based on fuel sulphur content), NO_x, NMVOC, CH_4, CO, TSP, PM_{10} and $PM_{2.5}$ emission factors are less accurate. Though many measurements have been made, the experimental data rely on the individual measurement and combustion conditions. The uncertainties for N_2O and NH_3 emission factors increase even further due to the small number of measurements available. For heavy metals and PAH, experimental data are so scarce that uncertainty becomes very high.

A special note, however, must be made for energy. The uncertainties due to the subsequent treatment of DEA data for road transport, fisheries and the non-road relevant sectors, explained in DS 1.3.1, trigger some uncertainties in the fuel-use figures for these sectors. This point is, though, more relevant for QA/QC description for data processing, Level 1.

Data Storage level 1	1. Accuracy	DS.1.1.2	Quantification of the uncertainty level of every single data value including the reasoning for the specific values.

The general uncertainties of the DEA fuel-use information, DMI temperature data, road transport stock totals and the CAA-DK flight statistics are zero. For domestic aviation fuel use, the uncertainty is as prescribed by the IPCC Good Practice Guidance manual. For road transport, it is not possible to quantify the uncertainties (1) of stock distribution into COPERT III-relevant vehicle subsectors and (2) of the national mileage figures, as such. For non-road machinery stock and operational data, the uncertainty figures are given in Winther et al. (2006).

For emission factors, the uncertainties for mobile sources are determined as suggested in the IPCC and UNECE guidelines. The uncertainty figures are listed in Paragraph 3.1.3 for greenhouse gases, and in Illerup et al. (2005b) and Winther et al. (2006) for the remaining emission components.

Data Storage level 1	2.Comparability	DS.1.2.1	Comparability of the data values with similar data from other countries, which are comparable with Denmark, and evaluation of discrepancy.

Work has been carrried out to compare Danish figures with corresponding data from other countries in order to evaluate discrepancies. The comparisons have been made on a CRF level, mostly for implied emission factors (Thomsen et al., 2006).

Data Storage level 1	4.Consistency	DS.1.4.1	The origin of external data has to be preserved whenever possible without explicit arguments (referring to other PMs)

It is ensured that the original files from external data sources are archived internally at NERI. Subsequent raw data processing is carried out either in the NERI database models or in spreadsheets (data processing level 1).

Data Storage level 1	6.Robustness	DS.1.6.1	Explicit agreements between the external institution holding the data and NERI about the condition of delivery

For transport, NERI has made formal agreements with regard to external data deliverance with (Table 3.32 external data source Id's in brackets): DEA (T1), CAA-DK (T3), Danish State Railways (T9) and the Danish Road Directorate (T2). The latter agreement is currently being renegotiated due to an internal restructuring of the traffic data responsibilities in the Ministry of Transport and Energy.

Data Storage level 1	7.Transparency	DS.1.7.1	Summary of each dataset, including the reasoning for selecting the specific dataset

Please refer to DS 1.1.1. In this measurement point, the reason for external data selections in different inventory areas is given.

Data Storage level 1	7.Transparency	DS.1.7.3	References for citation for any external dataset have to be available for any single value in any dataset.

The references for external datasets are provided in the present report.

Data Storage level 1	7.Transparency	DS.1.7.4	Listing of external contacts for every dataset

The following list shows the external data source (source Id in brackets), the responsible person and contact information for each area where formal data deliverance agreements have been made.

Danish Energy Authority (T1): Anders B. Hansen (abh@ens.dk) and Peter Dal (pd@ens.dk)

Danish Road Directorate (T2): Bo Ekman (be@vd.dk)

Civil Aviation Agency of Denmark (T3): Henrik Gravesen (hgr@slv.dk)

Danish State Railways (T9): Rikke Næraa (rikken@dsb.dk)

Data Processing Level 1

Data Processing level 1	1. Accuracy	DP.1.1.1	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to type of variability. (Distribution as: normal, log normal or other type of variability)

In the mobile part of the Danish emission inventories, no uncertainty assessments are made at Data Processing Level 1, except for non-road machinery and recreational craft. For these types of mobile machinery, the stock and operational data variations are assumed to be normally distributed (Winther et al., 2006). Tier 1 uncertainty calculations produce final fuel-use uncertainties ready for Data Storage Level 2 (SNAP level 2: Inland waterways, agriculture, forestry, industry and household-gardening).

Data Processing level 1	1. Accuracy	DP.1.1.2	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to scale of variability (size of variation intervals)

For non-road machinery and recreational craft, uncertainty assessments are made by Winther et al. (2006), and the sizes of the variation intervals are given for activity data and emission factors.

Data Processing level 1	1. Accuracy	DP.1.1.3	Evaluation of the methodological approach using international guidelines

An evaluation of the methodological inventory approach has been made, which proves that the emission inventories for transport are made according to the international guidelines (Winther, 2005: Kyoto notat, in Danish). This paper will be translated into English and the conclusions will be implemented in the future national inventory reports.

Data Processing level 1	1. Accuracy	DP.1.1.4	Verification of calculation results using guideline values

It has been checked that the greenhouse gas emission factors used in the Danish inventory are within margin of the IPCC guideline values.

Data Processing level 1	2.Comparability	DP.1.2.1	The inventory calculation has to follow the international guidelines suggested by UNFCCC and IPCC.

See DP 1.1.3.

Data Processing level 1	3.Completeness	DP.1.3.1	Assessment of the most important quantitative knowledge which is lacking.

For sea-going vessels, a Danish research study will be carried out this year. A bottom-up methodology will be used (Tier 2), to disaggregate the emission contributions from fishing vessels and domestic sea transport into vessel types. For greenhouse gases, though, the emission totals are not foreseen to change substantially.

Data Processing level 1	3.Completeness	DP.1.3.2	Assessment of the most important cases where access is lacking with regard to critical data sources that could improve quantitative knowledge.

The most important area where the accessibility to critical data is lacking is road transport. More accurate national vehicle mileage data is available from the Danish Vehicle Inspection Programme; the data is not, however, disaggregated into COPERT input formats. Updated fuel-use and emission factors are also derived from the clustered EU 5th framework research projects, Particulates and ARTEMIS. The inventory work, however, still awaits the final dissemination of project results. Another important outcome of these EU research projects is an updated version of the COPERT model (version IV). Work will be made to improve the inventories by incorporating new mileage data and fuel-use and emission factors as soon as they become available.

Data Processing level 1	4.Consistency	DP.1.4.1	In order to keep consistency at a high level, an explicit description of the activities needs to accompany any change in the calculation procedure.

A log will be incorporated in the NERI transport models, explaining the model changes (input data, model principles), whenever they occur. The current explanations are included in Chapter 3.3 of the present report.

Data Processing level 1	5.Correctness	DP.1.5.1	Show at least once, by independent calculation, the correctness of every data manipulation.

During model development it has been checked that all mathematical model relations give exactly the same results as independent calculations. A list of examples with model and independent calculation results, one set for each mathematical model expression, will be made.

Data Processing level 1	5.Correctness	DP.1.5.2	Verification of calculation results using time-series
Data Processing level 1	5.Correctness	DP.1.5.3	Verification of calculation results using other measures

When NERI transport model changes are made relating to fuel use, it is checked that the calculated fuel-use sums correspond to the expected fuel-use levels in the time-series. The fuel-use check also includes a time-series comparison with fuel-use totals calculated in the previous model version. The checks are performed on a SNAP level and, if appropriate, detailed checks are made for vehicle/machinery technology splits.

As regards model changes in relation to derived emission factors (and calculated emissions), the time-series of emission factors (and emissions) are compared to previous model figures. A part of this evaluation includes an assessment, if the development corresponds to the underlying assumptions given by detailed input parameters. Among other things, the latter parameters depend on emission legislation, new technology phase-in, deterioration factors, engine operational conditions/driving modes, gasoline evaporation (hydrocarbons) and cold starts. For methodological issues, please refer to Section 3.3.2.

Data Processing level 1	5.Correctness	DP.1.5.4	Show one-to-one correctness between external data sources and the data bases at Data Storage level 2

For road transport, aviation and non-road machinery, whether all external data are correctly put into the NERI transport models is checked. This is facilitated by the use of sum queries which sum up stock data (and mileages for road transport) to input aggregation levels. However, spreadsheet or database manipulations of external data are, in some cases, included in a step prior to this check.

This is carried out in order to produce homogenous input tables for the NERI transport models (road, civil aviation, non-road machinery/recreational craft). The sub-routines perform operations, such as the aggregation/disaggregation of data into first sales year (Examples: Fleet numbers and mileage for road transport, stock numbers for tractors, harvesters, fork lifts) or simple lists of total stock per year (per machinery type for e.g. household equipment and for recreational craft). For civil aviation, additional databases control the allocation of representative aircraft to real aircraft types and the cruise distance between airports. A more formal description of the sub-routines will be made.

Regarding fuel data, it is checked for road transport and civil aviation that DEA totals (modified for road) match the input values in the NERI models. For the transport modes military, railways, national sea transport and fisheries, the DEA fuel-use figures go directly into Data Storage Level 2. This is also the case for the railway emission factors obtained from Danish State Railways and, generally, for the emission factors which are kept constant over the years.

The NERI model simulations of fuel-use and emission factors for road transport, civil aviation and non-road machinery refer to Data Processing Level 1.

Data Processing level 1	7.Transparency	DP.1.7.1	The calculation principle and equations used must be described
Data Processing level 1	7.Transparency	DP.1.7.2	The theoretical reasoning for all methods must be described
Data Processing level 1	7.Transparency	DP.1.7.3	Explicit listing of assumptions behind all methods

The NERI model calculation principles and basic equations are thoroughly described in the present report, together with the theoretical model reasoning and assumptions. Documentation is also given e.g. in Illerup et al. (2005b), Winther (2001, 2004) and Winther et al. (2006).

Data Processing level 1	7.Transparency	DP.1.7.4	Clear reference to dataset at Data Storage level 1.

In the different documentation reports for transport in the Danish emission inventories, there are explicit references for the different external data used.

Data Processing level 1	7.Transparency	DP.1.7.5	A manual log to collect information about recalculations

Recalculation changes in the emission inventories are described in the NIR and ECE reports as a standard. A manual log table in the NERI transport models to collect information about recalculations based on changes in emission factors and/or activity data will be established.

Data Storage Level 2

Data Storage level 2	5.Correctness	DS.2.5.1	Documentation of a correct connection between all data types at level 2 to data at level 1

In the various documentation reports behind the transport part of the Danish emission inventories there is a thorough documentation of the SNAP aggregated fuel use figures and emission factors, based on the original external data derived from external sources.

Data Storage level 2	5.Correctness	DS.2.5.2	Check if a correct data import to level 2 has been made.

At present, a NERI software programme imports data from prepared input data tables (SNAP fuel-use figures and emission factors) into the CollectER database. Subsequently, random tests are made in CollectER, covering each of the different input data tables, to check if the data transfer is according to plan. The intention is to make an automatic check of all imported data in Level 2, by comparing input data tables and updated data records in CollectER. Access to the latter data should be obtained from an automatic database query linking to the annual CollectER databases.

Suggested QA/QC plan for mobile sources

The following points make up the list of QA/QC tasks to be carried out directly in relation to the mobile part of the Danish emission inventories. The time plan for the individual tasks has not yet been prepared.

Data storage level 1

- Storage of external data (temperature distribution), EMEP-CORINAIR guidebook (mobile chapters).
- An elaboration of the PAH and heavy metal part of the inventory for mobile sources. Review of existing emission factors and inclusion of new sources.
- Finalisation of the data deliverance agreement for road transport.

Data processing level 1

- A log in the NERI transport models explaining model changes (input data, model principles)
- Inclusion of new Danish mileage data (source: Ministry of Transport and Energy)
- Inclusion of updated emission factors for road transport (source: ARTEMIS and Particulates)
- Documentation list of model and independent calculations to test every single mathematical relation in the NERI transport

models
- A formal description of sub-routines for external data manipulation

Data storage level 2
Development of a model that can check the correct data transfer from input tables to CollectER.

3.3.5 Recalculations

The following recalculations and improvements of the emission inventories have been made since the emission reporting in 2004.

Road transport
A revision of the 1985-2003 time-series of emissions has been made, based on revised fleet and mileage data from the Danish Road Directorate and corrections of road transport gasoline fuel use according to a new gasoline fuel-use estimate for non-road machinery. Additionally, a new model has been developed at NERI based on the COPERT methodology and emission factors. This decision was made in order to gain flexibility in output formats and to save working time during inventory update and debugging procedures.

Military
A revision of the 1985-2003 time-series of emission factors has been made based on new aggregated emission factors from road transport.

Corrections of aviation gasoline fuel use and emissions have been made for 1994.

Railways
No changes have been made.

Fishery
A complete revision of the 1985-2003 time-series of diesel fuel use and emissions has been made using amended diesel fuel consumption for small boats (inland waterways), which are subtracted from the Danish energy statistics diesel fuel use total for fishery. The latter diesel fuel results are from a specific Danish non-road research project (Winther et al., 2006).

Aviation
Small changes of 2001-2002 fuel use and emissions have been made for large aircraft, based on changes in representative aircraft groupings. For 2003, an error in jet fuel use has been corrected, thus influencing the total emission figures.

For 2002 and 2003, errors in aviation gasoline fuel use have been corrected, thus influencing the total emission figures.

Inland waterways/agriculture/forestry/household-gardening
A complete revision of the 1985-2003 time-series of fuel use and emissions has been made using results from a specific Danish non-road research project (Winther et al., 2006).

Uncertainties

The uncertainty factors for activity data have been changed to reflect specific national knowledge ((Winther et al., 2006) in the following SNAP categories: Inland waterways (a part of 1A3d: Navigation), Agriculture and Forestry (parts of 1A4c: Agriculture/forestry/fisheries), Industry (mobile part of 1A2f: Industry-other) and Residential (1A4b).

3.3.6 Planned improvements

The ongoing aspiration is to fulfil the requirements from UNECE and UNFCCC for good practice in inventory preparation for transport. A study has been completed for transport, reviewing the different issues of choices relating to methods (methods used, emission factors, activity data, completeness, time-series consistency, uncertainty assessment) reporting and documentation, and inventory quality assurance/quality control. This work and the overall priorities of NERI, taking into account emission source importance (from the Danish 2004 key source analysis), background data available and time resources, lay down the following list of improvements to be made in future.

Fisheries

Since fishing vessels are a key source of emissions, the calculation method for fisheries will be upgraded to Tier 2 based on detailed data for vessel numbers.

Emission factors

The Danish greenhouse gas emission factors will be compared with the factors suggested by IPCC.

QA/QC

Future improvements regarding this issue are dealt with in Section 3.1.4.

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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 DEA and published on their home page (DEA 2005b). A fuel correspondence list is enclosed in Annex 3.A. 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, as this approach is for the purpose of verification.

The Climate Convention reporting tables include a comparison of the national approach and the reference approach estimates. To make results comparable, the CO_2 emission from incineration of the plastic content of municipal waste is added in the reference approach. In the new CRF table format, it is no longer possible to add the CO_2 emission from combustion of the plastic part of municipal waste to the reference approach, nor is it possible to subtract fuel consumption for non-energy use of fuels. Therefore, the results will no longer be directly comparable. The results presented in this year's inventory are arrived at using the old method. From next year onwards, reporting will be changed to reflect the new CRF table format. Further consumption for non-energy purposes is subtracted in the reference approach, because non-energy use of fuels is not, as yet, included in the Danish national approach.

Three fuels are used for non-energy purposes: lube oil, bitumen and white spirit. The total consumption for non-energy purposes is relatively low – 12.2 PJ in 2004.

In 2004, the fuel consumption rates in the two approaches differ by 0.04% and the CO_2 emission differ by 0.04%. In the period 1990-2004, fuel consumption and the CO_2 emission differ by less than 1.55%. The differences are below 1% for all years except 1998.

A comparison of the national approach and the reference approach is illustrated in Figure 3.56.

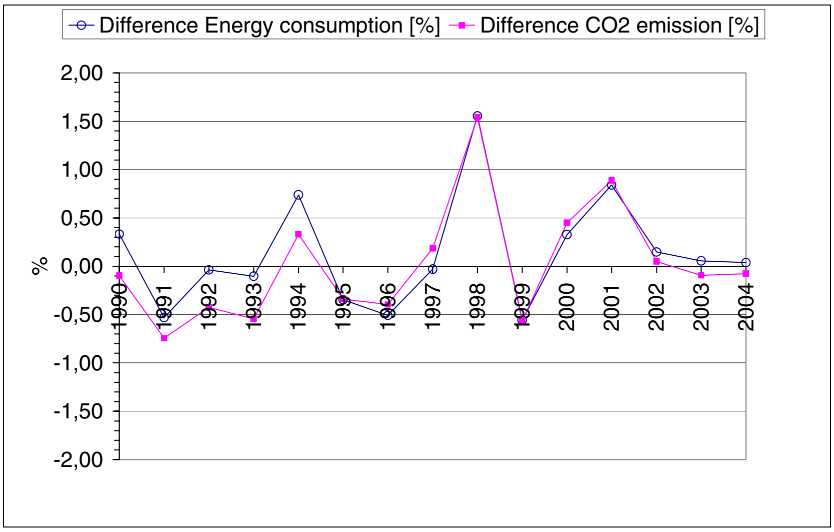

Figure 3.56 Comparison of reference approach and national approach

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 and no emissions are estimated for solid fuel.

3.5.1.2 Fugitive emissions from oil (1B2a)

The category "Fugitive emissions from oil (1B2a)" includes emissions from offshore activities and refineries.

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

In the year 2004, the length of transmission pipelines excluding offshore pipeline is 830 km. The length of distribution pipelines was 16870 km in 2004 (cast iron 0 km, steel 1660 km, plastics 15200 km). Two natural gas storage facilities are in operation in Denmark. In 2004 the gas input was 633 Mm^3 and the withdrawal was 431 Mm^3. Emission from gas storage is included in transmission.

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

Offshore flaring of natural gas is the main source of emissions in the Fugitive emission sector. Flaring in gas treatment and gas storage plants are, however, also included in the sector.

3.5.2 Methodological issues

3.5.2.1 Fugitive emissions from oil (1B2a)

Offshore activities

Emissions from offshore activities include emissions from extraction of oil and gas, onshore oil tanks, onshore and offshore loading of ships.

The total emission can then be expressed as:

$$E_{total} = E_{extraction} + E_{ship} + E_{oil\,tanks} \quad (3.5.1)$$

Fugitive emissions from extraction

According to the guidebook, the total fugitive emissions of VOC from extraction can be estimated by means of Equation 3.5.2.

$$E_{VOC,fugitive} = 40.2 \cdot N_P + 1.1 \cdot 10^{-2} P_{gas} + 8.5 \cdot 10^{-6} \cdot P_{oil} \quad (3.5.2)$$

where N_P is the number of platforms, P_{gas} (10^6 Nm^3) is the production of gas and P_{oil} (10^6 tons) is the production of oil.

It is assumed that the VOC contains 75% methane and 25% NMVOC, meaning that the total emission of CH_4 and NMVOC for extraction of oil and gas can be calculated as:

$$\begin{aligned} E_{extraction,NMVOC} &= E_{fugitive,NMVOC} + E_{flaring,NMVOC} \\ &= 0.25(40.2 \cdot N_P + 1.1 \cdot 10^{-2} P_{gas} + 8.5 \cdot 10^{-6} \cdot P_{oil}) + F_P \cdot EMF_{flaring,NMVOC} \end{aligned} \quad (3.5.3)$$

$$\begin{aligned} E_{extraction,CH4} &= E_{fugitive;CH4} + E_{flaring,CH4} \\ &= 0.75(40.2 \cdot N_P + 1.1 \cdot 10^{-2} P_{gas} + 8.5 \cdot 10^{-6} \cdot P_{oil}) + F_P \cdot EMF_{flaring,CH4} \end{aligned} \quad (3.5.4)$$

In Denmark, the venting of gas is assumed to be negligible because controlled venting enters the gas flare system.

Ships

This source includes the transfer of oil from storage tanks or directly from the well into a ship. This activity also includes losses during transport. When oil is loaded hydrocarbon vapour will be displaced by oil and new vapour will be formed, both leading to emissions. The emissions from ships are calculated by equation 3.5.5.

$$E_{ships} = EMF_{ships} \cdot L_{oil} \quad (3.5.5)$$

where EMF_{ships} is the emission factor for loading of ships off-shore and on-shore and L_{oil} is the amount of oil loaded.

Oil tanks

The emissions from storage of raw oil are calculated by equation 3.5.6.

$$E_{tanks} = EMF_{tanks} \cdot T_{oil} \quad (3.5.6)$$

where EMF_{tanks} is the emission factor for storage of raw oil in tanks.

Activity data

Activity data used in the calculations of the emissions is shown in Table 3.33 and is based on information from the Danish Energy Authority (Danish Energy Authority, 2005a and 20045) or from the green accounts from the Danish gas transmission company DONG (DONG, 2005).

Table 3.33 Activity data for 2004

Activity	Symbols	Year	
		2004	Ref.
Number of platforms	N_p	48	Danish Energy Agency (2005a)
Produced gas (10^6Nm3)	P_{gas}	10934	Danish Energy Agency (2005a)
Produced oil(10^3m3)	$P_{oil,vol}$	22614	Danish Energy Agency (2005a)
Produced oil (10^3ton)	P_{oil}	19448	Danish Energy Agency (2005a)
Oil loaded (10^3m3)	$L_{oil\ off\text{-}shore}$	4774	Danish Energy Agency (2005a)
Oil loaded (10^3ton)	$L_{oil\ off\text{-}shore}$	4106	Danish Energy Agency (2005a)
Oil loaded (10^3m3)	$L_{oil\ on\text{-}shore}$	14000	DONG (2005)
Oil loaded (10^3ton)	$L_{oil\ on\text{-}shore}$	12040	DONG (2005)

Mass weight raw oil = 0.86 ton/m^3

In the EMEP/CORINAIR Guidebook (Richardson, 1999) emission factors for different countries are given. In the Danish emission inventory the Norwegian emission factors are used (Table 3.30) (Flugsrud et al., 2000). The emissions for storage of oil are given in the green accounts from DONG for 2004 (DONG, 2005) and the emission factor is calculated on the basis of the amount of oil transported in pipeline.

Table 3.34 Emission factors.

	CH_4	NMVOC	Unit	Reference.
Ships off-shore	0.00005	0.001	Fraction of loaded	Richardson, 1999
Ships on-shore	0.000002	0.0002	Fraction of loaded	Richardson, 1999
Oil tanks	113	249	kg/10^3m^3	DONG, 2005

From the activity data in Table 3.33 and the emission factors in Table 3.34 the emissions for NMVOC and CH_4 are calculated in Table 3.35.

Table 3.35 CH_4 emissions for 2004 (tonnes):

	CH_4	NMVOC
Extraction (fugitive)	1529	509
Oil tanks	2045	4507
Offshore loading of ships	205	4106
Onshore loading of ships	24	2408
Total	**3803**	**11530**

Oil Refineries

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

Table 3.36 Oil Refineries. Processed crude oil, emissions and emission factors

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Crude oil (1000 Mg)	7263	7798	8232	8356	8910	9802	10522	7910	7906	8106	8406	8284	8045	8350	8264
CH4 emission (Mg)	37	39	42	43	57	48	62	45	45	45	50	44	43	37	613
CH4 emission factor (g/Mg)	5	5	5	5	6	5	6	6	6	6	6	5	5	4	74
NMVOC emission (Mg)	3667	3937	4203	4219	5855	4546	5875	4547	4558	4558	4983	4338	4302	3708	3732
NMVOC emission factor (g/Mg)	505	505	511	505	657	464	558	575	577	562	593	524	535	444	451

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 are based on annual environmental reports from DONG and on a Danish emission inventory for the years 1999-2003 reported by the Danish gas sector (transmission and distribution companies) (Karll 2003, Karll 2005). 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 2000-2004, emission inventories transmission, gas storage and gas treatment are registered separately and added.

Gas transmission data are shown in Table 3.37. Emissions from gas storage facilities and venting in the gas treatment plant are shown in Table 3.38. Gas distribution data are shown in Table 3.23.

Table 3.37 CH_4 emission from natural gas transmission

TRANSMISSION		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Transmission rate Mm^3	1)	2739	3496	3616	3992	4321	4689	5705	6956	6641	6795	7079	7289	7287	7275	7384
CH_4 emission Mg	2)		310	93	186	151	536	183	235	156	191	86	157	78	88	85
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	12,10	11,51

1) In 1990-1997 transmission rates refer to Danish energy statistics, in 1998 the transmission rate refers to the annual environmental report of DONG, in 1999-2003 emissions refer to DONG/Danish Gas Technology Centre (Karll 2003, Karll 2005)
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 2000-2004 the CH4 emission refers to DONG/Danish Gas Technology Centre (Karll 2003, Karll 2005)
3) IEF=Emission/transmission_rate. In 1990 the IEF is assumed to be the same as in 1991.

Table 3.38 Additional fugitive CH_4 emissions from natural gas storage facilities and venting in gas treatment plant

	2000	2001	2002	2004
Gas treatment plant	7.55 Mg	0 Mg	67 Mg	86 Mg
Gas storage facilities	76.48 Mg	72.68 Mg		

Table 3.39 CH_4 emission from natural gas distribution

DISTRIBUTION		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003)	2004
Distribution rate Mm^3	1)	1574	1814	1921	2185	2362	2758	3254	3276	3403	3297	3181	3675	3420	3420	3248
CH_4 emission Mg	2)										43	49	56	38.9	38.9	142
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	11.37	43.7

1) In 1999-2004 distribution rates refer to DONG / Danish Gas Technology Centre / Danish gas distribution companies (Karll 2005), 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 1999-2004 IEF=CH_4 emission / distribution rate. In 1990-1998 an average of the IEF in 1999-2001 is assumed.

The methane emission from the Danish gas distribution system is measured and calculated in accordance with the scheme prepared by the international working group, Marcogaz, realising the particular characteristics of the Danish distribution system.

The methane emission factor is found to be significantly lower in Denmark than in any other European country; the reason being that the distribution system in Denmark is relatively new.

In contrast to other countries with old distribution systems, partially made of cast ion pipes, the Danish Polyethylene (PE) distribution system is basically tight with minimal fugitive losses. The PE pipes, however, are vulnerable. Therefore, the methane emission in Denmark is largely caused by excavation damages, but emissions also occur in connection with construction and maintenance activities performed by the gas companies. These losses are measured or estimated by calculation in each case.

The Danish emission figures are produced by the individual gas companies and are collected, reviewed and reported by the Danish Gas Technology Centre (Karll, 2006).

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

Emissions from offshore flaring are estimated based on data for fuel consumption from the Danish energy statistics (DEA, 2004b) and emission factors for flaring. The emissions from flaring in gas treatment and gas storage plants are estimated based on the annual environmental reports of the plants.

The fuel consumption rates are shown in Table 3.40. Flaring rates in gas treatment and gas storage plants are not available until 1995.

The emission factors for offshore flaring are shown in Table 3.41. 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 1990-2004.

The time-series for the CO_2 emission from gas flaring fluctuates due to the fluctuation of offshore flaring rates as shown in Figure 3.57.

Table 3.40 Natural gas flaring rate (DEA 2004b)

Year	Flaring, offshore [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
2003	9333	33
2004	10299	25

Table 3.41 Emission factors for offshore flaring of natural gas

Pollutant	Emission factor	
CO_2	57,12	kg/GJ
CH_4	5	g/GJ
N_2O	1	g/GJ
SO_2	0,3	g/GJ
NO_x	300	g/GJ
NMVOC	3	g/GJ
CO	25	g/GJ

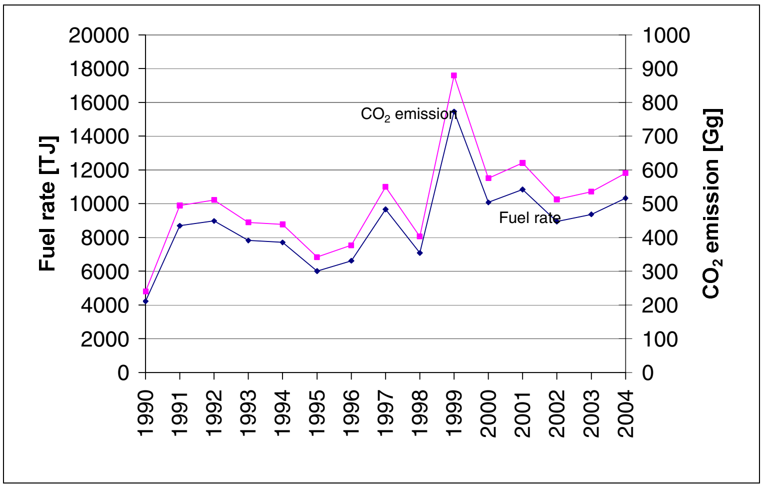

Figure 3.57 Time-series for gas flaring and the CO_2 emission in sector 1B2c ii Flaring, gas

The fuel consumption for offshore flaring was higher in 1999 due to the opening of new gas fields.

Besides 1999, consumption has been fairly stable for a number of years. The decrease from 15509 TJ in 1999 to 9333 TJ in 2003 represents a decrease of around 40%.

The natural gas produced in Denmark has low sulphur content. Therefore, no desulphurisation takes place. In 2004, the desulphurisation plant only operated for a total of 30 hours, according to the environmental report of Nybro gas treatment plant. Therefore, very little acid stripping takes place and almost all gas produced in Denmark is sweet. As a consequence no venting of CO_2 occurs.

3.5.3 Uncertainties and time-series consistency

Estimation of uncertainty is based on the Tier 1 methodology in IPCC Good Practice Guidance. The results of the uncertainty estimates are shown in Table 3.42.

Table 3.42 Uncertainty, CRF sector 1B Fugitive emissions

Pollutant	Uncertainty of emission inventory [%]	Uncertainty of emission trend [%]
CO_2	16	49
CH_4	52	54
N_2O	52	48
GHG	**15**	**43**

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

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

Table 3.43 Uncertainty of activity rates and emission factors

	Uncertainty Activity Rate	Uncertainty Emission Factor
CO_2	15	5
CH_4, oil and gas	15	50
N_2O	15	50

3.5.4 Source specific QA/QC and verification

The elaboration of a formal QA/QC plan started in 2004. A first version is now available (Sørensen et al., 2005).

The quality manual describes the concepts of quality work and definitions of sufficient quality, critical control points and a list of Points for Measuring (PMs). Please see Section 1.6 for the general description of QA/QC.

Data storage level 1

Table 3.44 List of external data sources

Dataset	Description	AD or Emf.	Reference	Contact(s)	Data agreement/ Comment
Data for offshore	Gas and oil production. Dataset for production of oil, gas and number of platforms. CRF 1B2a	Activity data	The Danish Energy Authority (DEA)	Katja Scharmann	No formal data agreement.
Environmental report from DONG	Gas and oil production. The amount of oil loaded onshore and emissions from raw oil tanks. CRF 1B2a	Activity data/emissions	DONG, 2005	Mike Robson	No formal data agreement.
Luftemissioner fra raffinaderiet (Statoil)	Fuel consumption and emission data. CRF 1B2a.	Activity data/emissions	Statoil	Anik Olesen/Dan Juul Andersen	No formal data agreement.
Shell-raffinaderiet, Fredericia, SO2 og NOx emissoner samt fuelforbrug	Fuel consumption and emission data. CRF 1B2a	Activity data/emissions	Shell	Lis Rønnow Rasmussen	No formal data agreement.
Energiproducenttællingen.xls	Energy consumption data for the refineries in Denmark. CRF 1B2a	Activity data	DEA	Anders Hansen/Peter Dal	Formal data agreement.
Environmental indicators of the gas industry	Data for natural gas transmission/distribution and storage. CRF 1B2b.	Activity data and emissions	DGC	Bent Karll/Jan K. Jensen (from 2005)	No formal data agreement.
Energy statistics	The Danish energy statistics on SNAP level. CRF 1B2c.	Activity data	DEA	Anders B. Hansen & Peter Dal	Data agreement in place
Emission factors	Emission factors stems from a large number of sources	Emission factors	See chapter regarding emission factors		

Data Storage level 1	1. Accuracy	DS.1.1.1	General level of uncertainty for every dataset including the reasoning for the specific values.

The DEA is responsible for the official Danish energy statistics as well as reporting to the IEA. NERI regards the data as being complete and in accordance with the official Danish energy statistics and IEA reporting. The uncertainties connected with estimating fuel consumption do not, therefore, influence the accordance between IEA data, the energy statistics and the dataset on SNAP level utilised by NERI. For the remaining datasets, it is assumed that the level of uncertainty is relatively small, except for the emissions from refineries. For further comments regarding uncertainties, see Chapter 3.5.3.

Data Storage level 1	1. Accuracy	DS.1.1.2	Quantification of the uncertainty level of every single data value including the reasoning for the specific values.

The uncertainty for external data is not quantified. The uncertainties of activity data and emission factors are quantified, see Chapter 3.5.3.

Data Storage level 1	2.Comparability	DS.1.2.1	Comparability of the data values with similar data from other countries, which are comparable with Denmark, and evaluation of discrepancy.

Systematic inter-country comparison has only been made on Data Storage Level 4. Refer to DS 4.3.2.

Data Storage level 1	3.Completeness	DS.1.3.1	Documentation showing that all possible national data sources are included, by setting down the reasoning behind the selection of datasets.

External data sources are the Danish Energy Authority and annual environmental reports from plants which are obligated to publish environmental reports. A summary of each dataset is not yet given.

Data Storage level 1	4.Consistency	DS.1.4.1	The origin of external data has to be preserved whenever possible without explicit arguments (referring to other PMs)

All external data are stored in the inventory file system and are accessible for all inventory staff members. Refer to Section 1.1.9.

Data Storage level 1	6.Robustness	DS.1.6.1	Explicit agreements between the external institution holding the data and NERI about the condition of delivery

Formal agreements are made with the DEA. Most of the other external data sources are available due to legal requirements in this regard. See Table. 3.44

Data Storage level 1	7.Transparency	DS.1.7.1	Summary of each dataset including the reasoning for selecting the specific dataset

See DS 1.3.1

Data Storage level 1	7.Transparency	DS.1.7.3	References for citation for any external data set have to be available for any single value in any dataset.

Refer to Table 3.44 for general references. The references are available in the inventory file system. Refer to Section 1.1.9.

Data Storage level 1	7.Transparency	DS.1.7.4	Listing of external contacts for every dataset.

Refer to Table 3.44

Data Processing Level 1

Data Processing level 1	1. Accuracy	DP.1.1.1	Uncertainty assessment for every data source as input to Data Storage Level 2 in relation to type of variability (distribution as: normal, log normal or other type of variability)

Refer to Section 1.7 in the Danish NIR and the QA/QC Section 3.5.3.

Data Processing level 1	1. Accuracy	DP.1.1.2	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to scale of variability (size of variation intervals)

The uncertainty assessment of activity data and emission factors are discussed in Section 1.7 concerning uncertainties.

Data Processing level 1	1. Accuracy	DP.1.1.3	Evaluation of the methodological approach using international guidelines

The methodological approach is consistent with international guidelines and described in Section 3.5.2.

Data Processing level 1	1. Accuracy	DP.1.1.4	Verification of calculation results using guideline values.

This PM has only been carried out for some of the sources, but will be completed for the key sources.

Data Processing level 1	2.Comparability	DP.1.2.1	The inventory calculation has to follow the international guidelines suggested by UNFCCC and IPCC.

The calculations follow the principles in international guidelines.

Data Processing level 1	3.Completeness	DP.1.3.1	Assessment of the most important quantitative knowledge which is lacking.

Regarding the emissions from refineries, more detailed data material would be preferred.

Data Processing level 1	3.Completeness	DP.1.3.2	Assessment of the most important cases where access is lacking with regard to critical data sources that could improve quantitative knowledge.

No accessibility to critical data sources is lacking.

Data Processing level 1	4.Consistency	DP.1.4.1	In order to keep consistency at a high level, an explicit description of the activities needs to accompany any change in the calculation procedure.

A change in calculating procedure would entail that an updated description would be elaborated.

Data Processing level 1	5.Correctness	DP.1.5.1	Show at least once, by independent calculation, the correctness of every data manipulation.

During data processing it is checked that calculations are performed correctly. However, documentation for this needs to be elaborated.

Data Processing level 1	5.Correctness	DP.1.5.2	Verification of calculation results using time-series.

A time-series, for activity data on SNAP level as well as emission factors is used to identify possible errors in the calculation procedure.

Data Processing level 1	5.Correctness	DP.1.5.3	Verification of calculation results using other measures.

This PM has only been carried out for some of the sources.

Data Processing level 1	5.Correctness	DP.1.5.4	Shows one-to-one correctness between external data sources and the databases at Data Storage level 2.

There is a direct line between the external datasets, the calculation process and the input data used on Data Storage level 2. During the calculation process, numerous controls are in place to ensure correctness, e.g. sum checks of the various stages in the calculation procedure.

Data Processing level 1	7.Transparency	DP.1.7.1	The calculation principle and equations used must be described.
Data Processing level 1	7.Transparency	DP.1.7.2	The theoretical reasoning for all methods must be described.
Data Processing level 1	7.Transparency	DP.1.7.3	Explicit listing of assumptions behind all methods.

Direct references to the NIR will be worked out.

Data Processing level 1	7.Transparency	DP.1.7.4	Clear reference to data set at Data Storage level 1.

References to external data sets will be worked out for all sources.

Data Processing level 1	7.Transparency	DP.1.7.5	A manual log to collect information on recalculations.

At present, a manual log table is not in place on this level. However, this feature will be implemented in the future. A manual log table is incorporated in the national emissions database, Data Storage level 2.

Data Storage level 2	5.Correctness	DS.2.5.1	Documentation of a correct connection between all data types at level 2 to data at level 1

To ensure a correct connection between data on level 2 to data on level 1, different controls are in place, e.g. control of sums and random tests.

Data Storage level 2	5.Correctness	DS.2.5.2	Check if a correct data import to level 2 has been made.

Data import is checked by use of sum control and random testing. The same procedure is applied every year in order to minimise the risk of data import errors.

Suggested QA/QC plan for fugitive emissions

A list of QA/QC tasks to be performed directly in relation to the fugitive emission part of the Danish emission inventories will be prepared in 2006, together with a time-table for the individual tasks.

3.5.5 Recalculations

3.5.5.1 Fugitive emission from solid fuels, CRF sector 1B1c

Coal mining does not occur in Denmark and no emissions are estimated for solid fuel.

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

No recalculation has been carried out since last year.

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.

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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 sources identified is presented in Table 4.1 with an indication of the contribution to the industrial part of the emission of greenhouse gases in 2004. The emissions are extracted from the CRF tables.

Table 4.1 Overview of industrial greenhouse gas sources (2004).

Process	IPCC Code	Substance	Emission kton CO2-eq.	%
Cement	2A		1539	50,31%
Refrigeration	2F	HFCs+PFCs	612	20,00%
Nitric acid	2B	N2O	531	17,34%
Foam blowing	2F	HFCs	144	4,72%
Lime and bricks	2A		110	3,59%
Limestone and dolomite use	2A		63,7	2,08%
Other (laboratories, dobble glaze windows)	2F	SF6	23,0	0,75%
Other (container glass, glass wool)	2A		13,3	0,43%
Electrical equipment	2F	SF6	10,2	0,33%
Aerosols / Metered dose inhalers	2F	HFCs	8,65	0,28%
Catalysts / fertilisers	2B		3,01	0,10%
Road paving	2A		1,76	0,06%
Asphalt roofing	2A		0,02	0,00%
Metal production	2C		0,00	0,00%
Total			3060	100,00%

The subsectors *Mineral products*, including the estimates (2A), constitutes 47%, *Chemical industry* (2B) constitutes 29%, and *Consumption of halocarbons and SF_6* (2F) constitutes 24% of the industrial emission of greenhouse gases. The total emission of greenhouse gases (excl LUCF) in Denmark is estimated to 74.01 Mt CO_2-eq., of which industrial processes contribute with 3.13 Mt CO_2-eq. (4.2%). The key sources in the industrial sector constitute 1-2% of the total emission of greenhouse gases. The trends in greenhouse gases from the industrial sector are presented in Table 4.2 and they will be discussed sector by sector below. The emissions are extracted from the CRF tables.

Table 4.2 Emission of greenhouse gases from industrial processes in different subsectors from 1990-2004.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CO_2 (Gg CO_2)															
A. Mineral Products	1072	1246	1366	1383	1406	1407	1517	1685	1682	1610	1640	1660	1696	1571	1728
B. Chemical Industry	0.8	0.8	0.8	0.8	0.8	0.8	1.45	0.87	0.56	0.58	0.65	0.83	0.55	1.05	3.01
C. Metal Production	28.4	28.4	28.4	31.0	33.5	38.6	35.2	35.0	42.2	43.0	40.7	46.7	NA,NO	NA,NO	NA,NO
CH_4															
N_2O (Gg N_2O)															
B. Chemical Industry	3.36	3.08	2.72	2.56	2.60	2.92	2.69	2.74	2.60	3.07	3.24	2.86	2.50	2.89	1.71
HFCs (Gg CO_2 eqv.)															
F. Consumption of Halocarbons and SF6				93.9	135	218	329	324	411	503	604	647	672	695	749
PFCs (Gg CO_2 eqv.)															
F. Consumption of Halocarbons and SF6					0.05	0.50	1.66	4.12	9.10	12.5	17.9	22.1	22.2	19.3	15.9
SF6 (Gg CO_2 eqv.)															
F. Consumption of Halocarbons and SF6	44.5	63.5	89.2	101	122	107	61.0	73.1	59.4	65.4	59.2	30.4	25.0	31.4	33.1

A number of improvements have been planned and are in progress, e.g. inclusion of iron foundries.

4.2 Mineral products (2A)

4.2.1 Source category description

The subsector *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)
- Limestone and dolomite use (SNAP 040618)
- Roof covering with asphalt materials (SNAP 040610)
- Road paving with asphalt (SNAP 040611)
- Production of container glass/glass wool (SNAP 040613)

Production of cement is identified as a key source; see *Annex 1: Key sources*.

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

Table 4.3 Time-series for emission of CO_2 (kt) from *Mineral products (2A).*

2A	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1 Production of Cement	882	1088	1192	1206	1192	1204	1282	1441	1452	1365	1406	1432	1452	1370	1539
2 Production of Lime and Bricks	152	118	132	129	144	132	130	139	122	126	123	119	141	112	110
3 Limestone and dolomite use	18.1	23.2	25.2	32.6	53.1	55.2	89.3	89.6	91.2	99.2	93.6	92.2	85.4	74.2	63.7
5 Asphalt roofing	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.02	0.02
6 Road paving	1.76	1.76	1.79	1.81	1.75	1.77	1.77	1.77	1.70	1.75	1.72	1.66	1.66	1.67	1.76
7 Other	17.4	15.6	14.5	14.1	14.9	14.1	13.9	14.0	15.0	18.1	15.9	16.0	16.3	13.5	13.3
Total	1072	1246	1366	1383	1406	1407	1517	1685	1682	1610	1640	1660	1696	1571	1728

The increase in CO_2 emission is most significant for the production of cement. From 1990 to 2004, the CO_2 emission increased from 882 to 1539 kt CO_2, i.e. by 75%. 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 1990-2003.

4.2.2 Methodological issues

The CO_2 emission from the production of cement has been estimated from the annual production of cement expressed as TCE (total cement equivalents[5]) and an emission factor estimated by the company (Aalborg Portland, 2005). The emission factor has been estimated from the loss of ignition determined for the different kinds of clinkers produced, combined with the volumes of grey and white cements produced. Determination of loss of ignition takes into account all the potential raw materials leading to release of CO_2 and omits the Ca-sources leading to generation of CaO in cement clinker without CO_2 release. The applied methodology is 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. However, it is the best available estimate, based on expert knowledge at the company. However, detailed information on CO_2 release is expected to be available for the next inventory due to inclusion of data supplied by the company to the EU ETS.

The CO_2 emission from the production of burnt lime (quicklime) as well as hydrated lime (slaked lime) has been estimated from the annual production figures, registered by Statistics Denmark, and emission factors. The emission factors applied are 0.785 kg CO_2/kg CaO as

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

recommended by IPCC (IPCC (1996), vol. 3, p. 2.8) and 0.541 kg CO_2/kg hydrated lime (calculated from company information on composition of hydrated lime (Faxe Kalk, 2003)).

The CO_2 emission from the production of bricks and tiles has been estimated from information on annual production registered by Statistics Denmark, corrected for amount of yellow bricks and tiles. This amount is unknown and, therefore, is assumed to be 50%. 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.

The CO_2 emission from the production of container glass/glass wool has been estimated from production statistics published in environmental reports from the producers (Rexam Holmegaard, 2005; Saint-Gobain Isover, 2005) and emission factors based on release of CO_2 from specific raw materials (stoichiometric determination).

The CO_2 emission from consumption of limestone for fluegas cleaning has been estimated from statistics on generation of gypsum (wet flue gas cleaning processes) and the stoichiometric relations between gypsum and release of CO_2:

$$SO_2\ (g) + ½O_2\ (g) + CaCO_3\ (s) + 2H_2O \rightarrow CaSO_4{,}2H_2O\ (s) + CO_2\ (g)$$

and the emission factor is: 0.2325 ton CO_2/tonne gypsum.

Statistics on the generation of gypsum from power plants are compiled by Energinet.dk. Information on the generation of gypsum at waste incineration plants does not explicitly appear in the Danish waste statistics (Miljøstyrelsen, 2005). However, the total amount of waste products generated can be found in the statistics. The amount of gypsum is calculated by using information on flue gas cleaning systems at Danish waste incineration plants (Illerup et al., 1999; Nielsen & Illerup, 2002) and waste generation from the different flue gas cleaning systems (Hjelmar & Hansen, 2002).

The CO_2 emission from the production of expanded clay products has been estimated from production statistics compiled by Statistics Denmark and an emission factor of 0.045 tonne CO_2/tonne product.

The CO_2 emission from the refining of sugar is estimated from production statistics for sugar and a number of assumptions: consumption of 0.02 tonne $CaCO_3$/tonne sugar and precipitation 90% CaO resulting in an emission factor at 0.0088 tonne CO_2/tonne sugar.

The indirect emission of CO_2 from asphalt roofing and road paving has been estimated from production statistics compiled by Statistics Denmark and default emision factors presented by IPCC/Corinair. The default emission factors, together with the calculated emission factor for CO_2, are presented in Table 4.4.

Table 4.4 Default emission factors for application of asphalt products.

		Road paving with asphalt	Use of cut-back asphalt	Asphalt roofing
CH_4	g/tonnes	5	0	0
CO	g/tonnes	75	0	10
NMVOC	g/tonnes	15	64935	80
Carbon content fraction of NMVOC	%	0.667	0.667	0.8
Indirect CO_2	kg/tonnes	0.168	159	0.250

4.2.3 Uncertainties and time-series consistency

The time-series are presented in Table 4.3. The methodology applied for the years 1990-2004 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 1990-2004. Furthermore, the activity data originates from the same company for all years.

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

The source-specific uncertainties for mineral products are presented in Section 4.7. The overall uncertainty estimate is presented in Section 1.7.

4.2.4 Verification

The estimation of CO_2 release from the production of bricks based on an assumption of 50% yellow bricks has been verified by comparing the estimate with actual information on emission of CO_2 from calcination of lime compiled by the Danish Energy Authority (DEA) (Danish Energy Authority, 2004). The information from the companies (tile-/brickworks; based on measurements of $CaCO_3$ content of raw material) has been compiled by DEA in order to allocate a CO_2 quota to Danish companies with the purpose of future reductions. The result of the comparison is presented in Figure 4.1.

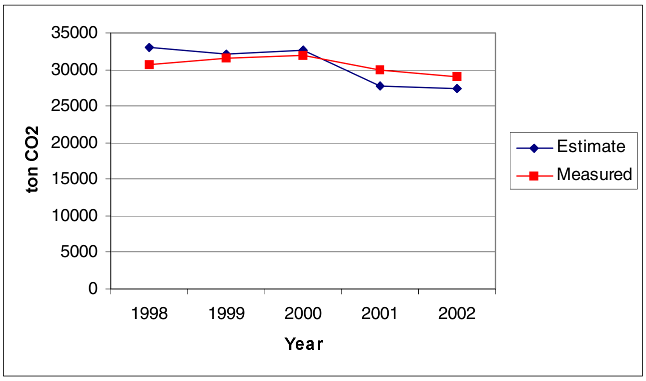

Figure 4.1 Estimated and "measured" CO_2 emission from tile-/brickworks; "measured" means information provided to the Danish Energy Authority by the individual companies (Danish Energy Authority, 2004).

Figure 4.1 shows a reasonable correlation between the estimated and measured CO_2 emission.

4.2.5 Recalculations

A number of new sources have been included, e.g. consumption of limestone and dolomite for flue gas cleaning, production of mineral wool, expanded clay products and refining of sugar as well as asphalt roofing and road paving.

4.2.6 Source-specific planned improvements

Regarding the production of cement, dialogue with the company will continue with the aim to obtain more detailed information on production statistics (i.e. production of different types of clinker) and corresponding emission factors. In addition to the dialogue with the company, information supplied by the company to EU ETS will be included.

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

4.3 Chemical industry (2B)

4.3.1 Source category description

The subsector *Chemical industry* (2B) covers the following processes:

- Production of nitric acid/fertiliser (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 4.5.

Table 4.5 Time-series for emission of greenhouse gasses from Chemical industry (kt CO_2-eq.).

2B	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
2 Nitric acid production	1043	955	844	795	807	904	834	848	807	950	1004	885	774	895	531
5 Other	0.80	0.80	0.80	0.80	0.80	0.80	1.45	0.87	0.56	0.58	0.65	0.83	0.55	1.05	3.01
Total	1044	956	844	796	807	905	836	849	807	951	1004	886	775	896	534

The emissions are extracted from the CRF tables and the values are rounded.

The emission of N_2O from nitric acid production is the most considerable source of GHG from the chemical industry. The trend for N_2O from 1990 to 2003 shows a decrease from 3.36 to 2.89 kt, i.e. -14%, and a 40% decrease from 2003 to 2004. However, the activity and the corresponding emission show considerable fluctuations in the period considered and the decrease from 2003 to 2004 can be explained by the closing of the plant in the middle of 2004.

From 1990 to 2004, the emission of CO_2 from the production of catalysts/fertilisers has increased from 0.80 to 3.01 kt, due to an increase in the activity as well as changes in raw material consumption.

4.3.2 Methodological issues

The N_2O emission from the production of nitric acid/fertiliser is based on measurement for 2002. For the previous years, the N_2O emission has been estimated from annual production statistics from the company and an emission factor of 7.5 kg N_2O/tonne nitric acid, based on the 2002 emission measured (Kemira Growhow, 2004). The production of nitric acid ceased in the middle of 2004.

The CO_2 emission from the production of catalysts/fertilisers is based on information in an environmental report from the company (Haldor Topsøe, 2005), combined with personal contacts. In the environmental report, the company has estimated the amount of CO_2 from the process and the amount from energy conversion. Based on information from the company, the emission of CO_2 has been calculated from the composition of raw materials used in the production (for the years 1990 and 1996-2004). For the years 1991-1995, the production, as well as the CO_2 emission, has been assumed to remain the same as in 1990.

4.3.3 Uncertainties and time-series consistency

The time-series are presented in Table 4.5. The applied methodology regarding N_2O is considered to be consistent. The activity data is based on information from the specific company. T he emission factor applied has been constant from 1990 to 2001 and is based on measurements in 2002. The production equipment has not been changed during the period.

The estimated CO_2 emissions are considered to be consistent as they are based on stoichiometric relations combined with company assumptions for the years 1991-1995.

The source-specific uncertainties for the chemical industry are presented in Section 4.7. The overall uncertainty estimate is presented in Section 1.7.

4.3.4 Recalculations

The emission of CO2 has been estimated from information on consumption of raw materials combined with assumptions by the company.

4.3.5 Source-specific planned improvements

No improvements are planned for this sector.

4.4 Metal production (2C)

4.4.1 Source category description

The subsector *Metal production* (2C) covers the following process:

- Steelwork (SNAP 040207)

The time-series for emission of CO_2 from *Metal production* (2C) is presented in Table 4.6. The emissions are extracted from the CRF tables and the values presented are rounded.

Table 4.6 Time-series for emission of CO_2 (kt) from *Metal production*.

2C	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1 Iron and steel production	28.4	28.4	28.4	31.0	33.5	38.6	35.2	35.0	42.2	43.0	40.7	46.7	NA,NO	NA,NO	NA,NO

From 1990 to 2001, the CO_2 emission from the electro-steelwork has increased from 28 to 47 kt, i.e. by 68%. The increase in CO_2 emission is similar to the increase in the activity as the consumption of metallurgical coke per amount of steel sheets and bars produced has almost been constant during the period. The electro-steelwork reopened in 2004/2005 and will be included in the next inventory.

4.4.2 Methodological issues

The CO_2 emission from the consumption of metallurgical coke at steelworks has been estimated from the annual production of steel sheets and steel bars combined with the consumption of metallurgical coke 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/tonne metallurgical coke) is based on values in the IPCC-guidelines (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-series (see Table 4.6) is considered to be consistent as the same methodology has been applied for the whole period. The activity, i.e. amount of steel sheets and bars produced as well as consumption of metallurgical coke, has been published in environmental reports. The emission factor (consumption of metallurgical coke 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, production stopped.

The source-specific uncertainties for the metal production are presented in Section 4.7. The overall uncertainty estimate is presented in Section 1.7.

4.4.4 Recalculations

No source-specific recalculations have been performed regarding emissions from the metal production.

4.4.5 Source-specific planned improvements

Production statistics and information on consumption of raw materials will be completed for 1990-1993. The mass balance (i.e. amounts of steel bars and steel sheets produced as well as consumption of metallurgical coke) for the steelworks will be improved/verified. The electro-steelwork is in operation again, from 2004/2005, and the source will once again be included in NIR reports in future.

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

4.5 Production of Halocarbons and SF_6 (2E)

There is no production of Halocarbons or SF_6 in Denmark.

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

4.6.1 Source category description

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

- 2C: SF_6 used in Magnesium Foundries SNAP 040304: SF_6; *see Table 4.7*
- 2F: Refrigeration SNAP 060502: HFC32, 125, 134a, 152a, 143a, PFC (C_3F_8); *see Table 4.8*
- 2F: Foam blowing SNAP 060504: HFC134a, 152a; *see Table 4.9*
- 2F: Aerosols/Metered dose inhalers SNAP 060506: HFC134a; *see Table 4.10*
- 2F: Production of electrical equipment SNAP 060507: SF_6; *see Table 4.10*
- 2F: Other processes SNAP 060508:SF_6, PFC (C_3F_8); *see Table 4.11*

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

Table 4.7 SF_6 used in magnesium foundries (t).

2C	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
SF_6 used in magnesium foundries	1.30	1.30	1.30	1.50	1.90	1.50	0.40	0.60	0.70	0.70	0.89	NO	NO	NO	NO

Table 4.8 Consumption of HFCs and PFC in refrigeration and air condition systems (t).

2F Refrigeration	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
HFC32	NE	NE	NE	NA	NA	0.11	0.84	1.77	2.72	3.77	5.75	7.33	8.44	10.1	12.0
HFC125	NE	NE	NE	NA	0.23	2.58	9.46	15.8	21.8	31.7	43.1	45.1	48.5	54.9	59.9
HFC134a	NE	NE	0.32	2.63	10.3	14.3	16.3	34.2	45.9	94.3	112	128	151	162	169
HFC152a	NE	NE	NE	NA	NA	NA	NA	0.05	0.36	0.49	0.58	0.58	0.51	0.41	0.33
HFC143a	NE	NE	NE	NA	0.22	2.43	8.65	13.7	19.3	29.1	39.6	40.1	43.2	49.0	52.8
PFC (C3F8)	NE	NE	NE	NA	0.01	0.07	0.24	0.59	1.30	1.78	2.29	2.64	2.67	2.51	2.27

Table 4.9 Consumption of HFCs in foam blowing (t).

2F Foam blowing	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
HFC32	NE	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA	3.72	NA	NA	NA
HFC125	NE	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA	3.72	NA	NA	NA
HFC134a	NE	NE	2.00	66.4	87.1	136	187	138	164	125	127	132	122	98.8	110
HFC152a	NE	NE	3.00	30.0	46.0	43.4	32.2	15.2	9.30	37.7	16.2	12.8	12.5	1.63	5.81

Table 4.10 Consumption of HFC in aerosols/metered dose inhalers (t).

2F Aerosols	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
HFC134a	NE	NE	NE	NA	NA	NA	NA	NA	0.60	8.10	12.9	9.24	7.59	7.40	6.65

Table 4.11 Consumption of SF_6 in electrical equipment (t).

2F Electrical equipment	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
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	0.37	0.40	0.43

Table 4.12 Consumption of SF6 and PFC in other processes (t).

2F Other	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
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	0.68	0.91	0.96
PFC (C3F8)	NE,NO	NE,NO	NE,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.27	0.52	0.50	0.25	NA,NO

The emission of SF_6 has been decreasing in recent years due to the fact that activities under Magnesium Foundry no longer exist and due to a decrease in the use of electric equipment. Also, a decrease in "other" occurs, which for SF_6 is used in window plate production use, laboratories and in the production of running shoes.

The emission of HFCs increased rapidly in the 1990s and, thereafter, increased more modestly due to a modest increase in the use of HFCs as a refrigerant and a decrease in foam blowing. The F-gases have been regulated in two ways since 1 March 2001. For some types of use there is a ban on use of the gases in new installations and for other types of use, taxation is in place. These regulations seem to have influenced emissions so that they now only increase modestly.

Table 4.13 quantifies an overview of the emissions of the gases in CO_2-eq. The reference is the trend table as included in the CRF table for year 2004.

Table 4.13 Time-series for emission of HFCs, PFCs and SF_6 (kt CO_2-eq.).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
HFCs	0,00	0,00	0,00	93,9	135	218	329	324	411	503	605	647	672	695	749
PFCs	0,00	0,00	0,00	0,00	0,05	0,50	1,66	4,12	9,10	12,5	17,9	22,1	22,2	19,3	15,9
SFs	44,5	63,5	89,2	101,2	122	107	61,0	73,1	59,4	65,4	59,2	30,4	25,0	31,4	33,1
Total	44,5	63,5	89,2	195	257	326	392	401	480	581	682	700	719	746	798

The decrease in the SF_6 emission has brought its emissions in CO_2-eq. down to the level of PFC. Overall, and for all uses, the most dominant group by far is HFCs. In this grouping, HFCs constitute a key source, both with regard to the key source level and trend analysis. In the level analysis, the HFC group is number 16 out of 21 key sources and contributed, in 2004, 1.2% to the national total.

4.6.2 Methodological issues

The data for emissions of HFCs, PFCs, and SF_6 has been obtained in continuation on work on inventories for previous years. The determination includes the quantification and determination of any import and export of HFCs, PFCs, and SF_6 contained in products and substances in stock form. This is in accordance with the IPCC guidelines (IPCC (1996), vol. 3, p. 2.43ff), as well as the relevant decision trees from the IPCC Good Practice Guidance (GPG, IPCC (1999) p. 3.53ff).

For the Danish inventories of F-gases, a Tier 2 bottom-up approach is basically used. As for verification using import/export data, a Tier 2 top-down approach is applied. In an annex to the F-gas inventory report 2004 (Danish Environmental Protection Agency, 2006), there is a specification of the approach applied for each sub-source category.

The following sources of information have been used:

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

Suppliers and/or producers provide consumption data of F-gases. Emission factors are primarily defaults from the GPG, which are assessed to be applicable in a national context. In case of commercial refrigerants and Mobile Air Condition (MAC), national emission factors are defined and used.

Import/export data for sub-source categories where import/export is relevant (MAC, fridge/freezers for household) are quantified on estimates from import/export statistics of products + default values of the amount of gas in the product. The estimates are transparent and described in the annex to the report referred to above.

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

- Screening of the market for products in which F-gases are used
- Determination of averages for the content of F-gases 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 lapse between consumption and emission. The actual emission includes Danish emissions from production, from products during their lifetimes and from waste products.

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

The potential emissions have been calculated as follows:

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

The substances have been accounted for in the survey according to their trade names, which are mixtures of HFCs used in the CRF, etc. In the transfer to the "pure" substances used in the CRF reporting schemes, the following ratios have been used; see Table 4.14.

Table 4.14 Content (w/w%) of "pure" HFC in HFC-mixtures, used as trade names.

HFC mixtures	HFC-32	HFC-125	HFC-134a	HFC-143a	HFC-152a	HFC-227ea
HFC-365						8%
HFC-401a					13%	
HFC-402a		60%				
HFC-404a		44%	4%	52%		
HFC-407a	23%	25%	52%			
HFC-410a	50%	50%				
HFC-507a		50%		50%		

The national inventories for F-gases are provided and documented in a yearly report (Environmental Protection Agency, 2006). Furthermore, detailed data and calculations are available and archived in an electronic version. The report contains summaries of methods used and information on sources as well as further details on methodologies.

Activity data is described in a spreadsheet for the current year.

4.6.3 Uncertainties and time-series consistency

The time-series for emission of Halocarbons and SF_6 are presented in Section 4.6.1. The time-series are consistent as regards methodology. No potential emission estimates are included as emissions in the time-series and the same emission factors are used for all years.

No appropriate measures of uncertainties have been established and no uncertainty estimates following the GPG procedures have been developed for the F-gas calculations, to date.

In general, uncertainty in inventories will arise through at least three different processes:

A. Uncertainties from definitions (e.g. incomplete, unclear, or faulty definition of an emission or uptake);
B. Uncertainties from natural variability of the process that produces an emission or uptake;

C. Uncertainties resulting from the assessment of the process or quantity depending on the method used: (i) uncertainties from measuring; (ii) uncertainties from sampling; (iii) uncertainties from reference data that may be incompletely described, and (iv) uncertainties from expert judgement.

Uncertainties due to poor definitions are not expected to be an issue in the F-gas inventory. The definitions of chemicals, the factors, sub-source categories in industries etc. are well defined.

Uncertainties from natural variability are likely to occur over the short-term while estimating emissions in individual years. But over a longer time period, 10-15 years, these variabilities level out in the total emission. This is due to that input data (consumption of F-gases) is known and is valid data, and has no natural variability due to the chemicals stabile nature.

Uncertainties that arise due to imperfect measurement and assessment are probably an issue for the:

- emission from MAC (HFC-134a)
- emission from commercial refrigerants (HFC-134a).

Due to the limited knowledge for these sources, the expert assessment of consumption of F-gases can lead to inexact values of the specific consumption of F-gases.

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

The source-specific uncertainties for consumption of halocarbons and SF_6 are presented in Section 4.7. The overall uncertainty estimate is presented in Section 1.7.

4.6.4 QA/QC and verification

4.6.4.1 Comparison of emissions estimates using different approaches

Inventory agencies should use the Tier 1 potential emissions method for a check on the Tier 2 actual emission estimates. Inventory agencies may consider developing accounting models that can reconcile potential and actual emission estimates and which may improve the determination of emission factors over time.

This comparison was carried out in 1995-1997 and, for all three years, it shows a difference of approx. factor 3 higher emission by using potential emission estimates.

Inventory agencies should compare bottom-up estimates with the top-down Tier 2 approach, since bottom-up emission factors have the highest associated uncertainty. This technique will also minimise the possibility that certain end-uses are not accounted for in the bottom-up approach.

This comparison has not been developed.

4.6.4.2 National activity data check

For the Tier 2a (bottom-up) method, inventory agencies should evaluate the QA/QC procedures associated with estimating equipment and product inventories to ensure that they meet the general procedures outlined in the QA/QC plan and that representative sampling procedures are used. This is particularly important for the ODS (Ozone Depleting Substances)-substitute subsectors because of the large populations of equipment and products.

The spreadsheets containing activity data have incorporated several data-control mechanisms, which ensure that data estimates do not contain calculation failures. A very comprehensive QC procedure on the data in the model for the whole time-series has been carried for the present submission in connection with the process which provided, (1) data for the CRF background tables 2(II).F. for the years (1993)-2002 and (2) data for potential emissions in CRF tables 2(I). This procedure consisted of a check of the input data for the model for each substance. As regards the HFCs, this checking was carried out in relation to their trade names. Conversion was made to the HFC substances used in the CRF tables, etc. A QC was that emission of the substances could be calculated and checked comparing results from the substances as trade names and as the "no-mixture" substances used in the CRF.

4.6.4.3 Emission factors check

Emission factors used for the Tier 2a (bottom-up) method should be based on country-specific studies. Inventory agencies should compare these factors with the default values. They should determine if the country-specific values are reasonable, given similarities or differences between the national source category and the source represented by the defaults. Any differences between country-specific factors and default factors should be explained and documented.

Country-specific emission factors are explained and documented for MAC and commercial refrigerants and SF_6 in electric equipment. Separate studies have been carried out and reported. For other sub-source categories, the country-specific emission factors are assessed to be the same as the IPCC default emission factors.

4.6.4.4 Emission check

As the F-gas inventory is developed and made available in full in spreadsheets, where HFCs data relate to trade names, special procedures are performed to check the full possible correctness of the transformation to the CRF-format through Access databases.

4.6.5 Recalculations

No source-specific recalculations have been performed regarding emissions of F-gases.

4.6.6 Planned improvements

It is planned to improve uncertainty estimates as well as the information on the choice of EFs and the specific approaches applied.

4.7 Uncertainty

The source-specific uncertainties for industrial processes are presented in Table 4.16. The uncertainties are based on IPCC guidelines combined with assessment of the individual processes.

The producer has delivered the activity data for production of cement as well as calculated the emission factor based on quality measurements. The uncertainties on activity data and emission factors are assumed to be 1% and 2%, respectively.

The activity data for production of lime and bricks are based on information compiled by Statistics Denmark. Due to the many producers and the variety of products, the uncertainty is assumed to be 5%. The emission factor is partly based on stoichiometric relations and partly on an assumption of the number of yellow bricks. The last assumption has been verified (see Section Table 4.16). The combined uncertainty is assumed to be 5%.

The producers of glass and glass wool have registered the consumption of - raw materials containing carbonate. The uncertainty is assumed to be 5%. The emission factors are based on stoichiometric relations and, therefore, uncertainty is assumed to be 2%.

The producers have registered the production of nitric acid during many years and, therefore, the uncertainty is assumed to be 2%. The measurement of N_2O is problematic and is only carried out for one year. Therefore, uncertainty is assumed to be 25%.

The uncertainty for the activity data as well as for the emission factor is assumed to be 5% for production of catalysts/fertilisers and iron and steel production.

The emission of F-gases is dominated by emissions from refrigeration equipment and, therefore, the uncertainties assumed for this sector will be used for all the F-gases. The IPCC propose an uncertainty at 30-40% for regional estimates. However, Danish statistics have been developed over many years and, therefore, the uncertainty on activity data is assumed to be 10%. The uncertainty on the emission factor is, on the other hand, assumed to be 50%. The base year for F-gases for Denmark is 1995.

Table 4.15 Uncertainties on activity data and emission factors as well as overall and trend uncertainties for the different greenhouse gases.

	Activity data uncertainty	Emission factor uncertainty				
	%	CO_2 %	N_2O %	HFCs[3] %	PFCs[3] %	SF_6[3] %
2A1. Production of Cement	1	2				
2A2. Production of Lime and Bricks	5	5				
2A3. Limestone and dolomite use	5	5				
2A5. Asphalt roofing	5	25				
2A6. Road paving with asphalt	5	25				
2A7. Other[1]	5	2				
2B2. Nitric acid production	2		25			
2B5. Other[2]	5	5				
2C1. Iron and Steel production	5	5				
2F. Consumption of HFC	10			50		
2F. Consumption of PFC	10				50	
2F. Consumption of SF_6	10					50
Overall uncertainty in 2003		2.039	25.08	50.99	50.99	50.99
Trend uncertainty		2.208	1.439	48.65	447.7	4.466

1. Production of container glass and glass wool.
2. Production of catalysts/fertilisers.
3. The base year for F-gases is for Denmark 1995.

4.8 Quality assurance/quality control (QA/QC)

The approach used for quality assurance/quality control (QA/QC) is presented in Chapter 1.6. The present chapter presents QA/QC considereations for industrial processes based on a series of Points of Measuring (PMs); see Section 1.6.

Data Storage level 1	1. Accuracy	DS.1.1.1	General level of uncertainty for every dataset including the reasoning for the specific values.

The uncertainty assessment has been performend on Tier 1 level by using default uncertainty factors. The applied uncertainty factors are presented in Table 4.16.

Data Storage level 1	1. Accuracy	DS.1.1.2	Quantification of the uncertainty level of every single data value including the reasoning for the specific values.

See DS.1.1.1. As Tier 1 and default uncertainty factors are applied, the individual datasets have not been assessed.

Data Storage level 1	2.Comparability	DS.1.2.1	Comparability of the data values with similar data from other countries, which are comparable with Denmark, and evaluation of discrepancy.

Comparability of the data has not been performend at "Data Storage level 1". However, investigation of comparability at CRF level is in progress.

The applied data sets are presented in Table 4.16.

Data Storage level 1	3.Complete ness	DS.1.3.1	Documentation showing that all possible national data sources are included setting down the reasoning behind the selection of datasets.

Table 4.16 Applied data sets

File or folder name	Description	AD or E	Reference	Contact(s)	Comment
Danisco_assens_dk_2005.pdf		AD	www.danisco.dk www.cvr.dk		AD used for estimation of production at three different locations 1990-1995.
Danisco_nakskov_dk_2005.pdf		AD	www.danisco.dk www.cvr.dk		AD used for estimation of production at three different locations 1990-1995.
Danisco_nykobing_dk_2005.pdf		AD	www.danisco.dk www.cvr.dk		AD used for estimation of production at three different locations 1990-1995.
Faxe_Kalk-brandt_kalk.pdf	Chemical composition of product.		www.faxekalk.dk		
Faxe_Kalk-hydratkalk_191103.pdf	Chemical composition of product.		www.faxekalk.dk		
Haldor Topsoe gr2004.pdf		AD, E	www.cvr.dk		
Kemira GR2003.pdf		AD, E	www.kemira-growhow.com		
Rexam Glas Holmegaard gr2004.pdf		E	www.cvr.dk		
Rockwool mr2004 I.pdf Rockwool mr2004 II.pdf		AD	www.cvr.dk		
Saint Gobain – Miljøredegørelse 2004 verificeret udgave.pdf		AD,E	Saint-Gobain Isover www.isover.dk	Anette Åkesson	
Stålvalseværket (2002) – paper version.		AD, E	Stålvalseværket		
Aalborg Portland miljoredegorelse_2004.pdf		AD, E	www.aalborg-portland.dk		
Haldor Topsoe 1990.xls		E	Haldor Topsøe	Alan Willumsen	
Haldor Topsoe - emissioner 1996 - 2004.xls		E	Haldor Topsøe	Alan Willumsen	
Aalborg Portland energy 2000-2004 answer.xls		AD	Aalborg Portland	Henrik Møller Thomsen	
DS produktion af aluminium I.xls		AD	Danmarks Statistik; www.statistikbanken.dk		
DS produktion af klinker + letbeton.xls		AD	Danmarks Statistik; www.statistikbanken.dk		
DS produktion af sukker.xls		AD	Danmarks Statistik; www.statistikbanken.dk		
DS produktion af øl.xls		AD	Danmarks Statistik; www.statistikbanken.dk		

The data sources - in general - can be grouped as follows:

- Company specific environmental reports
- Personal communication with individual companies
- Company-specific information compiled by Danish Energy Authority in relation to the EU-ETS
- Industrial organisations
- Statistics Denmark
- Secondary literature
- IPCC guidelines

The environmental reports contribute with company-specific emission factors, technical information and, in some cases, activity data. The environmental reports are primarily used for large companies and, for some companies, are supplemented with information from personal contacts, especially for completion of the time-series for the years before the legal requirement to prepare environmental reports (i.e. prior to 1996).

Statistics Denmark is used as source for activity data as they are able to provide consistent data for the period 1990-2004. In the cases where the statistics do not contain transparent data, statistics from industrial organisations are used to generate to required activity data.

For many of the processes, the default emission factors are based on chemical equations and are, therefore, the best choice. In some cases, the default EF has been modified in order to reflect local conditions.

Secondary literature may be used in the interpretation or in disaggregation of the public statistics.

Data Storage level 1	4.Consistency	DS.1.4.1	The origin of external data has to be preserved whenever possible without explicit arguments (referring to other PMs).

See DS.1.4.1. Consistency is secured by aplication of the same data source over the period in question, e.g. activity data from Statistics Denmark, or by using personal contacts in the individual companies to obtain activity data for the period when environmental reports were not mandatory. For some activities, statistics compiled by industrial organisations were applied.

Data Storage level 1	6.Robustness	DS.1.6.1	Explicit agreements between the external institution holding the data and NERI about the condition of delivery.

An agreement regarding inclusion of information - compiled by Danish Energy Authority for EU-ETS - in the Danish GHG-inventory has been signed. The data reported to DEA for the year 2005 will be available for the next GHG-inventory.

Data Storage level 1	7.Transparency	DS.1.7.1	Summary of each dataset including the reasoning for selecting the specific dataset.

The datasets applied are presented in Table 4.16. For the reasoning behind their selection, see DS.1.3.1.

Data Storage level 1	7.Transparency	DS.1.7.3	References for citation for any external dataset have to be available for any single value in any dataset.

The data applied, including references for citation, are presented in Table 4.16.

Data Storage level 1	7.Transparency	DS.1.7.4	Listing of external contacts for every dataset.

The applied data including external contacts are presented in Table 4.16.

Data Processing level 1	1. Accuracy	DP.1.1.1	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to type of variability (distribution as: normal, log normal or other type of variability).

The uncertainty assessment has been performed on Tier 1 level, assuming a normal distribution of activity data as well as emision data, by application of default uncertainty factors. Therefore, no considerations regarding distribution or type of variability have been performed.

Data Processing level 1	1. Accuracy	DP.1.1.2	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to scale of variability (size of variation intervals).

See DP.1.1.2.

Data Processing level 1	1. Accuracy	DP.1.1.3	Evaluation of the methodological approach using international guidelines.

The applied methodologies are in line with the internation guidelines issued by the IPCC combined with national adjustments. The degree of fulfilment of the required methodology has been documented in an internal note (Kyoto note).

Data Processing level 1	1. Accuracy	DP.1.1.4	Verification of calculation results using guideline values.

The emission factors applied are mostly based on chemical equations and are, therefore, in accordance with the default EFs. E.g. for production of nitric acid, where the emission factor is dependent on process conditions, a comparison has been made to the default EF listed in the guideline. E.g. for the deviation of the emission factor for calcination in the cement process, an explanation has been developed in cooperation with the company.

Data Processing level 1	2.Comparability	DP.1.2.1	The inventory calculation has to follow the international guidelines suggested by UNFCCC and IPCC.

See DP.1.1.3

Data Processing level 1	3.Completeness	DP.1.3.1	Assessment of the most important quantitative knowledge which is which is lacking.

This issue will be investigated further.

Data Processing level 1	3.Completeness	DP.1.3.2	Assessment of the most important cases where access is lacking with regard to critical data sources that could improve quantitative knowledge.

Accessibility to critical company-specific information will be established as a consequence of the formal agreement with the Danish Energy Authority concerning data compiled in relation to the EU-ETS.

Data Processing level 1	4.Consistency	DP.1.4.1	In order to keep consistency at a high level, an explicit description of the activities needs to accompany any change in the calculation procedure.

Recalculations are described in the NIR. A manual log is included in the tool used for data processing at Data Processing level 2. This log also includes changes on Data Processing level 1.

Data Processing level 1	5.Correctness	DP.1.5.1	Show at least once, by independent calculation, the correctness of every data manipulation.

The sector report for industry (in prep.) presents an independent example of the calculations to ensure the correctness of every data manipulation.

Data Processing level 1	5.Correctness	DP.1.5.2	Verification of calculation results using time-series.

The calculations are verified by checking the time-series.

Data Processing level 1	5.Correctness	DP.1.5.3	Verification of calculation results using other measures.

A methodology to verify calculation of results using other measures will be developed.

Data Processing level 1	5.Correctness	DP.1.5.4	Shows one-to-one correctness between external data sources and the databases at Data Storage level 2.

A methodology to check the correctness between external data sources and the databases at storage level 2 will be developed.

Data Processing level 1	7.Transparency	DP.1.7.1	The calculation principle and equations used must be described.

The calculation principles and equations are based on the methodology presented by the IPCC. A detailed description can be found in the sector report for industry (in prep.).

Data Processing level 1	7.Transparency	DP.1.7.2	The theoretical reasoning for all methods must be described.

The theoretical reasoning for choice or development of methods is described in detail in the sector report for industry (in prep.).

Data Processing level 1	7.Transparency	DP.1.7.3	Explicit listing of assumptions behind all methods.

The assumptions used in the different methods are described in the sector report for industry (in prep.) and also included in the present report. An explicit list of assumptions will be developed in the coming sector report.

Data Processing level 1	7.Transparency	DP.1.7.4	Clear reference to data set at Data Storage level 1.

Explicit references from the data processing to each dataset can be found in the sector report for industry (in prep.).

Data Processing level 1	7.Transparency	DP.1.7.5	A manual log to collect information about recalculations.

A manual log is included in the tool used for data processing at data level 2. This log also includes changes on Data Processing level 2. A detailed log will be developed in the sector report for industry (in prep.).

Data Processing level 2	5.Correctness	DS.2.5.1	Documentation of a correct connection between all data types at level 2 to data at level 1.

The sector report for industry (in prep.) presents the connection between the datasets on Data Storage level 1 and Data Processing level 2. Individual calculations are used to check the output of the data processing tool used at Data Processing level 2.

Data Processing level 2	5.Correctness	DS.2.5.2	Check if a correct data import to level 2 has been made.

See DS.2.5.2.

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5 Solvents and other product use (CRF Sector 3)

5.1 Overview of the sector

Use of solvents and other organic compounds in industrial processes and households are important sources of evaporation of non-methane volatile hydrocarbons (NMVOC), and are related to the source categories, Paint application (CRF sector 3A), Degreasing and dry cleaning (CRF sector 3B), Chemical products, manufacture and processing (CRF sector 3C) and Other (CRF sector 3D). In this section, a new methodology for the Danish NMVOC emission inventory is presented and the results for the period 1995 – 2004 are summarised. The method is based on a chemical approach and this implies that the SNAP category system is not directly applicable. Instead, emissions will be related to specific chemicals, products, industrial sectors and households and to the CRF sectors mentioned above.

5.2 Paint application (CRF Sector 3A), Degreasing and dry cleaning (CRF Sector 3B), Chemical products, Manufacture and processing (CRF Sector 3C) and Other (CRF Sector 3D)

5.2.1 Source category description

Table 5.1 and Figure 5.1 show the emissions of chemicals from 1985 to 2004, where the used amounts of single chemicals have been assigned to specific products and CRF sectors. The methodological approach for finding emissions in the period 1995 - 2004 is described in the following section. A linear extrapolation is made for the period 1985 – 1995. A general decrease is seen throughout the sectors. Table 5.2 shows the amounts of chemicals used for the same period. Table 5.1 is derived from Table 5.2 by applying emission factors relevant to individual chemicals and production or use activities. Table 5.3, showing the amount of products used, is derived from Table 5.2, by assessing the chemical content comprised within products belonging to each of the four source categories. As a first approach, the conversion factors are very rough estimates and more thorough investigations are needed in order to quantify the amount of products used more accurately.

In Table 5.4, the emission for 2004 is split according individual chemicals. Propane and butane are main contributors and can be attributed to propellants in spraying cans. Turpentine is defined as a mixture of stoddard solvent and solvent naphtha. For each chemical the emission factors are based on rough estimates from SFT (1994). High emission factors are assumed for use of chemicals (products) and lower factors for industrial production processes.

Table 5.1 Emission of chemicals in Gg pr year

Total emissions Gg pr year	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985
Paint application (3A)	6.6	6.1	5.6	5.8	6.5	6.4	6.7	8.4	7.2	6.3	7.2	7.4	7.5	7.6	7.8	7.9	8.0	8.1	8.3	8.4
Degreasing and dry cleaning (3B)	8.7	9.1	9.8	11.0	11.8	10.7	11.6	11.8	12.9	12.1	13.1	13.5	14.0	14.4	14.8	15.2	15.6	16.0	16.5	16.9
Chemical products, manufacturing and processing (3C)	0.74	0.65	0.78	0.75	0.80	0.78	0.74	0.80	0.79	0.79	0.84	0.85	0.86	0.87	0.88	0.89	0.90	0.91	0.91	0.92
Other (3D)	20.3	18.6	18.0	18.8	19.3	19.3	19.3	19.7	20.0	20.4	20.0	20.1	20.3	20.4	20.5	20.6	20.7	20.9	21.0	21.1
Total NMVOC	36.4	34.4	34.1	36.1	38.4	37.1	38.3	40.8	40.8	39.6	41.4	42.1	42.7	43.4	44.1	44.8	45.4	46.1	46.8	47.5
Total CO_2 [a]	113	107	106	113	120	116	119	127	127	123	129	131	133	135	137	140	142	144	146	148

[a] 0.85*3.67*total NMVOC

Table 5.2 Used amounts of chemicals in Gg pr year

Used amounts of chemical Gg pr year	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985
Paint application (3A)	26.4	17.4	17.4	17.7	19.8	18.5	25.0	57.3	22.9	20.1	131	137	143	149	155	161	167	173	179	185
Degreasing and dry cleaning (3B)	42.3	39.2	42.3	41.7	45.5	42.8	45.3	49.5	49.0	47.6	58.7	59.9	61.2	62.4	63.6	64.9	66.1	67.3	68.6	69.8
Chemical products, manufacturing and processing (3C)	76.5	67.3	80.1	76.8	82.7	79.7	75.8	82.1	80.8	80.8	71.6	72.9	74.2	75.5	76.8	78.1	79.4	80.7	82.1	83.4
Other (3D)	87.1	72.9	69.6	71.8	71.9	70.0	65.3	73.2	64.2	65.6	96.2	97.9	99.5	101	102	104	106	108	109	111
Total NMVOC	249	206	209	208	220	211	211	262	217	214	357	367	378	388	398	408	419	429	439	449

Table 5.3 Used amounts of products in Gg pr year

Amounts of products Gg pr year	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985
Paint application (3A)	176	116	116	118	132	123	167	382	153	134	207	215	223	231	240	248	256	264	272	280
Degreasing and dry cleaning (3B)	85	78	85	83	91	86	91	99	98	95	100	102	104	106	108	109	111	113	115	117
Chemical products, manufacturing and processing (3C)	382	336	401	384	414	398	379	411	404	404	414	418	422	427	431	435	439	443	447	452
Other (3D)	435	365	348	359	359	350	326	366	321	328	313	305	297	290	282	274	266	258	251	243
Total products	1078	895	949	944	996	957	962	1258	976	961	1034	1040	1047	1053	1060	1066	1073	1079	1086	1092

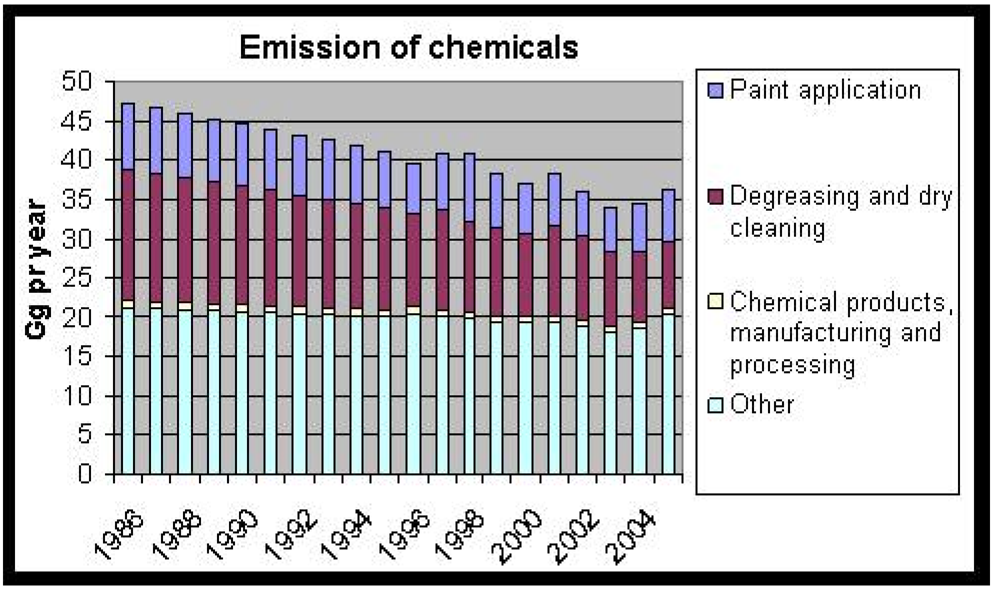

Figure 5.1 Emissions of chemicals in Gg per year. The methodological approach for finding emissions in the period 1995 – 2004 is described in the text and a linear extrapolation is made for 1985 – 1995. The underlying figures can be seen in Table 5.1.

Table 5.4 Chemicals with highest emissions 2004

Chemical	Emissions 2004 (kg)	Emission factors (mainly estimated from SFT, 1994) (%)	
		Use	Production and processing
turpentine (stoddard solvent & solvent naphtha)	7025459	50	1
propane	5000000	100	1
butane	5000000	100	1
glycerol	3247520	20	1
aminooxygengroups	2828243	50	1
ethanol	1944095	15	1
acetone	1673282	90	1
formaldehyde	1633580	10	1
methanol	1577863	5	1
propylalcohol	1529555	90	1
pentane	1454658	33	1
phenol	655127	25	1
naphthalene	562551	5	1
ethandiol	530415	25	1
etheralcoholes	506051	60	1
monobutylether	287473	95	1
cyanates	275260	50	1
propylenglycol	240819	10	1
tetrachloroethylene	235951	80	1
butanone	232855	80	1
1-butanol	229984	25	1
xylene	209444	5	1
toluendiisocyanate	183936	5	1
acyclic monoamines	86368	50	1
toluene	81633	5	1
dioctylphthalate	66625	5	1
butanoles	37827	25	1
diethylenglycol	15724	25	1
triethylamine	12916	50	1
methylbromide	6375	80	1
diamines	469	80	1

5.2.2 Methodological issues

The emissions of Non-Methane Volatile Organic Compounds (NMVOC) from industrial, production process and household use in Denmark have been assessed. Until 2002, the NMVOC inventory in Denmark was 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 emitted as a consequence of use. Mass balances are simple and functional methods for calculating the use and emissions of chemicals

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

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

where "hold up" is the difference in the amount in stock at 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 chemical emitted 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 5.2.

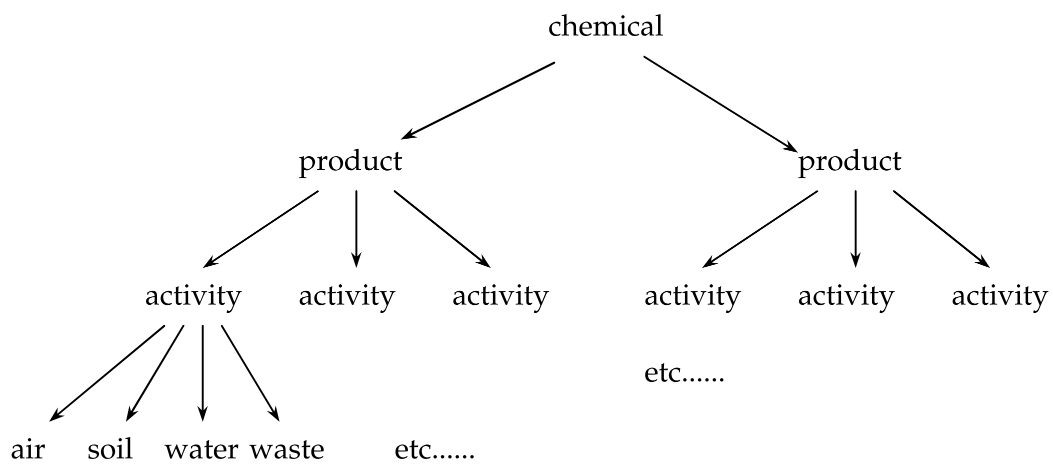

Figure 5.2 Methodological flow in a chemical-based emission inventory.

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 is 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 number 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", cf. Annex 3.F, 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. It is important to be aware that some chemicals are comprised in products and will not be found as separate chemicals in databases, e.g. di-ethylhexyl-phthalate (DEHP), which is the predominant softener in PVC. In order to include these chemicals, the product use must be found and the amount of chemical in the product must be estimated. It is important to distinguish between the amount of chemical that enters the mass balance as pure chemical and the amount that is associated with a product, in order not to overestimate the use.

Production, import and export figures are extracted from Statistics Denmark, from which a list of 427 single chemicals, plus a few groups and products is generated. For each of these, a *use* amount in tonnes per year (from 1995 to 2004) is calculated. It is found that 44 different NMVOCs comprise over 95% of the total use, and it is these 44 chemicals that are investigated further.

In the Nordic SPIN database (Substances in Preparations in Nordic Countries), information for industrial use categories and products specified for individual chemicals, according to the NACE coding system, is available. This information is used to distribute the *use* amounts of individual chemicals to specific products and activities. The product amounts are then distributed to the CRF sectors 3A – 3D.

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. Emission factors can be related to production processes and to use. In production processes, the emissions of solvents are typically low and in use it is often the case that the entire fraction of chemical in the product will be emitted to the atmosphere. Each chemical will, therefore, be associated with two emission factors, one for production processes and one for use.

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
- yearly trend in NMVOC emissions, expressed as total NMVOC and single chemical, and specified in industrial sectors and households.

5.2.3 Uncertainties and time-series consistency

Estimation of uncertainty is based on the Tier 1 methodology in IPCC Good Practice Guidance. Input to the uncertainty estimates are shown in Table 5.5.

Important uncertainty issues related to the new approach are:

(i) Identification of chemicals that qualify as NMVOCs. The definition is vague and no approved list of agreed NMVOCs is available. Although a tentative list of 650 chemicals from the "National Atmospheric Emission Inventory" has been used, it is possible that relevant chemicals are not included.

(ii) Collection of data for quantifying production, import and export of single chemicals and products where the chemicals are comprised. For some chemicals no data are available in Statistics Denmark. This can be due to confidentiality or that the amount of chemicals must be derived from products in which they are comprised. For other chemicals, the amount is the sum of the single chemicals *and* product(s) where they are included. The data available in Statistics Denmark is obtained from the Danish Customs & Tax Authorities and they have not been verified in this assessment.

(iii) Distribution of chemicals on products, activities, sectors and households. The present approach is based on amounts of single chemicals. To differentiate the amounts into industrial sectors, it is necessary to identify and quantify the associated products and activities and assign these to the industrial sectors and households. No direct link is available between the amounts of chemicals and products or activities. From the Nordic SPIN database, it is possible to make a relative quantification of products and activities used in industry and, combined with estimates and expert judgement, these products and activities are differentiated into sectors. The contribution from households is also based on estimates. If the household contribution is set too low, the emission from industrial sectors will be too high and vice versa. This is due to the fact that the total amount of chemical is constant. A change in the distribution of chemicals between industrial sectors and households will, however, affect the total emissions, as different emission factors are applied in industry and households, respectively.

A number of activities are assigned as "other", i.e. activities that can not be related to the comprised source categories. This assignment is based on expert judgement, but it is possible that the assigned amount of chemicals may more correctly be included in other sectors.

More detailed information from the industrial sectors is still required.

(iv) In this first version of the NMVOC emission inventory, rough estimates and assumed emission factors are used. These are defined for the individual chemicals, where a more appropriate approach, in some cases, could be to define emission factors for sector-specific activities.

A quantitative measure of uncertainty has not been assessed within this first inventory. Single values have been used for emission factors and activity distribution ratios, etc. and, to be able to perform a stochastic evaluation, more information is needed.

Table 5.5 Emission uncertainties for solvents (NMVOCs). Only combined uncertainties are applied as uncertainties are not differentiated into activity data and emission factors in the Emission Inventory Guidebook. Furthermore uncertainties are only stated for the total emissions. This uncertainty is distributed equally on activity data and emission factors.

Source Activity	SNAP code	Activity	Base year emission	2004 emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty
			Input data (Mg)	Input data (Mg)	Input data (%)	Input data (%)	(%)
Paint application	60101 60102 60103 60104 60105 60106 60107 60108 60109	Manufacture of Automobiles Car Repairing Construction and Buildings Domestic Use Coil Coating Boat Building Wood Other Industrial Paint Application Other Non-Industrial Paint Application	7751	6627	NE	NE	NE
Degreasing and dry cleaning	60201 60202 60203 60204	Metal Degreasing Dry Cleaning Electronic Components Manufacturing Other Industrial Dry Cleaning	14792	8742	NE	NE	NE
Chemical products, manufacturing and processing	60301 60302 60303 60304 60305 60306 60307 60308 60309 60310 60311 60312 60313 60314	Polyester Processing Polyvinylchloride Processing Polyurethane Foam Processing Polystyrene Foam Processing Rubber Processing Pharmaceutical Products Manufacturing Paints Manufacturing Inks Manufacturing Glues Manufacturing Asphalt Blowing Adhesive, Magnetic Tapes, Film and Photographs Manufacturing Textile Finishing Leather Tanning Other	878	740	NE	NE	NE
Other	60401 60402 60403 60404 60405 60406 60407 60408 60409 60411 60412	Glass Wool Enduction Mineral Wool Enduction Printing Industry Fat, Edible and Non-Edible Oil Extraction Application of Glues and Adhesives Preservation of Wood Underseal Treatment and Consevation of Vehicles Domestic Solvent Use (Other Than Paint Application) Vehicles Dewaxing Domestic Use of Pharmaceutical Products Other(Preservation of Seeds, ...)	20504	20301	NE	NE	NE
total	60000	Solvent and Other Product Use	44086	36409	46	46	65

NE: Not estimated

5.2.4 QA/QC and verification

Table 5.6 External and internal data

File or folder name	Description	AD or Emf.	Reference	Contact(s)	Data agreement/ Comment
"Emissioner NMVOC" folder	Production, import and export data from Statistics Denmark	Activity data	Statistics Denmark	Patrik Fauser	
NMVOC emissions.xls	Calculations, emissionfactors, SPIN data. For industrial branches	Activity data and emission-factors	Statistics Denmark, SPIN, reports, personal communication	Patrik Fauser	
Use Category National.xls	Calculations, emissionfactors, SPIN data. For CRF	Activity data and emission-factors	Statistics Denmark, SPIN, reports, personal communication	Patrik Fauser	

The QA/QC procedure is outlined in Section 1.6. In general, Critical Control Points (CCP) have been defined as elements or actions which need to be addressed in order to fulfil the quality objectives. The CCPs have to be based on clear measurable factors, expressed through a number of Points for Measuring (PM). In Section 1.6, the list of PMs are listed.

Data Storage level 1	1. Accuracy	DS.1.1.1	General level of uncertainty for every dataset, including the reasoning for the specific values.

The sources of data described in the methodology section and in DS.1.2.1 and DS.1.3.1 are used in this inventory. It is the accuracy of these data that defines the uncertainty of the inventory calculations. Any data value obtained from Statistics Denmark and SPIN is given as a single point estimate and no probability range or uncertainty is associated with this value. The emission factors stated in the Norwegian solvent inventory are rough estimates, given either as single values or as ranges, for groups of chemicals. Information from reports is sometimes given in ranges.

Data Storage level 1	1. Accuracy	DS.1.1.2	Quantification of the uncertainty level of every single data value, including the reasoning for the specific values.

No uncertainty levels are quantified for the external data.

Data Storage level 1	2. Comparability	DS.1.2.1	Comparability of the data values with similar data from other countries, which are comparable with Denmark, and evaluation of the discrepancy.

1) Production and import/export data from Statistics Denmark for single chemicals can be directly compared with data from Eurostat for other countries. This has been carried out for a few chosen chemicals and countries. Furthermore, selected Danish data from Eurostat have been validated with data from Statistics Denmark in order to check the consistency in data transfer from national to international databases.

2) Use categories for chemicals in products are found from Nordic SPIN database. Data for all Nordic countries are available and reported uniformly. For selected chemicals, a comparison of chemical amounts and use has been made between countries.

3) The Norwegian solvent inventory has been used for input on methodological issues and for estimates on emission factors. The methodology has been adjusted for Danish conditions, while many emission factors are identical to the emission factors suggested in the Norwegian inventory.

Data Storage level 1	3.Completeness	DS.1.3.1	Documentation showing that all possible national data sources are included, by setting down the reasoning behind the selection of datasets.

A number of external date sources form the basis for calculating emissions of single chemicals. The general methodology in the emission inventory is described above.

1) *Statistics Denmark.* Statistics Denmark is used as provider of the main database for collecting data on production, import and export of single chemicals, chemical groups and certain products. In order to obtain a uniform and unique set of data, it is crucial that the data for e.g. production of single chemicals is in the same reporting format and from the same source. The amount of data is very comprehensive and is linked with the data present in Eurostat. The database covers all sectors and is regarded as complete on a national level.

2) *Nordic SPIN database (Substances in Preparations in Nordic Countries).* SPIN provides data on the use of chemical substances in Norway, Sweden, Denmark and Finland . It is financed by the Nordic Council of Ministers, Chemical Group and the data is supplied by the product registries of the contributing countries. The Danish product register (PROBAS) is a joint register for the Danish Working Environment Authority and the Danish EPA and comprises a large number of chemicals and products. The information is obtained from registration, according to the Danish EPA rules, and from scientific studies and surveys and other relevant sources. The product register is the most comprehensive collection of chemical data in products for Denmark and the availability of data from the other Nordic countries enables an inter-country comparison. For each chemical the data is reported in a uniform way, which enhances comparability, transparency and consistency.

3) *Reports and personal contacts from industrial branches*. It is fundamental to have information from the industrial branches that have direct contact with the activities, i.e. chemicals and products of interest. The information can be in the form of personal communication, but also reported surveys are of great importance. In contrast to the more generic approach of collecting information from large databases, the expert information from industrial branches may give valuable information on specific chemicals and/or products. By considering both sources, a verification, and optimum reliability and accuracy is obtained. The propane and butane use, as described above, is a good example of the importance of industrial branch information.

4) The present inventory procedure builds partly on information from the previous Danish solvent emission inventory, which is based on questionnaires to industrial branches. Furthermore, the Norwegian solvent inventory has been used for input on methodological issues and for estimates on emission factors.

Data Storage level 1	4.Consistency	DS.1.4.1	The origin of external data has to be preserved whenever possible without explicit arguments (referring to other PMs)

Data are predominantly extracted from the internet (Statistics Denmark and SPIN). These are saved as original copies in their original form, cf. Table 5.6. Specific information from industries and experts are saved as e-mails and reports.

Data Storage level 1	6.Robustness	DS.1.6.1	Explicit agreements between the external institution holding the data and NERI about the conditions of delivery.

As stated in DS.1.4.1, most data is obtained from the internet. No explicit agreements have been made with external institutions.

Data Storage level 1	7.Transparency	DS.1.7.1	Summary of each dataset including the reasoning for selecting the specific dataset.

See DS.1.3.1.

Data Storage level 1	7.Transparency	DS.1.7.3	References for citation for any external dataset have to be available for any single figure in any dataset.

See Table 5.6.

Data Storage level 1	7.Transparency	DS.1.7.4	Listing of external contacts to every dataset.

See Table 5.6.

Data Processing level 1	1. Accuracy	DP.1.1.1	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to type of variability. (Distribution as: normal, log normal or other type of variability)

Tier 1 assumes normal distribution of activity data and emission factors.

Data Processing level 1	1. Accuracy	DP.1.1.2	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to scale of variability (size of variation intervals)

In the Emission Inventory Guidebook uncertainty estimates for the final emission calculations are given for the associated SNAP codes. These codes and uncertainty estimates are shown in Table 5.5.

Data Processing level 1	1. Accuracy	DP.1.1.3	Evaluation of the methodological approach using international guidelines

The methodological approach described in Section 5.2.3 is based on the detailed methodology as outlined in the Emission Inventory Guidebook.

Data Processing level 1	1. Accuracy	DP.1.1.4	Verification of calculation results using guideline values

No guideline values are stated for Denmark in the Emission Inventory Guidebook.

Data Processing level 1	2.Comparability	DP.1.2.1	The inventory calculation has to follow the international guidelines suggested by UNFCCC and IPCC.

See DP.1.1.3 and DS.1.3.1.

Data Processing level 1	3.Completeness	DP.1.3.1	Assessment of the most important quantitative knowledge which is lacking.

In "Uncertainties and time-series consistency", Section 5.2.4, important uncertainty issues related to a lack of quantitative knowledge which is stated. To summarise: (i) Identification and inclusion of all relevant chemicals, (ii) Collection of data for quantifying production, import and export of single chemicals, (iii) Distribution of chemicals on products, activities, sectors and households, (iv) Emission factors for single chemicals, products and industrial and household activities.

Data Processing level 1	3.Completeness	DP.1.3.2	Assessment of the most important cases where access is lacking with regard to critical data sources that could improve quantitative knowledge.

The issues refer to DP.1.3.1: (i) Identification of chemicals that qualify as NMVOCs. The definition is vague, and no approved list of agreed NMVOCs is available. Although a tentative list of 650 chemicals from the "National Atmospheric Emission Inventory" has been used, it is possible that relevant chemicals are not included, (ii) For some chemicals no data are available in Statistics Denmark. This can be due to confidentiality or that the amount of chemicals must be derived from products in which they are comprised, (iii) No direct link is available between the amounts of chemicals and products or activities. From the Nordic SPIN database, it is possible to make a relative quantification of products and activities used in industry and, combined with estimates and expert judgement, these products and activities are differentiated into sectors. More detailed information from the industrial sectors is still required, (iv) For many industrial and household activities involving solvent-containing products, no estimates on emission factors are available. Large variations occur between industry and product groups. Given the large number of chemicals, more specific knowledge regarding industrial processes and consumption is needed.

Data Processing level 1	4.Consistency	DP.1.4.1	In order to keep consistency at a high level, an explicit description of the activities needs to accompany any change in the calculation procedure

Any changes in calculation procedures are noted for each year's inventory.

Data Processing level 1	5.Correctness	DP.1.5.1	Show at least once, by independent calculation, the correctness of every data manipulation.

Calculations performed by IIASA using RAINS codes, which are based on a different methodological approach give total emission values that are similar to the emissions found in the present approach.

Data Processing level 1	5.Correctness	DP.1.5.2	Verification of calculation results using time-series

No detailed guidelines or calculations are accessible for time-series. These are, therefore, not used in verification.

Data Processing level 1	5.Correctness	DP.1.5.3	Verification of calculation results using other measures.

No other measures are used for verification.

Data Processing level 1	5.Correctness	DP.1.5.4	Shows one-to-one correctness between external data sources and the databases at Data Storage level 2

The transfer of emission data from level 1, storage and processing, to Data Storage level 2 is manually checked.

Data Processing level 1	7.Transparency	DP.1.7.1	The calculation principle and equations used must be described.

See the methodological approach described in Section 5.2.3.

Data Processing level 1	7.Transparency	DP.1.7.2	The theoretical reasoning for all methods must be described.

See the methodological approach described in Section 5.2.3.

Data Processing level 1	7.Transparency	DP.1.7.3	Explicit listing of assumptions behind all methods

See the methodological approach described in Section 5.2.3.

Data Processing level 1	7.Transparency	DP.1.7.4	Clear reference to dataset at Data Storage level 1.

See Table 5.6

Data Processing level 1	7.Transparency	DP.1.7.5	A manual log to collect information about recalculations.

Any changes in calculation procedures and methods are noted for each year's inventory.

Data Storage level 2	5.Correctness	DS.2.5.1	Documentation of a correct connection between all data types at level 2 to data at level 1.

See DP.1.5.4.

Data Storage level 2	5.Correctness	DS.2.5.2	Check if a correct data import to level 2 has been made.

See DP.1.5.4.

5.2.5 Recalculations

The previous method was based on results from an agreement between the Confederation of Danish Industries (DI) and the Danish Environmental Protection Agency (Danish EPA). The emissions from various industries were reported to the Danish EPA. The reporting was not annual and linear interpolation was used between the reporting years. It is important to note that not all solvent use was included in this agreement and no activity data were available. It is not possible to perform direct comparison of methodologies or to make corrections to the previous method, due to the fundamental differences in structure. However, an increase in total emissions was expected due to the more comprehensive list of chemicals.

Improvements and additions are continually being implemented in the new approach, due to the comprehensiveness and complexity of the use and application of solvents in industries and households. The improvements in the 2004 reporting include revisions of the following:

1. Propane and butane use.
2. Refinement of distribution of use categories in industrial branches
3. Emission factors for use and for production and processing

Refering item 1). The amount of propane and butane used amounts to approximately 100 000 tonnes per year, according to production, import and export data from Statistics Denmark. Propane and butane are used as propellants in spray cans and as fuel (LPG). No information is provided with regard to the relative distribution between propane and butane. The total of 100 000 tonnes, however, unrealistically high according to "Aerosol Industriens Brancheforening" and "Branchen for Komprimerede Gasser". They estimate the amount of propane and butane produced to be approximately 80 000 tonnes per year in Denmark. 70 000 tonnes per year is used as LPG, which is in agreement with information from the Danish Energy Authority. The remainder is exported. A report from the Danish EPA states that 5 000 tonnes of propane is used per year in Denmark, equivalent to approximately 16 million spray cans. The "Aerosol Industriens Brancheforening" and "Branchen for Komprimerede Gasser" estimate an annual consumption of 35 million spray cans and, assuming that butane contributes with an amount equal to that of propane, the total consumption of propane and butane is 10000 tonnes per year. The spray cans are mainly for cosmetics and the propellant used must be odourless – only produced in small amounts in Denmark. In conclusion, a total of 10000 tonnes of propane and butane is imported per year and used as propellant in spray cans. Assuming an emission factor of 100% during use, the total propane and butane emissions are 10,000 tonnes per year.

Refering item 2). One of the uncertainty aspects in the inventory is the distribution of chemicals on products, activities, sectors and households, cf. iii) in the uncertainties and time-series consistency section, above. A refinement has been made in this latest inventory, where some use categories have been designated to other uses and sectors. The emission factors are different for production and use which will give different emissions for 2004.

Refering item 3). The emission factors are also a major source of uncertainty in the inventory, cf iv) above. For some chemicals, new estimates are assessed. In general, higher emission factors have been attributed to use and lower estimates to production and processing, cf. Table 5.4.

5.2.6 Planned improvements

ii), iii) and iv) are to be addressed in the following inventory, where more detailed information is obtained for selected industries with respect to products and chemicals used and for the emission factors related to the activities.

5.3 References

Statistics Denmark, http://www.dst.dk/HomeUK.aspx

SPIN on the Internet. Substances in Preparations in Nordic Countries, http://www.spin2000.net/spin.html

Emission Inventory Guidebook 3rd edition, prepared by the UN-ECE/EMEP Task Force on Emissions Inventories and Projections, 2002 update. Available on the Internet at http://reports.eea.eu.int/EMEPCORINAIR3/en (07-11-2003)

Solvent Balance for Norway, 1994. Statens Forurensningstilsyn, rapport 95:02

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

The emission of greenhouse gases from agricultural activities includes the CH_4 emission from enteric fermentation and manure management, and the 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 soils is given in CRF Table 4s2. CO_2 emissions from agricultural soils are estimated, but included in the LULUCF sector.

Emission from rice production, burning of savannas and crop residues does not occur in Denmark and the CRF Tables 4.C, 4E and 4.F have, consequently, not been completed. Burning of plant residue has been prohibited since 1990 and may only take place in connection with continuous cultivation of seed grass. It is assumed that the emission is insignificant and, hence, not included in the emission inventory.

6.1 Overview

In CO_2 equivalents, the agricultural sector - without LULUCF - contributes with 15% of the overall greenhouse gas emission (GHG) in 2004. 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 livestock production, which in Denmark is dominated by the production of cattle and pigs. In 2004, the N_2O emission contributed with 63% of the total GHG emission and CH_4 contributed with the remaining 37%.

From 1990 to 2004, the emissions decreased from 13.0 Gg CO_2 eqv. to 10.0 Gg CO_2 eqv., which corresponds to a 23% reduction (Table 6.1). Since the previous reporting (2005 submission), there have been some changes which include a recalculation of N_2O emission from histosols and CH_4 emission from enteric fermentation. The change has affected the total emission 1990 – 2003 by less than 2% (Section 6.8).

Table 6.1 Emission of GHG in the agricultural sector in Denmark 1990 – 2004 (CRF)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
						Gg CO_2-eqv.									
CH_4	4011	4023	4006	4069	4018	4036	4003	3906	3942	3803	3816	3921	3861	3821	3740
N_2O	9037	8879	8580	8374	8155	7947	7607	7526	7496	7052	6795	6655	6399	6210	6259
Total	13048	12902	12586	12443	12173	11984	11610	11432	11438	10855	10611	10576	10261	10031	9999

Figure 6.1 shows the distribution of the greenhouse gas emission across the main agricultural sources. The decrease in total emissions can largely be attributed to the decrease in N_2O emissions from agricultural soils – the total N_2O emission from 1990-2004 has decreased by 31%. This reduction is due to a proactive national environmental policy over the last twenty years. The environmental policy has introduced a series of measures to prevent loss of nitrogen from agricultural soil to the aquatic environment. The measures include improvements to the utilisation of nitrogen in manure, a ban on manure application during autumn and winter, increasing area with winter-green fields to catch nitrogen, a maximum number of animals per hectare and maximum nitrogen application rates for agricultural crops. The main part of the emission from the agricultural sector is related to livestock production. An active environmental policy has brought about a decrease in the N-excretion and emission per produced animal, which has reduced the overall GHG emission.

From 1990 to 2004, only a slight reduction in the total CH_4 emission has occurred. The emission from enteric fermentation has decreased due to a reduction in the number of cattle. On the other hand, the emission from manure management has increased due to a change towards greater use of slurry-based stable systems, which have a higher emission factor than systems with solid manure. By coincidence, the decrease and the increase almost balance each other out and the total CH_4 emission from 1990 to 2004 has decreased by 7%.

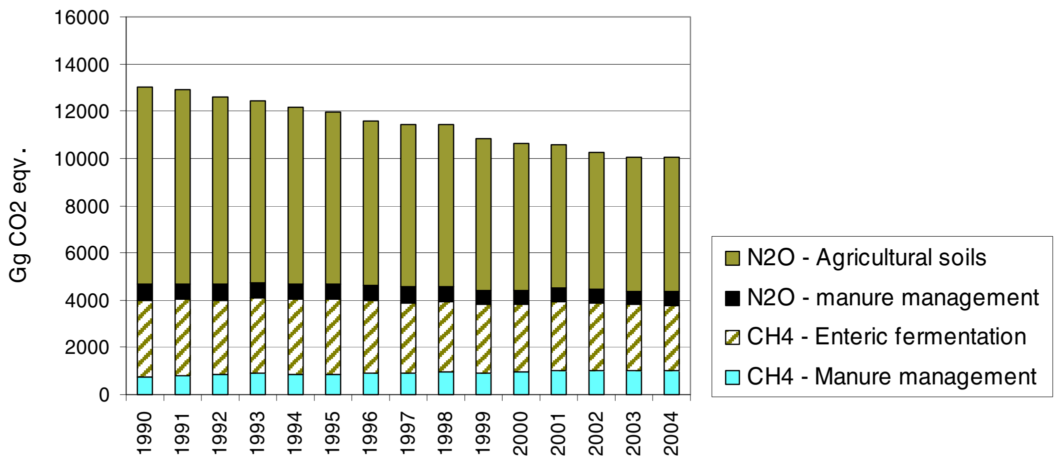

Figure 6.1 Danish greenhouse gas emissions 1990 – 2004

6.1.1 References – sources of information

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

Activity data and emission factors are collected and discussed in co-operation with specialists and researchers in various 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. In this way, both data and methods will be evaluated continually, according to the latest knowledge and information. NERI has established data agreements with the institutes and organisations to assure that the necessary data is available to prepare the emission inventory on time.

Table 6.2 List of institutes involved in the emission inventory for the agricultural sector.

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

The emissions from the agricultural sector are calculated in a comprehensive agricultural model complex called DIEMA (Danish Integrated Emission Model for Agriculture). This model complex, as shown in Figure 6.2, is implemented in great detail and is used to cover emissions of ammonia, particulate matter and greenhouse gases. Thus, there is a direct coherence between the ammonia emission and the emission of N_2O. A more detailed description has been published, but only in Danish (Mikkelsen et al. 2005). An English edition is in preparation and the report is currently undergoing review procedure in Sweden.

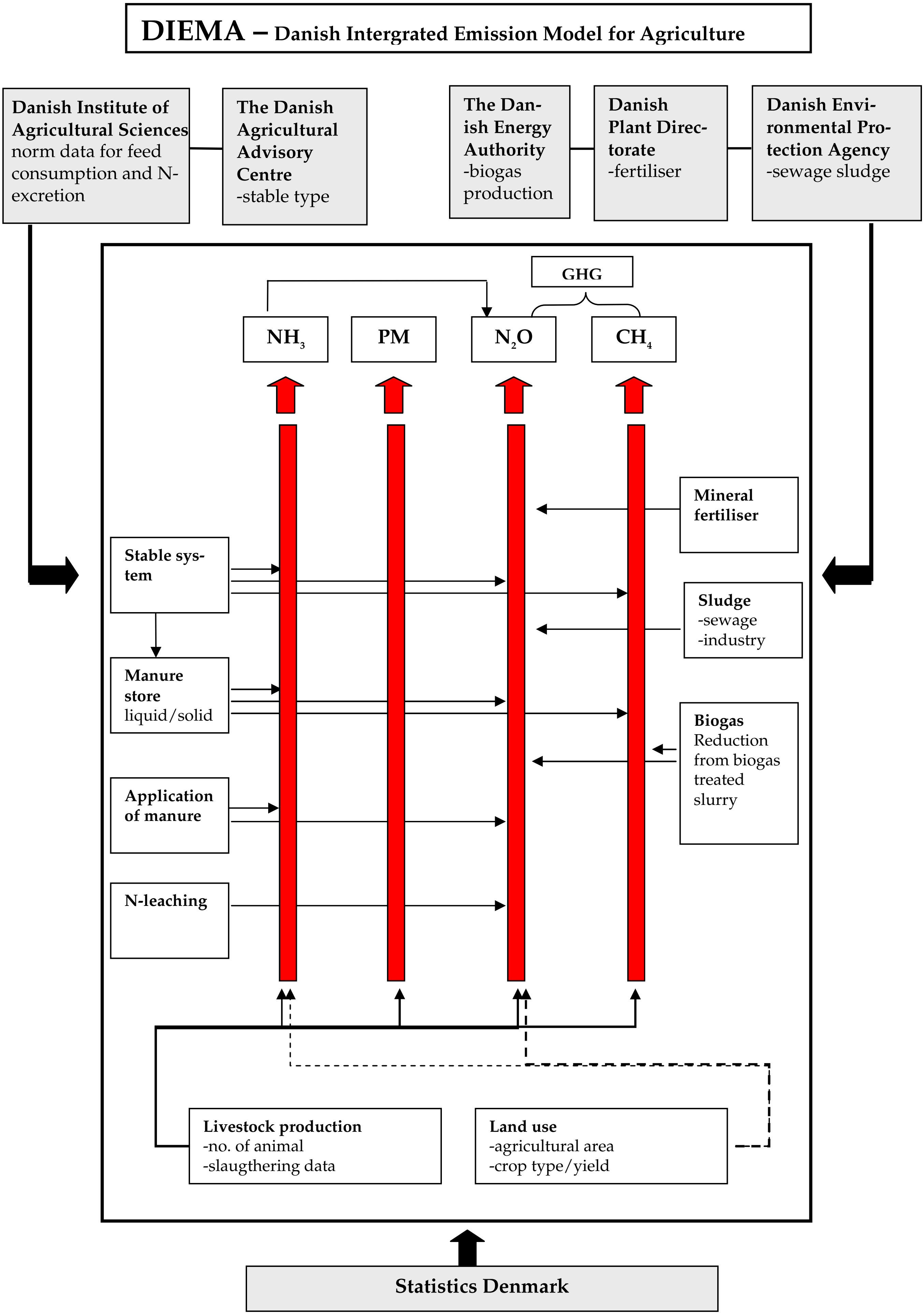

Figure 6.2 DIEMA – Danish Integrated Emission Model for Agriculture

The DIEMA model complex is build up as a number of spreadsheets, where data is linked between the sheets. The main part of the emission is related to livestock production. In short, the emission from livestock production is based on information concerning the number of animals, the distribution of animals according to stable type and final information on feed consumption and excretion.

DIEMA operates with 30 different livestock categories, according to livestock category, weight class and age. These categories are subdivided into stable type and manure type, which results in around 100 different combinations of livestock subcategories and stable types. For each of these combinations, information on e.g. feed intake, digestibility, excretion and methane conversion factors is attached. The emission is calculated from each of these subcategories and then aggregated to animal categories, as listed in CRF.

Table 6.3 shows an example of subcategories for cattle and swine. The emission is calculated from each of these subcategories and then aggregated in accordance with the IPCC livestock categories given in the CRF.

Table 6.3 Subcategories including in category of Dairy Cattle, Non-Dairy Cattle and Swine.

Aggregated livestock categories as given in IPCC	Subcategories in DIEMA	Number of stable type
Cattle[1]		
Dairy Cattle		9
Non-Dairy Cattle	Calves < ½ yr (bull)	2
	Calves < ½ yr (heifer)	2
	Bull > ½ yr to slaughter	8
	Heifer > ½ yr to calving	9
	Cattle for suckling	3
Swine	Sows	7
	Piglets	5
	Slaughter pigs	5

[1] For all subcategories, large breed and jersey cattle are distinguished from each other

It is important to point out that changes over the years, both to the total emission and the implied emission factor, are not only a result of changes in the numbers of animals, but also depend on changes in the allocation of subcategories, changes in feed consumption and changes in stable type.

Number of animals: Livestock production is primarily based on the agricultural census from Statistics Denmark. The emission from slaughter pigs and poultry is based on slaughter data. Approximate numbers of horses, goats and sheep on small farms are added to the number in the Agricultural Statistics, in agreement with the Danish Agricultural Advisory Centre (DAAC), as Statistics Denmark does not include farms less than 5 hectares. Statistics Denmark is the source for the database kept by FAO (Food and Agriculture Organization of the United Nations). This explains why the number of sheep, goats and horses in FAO and the Danish emission inventory disagree. The largest difference is found for horses. In the agricultural census, for 2004 the number of horses is estimated to be 39200. Including horses on small farms and riding schools, however, the number of horses rises to approximately 155,000. Based on the ERT recommendations, improvements to the documentation of number of horses, sheep and goats on small farms, in cooperation with DAAC, is planned.

Stable type: At present, there exist no official statistics concerning the distribution of animals according to stable type. The distribution is, therefore, based on an expert judgement from the Danish Agricultural Advisory Centre (DAAC). Approximately 90-95% of Danish farmers are members of DAAC and DAAC regularly collects statistical data from the farmers on different issues, as well as making recommendations with regard to farm buildings. Hence, DAAC have a very good feeling of which stable types are currently in use. By end of 2006, all farmers have to report which stable type they are using to the Danish Plant Directorate. These data will be available for the emission inventory in 2007.

Feed consumption and excretion: The Danish Institute of Agricultural Sciences (DIAS) delivers Danish standards related to feed consumption, manure type in different stable types, nitrogen content in manure, etc. The Danish Normative System for animal excretions is based on data from the Danish Agricultural Advisory Centre (DAAC). DAAC is the central office for all Danish agricultural advisory services. DAAC carries out a considerable amount of research itself, as well as collecting efficacy reports from the Danish farmers for dairy production, meat production, pig production, etc., to optimise productivity in Danish agriculture. In total, feed plans from 15-18% of the Danish dairy production, 25-30% of the pig production, 80-90% of the poultry production and approximately 100% of the fur production are collected. These basic feeding plans are used to develop the Danish Normative System. For dairy cows, approximately 800 feeding plans are used to develop the norm figures. Previously, the standards were updated and published every third or fourth year – the last one is Poulsen et al. from 2001. From 2001, NERI receives updated data annually directly from DIAS in the form of spreadsheets. These standards have been described and published in English in Poulsen & Kristensen (1998).

6.1.2 Key source identification

Most of the agricultural emission sources can be considered as key sources for both the emission level and trend (Table 6.4). The most important key source is the N_2O emission from agricultural soils, which contributes with 8% of the total national GHG emission in 2004.

Table 6.4 Key source identification from the agricultural sector 2004

CRF table	Compounds	Emission source	Key source identification
4.A	CH_4	Enteric fermentation	Level/trend
4.B(a)	CH_4	Manure management	Level/trend
4.B(b)	N_2O	Manure management	Level
4.D	N_2O	Indirect N_2O emission from nitrogen used in agriculture	Level/trend
4.D	N_2O	Direct N_2O emission from agricultural soils	Level/trend

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

6.2.1 Description

The major part of the agricultural CH_4 emission originates from digestive processes. In 2004, this source accounts for 27% of the total GHG emission from agricultural activities. The emission is primarily related to ruminants and, in Denmark, particularly to cattle, which, in 2004, contributed with 85% of the emission from enteric fermentation. The emission from pig production is the second largest source and covers 11% of the total emission from enteric fermentation (Figure 6.3), followed by horses (3%) and sheep and goats (1%).

6.2.2 Methodological issues

6.2.2.1 Implied emission factor

The implied emission factors for all animal categories are based on the Tier 2 approach. Feed consumption for all animal categories is based on the Danish normative figures (Poulsen et al. 2001). The normative 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% are included. The data is given in Danish feed units or kg feedstuff and is converted to mega joule (MJ). In Annex 3 Table 1 and 2, the average feed intake is shown, from 1990 to 2003, for each livestock category used in the Danish emission inventory. Annex 3, Table 3-5 provides additional information about feeding, milk yield and digestibility for cattle. Default values for the methane conversion rate (Y_m) given by the IPCC are used for all livestock categories, except for dairy cattle and heifers, where a national Y_m is used for all years. New investigations from DIAS have shown a change in fodder practice from use of sugarbeets to use of maize, which is now more common. This development in fodder practice reflects the change in the average Y_m from 6.39 in 1990 to 5.95 in 2004.

Table 6.5 shows the implied emission factors for all IPCC livestock categories. Due to changed data for feed consumption and allocation of subcategories, the implied emission factor may vary across the years. Cattle and pigs are the most important emission sources. The category “Non-Dairy Cattle” includes calves, heifers, bulls and suckler cows and the implied emission factor is a weighted average of these different subcategories (Annex 3, Table 2). The category “Swine” includes the subcategories sows, piglets and slaughter pigs.

No default values are recommended in the IPCC Reference Manual or Good Practice Guidance for poultry and fur farming. The enteric emission from poultry and fur farming is considered non-significant.

Table 6.5 Implied emission factor – Enteric Fermentation 1990 – 2004 (CRF table 4.A)

CRF table 4.A	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
								Kg CH_4/head/yr							
1. Cattle															
a. Dairy	116.59	115.90	114.96	114.19	120.01	121.50	118.50	118.21	118.52	117.66	117.21	119.31	121.46	124.12	126.18
b. Non-Dairy	35.45	35.49	35.42	35.45	35.17	35.36	35.02	35.28	35.19	35.45	35.55	35.73	35.85	35.72	35.72
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	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	13.15	13.15
6. Horses	21.34	21.34	21.34	21.34	21.34	21.34	21.34	21.34	21.34	21.34	21.34	21.34	21.34	21.34	21.34
8. Swine	1.07	1.10	1.12	1.10	1.10	1.07	1.11	1.10	1.10	1.13	1.11	1.10	1.11	1.10	1.09
9. Poultry	NE	NE	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	NE	NE

The increase in the implied emission factor (IEF) for dairy cattle from 1990-2004 is the result of increasing feed consumption due to rising milk yields. On average, the milk yield has increased from 6200 litre per cow per year in 1990 to approximately 8000 litre per cow per year in 2004 (Statistics Denmark) (Annex 3, Table 4). The relatively large difference in the IEF in 1993 and 1994 is due to the availability of data from DIAS. For the years 1990-1993, the same data concerning feed consumption is used (Laursen, 1987). In 1994, the data were updated (Laursen, 1994) and showed an increase of approximately 6%, which nearly corresponds to the increase in the milk yield in 1990-1994 (5%). In other words, the changes in feed intake from 1993 to 1994 for dairy cattle, Annex 3, Table 1, do not reflect a one-year change, but reflect the development from 1990-1994. Based on the ERT recommendations, an interpolation on feed intake from 1990 to 1994 will be performed in future to avoid jumps in the time-series. From 2001, annual data is available and this will reflect a continuous development.

For "Non-Dairy Cattle", there has been an increase in IEF. This is due to changes in allocation of the subcategories. The share of calves, which have the lowest emission factor, has decreased from 1990 to 2003 (Table 6.6). An increasing part of the bull calves are slaughtered or exported for slaughter or fattening. The Danish IEF for non-dairy cattle is lower compared with the default value given in the IPCC Reference Manual. This is due to lower weight and lower feed intake and a higher digestibility of feed compared with the values provided by the IPCC.

Table 6.6 Subcategories for Non Dairy Cattle 2004

Non Dairy Cattle - subcategories	Weight*	Energy intake (MJ/day)*	Feed Digestability (%)*		IEF – kg CH_4/head/yr
			summer	winter	
Calves, bull (0-6 month)		63.8	79	79	16.14
Calves, heifer (0-6 month)		41.2	78	78	16.62
Bull (6 month to slaughter)	large breed: 440 kg sl. weigh jersey: 330 kg sl. weight	109.4	75	78	30.45
Heifer (6 month to calving)		99.8	71	78	41.30
Suckling cattle		170.2	67	77	66.08
Average - Non-Dairy Cattle	**max. 300**				**35.72**

* The Danish Institute of Agricultural Science (Poulsen et al. 2001).

The implied emission factor for pigs is at around the same level as in 1990. Improved fodder efficacy for sows has resulted in a lower emission factor. On the other hand, there has been an increase in fodder intake for slaughter pigs and piglets due to an increase in weight. The changes from year to year primarily reflect the changes in the allocation of the subcategories.

The same feed intake for sheep, goats and horses are used for all years, which results in an unaltered IEF. The IEF for sheep and goats includes lambs and kids, which corresponds to the Danish normative data. This explains why the Danish IEF is nearly twice as high as the IPCC default value.

6.2.2.2 Activity data

In Table 6.7, the development in the number of animals from the agricultural statistics (Statistics Denmark) and DAAC from 1990 to 2004 is presented. The agricultural census does not include farms less than 5 ha. In the Danish emission inventory, the decision has been made to add number of sheep, goats and horses on small farms based on information from DAAC (see Chapter 1.1.1 – number of animals).

Since 1990, the number of swine and poultry has increased, in contrast to the number of cattle, which has decreased. Buffalo, camels and llamas, mules and donkeys are not relevant for Denmark.

Table 6.7 Number of animals from 1990 to 2004 (CRF table 4.A, 4.B (a) and 4.B (b))

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
								1000 head							
IPCC livestock categories:															
Dairy Cattle	753	742	712	714	700	702	701	670	669	640	636	623	610	596	563
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	1128	1082
Sheep*	92	107	102	88	80	81	94	78	83	83	81	92	74	83	79
Goats*	8	9	9	9	9	9	9	10	10	10	10	11	11	12	12
Horses*	135	137	138	140	141	143	144	146	147	149	150	152	153	155	155
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	12 949	13233
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	17 796	16598
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	2 361	2471

* Including animals on small farms (less than 5 ha), which are not covered by Statistics Denmark.

6.2.3 Time-series consistency

The total emission from enteric fermentation is given in Table 6.8. From 1990 to 2004, the emission has decreased by 17%, which is primarily related to a decrease in the number of dairy cattle from 753,000 in 1990 to 563,000 in 2004. The number of pigs has increased from 9.5 M in 1990 to 13.2 M in 2004, but this increase is only of minor importance in relation to the total CH_4 emission from enteric fermentation.

Table 6.8 Emission of CH_4 from Enteric Fermentation 1990 – 2004 (CRF)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
							Gg CH_4								
Dairy Cattle	87.81	85.96	81.84	81.55	83.95	85.35	83.02	79.24	79.30	75.33	74.49	74.38	74.04	73.98	71.10
Non-Dairy Cattle	52.68	52.53	52.35	52.51	49.42	49.08	48.76	47.05	46.04	44.21	43.82	45.87	42.54	40.31	38.66
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	1.43	1.36
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	0.15	0.16
Horses	2.88	2.91	2.94	2.98	3.01	3.04	3.07	3.10	3.14	3.17	3.20	3.23	3.26	3.30	3.31
Swine	10.14	10.74	11.74	12.71	12.03	11.91	12.03	12.53	13.28	13.09	13.26	13.87	14.15	14.22	14.49
Poultry	NE	NE	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	NE	NE
Total Gg CH_4	155.19	154.08	150.75	151.37	149.91	150.89	148.63	143.39	143.30	137.33	136.28	139.07	135.41	133.38	129.07
Total Gg CO_2 eqv.	3259	3236	3166	3179	3148	3169	3121	3011	3009	2884	2862	2920	2844	2801	2711

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

6.3.1 Description

The emissions of CH_4 and N_2O from manure management are given in CRF Table 4.B (a) and 4.B (b). This source contributes with 16% of the total emission from the agricultural sector in 2004 and the major part of the emission originates from the production of swine (55%) followed by cattle production (33%). The remaining part is mainly from poultry (7%).

6.3.2 Methodological issues

6.3.2.1 CH_4 emission

The IPCC Tier 2 approaches are used for the estimation of the CH_4 emission from manure management. The amount of manure is calculated for each combination of livestock subcategory and stable type.

The estimation is based on national data for feed consumption (Poulsen et al. 2001) and standards for ash content and digestibility. These data are given in Annex 3, Tables 6 to 9. Default values provided in the IPCC guidelines for the methane production B_o and MCF are used. For liquid systems, the MCF of 10% in the Reference Manual (IPCC 1996) is used, which is based on Husted (1996). In the Good Practice Guidance (IPCC 2000), the MCF for liquid manure has been changed from 10% to 39% for cold climates. The results from both Husted (1996) and Massé et al. (2003) indicate that the MCF of 10% reflects the Danish conditions better than MCF of 39%. Husted (1996) is, among other sources, based on measurements in Danish stables. Investigations described in Massé et al. (2003) are based on measurements in Canadian agricultural conditions similar to the Danish conditions.

Biogas plants using animal slurry reduce the emission of CH_4 and N_2O (Sommer et al. 2001). This reduction is included in the emission inventory. The reduced emission from biogas-treated slurry is included in the emission from dairy cattle and pigs for slaughter, which is the main source of the production of slurry.

In 2004, approximately 7% (0.90 M tonnes of cattle slurry and 1.10 M tonnes of pig slurry) were treated in biogas plants (DEA 2005). 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 by 0.93 Gg CH_4 (Table 6.9), which correspond a 2% reduction of the CH_4 emission from manure management in 2004.

Table 6.9 Reduced CH_4 emissions from biogas treated slurry 1990 – 2004

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Amount of treated slurry (M tonnes)	0.09	0.32	0.39	0.46	0.54	0.64	0.69	0.83	1.01	1.04	1.16	1.26	1.14	1.85	2.00
Reduced emission from cattle (Gg CH_4)	0.03	0.06	0.07	0.08	0.10	0.11	0.12	0.15	0.18	0.19	0.21	0.23	0.25	0.33	0.36
Reduced emission from pigs (Gg CH_4)	0.08	0.13	0.16	0.19	0.22	0.26	0.28	0.34	0.41	0.42	0.47	0.51	0.57	0.75	0.81
Total reduced emission (Gg CH_4)	0.11	0.19	0.23	0.27	0.32	0.37	0.40	0.48	0.59	0.61	0.68	0.74	0.82	1.08	1.17

CH_4 –implied emission factor

Table 6.10 shows the development in the implied emission factors from 1990 to 2004. Variations between the years reflect changes in feed intake, allocation of subcategories and changes in stable type system. IEF for dairy cattle has increased as a result of an increasing milk yield, but also because of change in stable types. In Annex 3D, Table 10 shows the changes in stable types from 1990 to 2004. Old-style tethering systems with solid manure have been replaced by loose-housing with slurry-based systems. The MCF for liquid manure is ten times higher than that for solid manure. For pigs, there has been a similar development with a move from solid manure to slurry-based systems.

For non-dairy cattle, the opposite development has taken place. An increasing proportion of bull-calves is raised in stables with deep litter, where the MCF is lower than for liquid manure.

The IEF for sheep and goats includes lambs and kids, which corresponds the Danish normative data. This explains why the Danish IEF is nearly twice as high as the IPCC default value.

The new CRF format allows registering of emissions from "Other" - see CRF Table 4s1. Denmark produces 2.5 million mink and fox and these contribute with 3 percent of the CH_4 emission from manure management.

Table 6.10 Implied emission factor – Manure Management 1990 – 2004 (CRF 4.B (a))

CRF Table 4.B(a)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
								Kg CH_4/head/yr							
1a. Dairy Cattle	13.48	13.54	13.61	13.69	14.56	14.64	14.73	14.30	13.96	13.94	16.06	16.97	17.89	19.00	19.70
1b. Non-Dairy Cattle	2.21	2.11	2.03	1.97	1.88	1.78	1.77	1.74	1.74	1.75	1.74	1.79	1.78	1.79	1.71
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	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	0.26	0.26
6. Horses	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56
8. Swine	2.25	2.39	2.51	2.49	2.52	2.48	2.59	2.60	2.61	2.71	2.66	2.64	2.66	2.59	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	0.02	0.02
10. Other Fur farming	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20

6.3.2.2 N_2O emission

The N_2O emission from manure management is based on the amount of nitrogen in the manure in stables. The emission from manure deposits on grass is included in "Animal Production" (Section 6.4.2.2). 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 systems without bedding. Nitrogen from poultry, without bedding, contributes less than 1% to the total amount of nitrogen in manure.

The total amount of nitrogen in manure has decreased by 7% from 1990 to 2004 (Table 6.11) and the N_2O emission has followed this development, despite the increasing production of pigs and poultry. This reduction is particularly due to an improvement in fodder efficiency, especially for slaughter pigs.

It is important to point out that the N-excretion rates shown in Table 6.10 are values weighted for the different subcategories (Table 6.3). N-excretion reflects nitrogen excreted per animal per year. The variations in N-excretion in the time-series reflect changes in feed intake, fodder efficiency and allocation of subcategories.

Table 6.11 Nitrogen excretion, annual average 1990 – 2004 (CRF table 4.B(b))

CRF table 4.B(b)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Livestock category								Kg N/head/yr							
Non-dairy	36.57	36.68	36.80	36.92	36.64	36.56	36.62	36.74	36.77	37.00	37.15	37.77	37.77	37.69	38.64
Dairy cattle	129.49	128.63	127.76	126.89	126.06	125.22	125.09	124.94	124.82	124.60	125.31	124.88	126.71	126.57	131.07
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	16.87	16.88	16.87
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	9.72	9.63	9.41
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	0.58	0.64	0.72
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	43.31	43.31
Fur farming	4.90	4.83	4.80	4.75	4.70	4.65	4.66	4.65	4.64	4.63	4.63	4.62	4.61	4.61	5.09
Goats	11.62	11.43	11.17	10.40	10.38	9.62	9.89	9.74	9.65	9.83	9.63	9.30	9.72	9.63	9.41
								Mill. kg N/yr							
N-excretion, total	293	291	293	293	283	274	275	274	279	270	270	275	277	273	273
N-excretion, stable	258	256	258	257	248	238	239	239	244	236	237	240	244	241	241

The effects from biogas-treated slurry are included in the N_2O-emission from 2006 onwards. Investigation shows that it is possible to reduce the N_2O emission from biogas-treated cattle slurry by approximately 36% and by 40% from pig slurry (Nielsen et al. 2002, Sommer et al. 2001). The average nitrogen content in slurry is 0.00538% for cattle slurry and 0.00541% for pig slurry. The reduced emission is included in the N_2O emission from manure management.

Table 6.12 Reduced N2O emissions from biogas-treated slurry 1990 – 2004

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
No. of bio plants	230	388	473	556	658	772	830	1005	1222	1253	1408	1524	1703	1854	
Amount of treated slurry (mill. tonnes)	0.09	0.32	0.39	0.46	0.54	0.64	0.69	0.83	1.01	1.04	1.16	1.26	1.41	1.85	2.00
Reduced emission from slurry (Gg N_2O)	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.05	0.05

6.3.3 Time-series consistency

In Table 6.13, the total emission from manure management from 1990 to 2004 is shown. The N_2O emission has decreased by 18%. The total emission from manure management has, nevertheless, increased by 11% in CO_2 equivalents due to the increase in the CH_4 emission.

Table 6.13 Emissions of N_2O and CH_4 from Manure Management 1990 – 2004 (CRF)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
N_2O emission															
Liquid manure (Gg N_2O)	0.31	0.30	0.30	0.30	0.28	0.27	0.27	0.26	0.26	0.25	0.26	0.26	0.26	0.25	0.25
Solid manure (Gg N_2O)	1.90	1.90	1.91	1.91	1.86	1.80	1.81	1.81	1.84	1.78	1.68	1.69	1.63	1.55	1.56
Total Gg N_2O	**2.21**	**2.20**	**2.21**	**2.20**	**2.14**	**2.07**	**2.07**	**2.07**	**2.10**	**2.04**	**1.94**	**1.95**	**1.90**	**1.80**	**1.81**
Total Gg CO_2 eqv.	685	681	684	683	663	642	642	643	652	631	601	604	588	558	560
CH_4 emission															
Total Gg CH_4	35.79	37.49	40.00	42.40	41.42	41.32	41.97	42.61	44.41	43.77	45.45	47.64	48.47	48.58	49.03
Total Gg CO_2 eqv.	**752**	**787**	**840**	**890**	**870**	**868**	**881**	**895**	**933**	**919**	**954**	**1000**	**1018**	**1020**	**1030**
Total Manure Management Gg CO_2 eqv.*	**1436**	**1468**	**1524**	**1573**	**1533**	**1509**	**1524**	**1538**	**1585**	**1550**	**1556**	**1604**	**1606**	**1579**	**1589**

* Incl. the reduction from biogas treated slurry.

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

6.4.1 Description

The N_2O emissions from agricultural soils, CRF Table 4.D, contribute, in 2004 with 57% of the total emission from the agricultural sector. Figure 6.6 shows the distribution and the development from 1990 to 2004 according to different sources. The main part of the emission originates as direct emission. The largest sources here are manure and fertiliser applied on agricultural soils. Another large source is the indirect N_2O emission, of which the emission from nitrogen leaching is an essential part. The category "Other" includes the emission from sewage sludge and sludge from industry used as fertiliser.

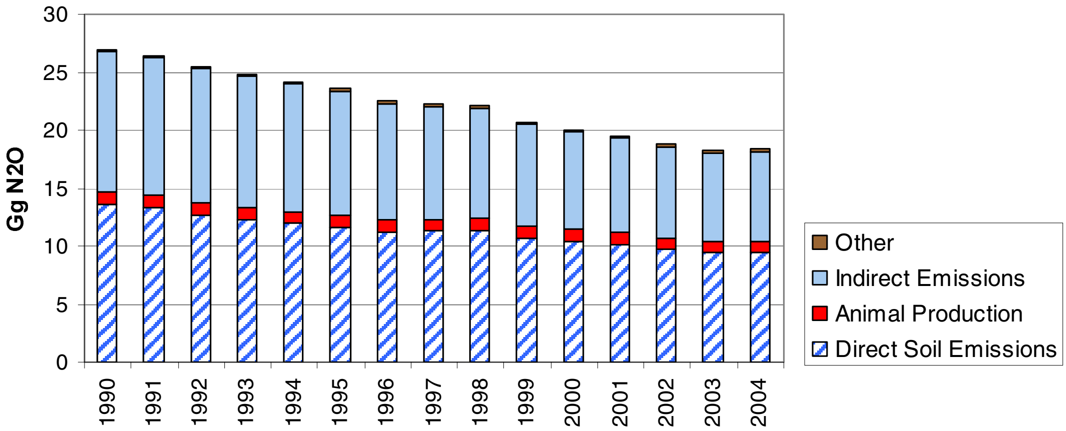

Figure 6.6 N_2O emissions from agricultural soils 1990 - 2004.

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 N_2O emission factors for all sources are based on the default values given in IPCC (2000), except for cultivation of histosols, which is based on a national factor. National data for the evaporation of ammonia is applied from the ammonia emission inventory, which is descriped in more detail in Denmark´s annual inventory report, due to the UNECE-Convention on Longe-Range Transboundary Air Pollution (Illerup et al. 2004). This report is avaible on the internet. A N_2O emission survey is presented in Table 6.14. The estimated emissions from the different sub-sources are described in brief in the text which follows.

Table 6.14 Emissions factor - N_2O emission from the Agricultural Soils 1990 - 2004

Agricultural soils – emission sources CRF table 4.D	Ammonia emission (national data)	N_2O emission (national value)	N_2O emission (IPCC default value)
			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		3 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			0.0125
Sewage Sludge Used as Fertiliser			0.0125

6.4.2.1 Direct Emissions

Synthetic fertiliser

The amount of nitrogen (N) applied to soil via use of synthetic fertiliser is estimated from sales estimates from the Danish Plant Directorate, the source for the FAO database. Table 6.15 shows the consumption of each fertiliser type. Furthermore, the ammonia emission factor for each fertiliser is given, based on national estimates from DIAS (Sommer and Christensen 1992, Sommer and Jensen 1994, Sommer and Ersbøll 1996). These emission factors are also in accordance with the emission factors recommended in the inventory guidebook for CLRTAP Emission Inventories – Table 5.1. The Danish value for the FracGASF is estimated at 0.02 and is considerably lower than that from the IPCC, i.e. 0.10. The ammonia emission depends on fertiliser type and the major part of the Danish emission is related to the use of calcium ammonium nitrate and NPK fertiliser, where the emission factor is 0.02 kg NH_3-N/kg N. The low Danish FracGASF is also probably due to the small consumption of urea (<1%), which has a high emission factor.

Table 6.15 Synthetic fertiliser consumption 2004 and the NH_3 emission factors.

Synthetic fertiliser year 2003	NH_3 Emission factor[1] (Kg NH_3-N / kg N)	Consumption[2] (M kg N)
Fertiliser type		
Calcium and boron calcium nitrate	0.02	0.4
Ammonium sulphate	0.05	3.3
Calcium ammonium nitrate and other nitrate types	0.02	86.3
Ammonium nitrate	0.02	12.0
Liquid ammonia	0.01	6.0
Urea	0.15	0.4
Other nitrogen fertiliser	0.05	12.2
NPK-fertiliser	0.02	70.4
Diammonphosphate	0.05	0.5
Other NP fertiliser types	0.02	8.5
NK fertiliser	0.02	6.2
Total consumption of N in synthetic fertiliser		206.7
Total emission of NH_3-N (M kg)	4.62	
Average NH_3-N emission (FracGASF)	0.02	

[1] Danish Institute of Agricultural Sciences (Sommer and Christensen 1992, Sommer and Jensen1994, Sommer and Ersbøll 1996)

[2] The Danish Plant Directorate

The use of mineral fertiliser includes fertiliser used in parks, golf courses and private gardens. Approximately 1-2% of the mineral fertiliser can be related to these uses outside the agricultural area.

As a result of increasing requirements for improved use of nitrogen in livestock manure, the consumption of nitrogen in synthetic fertiliser has halved from 1990 to 2004 (Table 6.16).

Table 6.16 Nitrogen applied as manure to agricultural soils 1990 - 2004

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
N content in synthetic fertiliser (kt N)	400	395	370	333	326	316	291	288	283	263	251	234	211	201	207
NH_3-N (kt NH_3-N)	9	8	8	8	8	8	7	6	6	6	6	5	5	4	5
N in fertiliser applied on soil (kt N)	392	386	362	325	318	308	284	281	277	257	246	229	206	197	201
N2O emission (Gg N_2O)	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	3.87	3.97

Manure applied to soil

The amount of nitrogen applied to soil is estimated as the N-excretion in stables minus the emission of ammonia in stables, under storage and in relation to the application of manure. These values are based on national estimations and are calculated in the ammonia emission inventory (Table 6.17). The total N-excretion in stables from 1990 to 2004 has decreased by 7%. Despite this reduction in N-excretion, the amount of nitrogen applied to soil remains almost unaltered, due to the reduction in the ammonia emission.

Table 6.17 Nitrogen applied as manure to agricultural soils 1990 - 2004

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
N-excretion in stable (kt N)	258	256	258	257	248	238	239	239	244	236	237	240	244	241	241
NH_3-N emission from stable, storage and application (kt NH_3-N)	77	75	75	73	69	65	64	64	65	63	63	63	62	59	59
N in manure applied on soil (kt N)	179	179	181	184	178	174	175	174	178	175	173	177	182	182	181
N2O emission (Gg N_2O)	3.51	3.52	3.56	3.62	3.50	3.41	3.45	3.43	3.50	3.43	3.40	3.47	3.57	3.57	3.56

The FracGASM is estimated as total N-excretion (N ab animal) minus the ammonia emission in stables, storage and application. The FracGASM has decreased from 0.26 in 1990 to 0.22 in 2004 (Table 6.18). This is the result of an active strategy to improve the utilisation of the nitrogen in manure.

Table 6.18 FracGASM 1990 - 2004

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Total N-excretion (kt N)	293	291	293	293	283	274	275	274	279	270	270	275	277	273	273
NH_3-N emission (kt NH_3-N)	77	75	75	73	69	65	64	64	65	63	63	63	62	59	59
FracGASM	0.26	0.26	0.25	0.25	0.24	0.24	0.23	0.23	0.24	0.24	0.23	0.23	0.22	0.22	0.22

N-fixing crops

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

The Danish inventory includes emissions from clover-grass, despite the fact that this source is not mentioned in the IPCC GPG. Area with grass and clover covered approximately 14% of the total agricultural area in 2004 and, for this reason, represents an important contributor to the total emission from N-fixing crops.

In Table 6.19 the background data for estimating the N-fixing is listed. The emission from N-fixing crops decreases from 1990-2004, largely due to a reduction in agricultural area.

Table 6.19 Emissions from N-fixing crops 2004

N_2O emission from nitrogen fixing crops			N-fixing		
	Dry matter Fraction	N-Fraction	Variations 1990-2004 kg N/ha	2004 kg N/ha	2004 Kg N fix total
Pulses*	0.85	0.0337	96-179	135	3 578
Lucerne	0.21	0.0064	307-517	423	1 755
Cereals and pulses for green fodder	0.23	0.0061	16-38	22	2 265
Pulses, fodder cabbage etc.	0.23	0.0061	0-1	NO	NO
Peas for canning*	0.85	0.0337	76-139	108	321
Seeds for sowing	NE	NE	181-186*	182	779
Grass and clover field in rotation	0.13	0.0052	41-94	92	18 149
Grass and clover outside rotation	0.13	0.0052	6-11	8	1 381
Aftermath	0.13	0.0052	6-15	15	2 330
Total N-fix					30 559

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

** Average - assumed that N-fix for red clover is 200 kg N/ha and 180 kg N/ha for white clover (Kyllingsbæk 2000)

Crop Residue

N_2O emissions from crop residues are calculated as the total aboveground quantity of crop residue returned to soil. For cereals, the aboveground residues are calculated as the amount of straw plus stubble and husks. The total amount of straw is given in the annual census and reduced by the amount used for feeding, bedding and biofuel in power plants. Straw for feed and bedding is subtracted because this quantity of removed nitrogen returns to the soil via manure. Data for nitrogen content in stubble and husks is provided by the Danish Institute of Agricultural Sciences (Djurhuus and Hansen 2003). Background data is given in Annex 3D, Table 11.

From 1990 to 2004, there have been some changes in the cultivation of crop types, but the total emission from crop residues remains practically unaltered (Table 6.20). The fraction of nitrogen in harvest crop residues has decreased, due to a decrease in areas with sugar beets, which have been replaced by green maize.

Table 6.20 Emissions from crop residue 1990 – 2004.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Crop residue							M kg N								
Stubble	18.9	18.5	19.0	19.1	18.3	18.2	18.7	18.8	18.9	18.7	18.6	18.6	18.3	17.6	17.0
Husks	11.4	11.1	11.8	11.4	11.5	11.6	12.3	12.5	12.6	11.8	12.0	12.3	11.5	12.0	12.0
Top of beets and potatoes	7.1	7.1	6.7	7.2	6.1	5.8	5.9	5.5	5.7	5.4	5.3	5.2	5.5	4.9	5.0
Leafs	6.8	6.7	6.7	10.1	10.4	10.3	9.7	8.1	7.9	8.7	9.0	9.2	9.1	9.1	8.5
Straw	15.1	14.3	6.1	3.9	5.4	10.4	10.7	11.6	11.4	10.1	10.8	11.6	9.0	9.0	9.0
Crop residue, total (M kg N)	59.3	57.7	50.3	51.7	51.7	56.2	57.2	56.5	56.5	54.7	55.7	57.0	53.4	52.5	51.6
N_2O emission (Gg)	1.17	1.13	0.99	1.01	1.02	1.10	1.12	1.11	1.11	1.07	1.09	1.12	1.05	1.03	1.01
FracR	0.31	0.30	0.32	0.37	0.34	0.29	0.27	0.28	0.28	0.27	0.27	0.24	0.27	0.26	0.26

Cultivation of histosols

N_2O emissions from histosols are based on the area with organic soils multiplied by the emission factor for C, the C:N relationship for the organic matter in the histosols and an emission factor of 1.25 of the total amount of released N. See the LULUCF section for further description.

6.4.2.2 Animal Production

The amount of nitrogen deposited on grass is based on estimations from the ammonia inventory. It is assumed that 15%, on average, of the nitrogen from dairy cattle is excreted on grass (expert judgement from the Danish Institute of Agricultural Science – Poulsen et al 2001). N-excretion on grass has decreased due to a reduction in the number of dairy cattle. An ammonia emission factor of 7% is used for all animal categories based on investigations from the Netherlands and the United Kingdom (Jarvis et al. 1989a, Jarvis et al., 1989b and Bussink 1994).

Table 6.21 Nitrogen excreted on grass 1990 - 2004

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
N-excretion, grass (kt N)	34	35	35	36	35	36	36	35	35	34	34	34	33	32	32
NH_3-N emission (kt NH_3-N)	2	2	2	3	2	2	3	2	2	2	2	2	2	2	2
N deposited on grass (kt N)	32	33	33	33	33	33	33	32	32	31	31	32	31	30	30
N_2O emission (Gg)	1.01	1.03	1.03	1.05	1.03	1.04	1.05	1.02	1.01	0.99	0.99	1.01	0.97	0.94	0.93

FracGRAZ is estimated as the volatile fraction from grazing animals compared with the total excreted nitrogen (N ab animal) (Table 6.22)

Table 6.22 FracGRAZ 1990 - 2004

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Total N-excretion (kt N)	293	291	293	293	283	274	275	274	279	270	270	275	277	273	273
N-excretion, grass (kt N)	34	35	35	36	35	36	36	35	35	34	34	34	33	32	32
FracGRAZ	0.12	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.12	0.13	0.13	0.13	0.12	0.12	0.12

6.4.2.3 Indirect Emissions

Atmospheric Deposition

Atmospheric deposition includes all ammonia emissions sources included in the Danish ammonia emission inventory (Illerup et al. 2004). This includes the emission from livestock manure, use of synthetic fertiliser, crops, ammonia-treated straw used as feed, and sewage sludge and sludge from industrial production applied to agricultural soils.

The emission from atmospheric deposition has decreased from 1990 – 2004 as a result of the reduction in the total ammonia emission, from 109400 tonnes of NH_3-N in 1990 to 77900 in 2004.

Table 6.23 Ammonia emission 2004 (DIEMA)

Ammonia emission	2004
	Tonnes NH_3-N
Manure	61 300
Synthetic fertiliser	4 600
Crops	11 500
NH_3 treated straw	400
Sewage sludge and sludge from the industrial production	100
Emission total	77 900
N_2O emission (Gg)	1.22

Nitrogen leaching and Run-off

The amount of nitrogen lost by leaching and run-off from 1986 to 2002 has been calculated by DIAS. The calculation is based on two different model predictions, SKEP/Daisy and N-Les2 (Børgesen and Grant, 2003), and for both models measurements from field studies are taken into account. The results of the two models differ only marginally. The average of the two model predictions is used in the emission inventory.

Figure 6.8 shows leaching estimated in relation to the nitrogen applied to agricultural soils as livestock manure, synthetic fertiliser and sludge. The average proportion of nitrogen leaching and runoff has decreased from 39% in the middle of the nineties to 34% in 2002. 34% is used in the calculations for 2002-2004. The decline is due to an improvement in the utilisation of nitrogen in manure. The reduction in nitrogen applied is particularly due to the fall in the use of synthetic fertiliser, which has reduced by more than 50% from 1990 to 2004.

The proportion of N input to soils lost through leaching and runoff (FracLEACH) used in the Danish emission inventory is higher than the default value of the IPCC (30%). $Frac_{LEACH}$ is higher than the default IPCC values. $Frac_{LEACH}$ has decreased from 1990 and onwards. At the beginning of 1990s, manure was often applied in autumn. The high values are partly due to the humid Danish climate, with the precipitation surplus during winter causing a downward movement of dissolved nitrogen. The decrease in $Frac_{LEACH}$ over time is caused by sharpened environmental requirements, banning manure application after harvest. The major part of manure application is made in spring and summer, where there is a precipitation deficit. The overall effect is that $Frac_{LEACH}$ has decreased. $Frac_{LEACH}$ in 2004 is the same as in 2003. The data reflects the Danish conditions and is considered as a best estimate.

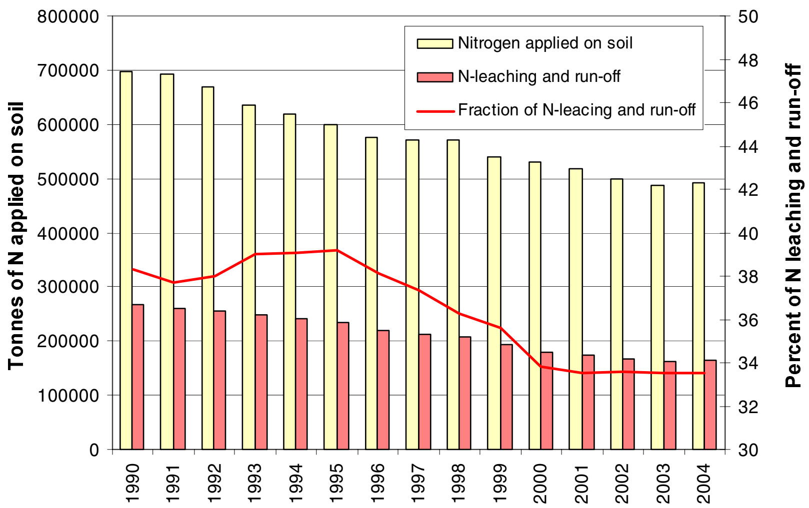

Figure 6.8 Nitrogen applied to agricultural soils and N-leaching from 1990 to 2004

6.4.2.4 Other Emissions

The category, "Other", includes sewage sludge and sludge from the industrial production applied to agricultural soils as fertiliser. Information about industrial waste, sewage sludge and the content of nitrogen is provided by the Danish Environmental Protection Agency. It is assumed that 1.9% of N-input applied to soil volatises as ammonia.

Table 6.24 Nitrogen in sludge applied on agricultural soils 1990 - 2004

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Nitrogen in sludge used as fertiliser (kt N)	4 644	5 939	6 870	9 455	8 946	9 135	9 175	8 487	8 860	8 033	8 773	10 792	11 600	11 572	13087
NH_3-N emission (kt NH_3-N)	58	60	72	93	83	87	85	74	70	69	68	66	67	67	58
N in sludge applied to soil (kt N)	4 586	5 879	6 797	9 362	8 863	9 048	9 090	8 413	8 790	7 965	8 705	10 726	11 532	11 505	13029
N2O emission (Gg N_2O)	0.09	0.12	0.13	0.18	0.17	0.18	0.18	0.17	0.17	0.16	0.17	0.21	0.23	0.23	0.26

6.4.3 Activity data

Table 6.25 provides an overview on activity data from 1990 to 2004 used in relation to the estimation of N_2O emission from agricultural soils. The amount of nitrogen applied to agricultural soil has decreased from 1088 mill. kg N to 751 mill. kg N, corresponding to a 31% reduction.

Table 6.25 Activity data – estimation of N_2O emission from agricultural soils 1990 – 2004 (CRF Table 4.D)

CRF – table 4.D	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
							Gg N								
Total amount of nitrogen applied on soil	1088	1068	1024	996	970	945	904	898	897	842	818	799	767	745	751
1. Direct Emissions															
Synthetic Fertiliser	392	386	362	325	318	308	284	281	277	257	246	229	206	197	202
Animal Waste Applied	179	179	181	184	178	174	175	174	178	175	173	177	182	182	181
N-fixing Crops	45	39	33	42	40	37	36	44	48	39	39	36	34	32	31
Crop Residue	59	58	50	52	52	56	57	56	56	55	56	57	53	53	52
2. Animal Production	32	33	33	33	33	33	33	32	32	31	31	32	31	30	30
3. Indirect Emissions															
Atmospheric Deposition	109	106	104	102	98	92	89	88	89	85	84	84	81	78	78
N-leaching and Runoff	267	261	254	248	241	235	219	213	207	192	179	174	168	163	165
4. Other															
Industrial Waste	2	3	3	5	5	5	5	5	5	4	5	7	8	8	10
Sewage Sludge	3	3	4	5	4	5	4	4	4	4	4	3	4	4	3

6.4.4 Time-series consistency

The N_2O emissions from agricultural soils have reduced by 32% from 1990 to 2004. This is largely due to a decrease in the use of synthetic fertiliser and a decrease in N-leaching as a result of national environmental policy, where action plans have focused on decreasing the nitrogen losses and on improving the nitrogen utilisation in manure.

Table 6.26 Emissions of N_2O from Agricultural Soils 1990 – 2004 (CRF Table 4.D)

CRF – table 4.D	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
							Gg N_2O								
Total N_2O emission	**26.94**	**26.45**	**25.47**	**24.81**	**24.17**	**23.57**	**22.47**	**22.20**	**22.08**	**20.71**	**19.98**	**19.52**	**18.75**	**18.23**	**18.38**
1. Direct Emissions	**13.00**	**13.63**	**13.39**	**12.68**	**12.23**	**11.94**	**11.66**	**11.23**	**11.28**	**11.36**	**10.68**	**10.45**	**10.15**	**9.69**	**9.45**
Synthetic Fertiliser	7.26	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	3.87
Animal Waste Applied	3.57	3.51	3.52	3.56	3.62	3.50	3.41	3.45	3.43	3.50	3.43	3.40	3.47	3.57	3.57
N-fixing Crops	0.79	0.88	0.77	0.65	0.83	0.79	0.73	0.71	0.86	0.95	0.77	0.76	0.71	0.67	0.63
Crop Residue	1.01	1.17	1.13	0.99	1.01	1.02	1.10	1.12	1.11	1.11	1.07	1.09	1.12	1.05	1.03
Cultivation of Histosols	0.38	0.38	0.37	0.37	0.37	0.38	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.35	0.35
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**	**0.97**	**0.94**	**0.93**
3. Indirect Emissions	**12.22**	**11.91**	**11.63**	**11.34**	**11.03**	**10.68**	**10.01**	**9.74**	**9.53**	**8.89**	**8.37**	**8.15**	**7.86**	**7.62**	**7.71**
Atmospheric Deposition	1.72	1.66	1.64	1.60	1.54	1.45	1.39	1.39	1.40	1.33	1.33	1.31	1.28	1.22	1.22
N-leaching and Runoff	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	6.40	6.49
4. Other	**0.09**	**0.12**	**0.13**	**0.18**	**0.17**	**0.18**	**0.18**	**0.17**	**0.17**	**0.16**	**0.17**	**0.21**	**0.23**	**0.23**	**0.26**
Industrial Waste	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	0.07	0.06
Sewage Sludge	0.03	0.05	0.06	0.09	0.09	0.09	0.09	0.09	0.10	0.09	0.10	0.14	0.16	0.16	0.20

6.5 NMVOC emission

Less than 1% of the NMVOC emission originates from the agricultural sector, which, in the Danish emission inventory, includes emission from arable land crops and grassland. Activity data is obtained from Statistics Denmark. The emission factor for land with arable crops is 393 g NMVOC/ha and for grassland, 2120 g NMVOC/ha (Fenhann and Kilde 1994), (Priemé and Christensen 1991).

Table 6.27 NMVOC emission from agricultural soils 1990 - 2004

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Arable crops (1000 ha)	2322	2307	2293	2254	2044	2064	2075	2138	2125	2064	2043	2060	2065	2062	2079
Grassland (1000 ha)	466	462	463	484	647	446	450	403	405	398	413	414	396	390	369
NMVOC emission (Gg)	1.90	1.89	1.88	1.91	2.18	1.76	1.77	1.69	1.69	1.65	1.68	1.69	1.65	1.64	1.60

6.6 Uncertainties

Table 6.25 shows the estimated uncertainties for some of the emission sources, based on expert judgement (Olesen et al. 2001, Gyldenkærne, pers. comm., 2005). The uncertainties for the number of animals and the number of hectares with different crops under cultivation are very small.

Due to the large number of farms included in the norm figures, the arithmetic mean can be assumed as a very good estimate, with a low uncertainty. Cattle and pigs are the most important animal categories for Denmark. All cattle have their own ID-number (ear tags) and, hence, the uncertainty in this number is almost non-existent. Statistics Denmark has estimated the uncertainty in the number of pigs to be less than 1%. The combined effect of low uncertainty in actual animal numbers, feed consumption and excretion rates gives a very low uncertainty in the activity data. The major uncertainty, therefore, relates to the emission factors.

The normative figures (Poulsen et al. 2001) are arithmetic means. Based on the feeding plans, the standard deviation in N-excretion rates between farms can be estimated to ±20% for all animal types (Hanne D. Poulsen, DIAS, pers. comm).

In general, the Tier 1 uncertainty is used in the emission factors. A normal distribution is assumed. In future, Monte Carlo simulations will be made to improve the outcome from the uncertainty analysis.

The highest uncertainty is connected with manure management. The emission factor for CH_4 from manure management is 10%. This figure may be underestimated and the uncertainty is, therefore, increased to 100% until further investigations reveal new data. Research on this topic will be made in Denmark in the next 2-3 years.

Table 6.28 Estimated uncertainty associated with activities and emission factors for CH_4 and N_2O

Source	Emission	Emission, Gg CO_2-eqv.	Activity data, %	Emission factor, %	Combined uncertainty	Total uncertainty, %	Uncertainty 95%, Gg CO_2-eqv.
4 Agriculture - total	**CH_4 and N_2O**	**9999**				**17**	**1711**
4.A Enteric Fermentation	CH_4	2711	10	8	13	13	347
4.B Manure Management	CH_4 and N_2O	1589	7	74	74	74	1178
	CH_4 – table 4.B(a)	1030	10	100	100		
	N_2O – table 4.B(b)	560	10	100	100		
4.D Agricultural Soils	N_2O	5699	8	19	21	21	1191
4.D1 Direct soil emissions	N_2O	2942	5	14	15	15	446
Synthetic Fertiliser	N_2O	1231	3	25	25		
Animal Waste Applied to Soils	N_2O	1103	10	25	27		
N-fixing Crops	N_2O	186	20	25	32		
Crop Residue	N_2O	314	20	25	32		
Cultivation of Histosols	N_2O	108	20	25	32		
4.D2 Animal Production	N_2O	288	20	25	32	32	92
4.D3 Indirect soil emissions	N_2O	2470	16	41	45	45	1101
Atmospheric Deposition	N_2O	379	10	50	51		
N-Leaching and Runoff	N_2O	2011	20	50	54		
4.D4 Other							
4.D4 Sewage N	N_2O	18	20	50	54		
4.D4 Industrial Waste Used as Fertiliser	N_2O	61	20	50	54		

6.7 Quality assurance and quality control - QA/QC

A general QA/QC plan for the agricultural sector is under development. The following Points of Measures (PM) are taken into account in the inventory for 2004.

Data Storage level 1	1. Accuracy	DS.1.1.1	General level of uncertainty for every dataset including the reasoning for the specific values.

The following external data are in used in the agricultural sector:

- Data from the annual agricultural census made by Statistics Denmark
- The Danish Plant Directorate
- Danish Institute of Agricultural Sciences (DIAS)
- Danish Agricultural Advisory Centre (DAAC)

The emission factors come from various sources:

- IPCC guidelines

- Danish Institute of Agricultural Sciences: NH_3 emission, CH_4 emission from enteric fermentation and manure management.

Statistics Denmark

The agricultural census made by Statistics Denmark is the main supply of basic agricultural data. In Denmark, all cattle, sheep and goats have to be registered individually and hence the uncertainty in the data is negligible. For all other animal types, farms having more than 10 animal units are registered.

DIAS

DIAS is responsible for the delivery of N-excretion data for all animal and housing types. Data on feeding consumption on commercial farms are collected annually by DAAC from on-farm efficacy controls. For dairy cattle, data is collected from 15-20% of all farms, for pigs, 25-30% and for poultry and mink, 90-100% of all farms. The farm data are used to calculate average N-ex from different animal and housing types. Due to the large amount of farm data involved in the dataset, N-ex is seen as a very good estimate for average N-ex.

Danish Plant Directorate

Total area with the various agricultural crops is provided to the Danish Plant Directorate via the agricultural subsidy system. For every parcel of land (via a vector-based field map with a resolution of >0.01 ha), the area planted with different crops is reported. If the total crop area within a parcel is larger than the parcel area, a manual control of the information is performed by the Plant Directorate. The area with different crops, therefore, represents a very precise estimate.

All farmers are obliged to do N-mineral accounting on a farm and field level with the N-excretion data from DIAS. Data at farm level is reported annually to the Danish Plant Directorate. The N figures also include the quantities of mineral fertilisers bought and sold. Suppliers of mineral fertilisers are required to report all N sales to commercial farmers to the Plant Directorate. The total sold to farmers is very close to the amount imported by the suppliers, corrected for storage. The total amount of mineral fertiliser in Denmark is, therefore, a very precise estimate for the mineral fertiliser consumed. This is also valid for N-ex in animal manure.

The Danish Plant Directorate, as the controlling authority, performs analysis of feed sold to farmers. On average, 1600 to 2000 samples are analysed every year. Uncertainty in the data is seen as negligible. The data are used when estimating average energy in feedstuffs for pigs, poultry, fur animals, etc.

Data Storage level 1	1. Accuracy	DS.1.1.2	Quantification of the uncertainty level of every single data value including the reasoning for the specific values.

Uncertainty in the data received is very low due to the very strict environmental laws in Denmark. Standard deviation regarding the numbers of cattle and pigs has been estimated to <0.7% . For poultry the standard deviation is <2.1%. For all years, 25-35% of all holdings are included in the census. The standard deviation for N-ex between farms is reported as 25% for dairy cattle and pigs, but due to the large numbers involved in the estimation of the average Nex, the average is assumed to be a precise estimate for the Danish agricultural efficacy level.

Data Storage level 1	2.Comparability	DS.1.2.1	Comparability of the data values with similar data from other countries, which are comparable with Denmark, and evaluation of discrepancy.

The Danish N-ex levels are generally lower than IPCC default values. This is due to the highly skilled, professional and trained farmers in Denmakr, with access to a highly competent advisory system.

The feed consumption per animal is in line with similar data from Sweden, although they are not quite comparable because Denmark is using feeding units (FE) which cannot easily be converted to energy content. Earlier, one feeding unit was defined as one kg of barley. Today, the calculations are more complicated and depend on animal type.

Data Storage level 1	3.Completeness	DS.1.3.1	Documentation showing that all possible national data sources are included by setting down the reasoning behind the selection of datasets.

See DS 1.1.1.

Data Storage level 1	4.Consistency	DS.1.4.1	The origin of external data has to be pre-served whenever possible without explicit arguments (referring to other PMs).

External data received are stored in the agricultural directory in NERI's IT system.

Data Storage level 1	6.Robustness	DS.1.6.1	Explicit agreements between the external institution holding the data and NERI about the conditions of delivery.

NERI has established formal data agreements with all institutes and organisations which deliver data, to assure that the necessary data is available to prepare the inventory on time.

Data Storage level 1	7.Transparency	DS.1.7.1	Summary of each dataset including the reasoning for selecting the specific dataset.

Please refer to DS 1.1.1.

Data Storage level 1	7.Transparency	DS.1.7.3	References for citation for any external data set have to be available for any single value in any dataset.

A great deal of documentation already exists in the literature list. A separate list of references is stored in:

I:/rosproj/luft_emi/inventory/2004/4_Agriculture/level_1a_storage /

Data Storage level 1	7.Transparency	DS.1.7.4	Listing of external contacts for every data-set.

Statistics Denmark:

Ole Olsen (olo@dst.dk) and Karsten K. Larsen (kkl@dst.dk)

DIAS:

Mrs. Hanne Damgaard Poulsen (HanneD.Poulsen@agrsci.dk)

Mr. Nick Hutchings (Nick.Hutchings@agrsci.dk)

Mr. Martin Nørregaard Hansen (MartinN.Hansen@agrsci.dk)

Mr. Sven G. Sommer (SvenG.Sommer@agrsci.dk)

The Danish Agricultural Advisory Centre:

Mr. Niels Henrik Lundgaard (NHL@landscentret.dk)

Mr. Jan Brøgger Rasmussen (JBR@landscentret.dk)

Danish Plant Directorate:

Mr. Troels Knudsen (tkn@pdir.dk)

The Danish Energy Authority:

Mr. Søren Tafdrup (st@ens.dk)

Data Processing level 1	1. Accuracy	DP.1.1.1	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to type of variability. (Distribution as: normal, log normal or other type of variability).

The Tier 1 methodology is used to calculate the uncertainties for the agricultural sector. The uncertainties are based on expert judgement (Olesen et al. 2001, Poulsen et al. 2004, Gyldenkærne, pers. comm., 2005) and a normal distribution is assumed. Further work will focus on the possibilities to carry out Monte Carlo simulations to improve the outcome from the uncertainty analysis.

Data Processing level 1	1. Accuracy	DP.1.1.2	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to scale of variability (size of variation intervals).

Please refer to DP 1.1.1.

Data Processing level 1	1. Accuracy	DP.1.1.3	Evaluation of the methodological approach using international guidelines.

DK has recently worked out a report with a more detailed description of the methodological inventory approach. This report is currently undergoing review in Sweden and will be used to evaluate and improve the inventory. Furthermore, data sources and calculation methodology developments are discussed in cooperation with specialists and researchers in different institutes and research sections. As a consequence, both the data and methods are evaluated continually according to the latest knowledge and information.

Data Processing level 1	1. Accuracy	DP.1.1.4	Verification of calculation results using guideline values.

Enteric CH_4 emissions are, in general, lower than the IPCC default values due to the professional way farms are managed in Denmark. Enteric fermentation from dairy cows is high and comparable with North American conditions. Due to the increase in milk production per dairy cow, there has been an increase in enteric fermentation of CH_4, and it is in line with that in the US, the Netherlands and Sweden.

CH_4 emissions from manure management have increased since 1990 because there has been an increase in manure handled as slurry. The emissions are higher than the default IPCC values for western Europe because of the higher percentage handled as slurry. However, due to the high efficacy at farm level, energy intake is lower per head and the subsequent CH_4 emission from slurry is, thereby, lower. Denmark uses an MCF factor of 10% as provided in the 1996 guidelines and not the 39% in the revision to the 1996 guidelines. For further explanation, see the text in the agriculture chapter.

$Frac_{LEACH}$ is higher than the default IPCC values. $Frac_{LEACH}$ has decreased from 1990 and onwards. In the beginning of 1990s, manure was often applied in autumn.The high values are partly due to the humid Danish climate, with the precipitation surplus during winter causing a downward moment of dissolved nitrogen. The decrease in $Frac_{LEACH}$ over time is caused by sharpened environmental requirements, banning manure application after harvest. As a result, most manure application occurs during spring and summer, where there is a precipitation deficit. The generally accepted leaching values in Denmark are 0.3 for mineral nitrogen and 0.45 for organic-bound nitrogen. These values are based on numerical leaching studies.

Data Processing level 1	2.Comparability	DP.1.2.1	The inventory calculation has to follow the international guidelines suggested by UNFCCC and IPCC.

The Danish emission inventory for the agricultural sector mainly meets the request as set down in the IPCC Good Practice Guidance.

Data Processing level 1	3.Completeness	DP.1.3.1	Assessment of the most important quantitative knowledge which is lacking.

All known major sources are included in the inventory.

Data Processing level 1	3.Completeness	DP.1.3.2	Assessment of the most important cases where access is lacking with regard to critical data sources that could improve quantitative knowledge.

In Denmark, only very few data are restricted (military installations). Accessibility is not a key issue; it is more lack of data.

Data Processing level 1	4.Consistency	DP.1.4.1	In order to keep consistency at a high level, an explicit description of the activities needs to accompany any change in the calculation procedure

The calculation procedure is consistent for all years.

Data Processing level 1	5.Correctness	DP.1.5.1	Show at least once, by independent calculation, the correctness of every data manipulation.

During the development of the model, thorough checks have been made by all persons involved in preparation of the agricultural section.

Data Processing level 1	5.Correctness	DP.1.5.2	Verification of calculation results using time-series.

Time-series for activity data, emission factors and total emission are performed to check consistency in the methodology, to avoid errors, to identify and explain considerable year to year variations.

Data Processing level 1	5.Correctness	DP.1.5.3	Verification of calculation results using other measures.

During the calculations, the results are checked according to the check-list.

Data Processing level 1	5.Correctness	DP.1.5.4	Shows one-to-one correctness between external data sources and the data bases at Data Storage level 2.

Output data to Data Storage Level 2 is checked for correctness according to the check-list.

Data Processing level 1	7.Transparency	DP.1.7.1	The calculation principle and equations used must be described.

All calculation principles are described in the NIR and the documentation report (Mikkelsen et al. 2004).

Data Processing level 1	7.Transparency	DP.1.7.2	The theoretical reasoning for all methods must be described.

All theoretical reasoning is described in the NIR and the documentation report (Mikkelsen et al. 2004).

Data Processing level 1	7.Transparency	DP.1.7.3	Explicit listing of assumptions behind all methods.

All theoretical reasoning is described in the NIR and the documentation report (Mikkelsen et al. 2004).

Data Processing level 1	7.Transparency	DP.1.7.4	Clear reference to dataset at Data Storage level 1.

A clear reference in the DP level 1 to DS level 1 is under construction.

Data Processing level 1	7.Transparency	DP.1.7.5	A manual log to collect information about recalculations.

Changes compared with the last emissions report are described in the NIR and the total emission changes is given in a table under the section, "Recalculation". The text describes whether the change is caused by changes in the dataset or changes in the methodology used. A logbook is kept in the spreadsheet mentioning all changes.

Data Storage level 2	5.Correctness	DS.2.5.1	Documentation of a correct connection between all data types at level 2 to data at level 1.

A manual check-list is under development for correct connection between all data types at level 1 and 2.

Data Storage level 2	5.Correctness	DS.2.5.2	Check if a correct data import to level 2 has been made.

A manual check-list is under development for correctness of data import to level 2.

6.8 Recalculation

Compared with an earlier emission inventory (2003 submission), some changes are made. These changes increase the total GHG emission from the agricultural sector by 0-2% (Table 6.29).

Table 6.29 Changes in GHG emission in the agricultural sector compared with the CRF reported last year (2003 submission)

GHG emission	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
								Gg CO_2 eqv.						
Previous	12 845	12 720	12 429	12 307	12 052	11 845	11 526	11 357	11 368	10 806	10 565	10 470	10 138	9 898
Recalculated	13 048	12 902	12 586	12 443	12 173	11 984	11 610	11 432	11 438	10 855	10 611	10 576	10 261	10 031
Change in Gg CO_2 eqv.	202	183	157	136	121	138	84	75	70	49	46	106	123	133
Change in pct.	1.6	1.4	1.3	1.1	1.0	1.2	0.7	0.7	0.6	0.5	0.4	1.0	1.2	1.3

There have been no changes in the methodology used to calculate the emissions, except from calculation of N_2O emission from histosols. The changes are summarised below.

- N_2O emission from histosols are recalculated and a national emission factor is used based on the C:N relationship for the organic matter in the histosols. A more detailed description is given in the chapter for the LULUCF sector.
- The CH_4 emission related to the enteric fermentation from dairy cattle and heifers has been recalculated. A national Y_m for all years is used. Research from DIAS has shown that the principal feedstuff used (sugar beets) in 1990 gives a higher methane conversion rate than the default value recommended in the IPCC reference manual. This has resulted in an increase of the emission by 4% for 1990 and 2% for 2003.

- The new CRF format is used, which allows inclusion of the CH_4 emission from manure management in fur farming. This animal category contributes with almost 3% of the total CH_4 emission from manure management.
- Updating of slaughter weight 2000 – 2003 for pigs. This has resulted in small changes in the number of slaughter pigs.
- A recalculation has been performed for horses 1990 – 2003 due to a revision of the Danish normative feeding norms for horses lighter than 400 kg.

6.9 Planned improvements

The Danish emission inventory for the agricultural sector largely meets the request as set down in the IPCC Good Practice Guidance. The Expet Review Team (ERT) has pointed out the needs for more detailed documentation, transparency and better explanations, especially related to the use of national data and national methodologies. A documentation report, which includes more information on DIEMA (the model complex system used to calculate both the ammonia and the GHG emission from the agricultural activities) is currently in review in Sweden. The final report based on this evaluation will contain a much more detailed description of both the background data and methodology used to estimate the emission. This report will be available in English and it is hope that this will be one, among other instruments, which will improve the Danish emission inventory. In the years to come, the NIR will focus on improvments in tranparency in relation to use of the national values, by means of improved explanations and relevance for tables in the report, and references to more detailed descriptions in other reports or inclusion of summary descriptions in the NIR itself.

In relation to the ERT recommendations, some specific improvements, as mentioned below, are planned:

- the documentation of number of horses, sheep and goats on small farms less than 5 ha, which is not included in the annual census from Statistics Denmark.

- carrying out an interpolation of feed intake for dairy cattle between 1990 and 1994 to avoid jumps in the time-series.

- improving the explanation of the model and background data used in estimating leaching and runoff.

- improving the description of the calculated emission from N-fixing crops.

Other issues which need to be improved are continuing work concerning the QA/QC plan and the estimation of uncertainties. The QA/QC plan for the agricultural sector is still under development, but, as a first step, a review of the existing data structure is carried out – see Section 6.7. The further work concerning the uncertainties will focus on the possibilities to bring about improvements by means of using a Monte Carlo simulation, which can improve the outcome from the uncertainty analysis.

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7 The Specific methodologies regarding Land Use, Land Use Change and Forestry (CRF Sector 5)

7.1 Overview

Since the submission to the UNFCCC in April 2005, emissions from mineral soils have been included and the area with organic soil has been revised. The methodology is described in Gyldenkærne et al. (2005) and in Gyldenkærne et al (2006). In the submission in 2004, organic soils were defined according to the Danish soil classification. In the present submission, a split has been made so the classification of organic soils accords with the IPCC guidelines. As a consequence, a recalculation has been performed both for CO_2 for the LULUCF sector and N_2O emissions for the agricultural sector. The LULUCF sector differs from the other sectors in that it contains both sources and sinks of carbon dioxide. LULUCF is reported in the new CRF format. Removals are, according to the guidelines in the new reporting format, given as negative signatures, and sinks are reported with positive signatures. This is the opposite to the way of reporting used in the remainder of the report. Emissions from LULUCF were estimated to comprise a sink of approximately 2 280 Gg CO_2 or 4% of the total reported Danish emission in 2004.

Approximately two-thirds of the total Danish land area is cultivated. Together with the large number of cattle and pigs, this presents a high (environmental) pressure on the landscape. To reduce the impact, an active policy has been adopted to protect the environment. The policy adopted aims to double the area of forest within the next 80-100 years, re-establish former wetlands and designate national parks. In Denmark, all natural habitats and forests are protected and, therefore, no conversions from forest or wetlands into cropland or grassland are made in the inventory, since such conversions in reality is not occurring.

A thorough GIS analysis of Land Use and Land Use Change has been made for the agricultural sector. The method is described in more detail in Section 7.3, Cropland. A full matrix of the total land area still needs to be prepared. In connection with reporting obligations, analyses of satellite monitoring for 1990 and later years will be performed in the near future.

The data are reported in the new CRF format under IPCC categories 5A (Forestry), 5B (Cropland), 5C (Grassland) and 5D (Wetlands). The IPCC categories 5E (Settlements) and 5F (Other) are not reported as changes within these categories are considered to be negligible or not to occur in Denmark.

Fertilisation of forests and other land is negligible and is, therefore, reported in the total for all fertiliser consumption under the agricultural sector. Drainage of forest soils is not reported. Liming is included in the LULUCF sector. All liming is reported under "Cropland", because only very limited amounts are used in forestry and on permanent grassland. Field burning of biomass is prohibited in Denmark and is, therefore, reported as not occurring (NO). Biomass burned in power plants is reported in the energy sector.

In Table 7.1 an overview of the emission from the LULUCF sector in Denmark is given, measured in Gg CO_2-eqv. Forests are sinks in Denmark, with approximately 3 500 Gg CO_2-eqv y^{-1}, and Cropland is estimated to have a net emission of approximately 2 400 Gg CO_2. Only organic soils are reported at the moment and the emission, therefore, relates to cultivation of organic soils. From 1990 and onwards, a decrease in the emission from Cropland has been estimated due to reduced agricultural area, an increase in hedgerows and reduced consumption of lime. Wetlands have gone from a net emitter to a sink, due to the establishment of wetlands.

Table 7.1 Overall emission (Gg CO_2) from the LULUCF sector in Denmark, 1990-2004

GREENHOUSE GAS SOURCE AND SINK CATEGORIES		5. Land Use, Land-Use Change and Forestry	A. Forest Land	B. Cropland	C. Grassland	D. Wetlands	E. Settlements	F. Other Land	G. Other
Base year 1990	(Gg)	5 551.7	-2 830.70	3 287.50	92.9	1.9	NE, NO	NE, NO	NE.NO
1991	(Gg)	551.7	-2 830.70	3 287.50	92.9	1.9	NE,NO	NE,NO	NO
1991	(Gg)	-1 546.40	-2 998.70	1 361.40	88.9	1.9	NE,NO	NE,NO	NO
1993	(Gg)	-1 154.00	-3 210.00	1 969.70	84.3	1.9	NE,NO	NE,NO	NO
1994	(Gg)	-1 613.00	-3 098.60	1 402.00	81.7	1.9	NE,NO	NE,NO	NO
1995	(Gg)	-1 664.40	-2 987.70	1 232.80	88.6	1.9	NE,NO	NE,NO	NO
1996	(Gg)	-1 211.50	-3 063.40	1 767.60	82.5	1.9	NE,NO	NE,NO	NO
1997	(Gg)	-1 172.50	-3 155.10	1 909.10	71.7	1.9	NE,NO	NE,NO	NO
1998	(Gg)	-1 946.50	-3 312.20	1 297.10	66.8	1.8	NE,NO	NE,NO	NO
1999	(Gg)	-1 221.30	-3 306.30	2 015.80	68.2	1.1	NE,NO	NE,NO	NO
2000	(Gg)	1 642.00	-652.9	2 227.10	71.1	-3.3	NE,NO	NE,NO	NO
2001	(Gg)	-756.9	-3 538.60	2 712.50	74.3	-5	NE,NO	NE,NO	NO
2002	(Gg)	-1 965.10	-3 813.30	1 779.20	75.9	-7	NE,NO	NE,NO	NO
2003	(Gg)	-1 940.40	-3 532.20	1 525.80	76	-10	NE,NO	NE,NO	NO
2004	(Gg)	-2 279.60	-3 449.40	1 108.50	73.8	-12.5	NE,NO	NE,NO	NO
Change from base year	%	-513	22	-66	-21	-743	0	0	0

7.2 Forest Land

7.2.1 Source category description

Danish forests cover only a small part of the country (11%) since the dominant land use in Denmark is agriculture. Danish forests are managed as closed canopy forests. The main objective is to ensure sustainable and multiple-use management. The main management system used to be the clear-cut system. Today, principles of nature-based forest management including continuous cover forestry are being implemented in many forest areas, e.g. the state forests (about ¼ of total forest area). Contrary to the situation in the other Scandinavian countries, forestry does not contribute significantly to the national economy.

The Danish Forest Act protects the main part of the forest area (about 80%) against conversion to other land uses. In principle, the majority of Danish forest area will always remain forest. It is the ambition to enlarge the forested area to 20-25% of the country area by the end of the 21st century. Afforestation of arable land is, therefore, encouraged by use of subsidies to private landowners. Subsidised afforestation areas are automatically protected as forest reserves. Denmark is the only part of the Kingdom with a forestry sector. Greenland and the Faroe Islands have almost no forest.

Since 1881, a Forestry Census has been carried out roughly every 10 years based on questionnaires to forest owners (Larsen and Johannsen, 2002). The two latest were carried out in 1990 and 2000. Since the data is based on questionnaires and not field observations, the forest definition may vary slightly, but the basic definition of a forest is that the forest area must be minimum 0.5 ha. There is no specific guideline on the crown cover or the height of the trees. Open woodland and open areas within the forest are not included.

In 1990, the forested area with trees was in the region of 411 000 ha (= 4 110 km^2), or approximately 10% of land area (Forestry Census, 1990). Broadleaved tree species made up 35% and coniferous species made up 65% of the forested area. See Table 7.2 for the distribution according to specific tree species and species categories.

Table 7.2 Total wooded area, temporarily uncovered area and distribution of forested area according to main tree species and species categories in 1990 and 2000. From Statistics Denmark (*http://www.statistikbanken.dk/*).

Area in ha	1990	2000
Total wooded area	**417089**	**473320**
Area temporarily without trees[1]	5702	4985
Broadleaves, total area	**143253**	**174385**
Beech	71764	79552
Oak	30247	43011
Ash	10158	12681
Sycamore maple	7979	9444
Other broadleaves	23105	29698
Conifers, total area	**268134**	**293950**
Norway spruce	135010	132237
Sitka spruce	35464	34223
Silver fir and other fir	7001	11919
Nordmann's fir	11841	28173
Noble fir	15115	15498
Other conifers	63703	71901

[1]Area not yet replanted with trees following clear-cutting

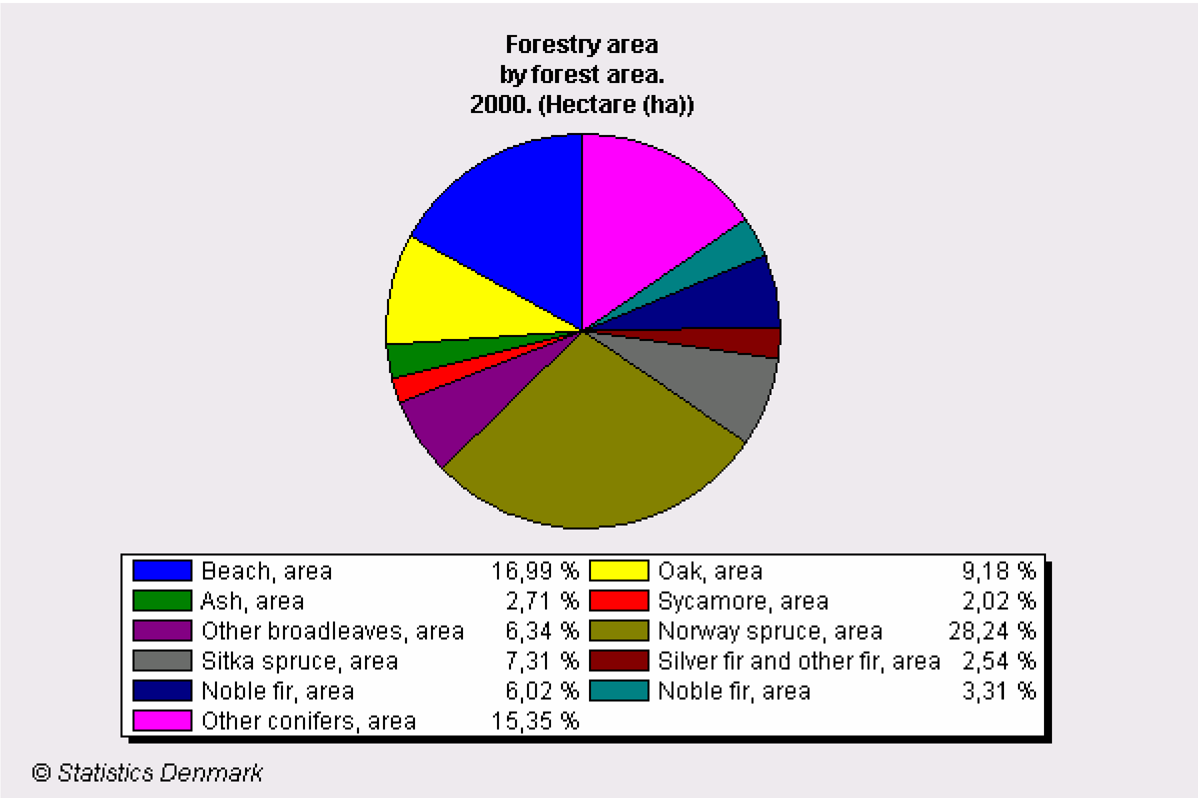

Figure 7.1 Tree species distribution to the total forested area in 2000. From Statistics Denmark (*http://www.statistikbanken.dk/*).

In 2000, the forested area with trees was 468 000 ha or approximately 11% of land area. The number of respondents for this survey was 32300, which is considerably higher than the 22300 in the 1990 survey. The increase in the number of respondents may, in fact, cause the changes in the forest area reported between 1990 and 2000 rather than real changes in the forest area. The increase in forested area is, therefore, only partly a result of afforestation of former arable land since 1990 (about 27 536 ha). Broadleaved tree species made up 37% and coniferous species made up 63% of the forest area. See Figure 7.1 and Table 7.2 for the distribution according to specific tree species and species categories.

Compared with other sectors, forestry has very low energy consumption. Green accounting and environmental management are being developed in the sector, partly with the intention of determining whether the use of fossil fuels can be reduced.

Danish forests are managed with special reference to multiple-use and sustainability, and carbon sequestration is just one of several objectives. The policy objective most likely to increase carbon sequestration is the 1989 target to double Denmark's forested area within 100 years. There are several measures aimed at achieving this objective. Firstly, a government subsidy scheme has been established that supports private afforestation on agricultural land. Secondly, governmental and municipal afforestation is also taking place and, thirdly, some private afforestation is taking place without subsidies. The Danish Forest and Nature Agency is responsible for policies on afforestation on private agricultural land and on state-owned land.

7.2.2 Methodological issues

7.2.2.1 Forest inventory data and reference values used in calculations

Standing stocks of wood in 1990 and 2000, and annual increments for the two periods 1990-99 and 2000-2004 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 Centre for Forest, Landscape and Planning[6]. In short, the estimates of standing volume and volume increments in the Forestry Census from 1990 and from 2000 are based on questionnaire information from forest owners on forest area distributed according to species and age classes, and information on site productivity. Based on standard yield table functions, this input data is used to estimate standing volume and rate of increment for each tree species category.

In 1990 the standing stock of wood was 64.8 million m^3, equivalent to 158 m^3 per ha, distributed with 40% broadleaved species and 60% coniferous species. This stock of wood was equivalent to 22 425 Gg C or 82 225 Gg CO_2. In 2000, the standing stock of wood was 77.9 million m^3, equivalent to 166 m^3 per ha, distributed with 37% broadleaved species and 63% coniferous species. This stock of wood was equivalent to 26 803 Gg C or 98 278 Gg CO_2. These two figures cannot be compared directly due to the differing numbers of respondents in the two censuses. The number of respondents in the 2000 survey was

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32 300, considerably higher than the number of 22 300 in the 1990 survey.

From 2002, a new sample-based National Forest Inventory (NFI) has been launched. The new NFI will replace the Forestry Census and measures 1/5 of the plots every year. The NFI will be completed by 2006 (after 5 years of field measurements), and the first background data for use in the NIR is expected in 2007. This type of forest inventory will be quite similar to inventories used in other countries, e.g. Sweden (see also Section 7.2.6).

Expansion factors are needed to convert stem volumes for conifers and total aboveground biomass for the broadleaves to total biomass. There is currently no information on expansion factors applicable to Danish conditions. However, a couple of studies will supply valuable national information within a year or so. 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 is converted to total biomass by an expansion factor of 1.2, based on Vande Walle et al. (2001) and Nihlgård and Lindgren (1977). These studies were chosen as the basis for expansion factors due to the geographical closeness of the study sites (Germany, Sweden and Belgium), and the studies concerned relevant Danish species like beech, oak and Norway spruce. Stand management may, evidently, differ from Danish "average" stand management, but variability in management may potentially be even larger within Denmark. The difference between expansion factors for conifers and broadleaves is 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 basic wood densities (Moltesen, 1988, see Table 7.3), and carbon content is finally calculated by using a carbon concentration of 0.5 g C g^{-1} dry mass.

Table 7.3 Basic wood densities for Danish tree species (Moltesen, 1988).

	Wood density (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 reporting on changes in forest carbon stores only considers the biomass of trees. There is no systematic information available on soil organic carbon for use in the reporting.

7.2.2.2 Annual CO_2-sequestration in forests planted before 1990

Net C sequestration in the periods 1990–1999 and 2000-2004 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 harvest intensity, especially for conifers. The harvesting intensity for broadleaves has also been decreasing since the late 1990s. The high net C sequestration is also partly a result of an uneven age class distribution with relatively many young stands.

The estimated gross wood increment for the period 2000–2003 is based on the most recent questionnaire-based Forestry Census of 2000. Harvesting is not included in estimates of gross wood increment. 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. The gross annual increment for 1990-99 was estimated at 4.6 million m^3 y^{-1} and around 5.2 million m^3 y^{-1} for 2000-09. 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 could now be replaced by reference values on site productivity from the State Forests. Further details on the calculation of the estimates can be found in Johannsen (2002).

Data on the amount of wood annually harvested (Figure 7.2) are obtained from Statistics Denmark (http://www.statistikbanken.dk/). Commercial harvesting was used in the 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% was added to the figures for commercial harvests of coniferous wood.

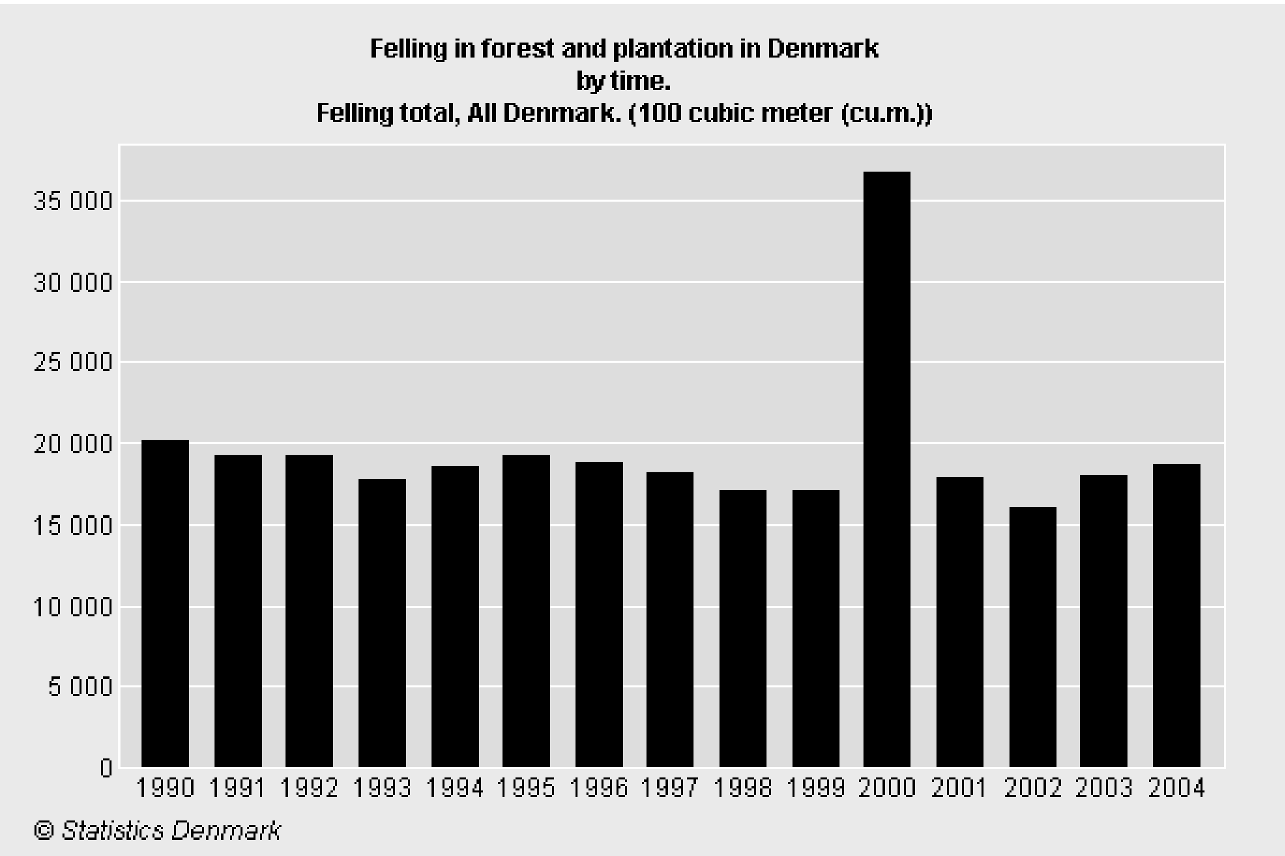

Figure 7.2 Total annual harvest of commercial wood in forests planted before 1990. The peak in 2000 is almost solely due to wind throw of conifers during the storm on Dec. 3, 1999. From Statistics Denmark (http://www.statistikbanken.dk/).

The net annual increment (gross wood increment minus harvested wood) was estimated to be approximately 2.3 million m^3 y^{-1} for 1990–1999 and is estimated to be approximately 2.7 million m^3 y^{-1} for 2000-2004 (Larsen and Johannsen, 2002). Rates of wood increment are converted to CO_2 uptake by using the expansion factors, basic wood densities and carbon concentration mentioned above.

The data on gross uptake of CO_2 due to annual gross increment, annual loss of CO_2 in harvested wood and the resulting net sink for CO_2 are given in Table 7.4. Figure 7.3 shows the dynamics in the C balance for broadleaves and conifers, respectively. The resulting net sink for CO_2 in existing forests in 1990 was around 3,000 Gg CO_2 yr^{-1} for the period 1990-1999 and somewhat higher (around 3,500 Gg CO_2 y^{-1}) for the period 2000-2004. In the year 2000, the sink was much lower than in all other years due to the storm in December 1999. The wind throw caused by this storm lead to the amount of wood harvested in 2000 being more than two times higher than during an average year. The storm-felled amount of wood amounted to 3.6 million m^3 distributed over about 20,000 ha (Larsen and Johannsen, 2002).

Table 7.4 Data on gross uptake of CO_2, loss of CO_2 due to harvesting (Figure 7.2) 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	2003	2004
Gross uptake of CO_2 (Gg yr^{-1})	-5743	-5743	-5743	-5743	-5743	-5743	-5743	-5743	-5743	-5743	-6083	-6083	-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	2658	2757
Net annual sink for CO_2 (Gg yr^{-1})	-2832	-3012	-2997	-3210	-3092	-2982	-3048	-3129	-3279	-3268	-594	-3465	-3725	-3424	-3326

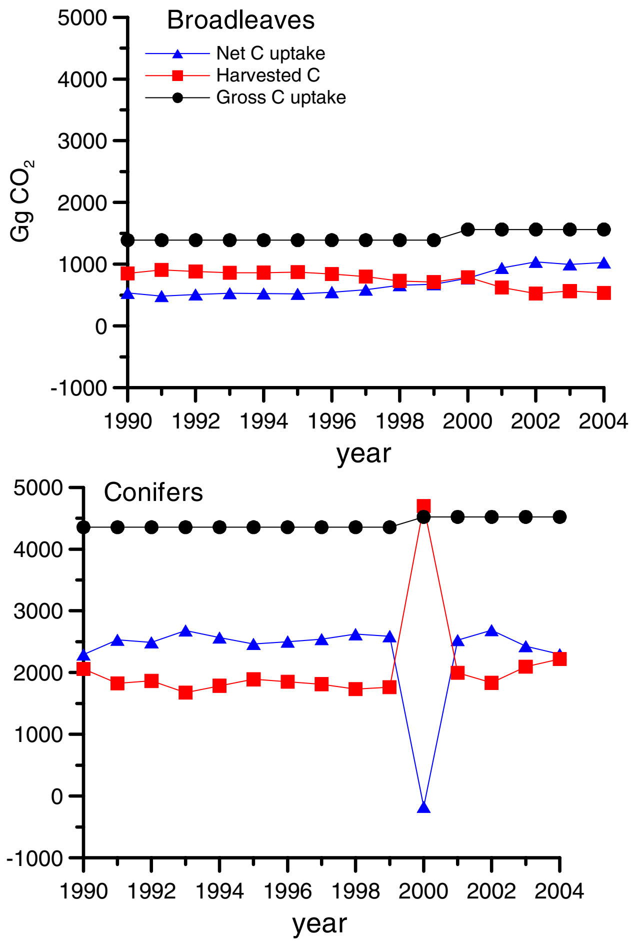

Figure 7.3 The C balance (in Gg CO_2) for broadleaves and conifers in forests planted before 1990. The wind throw of conifers during the storm on Dec. 3, 1999 is clearly visible in data for 2000.

For 2000-2004, the gross uptake of CO_2 was slightly higher than for 1990-1999. This is largely attributed to the higher number of respondents to the questionnaire, i.e. the forest area included was larger (440 000 ha vs. 411 000 ha in 1990. Annual gross increment per ha was similar for the two periods (11 m^3 ha^{-1} y^{-1}). The estimated increment in the period 2000-2004 was adjusted in order to account for the forest damage and changed age distribution caused by the storm in December 1999. Gross increment and, consequently, gross carbon uptake was negatively affected by the wind throw as the age distribution changed towards less productive reforested stands. The loss of increment is estimated at 182 000 m^3 yr^{-1} for the period 2000-2009.

7.2.2.3 Annual 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 4–5 000 ha yr^{-1} was needed, but, in reality, the afforestation rate has been much lower with an average afforestation rate of 1 839 ha yr^{-1} for the period 1990-2004. Afforestation is carried out on soils formerly used for agriculture (cropland). The annually afforested area is specified in Table 7.5. Data on the area afforested by state forest districts, other public forest owners and private land owners receiving subsidies is derived from an evaluation report on afforestation (National Forest and Nature Agency, 2000). Area data for the years 1999-2004 is obtained from the records of the 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 in the period 1990-99. However, the Nordmann's fir plantations were not included in the reported afforested area. The reason for this is, firstly, that Nordmann's fir plantations seldom become closed forest as the trees are harvested within a ten year rotation and, secondly, changes in the market for Christmas trees may force land owners 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 where 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 yield tables used for calculation of carbon stores are valid for yield class 2 (on a scale decreasing from 1 to 4). No distinction is made between growth rates on different soil types. Growth rates are usually relatively high for afforested soils inspite of different parent materials (Vesterdal et al., 2006). This is due to the nutrient-rich topsoil, which is a legacy of former agricultural fertilisation and liming. 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 (see Appendix A2).

The reason for the use of a different methodology for carbon sequestration following afforestation is partly historical. Estimation of C sequestration for afforested lands started in a period with no previous data from a Forestry Census, and has been maintained to keep a consistent time-series. However, the yield tables used for growth estimates are similar for forests existing before 1990 and afforestation since 1990. When the new NFI and new growth models are introduced in a few years (see 7.2.6), further harmonisation of the calculation methods is considered.

Table 7.5 Distribution of afforestation area (ha) according to 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	3304	611	4423	3613	810
2000	196	182	1764	611	2753	2115	638
2001	175	50	1288	611	2124	1570	554
2002	200	29	1497	611	2337	1824	514
2003	300	78	1537	611	2526	1971	555
2004	200	39	463	611	1314	849	465

Wood volumes are converted to carbon stocks by the same method as for forests existing before 1990, except that a higher expansion factor, 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, at present, as a conservative estimate. This is evidently an area in need of improvement.

To date, there have been no thinning operations in the stands afforested since 1990; thus there have been no reported emissions of carbon. However, decomposition rates for the various slash components following harvesting are included in the model and these dynamics can be included when stands reach the age of first thinning. The first thinning operations in the model are carried out at the age of about 15 years for conifers and 25 years for oak. 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).

Soil carbon pools have not been included in the model to date. Based on studies of soils in chronosequences 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, results from an EU project (http://www.sl.kvl.dk/afforest/) indicate that this may not be the case, following afforestation on other soil types (Vesterdal et al., 2006). There is currently no systematic data available to explore this further.

The annual CO_2 uptake, and the cumulated CO_2 uptake and afforested area since 1990 are given in Table 7.6, and the annual CO_2 uptake is given for broadleaved and coniferous species separately in Fig. 7.4. As shown in Table 7.6, annual sequestration of CO_2 in forests established since 1990 has gradually increased to 124 Gg CO_2 in 2004; for further details, see Annex A2. 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 7.6 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	2003	2004
Annual CO_2 uptake (Gg yr^{-1})	0	-1	-3	-5	-8	-10	-16	-24	-34	-43	-59	-74	-88	-108	-124
Cumulated CO_2 uptake (Gg)	0	-1	-4	-10	-17	-28	-44	-68	-102	-145	-204	-278	-365	-473	-597
Cumulated afforestation area (ha)	730	1723	2978	4258	5749	7075	8451	10711	12116	16539	19292	21416	23754	26280	27594

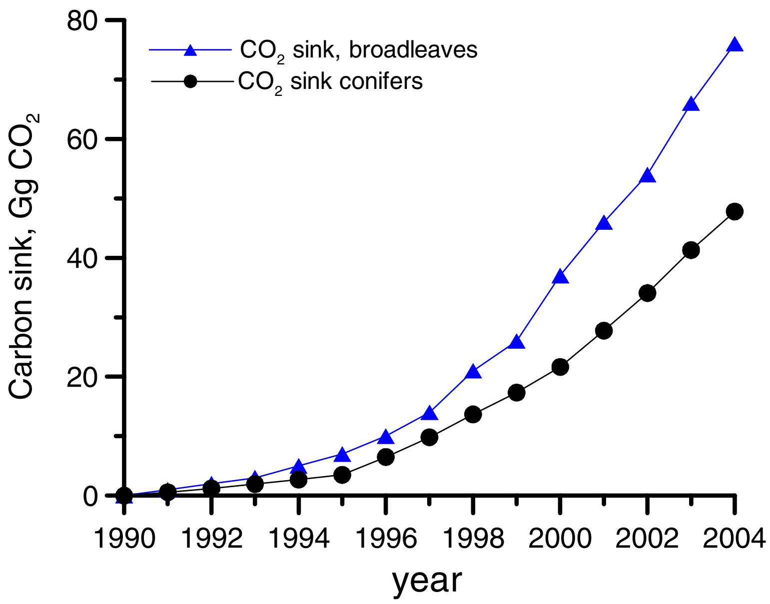

Figure 7.4 The contribution of broadleaved and coniferous species to the total afforestation C sink (in Gg CO_2).

During the Kyoto commitment period 2008–2012 (5 years), it is estimated that the Danish afforestation activities will result in sequestration of 1 308 Gg CO_2. This amount of C results from the afforestation of 43 000 ha of former arable land over the period 1990–2012. The sink capacity is based on a conservative estimate of approximately 1,900 ha of land afforested annually in the period 2005-2012, but it is possible that other instruments in addition to subsidies will make it possible to increase the rate of afforestation and eventually the sequestration of CO_2.

7.2.2.4 Total contribution of forestry

Table 7.7 shows the figures reported in this NIR report distributed to the land uses *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 7.7 CO_2 stores and annual uptake in forests in Gg, 1990 – 2004. 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	2003	2004
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	-3532	-3450
CO_2 uptake in forests existing before 1990	-2832	-3012	-2997	-3210	-3092	-2982	-3048	-3129	-3279	-3268	-594	-3465	-3725	-3424	-3326
CO_2 uptake due to afforestation since 1990	0	-1	-3	-5	-8	-10	-16	-24	-34	-43	-59	-74	-88	-108	-124

7.2.3 Uncertainties and time-series consistency

7.2.3.1 Uncertainty of the reported sinks

In response to previous reviews, the probably high but currently unknown uncertainty for CO_2 uptake in forestry is discussed. 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.

To date, the design of the currently used Danish Forestry Census has not made it possible to address uncertainty of inventory data used to estimate the reported sink for CO_2 in Danish forests quantitatively. The uncertainty of the volume and increment estimates in the Forestry Census 1990 and 2000 is 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 90% stocking, but the rate may be lower. The very fragmented shape of the Danish forest area results in many borders and hence a reduction in the actual productivity in the area as a whole. Furthermore, the yield table functions are based on a certain frequency of thinning, which, in turn, affects 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 with regard to 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 the 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 harvest based on a design with permanent sampling plots and partial replacement. The new design will enable an assessment of uncertainty related to inventory data.

7.2.3.2 Time-series consistency

The forest area in 1990 and 2000 was not the same for forests existing before 1990 (411,000 and 440,000 ha, respectively). This is due to the nature of the Forestry Census, i.e. there were different numbers of respondents in 1990 and 2000. It is recognised that this is a problem. The difference in gross uptake of CO_2 between 1990-1999 and 2000-2004 is almost solely due to the difference in numbers of respondents to the questionnaire (i.e. forest area reported) as annual gross increment per ha was similar for the two periods. However, as mentioned below (Section 7.2.6), avoiding recalculation of the present data based on the Forestry Census is preferred due to the forthcoming large data revision based on the new National Forest Inventory.

In addition to this coming revision, work is currently being initiated on reconstruction of the land use matrix for 1990 (databases, remote sensing data and aerial photos). Elaboratation of forest maps for 1990 and 2005 is planned and the project will also outline a procedure for updating these maps. This is necessary in order to be able to apply the same forest definition (FAO-TBFRA) to the year 1990 as that used in the commitment period.

7.2.4 Source specific QA/QC and verification

QA for the area of existing forests is carried out by Statistics Denmark and QA for afforestation area is mainly carried out by the Danish Forest and Nature Agency, as this organisation is responsible for the administration of subsidies. Harvesting data to support estimates of emissions from forests existing before 1990 are derived from Statistics Denmark. The QA of harvesting data is, therefore, placed under QA within Statistics Denmark. Spreadsheets are in secure files at the Danish Centre for Forest, Landscape and Planning.

QA/QC – A manual check-list is under development for correct connection between all data types at level 1 and 2.

7.2.5 Source-specific recalculations

Since the submission to the UNFCCC in April 2005, no methodological revisions have been carried out, but the current section has been amended with the addition of more information (e.g. Figs. 7.3 and 7.4).

For stands afforested since 1990, minor revision was made of the afforestation areas in the year 2003. The Danish Forest and Nature Agency discovered a minor discrepancy in their database on land area for subsidised afforestation projects. The subsidised afforestation area was consequently reduced slightly from 1 558 to 1 537 ha, i.e. the total afforested area was reduced by 21 ha. This has had no visible effect on the CO_2 uptake in the period 1990-2004 as the stands involved are very young.

7.2.6 Source-specific planned improvements

7.2.6.1 The new National Forest Inventory

The most important improvement for the reporting of the source category Forest Land was the initiation of the new sample-based National Forest Inventory (NFI) in 2002. The NFI will replace the Forestry Census as source of activity data and removal data. Statistics Denmark is still expected to supply background data for emission (harvesting), but those data can be combined with harvesting data from the NFI.

The mission of the NFI is, as stated in the Forest Act of Denmark, to improve the understanding and management of the Danish Forests by maintaining a comprehensive inventory of their status and trends. The objectives of the inventory are to acquire information on wood volume by tree species and diameter class, area estimates of forest land by type, stand size, ownership, site quality and stocking. Additional information, such as changes in the forest area, growth, mortality, timber removals and measures for successful regeneration, is also included in the inventory. The National Forest Inventory uses a continuous sample-based inventory with partial replacement of plots. The NFI system gives good estimates of both growth (permanent clusters) and current status (all clusters – including temporary clusters). The sampling of variables must be economically feasible. The selected variables must cover the indicators concerning sustainable forest management and meet the data needs for national and international forest statistics.

The NFI was initiated in 2002 and has collected data on approximately 60% of the total number of sample plots. One fifth of the sample plots are visited every year. The fourth year of data collection (2005) is currently being planned. Over the three years more than 4,500 plots have been visited and inventoried by the 3 two-man teams travelling from May through to September. Finalisation of the first full measurement for all of Denmark is expected in 2006 and data will be prepared and analysed for a report in 2007.

7.2.6.2 Improvements planned based on NFI and other sources

The background data to come from the sample-based NFI will provide much better estimates of the status of the forest area since 1990 and the development in forest area in the future. Furthermore, growth and harvesting estimates will be based on real sample plots, enabling quantification of error for background data used in calculation of carbon stock changes.

As a first step, after the first full rotation (five years), the NFI is able to supply new activity data, whereas remeasurements are necessary to assess carbon stock changes. Due to the continuous monitoring every year of one fifth of the sample plots, the first estimates of carbon stock changes may possibly be obtained following just one or two years of measurements in the second rotation of the NFI.

The NFI also supports reporting of more carbon pools than previously. Coarse woody debris and understorey vegetation is monitored and carbon stock changes will be estimated. Unfortunately, soil sampling has not, to date, been included as part of the NFI. However, simple measurements of forest floor thickness in each plot enable estimation of carbon stock changes in the litter pool according to the IPCC GPG. Existing national data on forest floor depth/mass relationships can be used for this purpose.

For afforested cropland, the NFI will provide activity data for comparison with the other data sources currently used (subsidised afforestation area). The NFI may have limitations in relation to gauging the relatively small afforestation area. However, the NFI will provide a better estimate of the residual area of land afforested by private landowners without subsidies than the current estimate based on the Forestry Census.

A weakness in the Danish biomass carbon estimates is the lack of national biomass expansion factors or functions. However, national data on aboveground biomass expansion functions for Norway spruce will be available within a couple of years. Data on belowground carbon is even scarcer. To date, it has only been possible to conduct a pilot study in Norway spruce in a thinning trial at one site. However, root-top relationships from these stands will provide a improved basis for selecting root-top relationships for Norway spruce from the literature. Within a year or so, another project on root architecture will also contribute with expansion functions for belowground biomass for the four most common Danish tree species.

Additionally, work has just been initiated on a reconstruction of the land use matrix by 1990 and 2005 by use of databases, satellite photos and aerial photos.

7.3 Cropland

As mentioned in the overview, Section 7.1, a detailed GIS analysis has been performed on the agricultural area with data on land use in 1998. With data from EUs IACS (Integrated Administration and Control System), the EUs LPIS (Land Parcel Information System) and detailed soil maps (1:25000), a detailed GIS analysis has been made. The total Danish agricultural area of approximately 2.7 million hectares has been related to approximately 700 000 individual fields, which, in turn, are located within 220 000 land parcels. This gives an average field size of less than four hectares. The actual crop grown in each field is known from 1998 and onwards. However, for simplicity the distribution between mineral soils and organic soils is kept constant for all years from 1990 to 2004.

7.3.1 Source category description

The main sources/sinks on Cropland are land use, establishing of hedgerows and perennial horticulture. Table 7.8 shows the development in the agricultural area from 1990 to 2004 (Statistics Denmark). In Denmark, a continuous decrease of 10-12,000 hectares per year in the agricultural area is observed. A part of the area is used for reforestation, settlements, nature conservation etc., but no clear picture is available yet.

Table 7.8 Agricultural areas in Denmark 1990-2003, hectare.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Annual crops (CM) [1]	2239127	2223632	2206656	2011670	1958047	1971896	1982942	2051133	2016456	1958815	1939902	1952940	1972009	1950587	2032277
Grass in rotation (CM)	306325	308789	317246	355019	395993	310568	329496	307065	339597	323909	330834	326553	292566	302896	290522
Permanent grass (GM)	217235	212030	207932	197229	191000	207122	192851	167600	156260	159530	166261	173702	177546	177635	172536
Horticulture – vegetables (CM)	16428	15994	16747	15771	12886	12915	11053	9554	10202	10523	10803	9616	8903	9933	9763
Horticulture – permanent (CM)	7892	7944	8975	8255	8665	8367	8457	7874	7505	7683	8010	8447	7976	8330	7816
Set-a-side (CM)	3861	4694	4047	159200	221326	217801	191683	147877	141900	184141	192441	202757	206555	208893	1995010
Total	2790868	2773083	2761603	2747144	2787917	2728669	2716482	2691103	2671920	2644601	2648251	2674015	2665555	2658274	2645304

[1] CM means that the area is treated under Cropland Management. GM refers to Grassland Management.

7.3.2 Methodological issues

For 1998, the distribution of the agricultural area between mineral soils and organic soils is subdivided into cropland and permanent grassland. Table 7.9 shows the main result from the GIS analysis. It can be seen that set-a-side, grass in rotation and permanent grass are more common within organic soils than within mineral soils. The percentage distribution in Table 7.11 is used for parameters when estimating the land use between different categories for all years between 1990 and 2004.

Table 7.9 The distribution of crops between organic and mineral soils in 1998 according to the GIS-analysis. The figures are given in hectares. The figures differ slightly from those in Table 7.8 due to use of different data sources.

Soil type	Annual crops in rotation	Set-a-side	Grass in rotation	Permanent grass	Total
Organic	82191	16056	24885	27864	150997
Mineral	2098396	126777	214053	114944	2554169
Total	2180587	142833	238938	142808	2705166

Table 7.10 The distribution of organic soils and mineral soils in percent in 1998.

Soil type	Annual crops in rotation	Set-a-side	Grass in rotation	Permanent grass	Total
Organic	54%	11%	16%	18%	100%
Mineral	82%	5%	8%	5%	100%

Table 7.11 The percentage distribution of the agricultural area used in the emission model.

Soil type	Annual crops in rotation	Set-a-side	Grass in rotation	Permanent grass
Organic	3.8%	11.2%	10.4%	19.5%
Mineral	96.2%	88.8%	89.6%	80.5%
Total	100.0%	100.0%	100.0%	100.0%

Furthermore, organic soils are divided into shallow and deep organic soils. 38% of organic soil is, according to the Danish soil classification, deep organic soil (Sven Elsnap Olesen, DIAS, pers. comm).

The carbon dioxide emission factor from the organic soils is based on emission data from Denmark, UK, Sweden, Finland and Germany, adjusted for differences in annual mean temperature to the average Danish climate (Svend E. Olesen, DIAS, 2005). E.g. data from southern Finland are adjusted with a factor of 2 and data from central Germany with a factor of 0.6. The GHG review report of the Danish GHG emissions for 2003 recommended that Denmark develop their own emissions factors. An application for funding to develop CS factors has been made.

The emission factors for organic soils are shown in Table 7.12 Negative values indicate a build up of organic matter. Wet organic soils are defined as having a water table between 0 and 30 centimetres.

Table 7.12 Emission factors for organic soils. Negative values indicate a built up of organic matter.

				Emission factor, t C $ha^{-1}y^{-1}$			
	% organic soils[1]	% with deep organic soils	% wet soils	Dry shallow	Dry deep	Wet shallow	Wet deep
Annual crops	3.8	38	0	5	8	0	0
Grass in rotation	11.2	38	0	5	8	0	0
Set-a-side	10.4	38	26	3	4	-0.5	-0.5
Permanent grass (drained)	19.5	38	26	3	4	-0.5	-0.5

[1]Percentage of the total area from the annual survey from Statistics Denmark classified as organic

Emissions of nitrous oxide from organic soils are estimated from degradation of organic matter and the C:N-ratio in the organic matter. Figure 7.5 shows the C:N-ratio for 160 different soils. Hence, for organic soils, a C:N-ratio of 20 is used. As emission factor, the IPCC Tier 1 value of 1.25% is used.

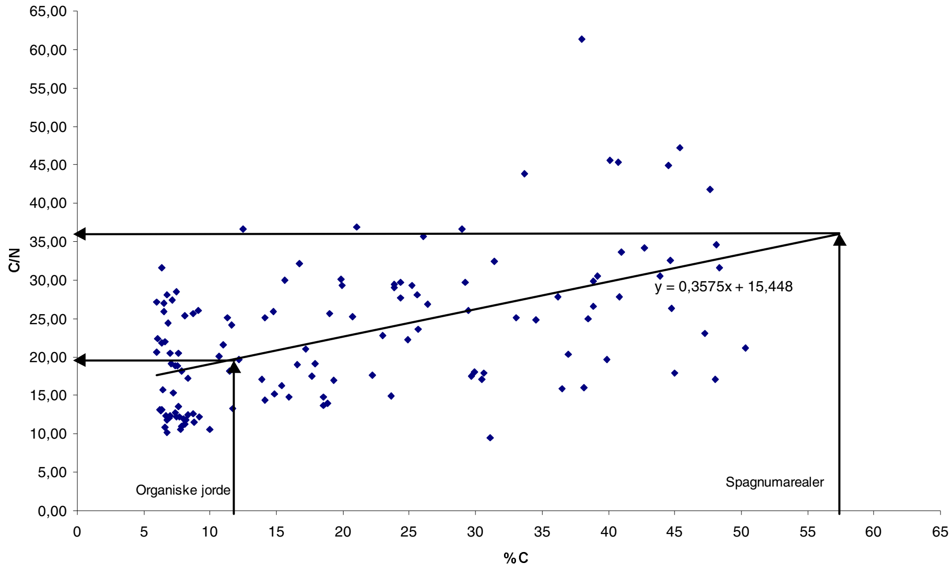

Figure 7.5 C:N-ratio in organic soils in relation to soil carbon content (Olesen 2004)

7.3.3 Emission from mineral soils

The removals/sinks from mineral soils are reported for the first time in this submission. A 3-pooled dynamic soil model has been developed (Petersen 2003, Petersen et al. 2002, 2005, Gyldenkærne et al. 2005) to calculate the soil carbon dynamics in relation to the Danish commitments to the UNFCCC. C-TOOL is run on a county-based level (average 250 000 hectares), where all different crops grown in that area are taken into account as regards: annual reported crop yield, the amount of crop residues returned to soil (data from Statistics Denmark), roots, amount of solid manure and slurry in the specific county based on output from the DIEMA-model (see the agricultural sector) for the different counties. C-TOOL is a 3-pooled dynamic model, where the approximate average half-lives for the three different pools are 0.6-0.7 years, 50 years and 6-800 years. The main part of the biomass returned to the soil each year is in the first and most easily degradable pool. C-TOOL is parameterised and validated against long-term field experiments (100-150 years) conducted in Denmark, UK (Rothamsted) and Sweden and is "State-of-the-art".

The Danish soil classification is divided into mineral soils and organic soils (see Section 7.3.2.3.). Danish organic soils are defined as soils having >10% SOM (Solid Organic Matter) against the IPCC definition, where organic soils have >20% SOM. The modelling with C-TOOL is performed under the assumption that soils above 10% SOM, but below 20% SOM, can be treated as mineral soils. In most models this may lead to overestimated decay rates, but as the realised decay of the model falls with a rising C:N- ratio, the decay rate is presumably within realistic boundaries, also for the mineral soils with high SOM content. However, this matter should be investigated further.

C-TOOL is initiated with data from 1980 and runs a multiple number of times until stability is reached before the emissions from 1980 and onwards are calculated. As temperature driver, actual monthly average temperatures are used. In Figure 7.6 and Table 7.13, the calculated emissions from 1980 to 2004 are shown.

The main drivers in the degradation of soil biomass are temperature and humidity. The Danish climate is quite humid with winter temperatures around zero degrees Celsius and, hence, the importance of soil humidity on the model outcome is low as opposed to temperature, which has a high effect on the emission. As mentioned, the major part of the biomass returned to soil is quite easily degradable. Warm winters with unfrozen soils in combination with high inputs of biomass will, therefore, yield high emissions from the soil compared with colder years, which will yield low emissions. E.g. the peaks in 1990, 1998 and 2000 are due to high harvest yields and normal temperatures, whereas the peak in 1993 in Figure 7.6 is due to a normal harvest year, but with very low temperatures with low degradation rates. However, the emissions modelled are found to be the most realistic emissions estimates for Denmark. In the most recent years (1999-2004), winters in Denmark have been very warm and, hence, the CO_2emission modelled from mineral soils is quite high in these years and higher than expected if average standard temperatures for 1961-90 are used. If average temperatures are used, the model calculation shows an increase in the soil C-stock in the period, 1999-2004.

As described in the agricultural sector, Danish farmers have faced increasing demands for lower environmental impact since the mid-1980s. This includes, among other things, the ban on field burning and the planting of winter green crops (winter cereals and autumn sown catch crops such as grass and rape) to reduce leaching of nitrogen as well as the ban on autumn applications of animal manure. These changes in agricultural practice influence the C-stock in soil in the longer term. The general effect on the C-stock in soil in the 1980s is that a decrease in the C-stock is apparent. In the 1990s, the C-stock seems to have stabilised and, in future, a small increase in the C-stock is expected, although it depends on the extent of global warming in near future.

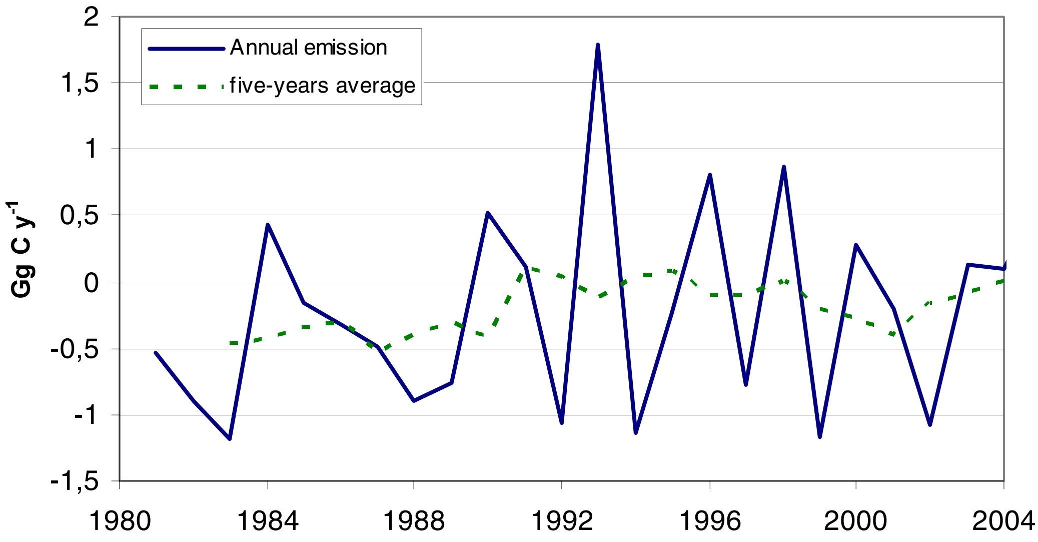

Figure 7.6 Modelled total annually emission and five-year average from all mineral soils in Denmark, Gg C/yr from 1980 to 2004.

Table 7.13 Modelled carbon stock (0-100 cm) in mineral soils from 1980 to 2004.

Year	Carbon stock, Gg C	Emission, Gg C/yr	Emission, Five-year average, Gg C/yr
1980	431.297071		
1981	430.765166	-0.531905	
1982	429.874044	-0.891122	
1983	428.696583	-1.177461	-0.4653804
1984	429.127762	0.431179	-0.4242988
1985	428.970169	-0.157593	-0.3446512
1986	428.643672	-0.326497	-0.2892132
1987	428.150788	-0.492884	-0.5283182
1988	427.250517	-0.900271	-0.3931418
1989	426.486171	-0.764346	-0.3050134
1990	427.00446	0.518289	-0.4197582
1991	427.118605	0.114145	0.1167984
1992	426.051997	-1.066608	0.0414664
1993	427.834509	1.782512	-0.107693
1994	426.693503	-1.141006	0.0316664
1995	426.465995	-0.227508	0.09099
1996	427.276937	0.810942	-0.0918138
1997	426.506947	-0.76999	-0.0967486
1998	427.37544	0.868493	0.006296
1999	426.20976	-1.16568	-0.1956316
2000	426.497475	0.287715	-0.255924
2001	426.298779	-0.198696	-0.4051602
2002	425.227327	-1.071452	-0.1536626
2003	425.349639	0.122312	-0.0855082[a]
2004	425.441447	0.091808	0.0134706[a]

[a]based on projected C input and climatic conditions for 2005 and 2006.

In Table 7.13, the modelled annual emissions and five-year average are shown. To reduce the interannual variability in the reporting to the UNFCCC, the recommended five-year average is used (IPCC 2004, Section 4.2.3.7 p 4.23).

No formal uncertainty assessment has been made so far.

A national Danish soil sampling programme was initiated in 1987 on around 380 agricultural fields scattered throughout Denmark, across all soil types. Resampling was made in 1998 and will take place again in the near future. From 1987 to 1998, a decrease in soil C was found on pig farms and on farms without animal husbandry. On cattle farms, an increase in soil C was registered, probably due to high manure application rates and a high percentage of grass in the rotation (grass has a large amount of root residue). An up-scaling to the whole Danish area yields a very uncertain and insignificant increase in soil C of two tonne C/ha, i.e. from 110 tonne/ha to 112 tonne/ha (0-50 cm) in the same period, indicating that the output from C-TOOL is in line with the soil samples.

7.3.4 Horticulture

Permanent horticultural plantations are reported separately under Cropland (Table 5.B). Permanent horticulture is only a minor production sector in Denmark. The total area for the various main classes is given in Table 7.14. Due to the limited area and small changes between years, the CO_2 removal/emission is calculated without a growth model for the different tree categories. Instead, the average stock figures are used in Table 7.15, multiplied by changes in the area to estimate the annual emissions/removals. Perennial horticultural crops account for approximately 0.07% of the standing C-stock.

The factors for estimating the C-stock in perennial horticulture are given in Table 7.15. Expansion factors and densities are the same as those used in forestry (Section 7.2).

Table 7.14 Area with perennial fruit trees and – bushes, C-stock and stock changes from 1990-2003.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Apples, ha	2726	2462	3006	2209	2061	1658	1854	1697	1660	1623	1679	1783	1574	1624	1673
Pears, ha	351	497	436	438	328	545	469	430	555	431	441	469	420	457	439
Cherries and Plumes, ha	2200	2200	2200	2222	2641	2854	3023	2794	2791	2956	3002	2903	2871	2967	2513
Black currant, ha	1269	1486	2091	1919	2351	1827	1783	1531	1280	1411	1492	1850	1939	2028	1976
Other, ha	250	250	250	449	337	348	343	323	235	272	412	376	384	448	756
Total, ha	6796	6895	7983	7237	7718	7232	7472	6775	6521	6693	7026	7381	7188	7524	7816
C_t, stock, Gg	64.846	62.530	70.859	60.303	62.637	59.485	63.356	58.079	57.540	58.381	60.135	61.368	58.121	60.316	56.759
Stock change, Gg y^{-1}	0.406	-2.316	8.329	-10.557	2.334	-3.152	3.871	-5.277	-0.540	0.842	1.754	1.233	-3.247	2.195	-3.556
CO_2-emission, Gg y^{-1}	1.489	-8.492	30.541	-38.708	8.558	-11.556	14.194	-19.348	-1.978	3.086	6.430	4.519	-11.905	8.048	-13.040

Table 7.15 Parameters used to estimate the C-stock in perennial horticulture (Gyldenkærne et al. 2005).

	Apples, old	Apples, new	Pears, Old	Pears, new	Cherries and Plumes	Black currant	Other fruits bushes
Stem diameter, m	0.09	0.07	0.07	0.05	0.09	0.042	0.042
Height, m	3.00	3.00	3.00	3.00	4.00	1.00	1.50
Numbers, ha^{-1}	1905	2700	1250	2300	1000	4500	3000
Form figure	1.20	1.20	1.20	1.20	1.20	1.00	1.00
Volume, m^3 ha^{-1}	43.63	37.41	17.32	16.26	30.54	6.23	6.23
Expansion factor	1.20	1.20	1.20	1.20	1.20	1.20	1.20
Density, t m^{-3}	0.56	0.56	0.56	0.56	0.56	0.56	0.56
Biomass, t ha^{-1}	29.32	25.14	11.64	10.93	20.52	4.19	4.19
C content, t C t^{-1} $biomasse^{-1}$	0.50	0.50	0.50	0.50	0.50	0.50	0.50
C, t ha^{-1}	14.66	12.57	5.82	5.46	10.26	2.09	2.09
C, t ha^{-1} (average)	13.61		5.64		10.26	2.09	2.09

7.3.5 Hedgerows

Since the beginning of the early 1970s, governmental subsidies have been provided to increase the area with hedgerows to reduce soil erosion. Annually, financial support is given to approximately 1 000 km of hedgerow. Only C-stock changes in subsidised hedgerows are included in the inventory, not private planting. In 1990, 75% of the old single-row Sitka spruce hedgerows were replaced with 3- to 6-rowed broadleaved hedges. In 2004, this replacement hedgerow only comprises 22% of the total, the remaining comprising new hedgerow, cf. Table 7.16. The figures are converted from kilometres to hectares according to the type of hedgerow. A simple linear growth model has been produced to calculate the sink/removal effect from hedgerows. The parameters are given in Table 7.17. New hedgerows account for approximately 0.7% of the standing C-stock. In 1990, there was a net emission because the removed hedgerows were 12-15 meters tall Sitka spruce. From 1994, the new hedgerow has comprised a net sink in due to increasing area and decreasing replacement rate.

Table 7.16 Areas with new hedgerows, C-stock and stock changes 1990-2004. (De danske Plantningsforeninger, 2004 and update)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Replaced, %	75	75	75	75	77	36	27	32	30	28	27	25	23	22	22
Replaced, km	696	830	804	706	610	291	278	351	307	279	292	298	63	187	110
Replaced, ha	174	207	201	177	152	73	70	88	77	70	73	74	16	47	28
New hedges, ha	464	553	536	471	460	482	610	628	576	579	626	682	207	474	320
Removed hedge, Gg C y-1	-29	-34	-33	-29	-25	-12	-11	-14	-13	-11	-12	-12	-3	-8	-5
Sink in new hedge, Gg C y-1	22	24	25	27	28	30	32	34	35	37	39	41	42	43	44
Stock change, Gg C y-1	-7	-10	-8	-2	3	18	20	19	23	26	27	29	39	36	40
Stock in new hedges, Gg C	155	179	204	231	259	289	320	354	389	427	466	507	549	592	636

Table 7.17 Parameters used for estimation of C in hedgerows (De danske Plantningsforeninger, 2004)

	Old hedges (1-row.)	New hedges (3-6 row.)
Wooden Stock, $m^3 ha^{-1}$	480	260
Density, broad-leaved	0.56	0.56
Density, spruce	0.37	0.37
Density used in the calculations	0.38	0.50
Above ground biomass, $m^3 ha^{-1}$	182	130
Expansion factor	1.80	1.20
Biomass, $m^3 ha^{-1}$	328	156
t C t $biomass^{-1}$	0.50	0.50
t C ha $hedgerow^{-1}$	164	78
Year from plantation to first thinning	-	25
Thinning per cent	-	45%
Year between thinning	-	10

7.3.6 Emission from organic soils

Organic soils are defined as having >20% OM. The emission from organic soils is estimated from the actual land use of the organic soils in four groups: annual crops, set-a-side, grass in rotation and permanent grassland. The latter is reported under grassland (Table 5.C).

The total organic area is given in Table 7.18. The emission factors are given in Table 7.13. For 1990 to 2004, the different classes are given as a fixed percentage of the total annual area from Statistics Denmark. The differences between years are due to inter-annual changes in the area from Statistics Denmark.

Table 7.18 C-emission from organic soils, Gg C y^{-1}.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Cropland, Gg C y^{-1}	-288	-287	-288	-289	-294	-278	-282	-279	-285	-278	-279	-279	-272	-273	-271
Grassland, Gg C y^{-1}	-25	-25	-24	-23	-22	-24	-22	-20	-18	-19	-19	-20	-21	-21	-20
Total organic soils	-313	-312	-312	-312	-316	-302	-305	-299	-303	-297	-298	-300	-293	-294	-291

7.4 Grassland

The area with grassland is defined as the area with permanent grass stated in the annual census from Statistics Denmark (Table 7.8). In 2004, 173 000 hectares is reported as permanent grassland. Based on the GIS analysis, it is concluded that 16 099 hectares are on organic soils and the remaining grassland is on mineral soils. Emissions/sinks from grassland on mineral soils are included in cropland mineral soils. For the organic soils, a CO_2 emission from drained areas with a water table below 30 cm is assumed. For areas with a water table between 0 and 30 cm, a build-up of organic matter is assumed (Table 7.12).

In Table 7.18, the annual emissions are given for grassland on organic soils. The emission from grassland is reduced from 25 Gg CO_2-C in

1990 to 20 Gg in 2003, due to a reduction in the area with permanent grass.

7.5 Wetland

Wetland includes land for peat extraction and re-established anthropogenic wetlands. Naturally occurring wetlands are not included in the inventory.

7.5.1 Wetlands with peat extraction

The area with peat extraction in Denmark is rather small. In 1990, the open area was estimated to be 1 067 hectares, decreasing to 885 hectares in 2004. All areas are nutrient-poor raised bogs. The emission from the open area is calculated according to the standard approach for nutrient-poor areas with an emission factor of 0.5 t C ha^{-1} y^{-1}. Because the underlying default factor is mainly based on Finnish data, a higher emission factor than recommended is chosen. This is in accordance with the difference in temperature between Denmark and Finland (see Section 7.3). The nitrous oxide emission from peatland is estimated from the total N-turnover multiplied by a standard emission factor of 1.25%. The C:N-ratio in the peat is estimated to be 36 in an analysis from the Danish Plant Directorate (PDIR 2004). Hence, the N_2O emission is estimated to 0.546 kg N_2O per t C.

Table 7.19 Annual emissions from the surface area where peat extraction takes place, Gg C y^{-1} and N_2O y^{-1}.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Emission, Gg C y^{-1}	0.533	0.535	0.535	0.531	0.528	0.527	0.524	0.524	0.522	0.442	0.442	0.442	0.442	0.442	0.442
Emission, Mg N_2O y^{-1}	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.24	0.24	0.24	0.24	0.24

7.5.2 Re-establishment of wetlands

In order to reduce leaching of nitrogen to lakes, rivers and coastal waters, Denmark has actively re-established wetlands since 1997. In total, 541 different areas ranging from 0.1 hectare up to 2 180 hectares have been reported to NERI. The total area converted to wetland up to the year 2003 is 4 792 hectares and 3 767 hectares with raised water table. In 2004, 1 622 hectares re-established wetlands and 318 hectares with raised water tables were reported. The area with raised water table will be unsuitable for annual cropping and protected by the legislation against future changes. Figure 7.7 shows the distribution of the areas in Denmark.

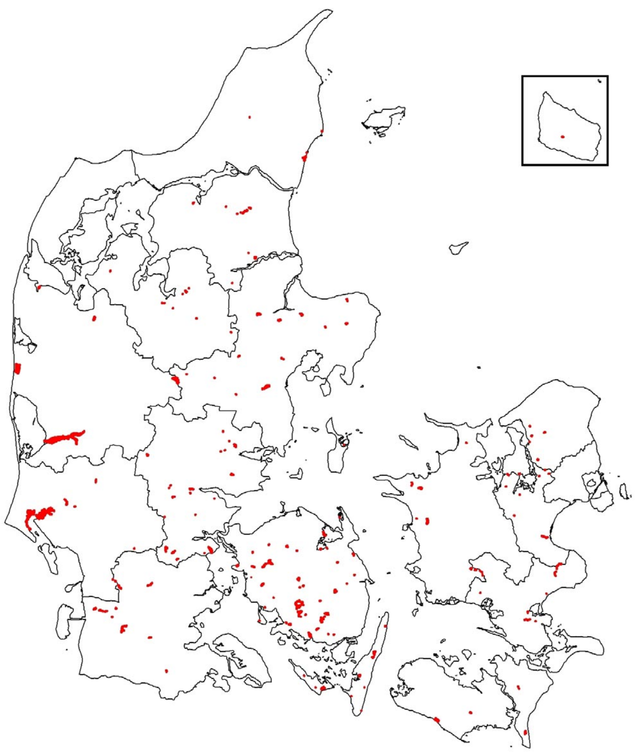

Figure 7.7 Areas with established wetlands and increased water tables from 1997 to 2003.

For every single area, a detailed vector-map is available. The GIS-analysis shows that only part of the area is on former cropland and that the distribution differs on mineral and organic soils (Table 7.20 and 7.21). 68% of the wetland area is on former cropland or grassland and 81% of the area with raised water table is on former cropland or grassland. Furthermore, it can be seen that there is a higher percentage of grassland in the areas with raised water table and that these areas have a higher percentage with organic soil. Only the areas with annual crops, set-a-side, grass in rotation and permanent grassland are included in the emission estimates in the inventory. The parameters used to estimate the emission are given in Table 7.12.

Table 7.20 Area classification of the established wetlands, in hectares.

	Area, total	Annual crops	Set-a-side	Permanent grassland	Grass in rotation	Total	Pct.
Dry mineral soil	2441	1155	325	367	225	2072	85%
Dry organic	2223	1072	432	296	106	1906	86%
Wet mineral	551	46	28	70	41	185	33%
Wet organic	521	58	56	74	7	195	38%
Other	676	12	7	8	4	31	4%
Total	6414	2342	849	814	383	4389	68%

Table 7.21 Area classification where the water table has been raised, in hectares.

	Area, total	Annual crops	Set-a-side	Permanent grassland	Grass in rotation	Total	Pct.
Dry mineral soil	1646	475	286	507	160	1427	87%
Dry organic	931	225	132	356	80	793	85%
Wet mineral	1003	37	17	627	89	770	77%
Wet organic	399	21	29	190	49	289	72%
Other	96	9	4	14	3	30	32%
Total	4075	767	468	1695	380	3310	81%

The net accumulation of C, with a standard sink factor of 0.5 t C ha y^{-1} for the former agricultural area is included in the CRF-Table, 5.D. The total annual net build-up from anthropogenic wetlands in 2003 is estimated at 3.84 Gg C (only former cropland and grassland is included) (Table 7.22). The decreased oxidation of organic matter in organic soils (due to the re-wetting) is included in Table 5.B and 5.C as a decrease in total area. Until a full matrix for the Danish area is performed, there will be some inconsistency in the total area.

Table 7.22 Increase in carbon sink in anthropogenically established wetlands, 1990-2004, Gg C y^{-1}.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Net sink. Gg G y^{-1}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.16	1.34	1.80	2.35	3.17	3.84

7.6 Settlements

C-stocks in settlements are not estimated. The annual changes in C-stock in settlements are assumed to be negligible, but as no estimates have been made they are reported as not estimated (NE) in the CRF Table 5.E

7.7 Other

C-stocks in other types of land are not estimated. The annual changes in C-stock in other types of land are assumed to be negligible, but because no estimates have been made they are reported as not estimated (NE) in the CRF Table 5.F.

7.8 Liming

Liming of agricultural soils has taken place for many years. The Danish Agricultural Advisory Centre (DAAC) has published the lime consumption for agricultural purposes annually since 1960 (Table 7.23). DAAC collects data from all producers and importers. By legislation, all producers and importers are forced to have their products analysed for acid neutralisation content. The analysis is carried out by the Danish Plant Directorate and published annually (PDIR 2004). The published data from DAAC is corrected for acid neutralisation content for each product and are thus given in pure $CaCO_3$. For this reason, there is no need to make the differentiation between lime and dolomite, as made in the guidelines, as this has already been included in the background data. The data from DAAC includes all different products used in agriculture, including e.g. $CaCO_3$ from sugar refineries.

The amount of lime used in private gardens has been estimated from the main supplier to private gardens. According to the company (Kongerslev Havekalk A/S, pers. comm.), they are responsible for 80% of the sale to private gardens. Their sales figures have been used to estimate the total consumption in private gardens. Furthermore, the figures are corrected for acid neutralisation capacity according to the data from the Danish Plant Directorate. This gives an approximate amount of 2 300 t $CaCO_3$ y^{-1} in private gardens. This figure has been used for all years.

Only a very small amount of lime is applied in forests (<0.5%) and on permanent grassland. Therefore, all liming is included in the inventory under cropland (CRF Table 5(IV)). The amount of C is calculated according to the guidelines, where the carbon content is 12/100 of the $CaCO_3$. It is assumed that all C disappears as CO_2 the same year the lime is applied.

The amount of lime used for agricultural purposes has declined by 70% since 1990. From 2003 to 2004, the consumption in agriculture has decreased to 356 t $CaCO_3$, or by 30%. This value is expected to be the lowest consumption needed to maintain appropriate pH values in Danish agricultural soils. The main reason for the reduced lime consumption is a decreased need for acid neutralisation due to reduced SO_x deposition in Denmark and reduced consumption of fertilisers containing ammonium. The inter-annual variation is primarily due to weather conditions (i.e. whether it is possible to drive on fields) and the prevailing economy in agriculture.

Table 7.23 Lime application on cropland, grassland and in forests, 1990-2004.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Agriculture, t $CaCO_3$	1283	1049	810	695	832	1125	891	1065	571	600	590	454	528	512	356
Private gardens, t $CaCO_3$	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Total, t $CaCO_3$	1285.3	1051.3	812.3	697.3	834.3	1127.3	893.1	1067.1	573.1	602.3	592.3	455.9	530.0	514.3	358.3
Total, Gg C y^{-1}	154.2	126.2	97.5	83.7	100.1	135.3	107.2	128.1	68.8	72.3	71.1	54.7	63.6	61.7	43.0

7.9 Uncertainties

A Tier 1 uncertainty analysis has been made for part of the LULUCF sector cf. Table 7.24. The uncertainty in the activity data is rather low. The highest uncertainty is associated to the emission factors. Especially the emission/sink from mineral soils and organic soils has a high influence on the overall uncertainty. Because there is used a dynamic soil model to calculate the emission/sink from mineral soils where the emission is averaged for five years it makes no sense to calculate an annual uncertainty for this source.

The LULUCF sector contributes to a large part of the total estimated uncertainty.

Table 7.24 Tier 1 uncertainty analysis for LULUCF for 2004. No estimates are given for forestry.

		Emission/sink, Gg CO2-eqv.	Activity data, %	Emission factor, %	Combined uncertainty	Total uncer-tainty, %	Uncertainty 95%, Gg CO_2-eqv.
5.A Forests		3532.2				NE	NE
Broadleaves, Forest remaining forest		997.3	NE	NE	NE		
Conifers, Forest remaining forest		2427.3	NE	NE	NE		
Broadleaves, Land converted to forest		66.3	NE	NE	NE		
Conifers, Land converted to forest		41.3	NE	NE	NE		
5.B Cropland and 5.C.Grassland		-1182.3				NE	NE
Mineral soils	CO_2	49	20	NE	NE		
Organic soils	CO_2	-1065	10	50	51.0	51.0	543.5
Hedgerows	CO_2	-146.3	5	20	20.6	20.6	30.1
Perennial horticulture	CO_2	-13.0	10	10	14.1	14.1	1.8
5.D Wetlands		1.7				63.5	1.1
Land for peat extraction	CO2	-0.4	10	50	51.0	51.0	0.2
Land for peat extraction	N2O	0.1	10	100	100.5	100.5	0.1
Re-established wetlands	CO2	2.1	10	50	51.0	51.0	1.1
Liming		226.2	5	50	50.2	50.2	113.7

7.10 Recalculation

No recalculations have been made except for organic soils where the area has been reduced by approximately 50% to comply with the IPCC definitions for organic soils (see text above, for explanation).

7.11 Planned improvements

Lime in animal fodder will be incorporated in future. Application for funding to establish Danish emission factors for organic soils, as recommended in the previous review of the Danish NIR in 2005, as well as preparing a new soil inventory for organic soils, has been made. Furthermore, an application for funding is being made for repeated measurements of soil C in the fixed Danish measuring points (Kvadratnettet), further verification of C-TOOL, verification of the emission factor for liming and establishment of a full land cover matrix for 1990 and 2005 and onwards.

In response to the review report on the 2005 submissions:

Paragraph 54
Regarding detection of forest area and comparability, this will be significantly improved with the new NFI, including the adoption of the FAO forest definition. The inclusion of "other wooded land", as defined in FAO, will also include areas with sparse tree cover.

Paragraph 56
The NIR will also provide improved information on definitions of wood volume, i.e there was no minimum top diameter for conifers or broadleaves. Bark was included while stumps were not. With regard to BEFs (Biomass Extension Factors), for conifers, these are used to expand stem biomass and, for broadleaves, BEFs are used to expand aboveground biomass. As stated in the NIR, there is currently no published data on total tree biomass to support development of BEFs. In the coming years, it is hoped that BEF studies will be funded, so national BEFs can be applied for the most common tree species. The use of values from Denmark in the Belgian NIR is difficult to understand, as, NERI are only aware of one single study in current publication from one Norway spruce stand. Furthermore, this study only dealt with aboveground biomass. NERI and others are currently working on publication of a couple of small studies on biomass distribution, which will support our reporting to some extent. In the NIR, we have referenced the relevant Belgian study that we used as a basis for broadleaf BEFS (Vande Walle et al. 2001).

Paragraph 57
Uptake of CO_2 from afforestation will also be based on different yield classes in the future (2007+). Currently, no distinction is made in the model input between growth rates on different soil types. Improved data on geographical location of afforestation areas will be obtained from the new NFI and incorporation of different yield classes according to location of afforested land will be worked upon. References for the published yield tables are provided, but more information on these will be included in the future.

7.12 QA/QC and verification

A general QA/QC plan for the land use sector is under development. For forestry, the formal QA/QC plan has not yet been implemented. This will take place in 2007. The following Points of Measure (PM) are taken into account.

Data Storage level 1	1. Accuracy	DS.1.1.1	General level of uncertainty for every dataset including the reasoning for the specific values.

The area estimates for cropland and grassland are very precise due to unrestricted access to detailed data from the EU’s Integrated Administration and Control System (IACS) on agricultural crops on field level and the use of the vector-based Land Parcel Information System (LPIS). This access includes both Statistics Denmark and NERI. The total uncertainty in the crop data is estimated by Statistics Denmark to be <0.5%. Together with detailed soil maps, this gives a unique opportunity to estimate the agricultural crops on different soil types and, hence, track changes in land use. However, IACS and LPIS are only available from 1998 and onwards, and estimates for 1990 are, therefore, more uncertain. The QA of crop data is made by Statistics Denmark. Data on hedgerows are based on subsidised hedgerows and QA is carried out by “Landsforeningen af Plantningsforeninger”, who is responsible for the administration of the subsidies. The uncertainty in the number of plants used for the hedgerows is not estimated, but is assumed to be very low because of the subsidy system. The re-establishment of wetlands is based on vector maps received from every county in Denmark. The uncertainty is not estimated, but is assumed to be very low due to the subsidy system.

Emissions from areas other than forestry, cropland, grassland, peat mines and re-established wetlands are not included. Denmark still needs to make a full land-use matrix for 1990 and onwards. This will be carried out in 2007 by analysing satellite data from the European Space Agency (ESA). Natural areas such as heathland, natural wetlands, etc. are, thus, not included in the inventory.

The amount of lime used is more uncertain. Data is collected by DAAC from all suppliers and importers, and published every year in "Planteavlsorientering." The data collected is assumed to be very reliable. No uncertainty analysis has been made, but it is assumed to be in the range of 5-10%.

A range of experts from the Danish Institute of Agricultural Sciences are repeatedly involved in discussions and report writings on topics related to the inventory.

Data Storage level 1	1. Accuracy	DS.1.1.2	Quantification of the uncertainty level of every single data value including the reasoning for the specific values.

Data Storage level 1	2.Comparability	DS.1.2.1	Comparability of the data values with similar data from other countries, which are comparable with Denmark, and evaluation of discrepancy.

No comparison of the activity data with other countries has been made.

Data Storage level 1	3.Completeness	DS.1.3.1	Documentation showing that all possible national data sources are included by setting down the reasoning behind the selection of datasets

See DS.1.1.1

Data Storage level 1	4.Consistency	DS.1.4.1	The origin of external data has to be preserved whenever possible without explicit arguments (referring to other PM's)

The original data files are stored at NERI in I:/rosproj/luft_emi/inventory/2004/5_LULUCF/level_1a_storage/

Data Storage level 1	6.Robustness	DS.1.6.1	Explicit agreements between the external institution holding the data and NERI about the conditions of delivery.

Signed formal agreements on data delivery have been made with Statistics Denmark, the Danish Plant Directorate, Danish Agricultural Advisory Centre and Danish Institute of Agricultural Sciences.

The signed formal agreements are stored in: I:/rosproj/luft_emi/inventory/allyears

No formal agreement has been made with Landsforeningen de Danske Plantningforeninger on data delivery. However, Landsforeningen de Danske Plantningforeninger are under public administration and thus are all data and maps directly available.

No formal agreements have been made with the Danish counties on data delivery for vector-based field maps for re-established wetlands because this public sector is currently under reconstruction. This issue will be addressed in 2007 and 2008.

Data Storage level 1	7.Transparency	DS.1.7.1	Summary of each dataset including the reasoning for selecting the specific data set.

Please refer to DS.1.1.1

Data Storage level 1	7.Transparency	DS.1.7.3	References for citation for any external dataset have to be available for any single value in any dataset.

Much documentation already exists in the literature list. A separate list of references is stored in:

I:/rosproj/luft_emi/inventory/2004/5_LULUCF/level_1a_storage/

Data Storage level 1	7.Transparency	DS.1.7.4	Listing of external contacts for every dataset.

External contacts are:

Statistics Denmark: Karsten K. Larsen (kkl@dst.dk)

Landsforeningen De danske Plantningsforeninger: Helge Knudsen (laeplant@post7.mail.dk)

DAAC: Torkild S.Birkmose (tsb@landscentret.dk)

DIAS: Bjørn Molt Pedersen (BjornM.Pedersen@agrsci.dk)

DIAS: Jørgen E. Olesen (JorgenE.Olesen@agrsci.dk)

DIAS: Hanne Damgaard Poulsen (HanneD.Poulsen@agrsci.dk)

Data Processing level 1	1. Accuracy	DP.1.1.1	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to type of variability. (Distribution as: normal, log normal or other type of variability.)

In the uncertainty calculations, a normal distribution of all activity data is assumed as well as for the emission factors. In many cases where data on emission factors are scare the uncertainty is based on expert judgement made by the institutions and persons involved.

Data Processing level 1	1. Accuracy	DP.1.1.2	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to scale of variability (size of variation intervals).

The uncertainty assessment for LULUCF is given in theNIR except for forestry. This will be included next year when a full NFI has been made. In the documentation reports, the size of the variation is normally given.

Data Processing level 1	1. Accuracy	DP.1.1.3	Evaluation of the methodological approach using international guidelines

The methodological approach mostly comprises scientific state-of-the-art methods. However, in some cases, the IPCC emission factors are chosen when it not has been possible to estimate more scientifically correct country-specific values.

Data Processing level 1	1. Accuracy	DP.1.1.4	Verification of calculation results using guideline values

Emission factors and growth functions have only briefly been compared with IPCC guidelines.

Data Processing level 1	2.Comparability	DP.1.2.1	The inventory calculation has to follow the international guidelines suggested by UNFCCC and IPCC.

The LULUCF inventory is made according to the IPCC GPG on LULUCF, 2004.

Data Processing level 1	3.Completeness	DP.1.3.1	Assessment of the most important quantitative knowledge which is lacking.

Emissions and sinks in forest soils are not included in the inventory. Application for financial funding has been made to cover this area. It is assumed that data for forest soils is available in 2008 or 2009.

Lime used in feedstuff is not covered in the inventory, or in the guidelines. Due to the large number of animals in Denmark, with optimal feeding, large quantities of $CaCO_3$ are applied to the soil through manure. A model for this is under development.

Natural habitats, natural wetlands, settlements and other land are not included in the inventory. At the moment no data are available.

Data Processing level 1	3.Completeness	DP.1.3.2	Assessment of the most important cases where access is lacking with regard to critical data sources that could improve quantitative knowledge.

In Denmark, only very few data are restricted (military installations). Accessibility is not a key issue; lack of data is more of an issue.

Data Processing level 1	4.Consistency	DP.1.4.1	In order to keep consistency at a high level, an explicit description of the activities needs to accompany any change in the calculation procedure

The calculation procedure is consistent for all years.

Data Processing level 1	5.Correctness	DP.1.5.1	Show at least once, by independent calculation, the correctness of every data manipulation.

During the development of the model thorough checks have been made by all persons involved in the LULUCF section.

Data Processing level 1	5.Correctness	DP.1.5.2	Verification of calculation results using time-series

During the development of the inventory, thorough checks of the timeseries have been made by all persons involved in the LULUCF section.

Data Processing level 1	5.Correctness	DP.1.5.3	Verification of calculation results using other measures

During the calculations the results are checked according to the check-list.

Data Processing level 1	5.Correctness	DP.1.5.4	Shows one-to-one correctness between external data sources and the databases at Data Storage level 2

Output data at Data Storage Level 2 is checked for correctness according to the check-list.

Data Processing level 1	7.Transparency	DP.1.7.1	The calculation principle and equations used must be described

All calculation principles are described in the NIR and the documentation report (Gyldenkærne et al. 2005).

Data Processing level 1	7.Transparency	DP.1.7.2	The theoretical reasoning for all methods must be described

All theoretical reasoning is described in the NIR and the documentation report (Gyldenkærne et al. 2005).

Data Processing level 1	7.Transparency	DP.1.7.3	Explicit listing of assumptions behind all methods

All theoretical reasoning is described in the NIR and the documentation report (Gyldenkærne et al. 2005).

Data Processing level 1	7.Transparency	DP.1.7.4	Clear reference to dataset at Data Storage level 1

A clear reference in the DP level 1 to DS level 1 is under construction.

Data Processing level 1	7.Transparency	DP.1.7.5	A manual log to collect information on recalculations

A manual log is under construction in the spreadsheets.

Data Storage level 2	5.Correctness	DS.2.5.1	Documentation of a correct connection between all data types at level 2 to data at level 1

A manual check list is under development for correct connection between all data types at level 1 and 2.

Data Storage level 2	5.Correctness	DS.2.5.2	Check if a correct data import to level 2 has been made.

A manual check list is under development for correctness of data import to level 2.

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8 Waste Sector (CRF Sector 6)

8.1 Overview of the Waste sector

The waste sector consists of the CRF source category 6.A Solid Waste Disposal on Land, 6.B. Wastewater Handling, 6.C. Waste Incineration and 6.D. Other.

For 6.A Solid Waste Disposal on Land CH_4 emissions are considered in the following as a result of calculations in continuation of previously used and reported methodology.

For 6.B. Wastewater Handling, the CH_4 and N_2O emissions are arrived at from a survey carried out 2004-2005 and were introduced in the inventory submissions for the first time in 2005, and in the NIR in 2005. For this submission the methodology has been somewhat revised.

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

For the source sector 6.D. "Other" emissions from combustion of biogas in biogas production plants are included (mentioned as Gasification of biogas in the CRF tables). These emissions have existed since 1994 and are very small for all years from 1994 to 2004 – below 0.03 Gg CO_2 equivalents, taken as the sum of the GHG contributions.

In Table 8.1, an overview of the emissions is presented. The emissions are taken from the CRF tables and are presented as rounded figures. The contribution from 6.D is not included, since the contribution (refered to above) is too small to affect the figures in overview.

Table 8.1 Emissions (Gg CO_2 equivalents) for the waste sector.

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
6 A. Solid Waste Disposal on Land	CH4	1334	1358	1366	1379	1335	1286	1274	1208	1162	1191	1192	1188	1131	1163	1074
6 B. Wastewater Handling	CH4	126	123	121	127	152	177	202	248	253	237	217	231	310	299	265
6 B. Wastewater Handling	N2O	88	83	73	91	92	85	69	65	66	62	65	57	58	50	53
6. Waste	total	1547	1564	1561	1598	1580	1548	1546	1521	1480	1489	1475	1477	1500	1512	1392

6.A Solid Waste Disposal on Land is the dominant source in the sector contributing to the time-series with 86% (1990) and 75% (2002) of total Gg CO_2 equivalents. In 2004, the contribution is 77%. Throughout the time-series, the emissions are decreasing due to a reduction in the amount of waste deposited.

6.B. Wastewater Handling. For this source, CH_4 contributes the most, to the sectoral total, rising from a contribution of 8 to 21%. In absolute terms, the CH_4 emission from this source displays a slightly increasing trend resulting from the increase in industrial influent load of total organic wastewater, a decrease in the final sludge disposal category "combustion" and the small recovery of methane potential by biogas production. N_2O from this source contributes with around 4-6% of the sectoral total. In absolute terms, N_2O emissions decrease over the time-series. The decrease is due to technical upgrading of wastewater treatment plants resulting in a decrease in effluent wastewater loads, i.e. decrease in activity data, determining the indirect emission of N_2O, which is the major contributor to the emission of N_2O.

As a result, the sectoral total in CO_2 equivalents decreases throughout the time-series. Compared with 1990, the 2004 emission is around 11% lower, Table 8.1.

8.2 Solid Waste Disposal on Land (CRF Source Category 6A)

8.2.1 Source category description

For many years, only managed waste disposal sites have existed in Denmark. Unmanaged and illegal disposal of waste is considered to play a negligible role in the context of this category.

The CH_4 emission from solid waste disposal on land at managed Solid Waste Disposal Sites (SWDS) constitutes, in 2004 as in previous years, a key source category, both with regard to level and trend. In the key-source level analysis for 2004, it is number 10 of 21 key sources and contributes with 1.6% of the national total. As regards the key-source trend analysis for 2004, the cateogory is number 20 on the list, where 21 sources are keys (Cf. Annex 1). The emission estimates for the CH_4 emission is decreasing from 1990 to 2004.

A quantitative overview of this source category is shown in Table 8.2 with the amounts of landfilled waste, the annual CH_4 emissions from the waste, the CH_4 collected at landfill sites and used for energy production, and the resulting emissions for the years 1990-2003. The amount of waste and the resulting CH_4 emission can be found in the CRF tables submitted as well.

In general, the amount of deposited waste has decreased markedly throughout the time-series. This is a result of action plans by the Danish government called the "Action plan for Waste and Recycling 1993-1997" and "Waste 21 1998-2004". The latter plan had, inter alia, the goal to recycle 64%, incinerate 24% and deposit 12% of all waste. The goal for deposited waste was met in 2000. Further, in 1996 a municipal obligation to assign combustible waste to incineration was introduced. In 2002, the Danish Government set up new targets for the year 2008 for waste handling in a "Waste Strategy2004-2008" report. According to this strategy, the target for 2008 is a maximum of 9% of the total waste to be deposited. In the waste statistics report for the year 2004, data shows that this target was met, since 8% of total waste was deposited in 2004 (Danish Environmental Protection Agency, 2006).

The decrease in the emission throughout the time-series is marked, but much less so than the decrease in the amount of waste 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 8.2 Waste amounts in landfills and their CH_4 emissions 1990-2004.

Year	Waste	Annual emission	Biogas collected	Annual net emission	
	kt	kt CH4	kt CH4	kt CH4	kt CO2-eqv.
1990	3175,1	64,0	0,5	63,5	1334,1
1991	3032,3	65,3	0,7	64,6	1357,6
1992	2889,6	66,5	1,4	65,1	1366,2
1993	2746,8	67,4	1,7	65,7	1379,4
1994	2604,0	68,2	4,6	63,6	1335,3
1995	1957,0	68,7	7,4	61,2	1285,6
1996	2507,0	68,8	8,2	60,7	1274,4
1997	2083,0	68,6	11,1	57,5	1207,8
1998	1859,0	68,5	13,2	55,3	1161,9
1999	1467,0	68,2	11,5	56,7	1190,7
2000	1482,0	67,8	11,0	56,8	1192,3
2001	1300,0	66,6	10,0	56,6	1188,0
2002	1174,0	65,1	11,2	53,9	1131,3
2003	966,0	63,2	7,8	55,4	1163,3
2004	1000,0	61,5	10,4	51,1	1073,6

Disposal of waste takes place at 134 registered sites (2004). The organic part of the deposited waste at these sites generates CH_4 gas, of which some is collected and used as biogas in energy-producing installations at 26 sites (2003).

8.2.2 Methodological issues

8.2.2.1 Activity data and emission factors

The data used for the amounts of municipal solid waste deposited at managed solid waste disposal sites is (according to the official registration) worked out by the Danish Environmental Protection Agency (DEPA) in the so-called ISAG database (DEPA 1997, 1998, 2000, 2001a, 2001b, 2002, 2004a, 2004b, 2005 and 2006). The registration of the amounts of waste deposited takes place in the ISAG database in the following waste categories:

Domestic Waste
Bulky Waste
Garden Waste
Commercial & Office Waste
Industrial Waste
Building & Construction Waste
Sludge
Ash & Slag

However, for CH_4 emission estimates, a division of waste types is needed in categories with data for the Degradable Organic Carbon

(DOC) content. For the following categories, investigations of DOC content etc. have been carried out for Danish conditions:

Waste food
Cardboard
Paper
Wet cardboard and paper
Plastics
Other combustible
Glass
Other, not combustible

The Danish investigation shows that the waste types contain the fraction of DOC as shown in Table 8.3.

Table 8.3 Fraction of DOC in waste types.

Waste Type:	DOC-fraction of Waste:
Waste food	0.20
Cardboard	0.40
Paper	0.40
Wet cardboard and paper	0.20
Plastics	0.85
Other combustible	0.20 - 0.57
Glass	0
Other, not combustible	0

Since the Danish solid waste disposal sites (SWDSs) are well-managed, it is assumed that 10% of the CH_4 produced by the waste is oxidised (OX = 0.1; refer GPG page 5.10) and that a methane correction factor of 1 can be used (GPG page 5.9, Table 5.1). Furthermore, 0.50 is used as the fraction of DOC dissimilated, which is considered good practice (GPG page 5.9). Finally, the fraction of CH_4 in landfill gas is taken as 0.45 (GPG page 5.10). These parameters lead to the calculation of a "general emission factor" for DOC as shown in Table 8.4.

Table 8.4 Calculation of general emission factor for DOC.

Parameter	Description	Input	Calculation
a	fraction of DOC oxidised	0.10	
1 – a = b	fraction of DOC not oxidised		0.90
c	fraction of DOC dissimilated	0.50	
b • c	fraction of DOC emitted as gas		0.45
d	fraction of gas emitted as CH_4	0.45 (as C)	
b • c • d	fraction of DOC emitted as CH_4	0.20 (as C)	
b • c • d • (12 + 4 • 1) /12	fraction of DOC emitted as CH_4 = emf for DOC	0.27 (as CH_4)	

DOC: Degradable Organic Carbon

Combining Table 8.3 and Table 8.4 give emission factors for waste types, Table 8.5.

Table 8.5 CH_4 emission factors according to waste types.

Waste type	DOC-fraction of waste (1)	Fraction of waste emitted as CH4 emf (2)
Waste food	0.2	0.054
Card-board	0.4	0.108
Paper	0.4	0.108
Wet card-board and paper	0.2	0.054
Plastics	0.85	0.2295
Other Combustible	0.20 - 0.57	0.054 - 0.155
Glass	0	0
Other not Combustible	0	0

Column (2) is column (1) multiplied by emf for DOC (= 0.27)
"Other Combustible" varies in DOC-fraction according to ISAG waste types.
Unit of column (2) is "fraction". Example: 1 tonne of waste food: 54 kg of CH4 is emitted

The emission estimates are built upon a composition of the deposited waste, as shown in Table 8.6, and are according to Danish investigations.

Table 8.6 ISAG waste types and their content (fraction) of waste types with calculated emission factor.

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

Table 8.6 forms the connection between the ISAG data (left column) and waste type (upper row) where emission factors have been calculated (Table 8.5). This composition is kept for the whole time-series.

The emission factors for the ISAG waste types are then calculated as the weighted average according to Table 8.5 and Table 8.6. The result is shown in Table 8.7.

Table 8.7 Emission factor (kg CH_4/kg waste) for ISAG waste types.

	ISAG Waste Type							
	Domestic Waste	Bulky Waste	Garden Waste	Commercial & office Waste	Industrial Waste	Building & Construct. Waste	Sludge	Ash & Slag
Weighted emission factor	0.0068	0.094	0.051	0.079	0.022	0.0076	0.045	0.0

The detailed explanation on the composition of waste and the methodology to obtain emission factors in this section of the NIR report has also been given, since the parameters in the CRF format are found not to be fully descriptive for the Danish data and for the methodology used.

The review team on the 2005 submission of data and the 2005 NIR pointed out that a more correct way to model the process of CH_4 emission in a landfill, as regards the recovery and the oxidation factor, is to use the oxidation factor after recovery. Unfortunately, this intervention by the review team came in January 2006, too late to be used in the emission estimations for the CRF format. In Section 8.2.2.2 of this report, the consequence of such a change, with regard to emissions, is examined. For figures in this section, the changes will be minor and influence in this section the emission factors in Table 8.7, only.

8.2.2.2 The model and its results

The CH_4 emission estimates from SWDSs are based on a First Order Decay (FOD) model suited to Danish conditions and according to an IPCC Tier 2 approach. The input parameters for the model are yearly amounts of waste, as reported to the ISAG database, and the emission factors according to Table 8.7. In the model, the half-life time of the carbon of 10 years is used, corresponding to:

$k = \ln 2/10 = 0.0693$ year^{-1}(refer GPG page 5.7)

which is in line with values mentioned in the GPG and close to the GPG default value of 0.05.

The time lag factor has been filled in in the CRF-format as zero, since the model used accounts for emissions from waste the same year as the waste is deposited.

The model calculations are not performed per landfill site, but for all waste deposited at all sites.

The yearly amounts of the different waste types and their emission factors are used to calculate the yearly potential emission. From the potential emission, the annual emission is calculated using the model. The CH_4 captured by biogas installations at some of the sites is subtracted from this emission. The result is annual net emissions. The amounts of CH_4 captured are according to the Danish energy statistics. The waste amounts and the calculated CH_4 emissions are shown in Table 8.8.

Table 8.8 Amounts of waste and CH_4 emissions for 1990-2004

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	0,5	63,5
1991	198,7	259,0	70,7	120,0	824,3	804,3	193,3	562,0	3032,3	83,7	65,3	0,7	64,6
1992	198,4	267,3	56,1	130,7	826,2	657,2	164,6	589,0	2889,6	82,2	66,5	1,4	65,1
1993	198,2	275,7	41,6	141,3	828,1	510,1	135,8	616,0	2746,8	80,7	67,4	1,7	65,7
1994	198,0	284,0	27,0	152,0	830,0	363,0	107,0	643,0	2604,0	79,2	68,2	4,6	63,6
1995	190,0	286,0	17,0	128,0	779,0	321,0	101,0	135,0	1957,0	74,7	68,7	7,4	61,2
1996	132,0	275,0	6,0	135,0	822,0	317,0	117,0	703,0	2507,0	71,4	68,8	8,2	60,7
1997	83,0	248,0	6,0	170,0	707,0	264,0	130,0	475,0	2083,0	65,9	68,6	11,1	57,5
1998	98,0	234,0	20,0	161,0	746,0	266,0	124,0	210,0	1859,0	66,3	68,5	13,2	55,3
1999	117,0	239,0	3,0	164,0	582,0	224,0	126,0	12,0	1467,0	63,5	68,2	11,5	56,7
2000	85,0	264,0	7,0	152,0	611,0	269,0	94,0	0,0	1482,0	62,5	67,8	11,0	56,8
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
2003	24,0	143,0	4,0	131,0	379,0	170,0	55,0	60,0	966,0	37,6	63,2	7,8	55,4
2004	11,0	132,0	5,0	140,0	452,0	172,0	42,0	46,0	1000,0	37,5	61,5	10,4	51,1

The total waste amount in Table 8.8 is the sum of the different waste types and thereby includes Industrial Waste, Building and Construction Waste. The total waste amount is reported as the activity data for the Annual Municipal Solid Waste (MSW) at SWDSs in the CRF Table 6.A. In so doing and in referring to the discussion of waste amounts in GPG, page 5.8, it is clear that these amounts are not really characteristics of the term "Municipal Solid Waste". Furthermore, it should be noted that these amounts are used to calculate the amount of waste produced per capita in the Table 6A,C of the CRF and that these per capita amounts may not, therefore, be comparable with those used by other parties using different approaches.

The implied emission factor (IEF) in the CRF tables reflects an aggregated emission factor for the model. This IEF has increased through the time-series from 1990 to 2004, despite the general decreasing trend in the amount of waste. This is due to the model, where emissions from the waste deposited are being calculated to take place in years after the actual year of deposition.

As mentioned in the section above, the review team pointed out that a more correct way to model the process of CH_4 emission in a landfill, as regards the recovery and the oxidation factor, is to use the oxidation factor after recovery. This could not be achieved in time for the addition of the data in the CRF format, so the data in the CRF tables is not changed accordingly and corresponds to the data given in Table 8.8. However, the consequence of such a change for this report is examined, Table 8.9.

Table 8.9 Amounts of waste and CH_4 emissions for 1990-2004. Oxidation after recovery.

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 before oxidation	Annual net emission after ox. 0.1
	kt								kt	kt CH4	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	94,7	71,1	0,5	70,6	63,6
1991	198,7	259,0	70,7	120,0	824,3	804,3	193,3	562,0	3032,3	93,0	72,6	0,7	71,9	64,7
1992	198,4	267,3	56,1	130,7	826,2	657,2	164,6	589,0	2889,6	91,3	73,9	1,4	72,4	65,2
1993	198,2	275,7	41,6	141,3	828,1	510,1	135,8	616,0	2746,8	89,7	74,9	1,7	73,2	65,9
1994	198,0	284,0	27,0	152,0	830,0	363,0	107,0	643,0	2604,0	88,0	75,8	4,6	71,2	64,1
1995	190,0	286,0	17,0	128,0	779,0	321,0	101,0	135,0	1957,0	83,0	76,3	7,4	68,8	62,0
1996	132,0	275,0	6,0	135,0	822,0	317,0	117,0	703,0	2507,0	79,3	76,5	8,2	68,3	61,5
1997	83,0	248,0	6,0	170,0	707,0	264,0	130,0	475,0	2083,0	73,3	76,3	11,1	65,1	58,6
1998	98,0	234,0	20,0	161,0	746,0	266,0	124,0	210,0	1859,0	73,6	76,1	13,2	62,9	56,6
1999	117,0	239,0	3,0	164,0	582,0	224,0	126,0	12,0	1467,0	70,6	75,7	11,5	64,3	57,8
2000	85,0	264,0	7,0	152,0	611,0	269,0	94,0	0,0	1482,0	69,5	75,3	11,0	64,3	57,9
2001	50,0	180,0	3,0	150,0	583,0	260,0	64,0	10,0	1300,0	55,4	74,0	10,0	64,0	57,6
2002	37,0	161,0	4,0	137,0	520,0	229,0	48,0	38,0	1174,0	48,8	72,3	11,2	61,1	55,0
2003	24,0	143,0	4,0	131,0	379,0	170,0	55,0	60,0	966,0	41,8	70,2	7,8	62,4	56,2
2004	11,0	132,0	5,0	140,0	452,0	172,0	42,0	46,0	1000,0	41,7	68,3	10,4	58,0	52,2

In Table 8.9, it can be seen that both the potential and the annual emission are higher than in Table 8.8, since oxidation has been removed in the model. For the Table 8.9, oxidation with Oxidation Factor = 0.1 is accounted for by reducing the annual net emission. This method corresponds to the assumption that the oxidation takes place in the top layers of the landfills. The resulting emission is shown in the far right column of Table 8.9. Compared with Table 8.8, the deviation is minor with systematic higher emissions ranging through the time-series from 0.1 to 2.4%. The change will be incorporated in the 2007 submissions.

Furthermore, a preliminary analysis has been carried out on the introduction of individual half-life times for the emissions of CH_4 from the waste sectors used, Table 8.10.

Table 8.10 Preliminary analyses of CH_4 emissions for 1990-2004 using individual half-life time for waste sectors.

	Domestic Waste	Bulky Waste	Garden Waste	Commercial & office Waste	Industrial Waste	Building & construction Waste	Sludge	Ash & slag	Waste Total Annual CH4 emission kt
Half-life time (year)	4	23	7	12	17	17	4		
Year	CH4 emission kt								
1990	12,4	8,9	5,6	3,5	9,6	6,2	12,5	0,0	58,9
1991	12,6	9,4	5,4	3,9	10,0	6,2	11,9	0,0	59,3
1992	12,7	9,9	5,2	4,2	10,3	6,2	11,2	0,0	59,6
1993	12,8	10,3	4,9	4,6	10,6	6,1	10,4	0,0	59,7
1994	12,9	10,8	4,6	5,0	10,9	5,9	9,5	0,0	59,7
1995	12,9	11,3	4,2	5,3	11,2	5,8	8,7	0,0	59,4
1996	12,3	11,7	3,8	5,6	11,5	5,7	8,1	0,0	58,7
1997	11,2	12,1	3,5	6,0	11,6	5,5	7,8	0,0	57,7
1998	10,5	12,4	3,3	6,4	11,8	5,4	7,4	0,0	57,1
1999	10,1	12,7	3,0	6,8	11,9	5,2	7,1	0,0	56,7
2000	9,4	13,0	2,7	7,1	11,9	5,1	6,7	0,0	55,9
2001	8,4	13,1	2,5	7,3	12,0	5,0	6,1	0,0	54,4
2002	7,5	13,2	2,3	7,5	12,0	4,8	5,4	0,0	52,7
2003	6,6	13,2	2,1	7,7	11,8	4,7	5,0	0,0	51,0
2004	5,6	13,2	1,9	7,9	11,7	4,6	4,5	0,0	49,3

Comparing Table 8.10 and Table 8.8, it can be seen that the emissions using individual half-life times are smaller for the whole time-series. The difference increases from 8% in 1990 to 20% in 2004. Please note that this comparison is for annual emission (not net emission). This approach, including considerations with regard to the size of half-life times, will be analysed in more depth in the future.

In Annex 3.E, further details on the model for the CH_4 emission from solid deposited waste are given.

8.2.3 Uncertainties and time-series consistency

8.2.3.1 Uncertainty

The parameters considered in the uncertainty analyses and the estimated uncertainties of the parameters are shown in Table 8.11. The reference is GPG, page 5.12, Table 5.2. For all uncertainties, symmetric values based on maximum numeric values are estimated as the uncertainties for the wholr inventory is a Tier 1 approach to be summed up in the GPG Table 6.1. Uncertainties are estimated on parameters, which are mostly used in factors for multiplication, so that the final uncertainty is estimated with Equation 6.4 in the GPG.

As regards the uncertainty given in the GPG for the methane generation constant, k, (-40%, +300%), this uncertainty cannot be included in simple equations for total uncertainties, such as GPG Equations 6.3 and 6.4. The reason is that k is a parameter in the exponential function for the formula for emission estimates. The FOD model has, therefore, been run with the k-values representing those uncertainties (-40%: k=0.0416 (half-life time, 16 years), +300%: k=0.2079 (half-life time, 3.33 years) as compared to the k=0.069 (half-life time, 10 years) used in the present model. Based on these runs on the actual potential emissions, actual mean differences on calculated CH_4 emissions for 1990-2004 are found to be –17.3% +7.8%.

The final uncertainty on the emission factor is based on uncertainty estimates in Table 8.11 and, by means of the GPG Equation 6.4, is calculated as:

Uncertainty of emission factor total % = SQRT($50^2+30^2+10^2+10^2+17.3^2$) = 62.6%

Table 8.11 Uncertainties for main parameters of emissions of CH_4 for SWDS

Parameter	Uncertainty	Note
The Waste amount sent to SWDS MSWT*MSWF	10%	Since the amounts are based on weighing at the SWDS the lower value in GPG is used
Degradable Organic Carbon DOC	50%	
Fraction of DOC dissimilated	30%	
Methane Correction Factor	10%	
Methane recovery and Oxidation Factor	10%	see the text
Methane Generation Rate Constant	17.3%	see the text

8.2.3.2 Time-series consistency and completeness

Registration of the amount of waste has been carried out since the beginning of the 1990s in order to measure the effects of action plans. The activity data is, therefore, considered to be consistently long enough to make the activity data input to the FOD model reliable. For further information on activity data, refer to Annex E.

The consistency of the emissions and the emission factor is a result of the same methodology and the same model used for the whole time-series. The parameters in the FOD model are the same for the whole time-series. The use of a model of this type is recommended in the IPCC GL and GPG. The half-life time parameter used is within the intervals recommended by the IPCC GPG.

As regards completeness, the waste amounts used, as registered in the ISAG system, do not only include traditional Municipal Solid Waste (MSW), but also non-MSW as Industrial Waste, Building and Construction Waste and Sludge. The composition of these waste types is, according to Danish data, used to estimate DOC values for the waste types (refer GPG page 5.10).

8.2.4 QA/QC and verification

8.2.4.1 QA/QC-procedure

The reviewers recommended an improved description and have in the review of the 2005 NIR acknowledged that this effort has taken place and has improved the NIR. It is the intention to publish a sector report for SWDS. The main effort has, however, centred on improving the description in the NIR and this section is to be regarded as a further improvement.

A proposal for formal agreements with regard to data deliverance has been put forward to DEPA concerning provision of annual waste amounts. However, such an agreement has not yet been signed. Since it is a statutory requirement that waste amounts are reported to DEPA, the agreement may potentially not be required (refer to the remarks under DS.1.3.1). DEPA makes a yearly report on the reception of the registrations, etc.

In general terms, for this part of the inventory, the Data Storage (DS) Level 1 and 2 and the Data Processing (DP) Level 1 can be described as follows:

Data Storage Level 1

The external data level refers to the placement of original data for amounts of waste categories or fractions. These categories/fractions are linked to data on waste types with known content of degradable organic carbon, see Section 8.2.2.1. Data for CH_4 recovery are used. Further (external) data are parameters to the FOD model. For further details on the external data, refer to the table below.

File or folder name	**Description**	**AD or Emf.**	**Reference**	**Contact(s)**	**Data agreement/ Comment**
http://www.mst.dk/udgiv/publications/2006/87-7614-962-5/pdf/87-7614-963-3.pdf	Report on 2004 amounts according to the waste fractions, Annex 1	Activity data	Danish Environmental Protection Agency, Waste Statistics 2004	Frank Marcher	The amounts are registered due to statutory requirements
Basic Data (Grunddata2004_DMU.xls)	Dataset for energy-producing SWDS	CH4 recovery data	The Danish Energy Authority (DEA)	Anders B. Hansen & Peter Dal	Prepared due to the obligation of DEA
swds_fod_model_2004.xls	Excel file with the FOD model	Parameters of the FOD model	IPCC GL GPG	Erik Lyck	

Data Processing Level 1

This level, for SWDS, comprises a stage where the external data are treated internally, preparing for the input to the NERI First Order of Decay model, see Section 8.2.2.1. The model runs are carried out and the output stored.

Data Storage Level 2

Data Storage Level 2 is the placement of selected output data from the FOD model as inventory data on SNAP levels in the Access (CollectER) database.

8.2.4.1 Points of measurement

The present stage of QA/QC for the Danish emission inventories for SWDS is described below for DS and DP level 1 Points of Measurement (PMs). This is to be seen in connection with the general QA/QC description in Section 1.6 and, especially, 1.6.10 on specific description of PMs common to all sectors, general to QA/QC.

Data Storage level 1	1. Accuracy	DS.1.1.1	General level of uncertainty for every dataset including the reasoning for the specific values

With regard to the general level of uncertainty, the amounts in waste fractions/categories are rather certain due to the statutory environment for these data, while the distribution of waste fractions according to waste type and their content of DOC is more uncertain. It is generally accepted that FOD models for CH_4 emission estimates offer the best and the most certain way of estimation. The half-lifes in the FOD models are an important parameter with some uncertainty.

Data Storage level 1	1. Accuracy	DS.1.1.2	Quantification of the uncertainty level of every single data value including the reasoning for the specific values.

The uncertainties of the DEPA data are not available in the DEPA reporting. The uncertainties are taken from the IPCC GL and GPG. A special uncertainty/sensitivity analyses connected to the uncertainty/variation of the half-life parameter is carried out. DEA data on CH_4 recovery are considered to be precise. Refer to Section 8.2.3.1 on uncertainty.

Data Storage level 1	2.Comparability	DS.1.2.1	Comparability of the data values with similar data from other countries, which are comparable with Denmark, and evaluation of discrepancy.

Only some comparison of Danish data values from external data sources with corresponding data from other countries has been carried out in order to evaluate discrepancies. For many countries SWDS waste amounts do not – as for the Danish data – include waste from industrial sources, which presents a difficulty with regard to comparison.

Data Storage level 1	3.Completeness	DS.1.3.1	Documentation showing that all possible national data sources are included by setting down the reasoning behind the selection of datasets.

The following external data sources are used for the inventory on SWDS (refer also to the table above):

1) Danish Environmental Protection Agency, ISAG database: amounts of the various waste fractions deposited (refer to Section 8.2.2.1).
2) A Danish investigation on the waste types in waste fractions and the content of degradable organic carbon in waste types.
3) Danish Energy Authority: Official Danish energy statistics: CH_4 recovery data.

The selection of sources is obvious. The ISAG database is based on statutory registrations and reporting from all Danish waste treatment plants for all waste entering or leaving the plants. Information concerning waste in the previous year must be reported to the DEPA each year, no later than 31 January. Registration is made by weight. For recovery data, the DEA registers the energy produced from plants where installations recover CH_4 for the energy statistics.

For the parameters of the FOD model, references are made to the IPCC GL and GPG.

Data Storage level 1	4.Consistency	DS.1.4.1	The origin of external data has to be preserved whenever possible without explicit arguments (referring to other PMs).

The origin of external activity data has been preserved as much as possible. The starting year for the FOD model used is 1960, using historic data for waste quantities. Since 1994, data is according to the Danish ISAG reporting system. For further information on the origin of activity data, refer to Annex 3E. Files are saved for each year of reporting. In this way changes to previously received data is reflected and explanations are given.

The FOD model and its parameters have been used consistently, throughout the time-series, refer to Section 8.2.3.2.

Data Storage level 1	6.Robustness	DS.1.6.1	Explicit agreements between the external institution holding the data and NERI about the conditions of delivery.

It is a statutory requirement that amounts of waste are reported annually to DEPA, no later than January 31 for the previous year which corresponds well with the inventory development. No explicit agreement has yet been made.

Data Storage level 1	7.Transparency	DS.1.7.1	Summary of each dataset including the reasoning for selecting the specific dataset

The summary of the dataset can be seen in Table 8.8 in Section 8.2.2.2. For the reasoning behind the selection of the specific dataset, refer to DS 1.3.1.

Data Storage level 1	7.Transparency	DS.1.7.3	References for citation for any external dataset have to be available for any single value in any dataset.

These references exist in the description given in the Section 8.2.2.1, under methodological issues.

Data Storage level 1	7.Transparency	DS.1.7.4	Listing of external contacts for every dataset

The following list shows the person responsible and contact information for delivery of data:

Danish Environmental Protection Agency: Frank Marcher (FM@MST.DK) and Lone Lykke Nielsen (LLN@MST.DK)

Danish Energy Authority: Anders B. Hansen (abh@ens.dk) and Peter Dal (pd@ens.dk)

Data Processing level 1	1. Accuracy	DP.1.1.1	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to type of variability. (Distribution as: normal, log normal or other type of variability)

Tier 1 uncertainty calculations are made. The use of the Tier 1 methodology presumes a normal distribution of activity data and emission factor variability. The extent to which this requirement is fulfilled still needs to be elaborated. The uncertainty on the half-life time cannot be implemented on a Tier 1 level and a special assessment has been given, see DS.1.1.2.

Data Processing level 1	1. Accuracy	DP.1.1.2	Uncertainty assessment for every data source as input to Data Storage level 2 in relation to scale of variability (size of variation intervals)

The uncertainty assessment has been given in Section 8.2.3.1. The uncertainty on the half-life time cannot be implemented on a Tier 1 level and a special assessment has been given, see DS.1.1.1.

Data Processing level 1	1. Accuracy	DP.1.1.3	Evaluation of the methodological approach using international guidelines

An evaluation of the methodological approach, in comparison with the Tier 1 level, has been made, see Section 8.2.4.2. This shows that the emissions from waste estimated according to the default methodology from the IPCC GL and GPG will deviate considerably from those in this submission, also since the waste amounts estimated in the latter methodologies deviate from those used for Denmark.

Data Processing level 1	1. Accuracy	DP.1.1.4	Verification of calculation results using guideline values

From the evaluation carried out, see DP.1.1.3, it is clear that no direct verification can be carried out, since the method is a Tier 2 method, in accordance with the IPCC GL and GPG.

Data Processing level 1	2.Comparability	DP.1.2.1	The inventory calculation has to follow the international guidelines suggested by the UNFCCC and IPCC.

The calculation used is a Tier 2 methodology from the IPCC GL and GPG.

Data Processing level 1	3.Completeness	DP.1.3.1	Assessment of the most important quantitative knowledge which is lacking.

There is no quantitative knowledge on either (1) the shift over time in waste types within waste fractions and in DOC content in waste types or (2) possible individual conditions relating to the SWD sites.

Data Processing level 1	3.Completeness	DP.1.3.2	Assessment of the most important cases where access is lacking with regard to critical data sources that could improve quantitative knowledge.

There is no direct data to elucidate the points mentioned under DP.1.3.1.

Data Processing level 1	4.Consistency	DP.1.4.1	In order to keep consistency at a high level, an explicit description of the activities needs to accompany any change in the calculation procedure.

There is no change in calculation procedure during the time-series and the activity data is, as far as possible, kept consistent for the calculation of the time-series.

Data Processing level 1	5.Correctness	DP.1.5.1	Show at least once, by independent calculation, the correctness of every data manipulation.

The model has been checked to give the results to be expected on fictive input data, se Annex 3E.

Data Processing level 1	5.Correctness	DP.1.5.2	Verification of calculation results using time-series

The time-series of activities and emissions in the FOD-model output, in the SNAP source categories and in the CRF format have been prepared. The time-series are examined and significant changes are checked and explained. Comparison is made with the previous year's estimate and any major changes are verified.

Data Processing level 1	5.Correctness	DP.1.5.3	Verification of calculation results using other measures

The correct interpretation in the model of the methodology and the parameterisation has been checked, refer DP.1.5.1.

Data Processing level 1	5.Correctness	DP.1.5.4	Shows one-to-one correctness between external data sources and the databases at Data Storage level 2

Data transfer control is made from the external data sources and to the SNAP source categories at level 2. This control is carried on further to the aggregated CRF source categories.

Data Processing level 1	7.Transparency	DP.1.7.1	The calculation principle and equations used must be described

The calculation principle and equations are described in Section 8.2.2. Further transparency comes as a consequence of using TIER 2 method of the IPCC GL and GPG, descriebed in these IPCC reports.

Data Processing level 1	7.Transparency	DP.1.7.2	The theoretical reasoning for all methods must be described

The theoretical reasoning is described in Section 8.2.2 and, due to the used of the Tier 2 method of the IPCC GL and GPG, is also described in these IPCC reports.

Data Processing level 1	7.Transparency	DP.1.7.3	Explicit listing of assumptions behind all methods

The assumption is that the emissions can be described according to a FOD model as described in the IPCC GL and GPG for SWDS. Furthermore, it is assumed that this FOD model can be run with the parameters as they are listed in Section 8.2.2.

Data Processing level 1	7.Transparency	DP.1.7.4	Clear reference to dataset at Data Storage level 1

Refer to the table at the start of this Section (8.2.4).

Data Processing level 1	7.Transparency	DP.1.7.5	A manual log to collect information about recalculations

Recalculation changes in the emission inventories are described in the NIR. The logging of the changes takes place in the yearly model file.

Data Storage level 2	5.Correctness	DS.2.5.1	Documentation of a correct connection between all data types at level 2 to data at level 1

The full documentation for the correct connection exists through the yearly model file, its output and report files made by the CollectER database system.

Data Storage level 2	5.Correctness	DS.2.5.2	Check if a correct data import to level 2 has been made

This check is performed, comparing model output and report files made by the CollectER database system, refer to DS.2.5.1.

Suggested QA/QC plan for SWDS

The following points are a list of QA/QC tasks to be considered directly in relation to the SWDS part of the Danish emission inventories:

Data at storage level 1

- A further comparison with external data from other countries in order to evaluate discrepancies.
- Agreement on the data deliverance consistency and stability.
- Investigations into the possibility of obtaining data on variations in waste fraction composition and DOC content in the time-series.

Data processing level 1

More work on uncertainty calculations.

Further evaluation of FOD modelling with half-life time depending on individual waste types.

8.2.4.2 QA on evaluation and verification

It is good practice, and a QA procedure, to compare the emission estimates included in the inventories with the IPCC default methodology.

In Table 8.12, default methodology is presented using the GPG and the IPCC GL, as appropriate. The parameters (on the pages of the IPCC GL and IPCC GPG) used are referred to in the table. As seen against the calculation of DOC in the default methodology, the Danish data is not suited for direct use. Referring to the formula in the GPG, p5.9, it is assumed (referring to Table 8.6, above) that A comprises “Cardboard”, “Paper” and “Wet Cardboard and Paper”; that B comprises “Plastic”, “Other Combustible” and “Other not Combustible”; and that C comprises “Waste Food”. A mean fraction of these categories was calculated for use in the default methodology.

Table 8.12 IPCC default methodology for CH_4 emissions from SWDS for 1990-2004

Parameter	Reference		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	Population	1000 cap	5135	5146	5162	5181	5197	5216	5251	5275	5295	5314	5330	5349	5368	5384	5398
MSW	Waste generation rate Table 6-1	kg/cap/year	1,26	1,26	1,26	1,26	1,26	1,26	1,26	1,26	1,26	1,26	1,26	1,26	1,26	1,26	2,26
MSWT	Waste generation GL Table 6-1	Gg/year	2362	2367	2374	2383	2390	2399	2415	2426	2435	2444	2451	2460	2469	2476	4453
MSWF	Fract. of waste to SWDS GL Table 6-1		0,20	0,20	0,20	0,20	0,20	0,20	0,20	0,20	0,20	0,20	0,20	0,20	0,20	0,20	0,20
MCF	Methan Corr Factor GPG p 5.8		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
DOC	Degr Organic C GPG p 5.9		0,19	0,19	0,19	0,19	0,19	0,19	0,19	0,19	0,19	0,19	0,19	0,19	0,19	0,19	0,19
DOCF	Fract DOC diss GPG p 5.9		0,55	0,55	0,55	0,55	0,55	0,55	0,55	0,55	0,55	0,55	0,55	0,55	0,55	0,55	0,55
F	Fractio CH4 in gas GPG p5.10		0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
Lo	Methan gener. pot GPG p5.8		0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07
R	Danish Energy statistics	Gg CH4/year	0,5	0,7	1,4	1,7	4,6	7,4	8,2	11,1	13,2	11,5	11,0	10,0	11,2	7,8	10,4
OX	Oxid. Factor GPG p5.10		0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
CH4 emissions		Gg CH4/year	29,7	29,6	29,0	28,8	26,3	23,9	23,5	20,9	19,2	20,9	21,4	22,4	21,4	24,5	47,5

The table shows that the default methodology underestimates the amounts of waste deposited and the CH_4 emissions by a factor of 2-3. The reason for this is that the default methodology does not seem to include Industrial Waste, which is deposited in considerable quantities in Denmark, Table 8.8.

A further option in the default methodology is to include the total waste amount registered with the waste generation rate for total waste, and include the fraction of waste deposited to SWDS, Table 8.13. The fraction as well as the generation rate for total waste is included in the CRF Table 6 A “Additional Information”.

Table 8.13 As Table 8.11 but with registered fraction of waste deposited to SWDS.

Parameter	Reference		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	Population	1000 cap	5135	5146	5162	5181	5197	5216	5251	5275	5295	5314	5330	5349	5368	5384	5398
MSW	Waste generation rate ISAG	kg/cap/year	5,4	5,5	5,6	5,7	5,9	6,0	6,7	6,7	6,3	6,3	6,7	6,5	6,7	6,4	6,8
MSWT	Waste generation GL Table 6-1	Gg/year	10169	10403	10637	10871	11105	11466	12912	12857	12233	12233	13031	12768	13105	12614	13359
MSWF	Fract. of waste to SWDS ISAG		0,30	0,28	0,27	0,25	0,23	0,24	0,20	0,16	0,15	0,12	0,11	0,10	0,09	0,08	0,08
MCF	Methan Corr Factor GPG p 5.8		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
DOC	Degr Organic C GPG p 5.9		0,19	0,19	0,19	0,19	0,19	0,19	0,19	0,19	0,19	0,19	0,19	0,19	0,19	0,19	0,19
DOCF	Fract DOC diss GPG p 5.9		0,55	0,55	0,55	0,55	0,55	0,55	0,55	0,55	0,55	0,55	0,55	0,55	0,55	0,55	0,55
F	Fractio CH4 in gas GPG p5.10		0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
Lo	Methan gener. pot GPG p5.8		0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07
R	Danish Energy statistics	Gg CH4/year	0,5	0,7	1,4	1,7	4,6	7,4	8,2	11,1	13,2	11,5	11,0	10,0	11,2	7,8	10,4
OX	Oxid. Factor GPG p5.10		0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
CH4 emissions		Gg CH4/year	194,9	187,4	178,9	170,2	158,7	168,8	157,4	121,2	105,2	83,3	81,5	72,4	65,2	57,3	58,8

The result of this adjusted default methodology is CH_4 emissions, which in the beginning of the time-series represent highly overestimated emissions and in the later part of the time-series represent underestimated emissions compared with the results of the FOD model. One explanation is that the FOD model reflects the ongoing process over the years with regard to the generation of CH_4 from waste deposited in previous years, while the default method only estimates emissions reflecting the waste deposited the same year.

8.2.5 Recalculations

For the submissions in 2006, recalculations have been carried out in relation to the final submission in 2005 of inventories 2002-2003. The recalculation represents only a minor correction and is solely due to updates in the energy statistics on the uptake of CH_4 by installations at SWDSs for energy production. For 2002, the correction of the actual CH_4 emission is – 2.2% and, for 2003, the correction is + 0.9%, refer to the recalculations in Chapter 10.

8.2.6 Planned improvements

In response to the expert review team for the 2005 submissions, the methodology has been analysed in this report beacuse of the differing interpretation of the oxidation occurring in the landfills. The suggestion from the review team will be incorporated in the CRF data for submissions in 2007. Further analyses will be carried out on the impact and sensitivity of individual half-life times for different waste fractions.

A further plan is to analyse the influence of a changed distribution of the composition of the deposited waste throughout the time-series. Data availability and expert judgement of the evidence for such a change forms part of the planned investigation.

Finally further QA/QC analyses will be taken into consideration.

References

Danish Environmental Protection Agency 2006: Waste Statistics 2004. http://www.mst.dk/udgiv/publications/2006/87-7614-962-5/pdf/87-7614-963-3.pdf

Danish Environmental Protection Agency 2005: Waste Statistics 2003. http://www.mst.dk/udgiv/publications/2005/87-7614-585-9/pdf/87-7614-586-7.pdf

Danish Environmental Protection Agency 2004b: Waste Statistics 2002. http://www.mst.dk/udgiv/publications/2004/87-7614-107-1/pdf/87-7972-109-8.pdf

Danish Environmental Protection Agency 2004a: Waste Statistics 2001. http://www.mst.dk/udgiv/publications/2004/87-7614-105-5/pdf/87-7972-106-3.pdf

Danish Environmental Protection Agency 2002: Waste Statistics 2000. http://www.mst.dk/udgiv/publications/2002/87-7972-027-7/pdf/87-7972-028-5.pdf

Danish Environmental Protection Agency 2001b: Waste Statistics 1999. http://www.mst.dk/udgiv/publications/2001/87-7944-351-6/pdf/87-7944-352-4.pdf

Danish Environmental Protection Agency 2001a: Waste Statistics 1998. http://www.mst.dk/udgiv/publications/2001/87-7944-351-6/pdf/87-7944-352-4.pdf

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Danish Environmental Protection Agency 2000: Waste Statistics 1996. http://www.mst.dk/udgiv/publications/2000/87-7909-433-3/pdf/87-7909-432-5.pdf

Danish Environmental Protection Agency 1997: Waste Statistics 1995. http://www.mst.dk/udgiv/publications/1997/87-7810-790-3/pdf/87-7810-790-3.pdf

8.3 Waste-water Handling (CRF Source Category 6B)

8.3.1 Source category description

This source category includes an estimation of the emission of CH_4 and N_2O from wastewater handling. CH_4 is emitted from anaerobic treatment processes, while N_2O may be emitted from anaerobic as well as aerobic processes. The category does not include any key sources (cf. Annex 1).

The Danish Environmental Protection Agency (DEPA) publishes data from municipal and private wastewater treatment plants (WWTPs). The data includes an overview of the influent load of wastewater at Danish WWTPs, treatment categories and processes, effluent quality parameters and sludge treatment processes at national level.

Methane emission

The net emission of CH_4 is calculated as the gross emission minus the amount of CH_4 potentially recovered and flared or used for energy production. The recovered or not emitted methane potential is calculated as the amount of sludge used for biogas (and thus included in the CO_2 emission from the energy production) or combusted (and thus included in the calculation of CO_2 emission from the combustion processes). A summary of the results on the emission of CH_4 from 1990 to 2004 is given in Table 8.14.

Table 8.14 CH_4 emissions recovered and flared or used for energy production, total methane potential not emitted, gross and net emission data [Gg].

Year	CH_4, external combustion	CH_4, internal combustion	CH_4,sandblasting products	CH_4, biogas	CH_4 potential not emitted	CH_4, gross	CH_4, net [1]
1990	2.39	4.67	1.20	0.24	8.51	14.42	5.91
1991	2.41	4.60	1.34	0.27	8.62	14.46	5.84
1992	2.43	4.52	1.49	0.30	8.73	14.51	5.78
1993	2.44	4.44	1.63	0.32	8.84	14.91	6.07
1994	2.46	4.36	1.78	0.35	8.95	16.20	7.24
1995	2.47	4.29	1.92	0.38	9.06	17.49	8.43
1996	2.49	4.21	2.07	0.40	9.17	18.79	9.62
1997	2.19	4.42	1.23	0.46	8.29	20.10	11.81
1998	2.52	4.05	2.36	0.45	9.39	21.42	12.03
1999	2.25	4.29	2.67	0.55	9.76	21.04	11.28
2000	3.64	3.12	3.61	0.51	10.88	21.22	10.34
2001	2.74	4.28	3.19	0.43	10.63	21.65	11.02
2002	1.91	3.47	2.87	0.41	8.65	23.43	14.78
2003	2.07	4.13	3.08	0.42	9.77	24.03	14.26
2004	2.07	4.13	3.23	0.39	10.35	22.96	12.61

Based on the data estimated, Table 8.14, a time trend analysis of the three main parameters, i.e. the gross emission, the methane potential not emitted and the net emission of methane, is shown in Figure 8.1.

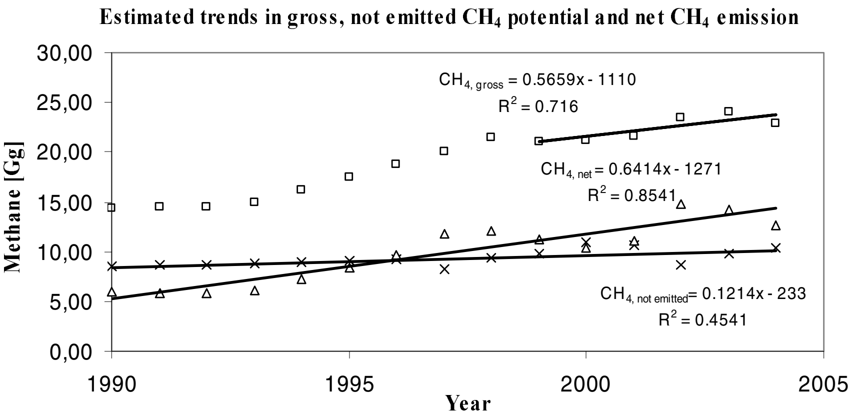

Figure 8.1 Estimated time trends for the gross emission of methane (open squares), methane potential not emitted; i.e. sum of columns 2 to 5, or column 6, in Table 8.14 (crosses) and net emission of methane (open triangles).

Figure 8.1 shows that the net emission of methane increases by around 0.64 Gg per year, as a result of the increase in the gross emission of, on average, 0.56 Gg per year, and a minor increase in the amount of methane potential not emitted of 0.1 Gg per year. The increasing time trend in the net emission is a result of the industrial influent load of TOW, which has increased from 0-5% in the years from 1984 to 1993 to an average contribution of 39% in the years from

1999 to 2004. In addition, the technical upgrades to the WWTPs and the goal of reducing the effluent nutrient loads in the Water Environment Action Plan (cf. Annex 3E) may have resulted in an increased emission from anaerobic treatment processes. Based on the above figures, 50% of the methane potential on average is combusted throughout the period, 1990-2004. The decrease in internal combustion is accompanied by a parallel increase in external combustion, and combustion processes included in the production and reuse of sludge in sandblasting products.

Nitrous oxide emission

The emission of N_2O from wastewater handling is calculated as the sum of contributions from wastewater treatment processes at the WWTPs and from sewage effluents. Emissions from effluent wastewater, i.e indirect emissions, include separate industrial discharges, rainwater-conditioned effluents, effluents from scattered houses, from mariculture and fishfarming. In Table 8.15, the contribution to the total emission of N_2O from effluents ia given in Columns 2 to 6. The total N_2O emission from efffluents is given in Column 7, the contribution from direct N_2O emission in Column 8 and the total N_2O emission, i.e. the sum of indirect and direct N_2O emissions, is given in the last column.

Table 8.15 N_2O emission from effluents from point sources, from wastewater treatment processes and in total [tonnes].

Year	N_2O, effluent from separate industry discharges	N_2O, rainwater conditioned effluent	N_2O, effluent from scattered houses	N_2O, effluent from mariculture and fish farming	N_2O, effluent from municipal and private WWTPs	N_2O, effluents in total	N_2O,WWTP, direct	N_2O,WWTP, direct and indirect [1]
1990	0	0	0	0	265	265	17	283
1991	0	14	0	0	237	252	17	269
1992	0	14	0	0	205	219	17	237
1993	40	16	20	27	170	273	20	293
1994	43	19	19	26	161	268	29	297
1995	39	14	18	27	140	238	37	275
1996	27	10	18	24	100	180	44	224
1997	28	13	18	23	76	158	52	210
1998	22	15	16	20	81	154	59	213
1999	14	15	15	22	81	147	53	200
2000	14	12	15	43	73	157	54	211
2001	13	12	16	28	66	134	50	185
2002	12	16	15	23	71	137	50	188
2003	8	11	15	18	57	109	52	161
2004	7	13	15	21	63	119	52	171

The trends in the N_2O emission direct from WWTPs, the indirect emission from wastewater effluent and the total, in Table 8.1, are presented graphically in Figure 8.2 below.

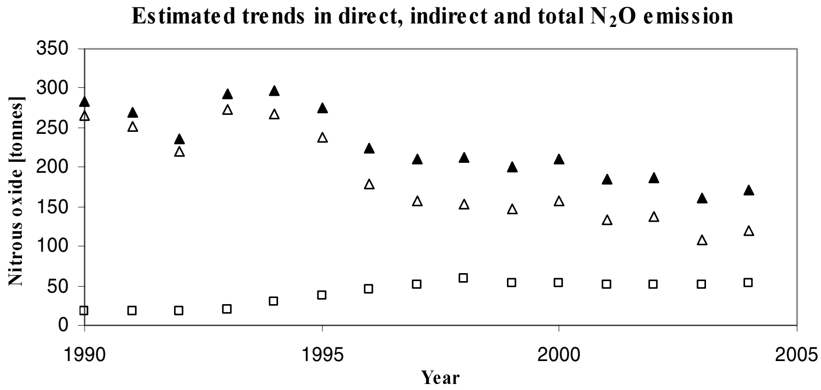

Figure 8.2 Time trends for direct emission of N_2O (open squares), indirect emission, i.e. from wastewater effluents (open triangles) and total N_2O emission (black triangles).

The direct emission trend increases slightly, reaching a stable level from 1997 onwards. The decrease in the indirect emission from wastewater effluent is due to the technical upgrading of the WWTPs and the resulting decrease in wastewater effluent nitrogen loads. The indirect emission, which is the major contributor to the emission of nitrous oxide, is not expected to decrease much more in future, as effluent reduction of N has increased from 65% in 1993 to 80% in 2004 (cf. Annex 3E, Table 3E.4).

8.3.2 Methodological issues

A country-specific methodology has been developed for estimating CH_4 and N_2O emissions for wastewater handling in Denmark (cf. Thomsen and Lyck, 2005). This section is divided into methodological issues related to the CH_4 and N_2O emission calculations, respectively.

8.3.2.1 Methodological issues related to the estimation of CH_4 emissions

The methodology developed for this submission for estimating emission of methane from wastewater handling follows the IPCC Guidelines (1996) and IPCC Good Practice Guidance (2000).

According to the IPCC GL, the emission should be calculated for domestic and industrial wastewater and the resulting two types of sludge, i.e. domestic and industrial sludge. The information available for the Danish wastewater treatment systems does not fit into the above categorisation as a significant fraction of the industrial wastewater is treated at centralised municipal wastewater treatment plants (WWTPs) and the data available for the total organic waste (TOW) does not differentiate between industrial and municipal sewage sludge. The IPPC default methodology for household wastewater has been applied by accounting and correcting for the industrial influent load (cf. Annex 3.E, Figure 3E.1).

The gross emission of CH_4 is calculated by using national data on total organic degradable waste (TOW) and a country-specific emission factor (EF).

The country-specific emission factor has been derived according to the IPCC GPG (page 5.16, Eq. 5.7). National statistics on the fraction of wastewater sludge (in wet weight), treated anaerobically, have been used as a measure of the Methane Conversion Factor (MCF), under the assumption that the treatment is 100% anaerobic. The MCF was multiplied by a default value of 0.6 kg CH_4/kg BOD for the maximum CH_4 producing capacity (B_0) to calculate EF. A representative value of 0.15 kg CH_4/kg BOD as EF was obtained for the Danish WWTPs (cf. Annex 3.E, Table 3E.7).

Of the total influent load of organic wastewater, the separated sludge has different final disposal categories. The fractions that are used for biogas, combustion or reuse including combustion include methane potentials that are either recovered or emitted as CO_2. These fractions have been subtracted from the calculated (theoretical) gross emission of CH_4.

Based on the available data, it has not been possible to disaggregate data into individual MCFs for the individual process steps at the WWTPs. Therefore, no weighted MCFs are available and the final disposal categories registered by DEPA have been used to calculate the amount of "not emitted" and recovered methane potential. An EF value given in IPCC (2003) for the sludge disposal category biogas has been used for calculating the recovered and not emitted methane potential.

Activity data and emission factors

Activity data for calculating the gross emission of methane is given in Table 8.16 and 8.17. Country-specific data on the total organic degradable waste in kg BOD/year are given in Table 8.16.

Table 8.16 Total degradable organic waste (TOW) calculated by use of country-specific data.

Year	1993	1999	2000	2001	2002	2003	2004
TOW_{BOD} (tonnes BOD/year)	99750	132000	144375	146160	152497	159858	143091
TOW_{COD} (tonnes BOD/year)		148500	138600	142560	159858	160571	163026

Data gap-filling procedures for arriving at TOW estimated from 1990 to 1998 are given in Annex 3.E, Figure 3E.1. In short, the default methodology has been used and corrected for the percent industrial contribution to the TOW, which increases nonlinearly and stabalises at, on average, 39% from 1999 and forward (cf. Annex 3E).

To arrive at the gross emission of methane, the TOW needs to be multiplied by an emission factor. The emission factor is calculated by multiplying the maximum methane producing capacity (B_o) with the fraction of BOD that will ultimately degrade anaerobically, i.e. the methane conversion factor (MCF).

Data on the fraction of sludge, in wet weight (ww), treated anaerobically, is used as an estimate of the "fraction of BOD that will ultimately degrade anaerobically". By doing so, it is assumed that all of the sludge treated anaerobically is treated 100% anaerobically and, therefore, no weighted MCF is calculated (cf. Thomsen & Lyck, 2005). The percentage of sludge that is treated anaerobically and the calculated emission factor for every year (where MCF data is available) is given in Table 8.17.

Table 8.17 Emission factors (EFs) calculated as the maximum CH_4 producing capacity multiplied by MCF.

Year*		1997	1999	2000	2001	2002
Stabilisation methods	Units	Sludge amounts				
Biological/Anaerobic	tonnes ww	363055	336654	459600	494655	262855
Biological/Aerobic		648686	829349	1110746	1217135	827703
Chemical		149028	271949	321427	330229	279911
Total		1160769	1437952	1891773	2042019	1370469
Anaerobic	percent	31	23	24	24	19
Aerobic		56	58	59	60	60
Chemical		13	19	17	16	20
MCF		0.31	0.23	0.24	0.24	0.19
EF	kg CH4 /kg BOD	0.19	0.14	0.15	0.15	0.12

*The Danish EPA has not yet released Data for 2003 and 2004.

The average fraction of sludge treated anaerobically is considered fairly constant, based on the available data. Furthermore, the average fraction of industrial influent load has reached a constant level from the year 1999 and forward (Annex 3.E, Table 3.E.3). This, in addition to the intensive technological upgrading of the Danish WWTPs from 1987 to 1996, is indicative of an optimised and stabilised situation regarding wastewater treatment processes. It seems reasonable to assume a constant emission factor of 0.15 kg CH_4 / kg BOD based on the wet weight (ww) fraction of sludge treated anaerobic.

To arrive at the net emission of methane from the Danish WWTPs, the recovered, flared or otherwise not emitted methane potential needs to be quantified.

Available activity data and the EF for calculating the recovered and flared CH_4 potential (theoretical negative methane emission) is given in Table 8.18.

Table 8.18 Sludge in percent of the total amount of sludge and tonnes dry weights (dw) according to disposal categories of relevance to CH_4 recovery.

Unit	Year**	Combustion internal	Combustion external	Biogas	Other*
percent	1987		24.6		18.5
	1997	15.5	6.2	1.5	0.8
	1999	7.4	14.8	1.9	9.1
	2000	15.0	9.2	1.6	14.4
	2001	14.8	6.3	1.0	11.3
	2002	11.4	4.4	0.9	10.0
total tonnes dw	1987	23330	11665		7667
	1997	23500	9340	2338	1211
	1999	23008	9845	2972	14140
	2000	11734	23591	*2476*	22856
	2001	23653	14532	1588	17883
	2002	15932	6120	1262	13989

*The category “Other” represents sludge which is combusted in cement furnaces and is used in further combusting processes for the production of sandblasting products.
**The Danish EPA has not yet released Data for 2003 and 2004.

The IPCC GPG background paper (2003) estimates the maximum methane producing capacity to be 200 kg CH_4/tonnes raw dry solids, which is also the emission factor (EF), as the methane conversion factor (MCF) is equal to unity for biogas process (EF= B_o * MCF). The fraction of the gross CH_4 emission, not emitted in reality, is then the dry weight of the biogas category multiplied by an EF of 200 kg CH_4/tonnes raw dry solids. For comparison, the biogas yield, i.e. EF, is given to be within 250 to 350 m^3/tonnes organic solids for sewage sludge in a report on biogas systems by IEA Bioenergy (Braun and Wellinger, 2003). The density of methane gas is 0.715 kg/m^3 at standard conditions, which gives an average EF of 214.5 kg CH_4/tonnes raw dry solids. The same EF is used for calculating the theoretical methane potential not emitted by the remaining disposal categories given in Table 8.18.

As seen from Table 8.18, there are gaps in the data on the annual amounts of final disposal categories. See Annex 3.E for details concerning data gap filling.

8.3.2.2 Methodological issues related to the estimation of N_2O emissions

While CH_4 is only produced under anaerobic conditions, N_2O may be generated by nitrification (aerobic processes) and denitrification (anaerobic processes) during biological treatment. Starting material in the influent may be urea, ammonia and proteins, which are converted to nitrate by nitrification. Denitrification is an anaerobic biological conversion of nitrate into dinitrogen. N_2O is an intermediate of both processes. Danish investigation indicates that N_2O is formed during aeration steps in the sludge treatments process as well as during anaerobic treatments; the former contributing most to the N_2O emissions during sludge treatment (Gejlsberg et al., 1999).

Methodology - Direct N_2O emission

A methodology for estimating the direct emission of N_2O from wastewater treatment processes has been derived. The EF is derived from a factor of 3.2 g N_2O/capita per year (Czepiel, 1995) multiplied by a correction factor of 3.52 to account for the industrial influent load. The average resulting emission factor for direct emission of N_2O is (3.52*3.2) 11.3 g N_2O/capita per year.

The correction factor of 3.52 is derived from the difference in average nitrogen influent load at large and medium-sized WWTPs, divided by the influent load at large-size WWTPs (cf. Annex 3.E, Table 3.E.10). This approach is based on the assumption that the large-size WWTPs receive industrial wastewater while the medium size operators mainly receive wastewater from households (cf. Annex 3.E, Background).

Until better data is available, simple regression of the relation between industrial influent load in percent and the EF is used for the years 1990 to 1997, after which the industrial contribution to the influent load is assumed constant and the EF of 11.3 g N_2O/capita per year is used in the calculations. The influent load of nitrogen is assumed to increase in a similar way to the industrial influent loads of BOD given in percent in Table 8.19. The estimated Danish emission factors, as a function of the increase in industrial influent load in the Danish WWTPs, are given in Table 8.19.

The direct emission from wastewater treatment processes is calculated according to the equation:

$$E_{N_2O,WWTP,direct} = N_{pop} \cdot F_{connected} \cdot EF_{N_2O,WWTP,direct}$$

where N_{pop} is the Danish population, $F_{connected}$ is the fraction of the Danish population connected to the municipal sewer system (0.9) and $EF_{N2O.WWTP.direct}$ are the emission factors given in Table 8.17.

Methodology – Indirect emissions - from sewage effluents

The IPCC default methodology only includes N_2O emissions from human sewage based on annual per capita protein intake. The methodology only accounts for nitrogen intake, i.e. faeces and urine. Not included are industrial nitrogen input and non-consumption protein from kitchen, bath and laundry discharges. The default methodology used for the 10% of the Danish population that is not connected to the municipal sewage system, is multiplied by a factor 1.75 to account for the fraction of non-consumption nitrogen (Sheehle and Doorn, 1997). For the remaining 90% of the Danish population, national activity data on nitrogen in discharge wastewater is available. This data is used in combination with the default methodology for the 10% of the Danish population not connected to the municipal sewer system. 10% is added to the effluent N load to account for the WWTPs not included in the statistics (DEPA 1994, 1996, 1997, 1998, 1999, 2001, 2002 and 2003). The formula used for calculating the emission from effluent WWTP discharges is:

$$E_{N_2O,WWTP,effluent} = [(P \cdot F_N \cdot N_{pop} \cdot F_{nc} \cdot F) + (D_{N,WWTP} + (D_{N,WWTP} \cdot 0.1))] \cdot EF_{N_2O,WWTP,effluent} \cdot \frac{M_{N_2O}}{2 \cdot M_N}$$

where

P is the annual protein per capita consumption per person per year.

F_N is the fraction of nitrogen in protein. i.e. 0.16 IPCC GL, p 6.28

N_{pop} is the Danish population

F_{nc} is the fraction of the Danish population not connected to the municipal sewer system, i.e. 0.1

F is the fraction of non-consumption protein in domestic wastewater. i.e. 1.75 (Sheehle and Doorn, 1997)

$D_{N.WWTP}$ is the effluent discharged sewage nitrogen load (with 10% added to account for data not included in the statistics)

$EF_{N2O.WWTP.effluent}$ is the IPCC default emission factor of 0.01 kg N_2O-N/kg sewage-N produced (IPCC GL, p 6.28)

M_{N2O} and M_{N2O} are the mass ratio i.e. 44/28 to convert the discharged units in mass of total N to emissions in mass N_2O

8.3.2.3 Activity data and emission factors

Activity data and EF for calculating the direct N_2O emission

Table 8.19 EF and activity data used for calculating the direct emission of N_2O from wastewater treatment processes at Danish WWTPs.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
N-pop (1000)	5140	5153	5170	5188	5208	5228	5248	5268	5287	5305	5322	5338	5351	5383	5397
F-connected	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0,9
% industrial load	2.5	2.5	2.5	5.0	13.6	22.2	30.8	39.4	48.0	41.0	42.0	38.0	38.0	37.0	40.5
Danish EF*	3,8	3,8	3,8	4,2	6,2	7,8	9,4	11,0	11,7	12,0	11,5	10,0	10,4	11,3	10,8

The industrial loads of wastewater influent loads given in Table 8.19 for years 1990-2003 have been estimated from the original and registered data (Table 3.E.3, Annex 3.E). For the years 1990 to 1992, the industrial influent load is set to an average of 2.5%. From the years 1993 to 1997, the percentages are assumed to continue to increase as shown in Table 8.19. The Danish emission factors are based on a regression of percent industrial loads versus the corrected emission factors given in Table 3.E.10 in Annex 3.E. The average fraction of industrial nitrogen influent is considered constant from the year 1999 and forward. This is consistent with a fairly constant fraction of industrial wastewater influent from 1999 and forward.

Activity data used for calculation of the indirect N_2O emission

In Table 8.20, activity data refers to $D_{N,\ WWTP}$, the effluent discharged nitrogen load.

Table 8.20 Discharges* of nitrogen from point sources [tonnes].

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Separate industrial discharges				2574	2737	2471	1729	1800	1428	863	897	812	752	509	469
Rainwater conditioned effluent		921	882	1025	1207	867	629	800	968	975	762	758	1005	685	827
Scattered houses				1280	1210	1141	1143	1123	997	972	979	1005	968	957	931
Mariculture and fish farming				1737	1684	1735	1543	1494	1241	1418	2714	1757	1487	1162	1335
Municipal and private WWTPs	16884	15111	13071	10787	10241	8938	6387	4851	5162	5135	4653	4221	4528	3614	4027

*It should be mentioned that it is not possible to estimate any direct emissions from industrial on-site wastewater treatment processes.

8.3.3 Uncertainties and time-series consistency

The parameters considered in the uncertainty analyses and the estimated uncertainties of the parameters are shown in Table 8.21. For all uncertainties, symmetric values based on maximum numeric value are estimated (cf. e.g. Section 8.2.3.1 of this chapter).

Table 8.21 Uncertainties for main parameters of emissions for wastewater handling.

Parameter	Uncertainty	Reference / Note	Emission type
TOW	±20%	Default IPCC value (GPG, Table 5.3, p 5.19); maximum uncertainty in the country-specific data is 28%	Gross CH_4 emission
Maximum methane producing Capacity (Bo)	±30%	Default IPCC value (GPG, Table 5.3, p 5.19)	
Fraction treated anaerobically, i.e. the methane conversion factor (MCF)	±28%	Based on the variation in registered data given in Annex 3.E , Table 3E.7	
Methane potential	±50%	Estimated based on IPCC background paper (2003)	Not emitted CH_4
Final disposal category data	±30%	Estimated to be equal to the uncertainty in influent loads of organic matter	
EFN_2O,direct	±30%	Calculated from average and standard deviation on data from Table 8.13, the uncertainty is around 10%. Due to uncertainty in the industrial influent load I, (cf. Annex 3.E, eq.1), the uncertainty at this point is set to 30%	Direct N_2O emission
Fconnected	±5%	Set equal to uncertainty on population number	
N_{pop} is the Danish population number	±5%	Default from IPCC GPG	
P is the annual protein per capita consumption per person per year	±30%	Not known / NERI estimate	Indirect N_2O emission
F_N is the fraction of nitrogen in protein	0%	Empirical number without uncertainty	
N_{pop} is the Danish population number	±5%	Default from IPCC GPG	
F_{nc} is the fraction of the Danish population not connected to the municipal sewer system	±5%	Set equal to uncertainty on population	
F is the fraction of non-consumption protein in domestic wastewater	±30%	Not known / NERI estimate	
$D_{N.WWTP}$ is the effluent discharged sewage nitrogen load	±30%	Not known / NERI estimate	
$EF_{N2O.WWTP.effluent}$ is the IPCC default emission factor of 0.01 kg N_2O-N/kg sewage-N produced	±30%	Not known / NERI estimate	
M_{N2O}	0%	Empirical number without uncertainty	

At this point, data regarding industrial on-site wastewater treatment processes is not available at a level that allows for calculation of the on-site industrial contribution to CH_4 or N_2O emissions. The degree to which industry is covered by the estimated emission is, therefore, dependent on the amount of industrial wastewater connected to the municipal sewer system. Any emissions from pre-treatment on-site are not covered at this stage of the method development.

The overall uncertainty on the emissions from uncertainty estimates in Table 8.21, and with the use of GPG Equation 6.3 and 6.4, is as follows:

<u>*Methane:*</u>

Uncertainty in estimating the gross emission of CH_4, U_{gross}:

U_{gross} = SQRT(28^2+20^2+30^2) = 46.7%

Uncertainty in estimating the recovered or not emitted CH_4, $U_{not\ emitted}$ is estimated to be equal for all four categories at this stage:

$U_{not\ emitted}$ = SQRT(30^2+50^2) = 58.3%

The total uncertainty, U_{total}, associated with CH_4 emission estimates is estimated to be around 40%, using Equation 6.3 (IPCC GPG, page. 6.12) and uncertainty quantities (x_i in eq. 6.3, IPCC GPG) set equal to the yearly average fraction treated anaerobically or by final sludge categories leading to a reduction in the gross emission.

<u>*Nitrous oxide:*</u>

Uncertainty estimates for the direct N_2O emission, U_{direct}:

U_{direct} = SQRT(30^2+5^2+5^2) = 30.8%

Uncertainty in the indirect N_2O emission, $U_{indirect}$, has been calculated as the uncertainty in the emission from the population connected and not connected to a WWTP, respectively, by use of Eq. 6.3 in the IPCC GPG.

The uncertainty associated with the emission of N_2O based on the proportion of the population not connected to a WWTP:

$U_{not\ connected}$ = SQRT(30^2+5^2+5^2+30^2+30^2) = 52.4%

The uncertainty in the emission from wastewater based on the proportion of the population connected to a WWTP:

$U_{connected}$ = SQRT(30^2+30^2) = 42.4%

The resulting total uncertainty in the N_2O emission is estimated to be in the region of 26% at this stage. The total uncertainty has been estimated based on uncertainty quantities equal to the fraction of the population connected and not connected to a WWTP, respectively. These fractions were multiplied by the average effluent N from households and WWTPs including industrial wastewater treatment, respectively (cf. Annex 3E, Table 3E.11 and Thomsen & Lyck, 2005).

When the uncertainty quantities are set equal to the fraction connected and not connected, the total uncertainty estimate is 25% (Eq. 6.3, IPCC GPG).

8.3.4 QA/QC and verification

This section has not been updated according to the newly implemented QA/QC procedure (cf. Section 1.6).

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.

A Quality Check has been performed according to the general procedure (Tier 1) described in Section 1.6.1. The time-series of the CRF and SNAP source categories, as they are found in the CORINAIR databases, have been checked and were in agreement. The total emissions when aggregated to CRF source categories are in agreement with the totals based on SNAP source categories.

<u>*Methane emissions*</u>

1. Comparison of country-specific TOW data with the default European method for calculating TOW given in IPCC (1996) for Europe.

The TOW that is derived from the default European method increased by a fraction corresponding to the Danish reported industrial contribution to the influent BOD. The industrial contribution to influent wastewater BOD is reported based on units of PE, and the result of the comparison indicates that the industrial influent load may be underestimated (cf. Annex 3.E).

In general, country-specific TOW values are comparable to the TOW data calculated by the default method when adjusted for industrial contribution, the uncertainty levels taken into account.

2. Comparison of country-specific gross emission of methane with the checking method and the default IPCC method (cf. Annex 3.E)

The IPCC GPG provides a checking method for calculating the CH_4 emission from domestic wastewater. The check method is based on default values (GPG, Box 5.1), where the only input parameter is the population of the country. The result of the checking method is used as reference for the two other methods for the purpose of quality assurance and validity assistance. Results are given in Table 8.22.

Table 8.22 Annual CH_4 emissions based on the checking method and the country-specific method for CH_4 gross emissions.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Population (1000)	5140	5153	5170	5188	5208	5228	5248	5268	5287	5305	5322	5338	5351	5383
CH_4 emissions (Gg) Check method	27.0	27.1	27.2	27.3	27.4	27.5	27.6	27.7	27.8	27.9	28.0	28.1	28.1	28.3
CH_4 emissions (Gg) Country-specific	18.0	18.3	18.7	19.0	19.3	19.6	20.0	20.3	20.6	20.9	21.2	21.6	21.9	22.9

According to Table 8.20, the gross emission ranges from approximately 27 to 28 Gg per year. The default fraction of organic matter that degrades anaerobically is too high, i.e. 0.8, whereas 0.2-0.4 is more realistic according to national data (cf. Table 8.18). On the other hand, the checking method does not account for the industry influent load that reached 42% in 2003. The two above aspects influence the size of the emission in opposite directions, which results in the highest similarity to last year's country-specific emission level (cf. Annex 3).

Overall the check method is a good way of verifying the correctness of the units, activity data and EF used in the country-specific calculations.

Nitrous oxide emissions

These calculations are more or less straightforward as the emission estimated is based on standard data on population, protein intake and default or constant emission factors not influenced by changed in the characteristics of the activity data. There is no checking method provided by the IPCC.

The methodology for calculating the direct emission should be further evaluated when more data becomes available.

For details regarding source-specific QA/QC and verification, see Annex 3.E.

8.3.5 Recalculations

The emissions from wastewater handling were until the 2005 submission reported as zero. So, the methodology used for the CRF Source Category 6B for CH_4 and N_2O emissions is included for the second time in this submission. Smaller revisions as compared to the 2005 submission have been performed.

8.3.6 Planned improvements

Consideration will be given to uncertainty analysis by way of the Monte Carlo analysis.

In the review report on the 2005 submission, the expert review team encouraged Denmark to estimate the domestic and the industrial wastewater contributions separately. This suggestion has been considered. National Statistics reports total TOC for industrial and household wastewater only. Separation of domestic and industrial wastewater could, however, be carried out for the purposes of comparison, by simply separating out the total TOC inlet input and emissions proportional to the percentage contribution to the wastewater influent load from industry. This way of separation will be implemented for 2007 submissions.

Furthermore, the expert review team encouraged Denmark to make revisions to the reporting of N2O emissions from human sewage and wastewater effluent. For 2007 submissions, the N2O emissions from human sewage will be reported in 6.B.3 and the emission from wastewater effluent N load will be reported in Domestic and Commercial wastewater, as suggested.

8.3.7 References

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8.4 Waste Incineration (CRF Source Category 6C)

8.4.1 Source category description

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

The amounts of waste incinerated are given in the CRF-Table 6A,C.

As regards further information on waste incineration, see the Energy sector in this report.

8.5 Waste Other (CRF Source Category 6D)

8.5.1 Source category description

Emissions from the combustion of biogas in biogas production plants is included in CRF sector 6D. The fuel consumption rate of the biogas production plants refers to the Danish energy statistics. The applied emission factors are the same as for biogas boilers (see NIR Chapter 3, Energy).

9 Other (CRF sector 7)

In CRF Sector 7, there are no activities and emissions for the inventories of Denmark. For the inventories of the Kingdom of Denmark (Denmark, Faroe Islands and Greenland) emissions for Faroe Islands and Greenland are in Sector 7.

See Annex 6.1 and 6.2.

10 Recalculations and improvements

10.1 Explanations and justifications for recalculations

Explanations and justifications for the recalculations performed for this submission and since submission of data in the CRF-format for submission to UNFCCC due April 15, 2005 (data as sent to EU March 13, 2005) are given in the following sector chapters:

Energy:	
• Stationary Combustion	Chapter 3.2.5
• Transport	Chapter 3.3.5
• Fugitive emissions	Chapter 3.5.5
Industry	
• Mineral Products	Chapter 4.2.5
• Chemical industry	Chapter 4.3.4
• Metal Production	Chapter 4.4.4 (no recalc.)
• Consumption of F-gases	Chapter 4.6.5 (no recalc.)
Solvents and Other Product Use	Chapter 5.2.5
Agriculture	Chapter 6.8
LULUCF	Chapter 7.10
Waste	
• Solid Waste Disposal on Land	Chapter 8.2.5
• Wastewater	Chapter 8.3.6

Energy

Stationary Combustion

For stationary combustion plants, the emission estimates have been updated according to latest energy statistics published by the Danish Energy Authority. The update includes the years 1990-2003. This is the main reason for the changes in this sector. However, changed fuel type aggregation also caused imperceptible changes.

The N_2O emission factor for Coal combusted in large power plants has been changed for 1990-2003.

Mobile sources

Road transport
A revision of the 1985-2003 time-series of emissions has been made based on revised fleet and mileage data from the Danish Road Directorate and corrections of road transport gasoline fuel use according to a new gasoline fuel use estimate for non-road machinery.

Military
A revision of the 1985-2003 time-series of emission factors has been made based on new aggregated emission factors from road transport. Corrections of aviation gasoline fuel use and emissions have been made for 1994.

Fishery
A complete revision of the 1985-2003 time-series of diesel fuel use and emissions has been made using changed amounts of diesel fuel use for small boats (inland waterways), which are subtracted from the Danish energy statistics diesel fuel-use sum for fishery. The latter diesel fuel results are from a specifically Danish non-road research project.

Aviation
Small changes of 2001-2002 fuel use and emissions have been made for large aircraft, based on changes in representative aircraft groupings. For 2003, an error in jet fuel use has been corrected, thus influencing the total emission figures. For 2002 and 2003, errors in aviation gasoline fuel use have been corrected, thus influencing the total emission figures.

Inland waterways/agriculture/forestry/household gardening
A complete revision of the 1985-2003 time-series of fuel use and emissions has been made using results from a specifically Danish non-road research project.

Industry
Emissions of CO_2 from production of mineral wool and expanded clay products, refining of sugar, flue gas cleaning (wet process) in relation to waste incineration, combined heat and power plants and power plants have been included. The indirect emission of CO_2 and the emission of NMVOC from asphalt roofing and road paving with asphalt have also been included. Company-specific activity data for consumption of carbonate-containing raw materials and emissions of CO_2 from this has been introduced. The recalculations are for the years 1990-2003.

Solvent
A survey based on new methodologies results in new NMVOC emission estimates. The changes are mainly caused by new information on the amounts of propane and butane used as propellants.

Agriculture
Small changes for emissions from the agricultural sector have taken place. This change reflects an increased emission from 1990-2003 by 0 –2%. There is no change in the calculation methodology.

Changes in the CH_4 emission is due to a recalculation of the emission factor for cattle. Recent research shows that the principal feeding stuff used (sugar beets) result in a higher methane conversion rate than the default values.

Due to changes in the methodology of calculating the emission from organic soils in the LULUCF sector, the N_2O emission in the agricultural sector from histosols has been recalculated.

Waste
The emission estimates methodology for wastewater handling was introduced in the submission March-April 2005 for the first time. Data in this methodology has been updated and revised in the inventories for this submission.

LULUCF

Cropland, grassland and wetlands
Mineral soils are, for the first time, incorporated in the inventory. The emission calculation is based on a 3-pooled dynamic model (C-TOOL) taking into account annual yield levels and annual differences in temperatures. C-TOOL is based on numerous input variables and gives a highly variable emission between years. The output should be seen as the absolute best estimate of the actual emission. In C-TOOL soils having an OM content between 10 and 20% (previously recorded as organic soils) are treated as a special type of mineral soil having a high OM content. The emission from this soil type is estimated by C-TOOL at a slightly lower emission than the emission from high OM soils.

In the inventories submitted March-April 2005, organic soils were defined according to the Danish soil classification as having more than 10% organic matter (OM). In the inventories for this submission, the area with organic soils is reduced to soils having more than 20% OM, according to the GPG guidelines, and consequently the emissions from organic soils are reduced. As a consequence of the changed size of area with organic soils, the N_2O emission from organic soils in the agricultural section been recalculated. Refer to the above.

10.2 Implications for emission levels

The recalculation tables of the CRF tables produced by Denmark for the first time with the new CRF software are not descriptive with regard to the recalculations made since the April 2005 submission. The reason for this is that the inclusion of the 2005 submission into the new software (which has been carried out by the UNFCCC Secretariat and cannot be changed by the parties) has some errors and has been carried out for the Kingdom of Denmark (Denmark inclusive Greenland and the Faroe Islands), which is submitted in a parallel submission to the inventories for Denmark. Only the inventories for Denmark have, until now, been analysed in detail as regards recalculation. Therefore, comparisons have been carried out in this chapter, comparing the 2005 submission in the "old" CRF format with the present submission in the "new" CRF format. Such a comparison also includes the differences arising from the differences between the two formats which affect emissions. For Denmark, this is the case for the sector "Solvents", where NMVOC emissions from the category C, *Chemical Products, Manufacture and Processing*, are now accounted for in CO_2 emissions also, and for the sector "Agriculture", where the Category *Fur Farming* can now be registered under CH_4 emissions from Manure Management. The analyses made with regard to recalculations for this chapter are shown in Tables 10.1 and 10.2.

Table 10.1 shows that for the **National Total CO_2 Equivalent Emissions without Land-Use Change and Forestry**, the general implication of the improvements and recalculations performed is small and the changes for the whole time-series are between -0.89 (year 1994) and 0.08% (2003), corresponding to -711.41 and 56.28 Gg CO_2-equiv., respectively.

Table 10.1. Recalculation performed in the year 2006 for inventories 1990-2003 compared with the submission of April 15, 2005.

			Total CO2 Equivalent Emissions with Land-Use Change and Forestry	Total CO2 Equivalent Emissions without Land-Use Change and Forestry
1990	Previous submission	CO2	69.486,51	69.328,22
	Latest submission	equivalent	69.593,96	69.042,31
	Difference	(Gg)	107,45	-285,91
		(%)	0,15	-0,41
1991	Previous submission	CO2	79.879,12	79.991,87
	Latest submission	equivalent	77.931,25	79.618,18
	Difference	(Gg)	-1.947,87	-373,70
		(%)	-2,44	-0,47
1992	Previous submission	CO2	73.538,97	73.791,36
	Latest submission	equivalent	71.888,63	73.435,05
	Difference	(Gg)	-1.650,34	-356,31
		(%)	-2,24	-0,48
1993	Previous submission	CO2	75.706,85	76.173,08
	Latest submission	equivalent	74.456,75	75.610,76
	Difference	(Gg)	-1.250,10	-562,32
		(%)	-1,65	-0,74
1994	Previous submission	CO2	79.375,88	79.706,14
	Latest submission	equivalent	77.381,69	78.994,73
	Difference	(Gg)	-1.994,19	-711,41
		(%)	-2,51	-0,89
1995	Previous submission	CO2	76.465,54	76.699,99
	Latest submission	equivalent	74.650,08	76.314,45
	Difference	(Gg)	-1.815,46	-385,54
		(%)	-2,37	-0,50
1996	Previous submission	CO2	89.610,16	90.032,61
	Latest submission	equivalent	88.428,56	89.640,02
	Difference	(Gg)	-1.181,60	-392,59
		(%)	-1,32	-0,44

Table 10.1. Cont.

			Total CO2 Equivalent Emissions with Land-Use Change and Forestry	Total CO2 Equivalent Emissions without Land-Use Change and Forestry
1997	Previous submission	CO2	79.830,05	80.272,92
	Latest submission	equivalent	78.784,10	79.956,55
	Difference	(Gg)	-1.045,95	-316,37
		(%)	-1,31	-0,39
1998	Previous submission	CO2	75.260,30	76.079,36
	Latest submission	equivalent	73.988,85	75.935,30
	Difference	(Gg)	-1.271,45	-144,07
		(%)	-1,69	-0,19
1999	Previous submission	CO2	72.029,87	72.900,07
	Latest submission	equivalent	71.534,43	72.755,69
	Difference	(Gg)	-495,44	-144,38
		(%)	-0,69	-0,20
2000	Previous submission	CO2	70.095,31	68.313,78
	Latest submission	equivalent	69.819,06	68.177,05
	Difference	(Gg)	-276,26	-136,73
		(%)	-0,39	-0,20
2001	Previous submission	CO2	68.566,08	69.724,02
	Latest submission	equivalent	68.935,92	69.692,80
	Difference	(Gg)	369,84	-31,22
		(%)	0,54	-0,04
2002	Previous submission	CO2	67.520,61	68.996,35
	Latest submission	equivalent	66.945,35	68.910,46
	Difference	(Gg)	-575,26	-85,89
		(%)	-0,85	-0,12
2003	Previous submission	CO2	72.803,53	74.007,81
	Latest submission	equivalent	72.123,65	74.064,09
	Difference	(Gg)	-679,88	56,28
		(%)	-0,93	0,08

For the **National Total CO_2 Equivalent Emissions with Land-Use Change and Forestry**, the general impact of the **recalculations** is rather small, although the impact is greater than without LULUCF, due to recalculations in the LULUCF Sector. The differences vary between -2.51% (1994) and +0.54% (2001), corresponding to -1994.19 and 369.84 Gg CO_2-equiv., respectively. These differences refer to recalculated estimates with major changes in the forestry sector for those years.

A further analysis of the contributing sources and sectors to the recalculations is carried out in the next section and Table 10.2.

10.3 Implications for emission trends, including time series consistency

It is a high general priority in the considerations leading to recalculations back to 1990 to have and preserve the consistency of the activity data and emissions time-series. As a consequence, activity data, emission factors and methodologies are carefully chosen to represent the emissions for the time-series correctly. Often, considerations regarding the consistency of the time-series have led to recalculations for single years when activity data and/or emission factors have been changed or corrected. Furthermore, when new sources are considered, activity data and emissions are introduced to the inventories for the whole time-series, based as far as possible on the same methodology.

In Section 10.2, it was mentioned 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 are between -0.89 and 0.08%. However, it should be noted that the small changes in the national total are an aggregated result of several 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 Table 10.2, below, where differences due to recalculations are given in Gg CO_2-equivalents. Memo items are not shown. The table is based on the CRF source categories where recalculations have been performed. Also, the differences on the level of the national total with and without LULUCF are shown – data which are also in Table 10.1. I.e. in Table 10.2, the contributions from the source categories to the total national result with regard to recalculation differences can be directly considered in absolute CO_2-equivalents. The table is based on data extracted from the tables in CRF-tables. In the following, when going through the table, remarks are made on the most important recalculations only; reference is made to the sector chapters (references given in Chapter 10.1).

For the *National Total CO_2 Equivalent Emissions without Land-Use Change and Forestry*, the sum of recalculations for all years is negative except for 2003.

From Table 10.2, it can be seen that, in general terms, the largest contributors to this "negative" recalculation are CO_2 from Energy, Transport, and CO_2 from Solvents, CH_4 from Energy, Fugitive emissions from Solid Fuel, and N_2O from Energy, Energy Industries. These recalculations are to an extent counteracted by the "positive" recalculations, mainly on CO_2 from Energy, Manufacturing Industries and Construction, and CO_2 from Industrial Processes, Mineral Products.

Table 10.2 Recalculation performed year 2006 for years 1990-2003. Differences (Gg CO_2-eqv) between 2006 submission and the April 2005 submission. Memo items are not shown. Activities with no emissions and with no changes are not shown.

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
GREENHOUSE GAS SOURCE AND SINK		**CO_2**	**CO_2**	**CO_2**	**CO_2**	**CO_2**	**CO_2**	**CO_2**	**CO_2**	**CO_2**	**CO_2**	**CO_2**	**CO_2**	**CO_2**	**CO_2**
Total National Emissions and Removals		**219,2**	**-1738,4**	**-1447,1**	**-994,7**	**-1703,1**	**-1589,4**	**-857,6**	**-790,4**	**-1133,9**	**-342,1**	**-145,6**	**455,5**	**-514,9**	**-610,7**
1. Energy		**-28,1**	**-30,5**	**-32,3**	**-203,9**	**-352,3**	**-112,1**	**-38,2**	**-34,7**	**-40,2**	**-32,9**	**-24,4**	**-32,4**	**-78,5**	**137,0**
1.A.	Fuel Combustion Activities	-28,1	-30,5	-32,3	-203,9	-352,3	-112,1	-38,2	-34,7	-40,2	-32,9	-24,4	-32,4	-78,5	137,0
1.A.1.	Energy Industries	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,6	0,0	0,0	0,0
1.A.2.	Manufacturing Industries and Construction	47,1	48,1	175,6	145,7	108,3	84,5	124,4	113,7	144,1	146,6	160,0	214,4	141,7	293,5
1.A.3.	Transport	-105,5	-105,5	-106,3	-276,7	-430,8	-184,8	-121,8	-118,9	-125,1	-119,4	-113,5	-150,5	-148,7	-180,8
1.A.4.	Other Sectors	30,3	26,8	-101,5	-72,9	-30,3	-11,8	-40,9	-29,5	-59,1	-60,2	-71,5	-96,3	-71,4	24,3
2. Industrial Processes		**33,9**	**36,1**	**38,8**	**46,5**	**71,2**	**71,4**	**107,4**	**108,7**	**106,7**	**114,6**	**107,6**	**102,0**	**95,3**	**83,8**
2.A.	Mineral Products	34,9	37,1	39,8	47,4	72,1	72,4	107,7	109,7	107,6	115,8	109,6	104,3	97,9	85,4
2.B.	Chemical Industry	-0,9	-0,9	-0,9	-0,9	-0,9	-0,9	-0,3	-1,0	-0,9	-1,2	-2,0	-2,3	-2,6	-1,6
3. Solvent and Other Product Use		**-180,0**	**-169,8**	**-159,6**	**-149,5**	**-139,3**	**-119,2**	**-138,1**	**-135,2**	**-76,0**	**-76,4**	**-92,6**	**-17,5**	**-44,9**	**-98,3**
5. Land-Use Change and Forestry (net)		**393,4**	**-1574,2**	**-1294,0**	**-687,8**	**-1282,8**	**-1429,9**	**-789,0**	**-729,6**	**-1127,4**	**-351,1**	**-139,5**	**401,1**	**-489,4**	**-736,2**
GREENHOUSE GAS SOURCE AND SINK		**CH4**	**CH4**	**CH4**	**CH4**	**CH4**	**CH4**	**CH4**	**CH4**	**CH4**	**CH4**	**CH4**	**CH4**	**CH4**	**CH4**
Total National Emissions and Removals		**8,1**	**-29,7**	**-59,3**	**-99,2**	**-112,4**	**-82,8**	**-118,2**	**-108,2**	**-26,5**	**-60,7**	**-61,0**	**-2,6**	**30,6**	**92,8**
1. Energy		**-75,4**	**-86,6**	**-84,8**	**-105,7**	**-123,1**	**-135,9**	**-136,1**	**-140,4**	**-72,8**	**-74,3**	**-67,6**	**-71,5**	**-64,3**	**-88,7**
1.A.	Fuel Combustion Activities	-4,3	-4,4	-4,1	-6,3	-7,8	-4,8	-3,8	-4,1	-1,0	-4,5	-4,9	-3,3	-3,3	3,6
1.A.1.	Energy Industries	0,0	0,0	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.A.2.	Manufacturing Industries and Construction	-1,6	-1,7	-1,7	-1,8	-1,8	-1,9	-1,9	-1,9	-1,9	-2,0	-2,0	-1,8	-3,8	-3,1
1.A.3.	Transport	-3,8	-3,7	-3,2	-5,2	-6,5	-3,4	-2,3	-2,6	0,7	-2,8	-3,2	-3,9	-4,0	-4,6
1.A.4.	Other Sectors	1,2	1,0	0,8	0,7	0,6	0,5	0,4	0,4	0,3	0,3	0,3	2,4	4,5	11,4
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	0,0	0,0
1.B.	Fugitive Emissions from Fuels	-71,1	-82,1	-80,7	-99,4	-115,3	-131,1	-132,4	-136,3	-71,8	-69,8	-62,8	-68,2	-61,0	-92,3
1.B.1.	Solid fuel	-72,4	-83,4	-82,0	-100,7	-117,8	-132,4	-133,6	-137,1	-72,9	-70,8	-63,8	-68,9	-62,3	-93,1
1.B.2.	Oil and Natural Gas	1,3	1,3	1,3	1,3	2,5	1,3	1,3	0,8	1,1	1,0	1,0	0,7	1,3	0,8
4. Agriculture		**157,8**	**138,4**	**112,7**	**91,9**	**75,9**	**98,0**	**42,3**	**35,9**	**29,0**	**11,1**	**6,9**	**66,7**	**87,0**	**115,6**
6. Waste		**-74,3**	**-81,5**	**-87,2**	**-85,4**	**-65,3**	**-44,9**	**-24,4**	**-3,6**	**17,3**	**2,5**	**-0,3**	**2,1**	**7,9**	**65,9**
6.A.	Solid Waste Disposal on Land	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	-24,9	10,5
6.B.	Wastewater Handling	-74,3	-81,5	-87,2	-85,4	-65,3	-44,9	-24,4	-3,6	17,3	2,5	-0,3	2,1	32,8	55,4
GREENHOUSE GAS SOURCE AND SINK		**N2O**	**N2O**	**N2O**	**N2O**	**N2O**	**N2O**	**N2O**	**N2O**	**N2O**	**N2O**	**N2O**	**N2O**	**N2O**	**N2O**
Total National Emissions and Removals		**-119,9**	**-179,8**	**-143,9**	**-156,2**	**-178,7**	**-143,2**	**-205,8**	**-147,4**	**-111,0**	**-92,6**	**-69,6**	**-83,0**	**-91,0**	**-162,0**
1. Energy		**-164,8**	**-225,3**	**-189,2**	**-202,7**	**-224,2**	**-183,3**	**-249,5**	**-185,5**	**-150,6**	**-129,2**	**-108,6**	**-123,1**	**-124,8**	**-168,7**
1.A.	Fuel Combustion Activities	-164,8	-225,3	-189,2	-202,7	-224,2	-183,3	-249,5	-185,5	-150,6	-129,2	-108,6	-123,1	-124,8	-168,7
1.A.1.	Energy Industries	-157,1	-217,3	-180,8	-190,9	-208,1	-173,0	-243,3	-178,3	-146,9	-126,1	-104,5	-111,8	-113,4	-156,9
1.A.2.	Manufacturing Industries and Construction	0,2	0,3	1,4	1,2	1,0	0,9	1,2	1,2	1,6	1,7	1,9	2,5	-1,2	0,3
1.A.3.	Transport	-6,4	-7,2	-7,3	-11,0	-15,2	-9,8	-5,7	-7,1	-3,5	-2,9	-4,1	-12,3	-8,1	-12,8
1.A.4.	Other Sectors	-1,5	-1,4	-2,6	-2,2	-2,0	-1,5	-1,9	-1,5	-1,9	-1,8	-2,0	-1,6	-2,0	0,6
1.A.5.	Other	0,0	0,3	0,2	0,1	0,1	0,3	0,1	0,2	0,2	0,0	0,0	0,1	0,0	0,0
4. Agriculture		**44,8**	**45,4**	**45,1**	**46,5**	**45,4**	**40,0**	**43,6**	**38,0**	**39,4**	**36,5**	**39,0**	**40,0**	**33,7**	**17,5**
5. Land-Use Change and Forestry (net)		**0,09**	**0,09**	**0,09**	**0,09**	**0,09**	**0,09**	**0,09**	**0,09**	**0,09**	**0,07**	**0,07**	**0,07**	**0,07**	**0,07**
6. Waste		**0,00**	**-0,01**	**-0,01**	**-0,01**	**-0,02**	**-0,03**	**0,01**	**0,02**	**0,03**	**0,03**	**0,03**	**0,03**	**0,05**	**-10,88**
6.B.	Wastewater Handling	0,00	-0,01	-0,01	-0,01	-0,02	-0,03	0,01	0,02	0,03	0,03	0,03	0,03	0,05	-10,90
Total CO2 equivalents emissions incl LULUCF		**107,4**	**-1947,9**	**-1650,3**	**-1250,1**	**-1994,2**	**-1815,4**	**-1181,6**	**-1045,9**	**-1271,4**	**-495,4**	**-276,2**	**369,9**	**-575,3**	**-679,9**
Total CO2 equivalents emissions excl LULUCF		**-285,9**	**-373,7**	**-356,3**	**-562,3**	**-711,4**	**-385,5**	**-392,6**	**-316,3**	**-144,0**	**-144,3**	**-136,7**	**-31,2**	**-85,9**	**56,3**

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

The review process following submission overseveral years, as well as the review reports, have been highly valuable for the improvements made and the recalculations performed. The final outcome of the most recent review process on the 2005 submissions is the review report available on:
http://unfccc.int/resource/docs/2006/arr/dnk.pdf

This review was a centralised review. The review team met 3-7 October, 2005. During this time, no questions were raised by the review team and no communication took place. The draft report was made available to us 5 January, 2006. Denmark responded by February 15 and written as well as other constructive communication with the review team took place until 21 February. The review report referred to above is dated 24 February, 2006.

The draft review report and the final report were made available to us rather late in the process of preparing the submissions for 2006, as regards data in CRF and documentation in the NIR. As a consequence, not all of the suggestions and comments made by the reviewers have been included in the present NIR or data submitted. However, the suggestions and comments have been taken onboard and progress will be made towards implementation of these in the 2007 submissions, but will have to await further consideration and work for future submissions.

For the response to the review report on the sector level, see the sector chapters of this NIR. Below, response is only made for cross-cutting and other selected items. Also, as regards further improvement on sector level, see the sector chapters of this NIR.

The response to the review team on cross-cutting topics is that a considerable effort has been made to improve QA/QC. For most sectors, a QA/QC procedure has been carried out describing, for each sector, the Points of Measurement in the QA/QC manual; refer to the sector sections in this NIR. For sectors or subsectors where this is not yet the case, so implementation of QA/QC procedures is planned. Furthermore, work is planned to take advantage of the experiences gained so far using the QA/QC manual and to discuss adjustments.

As regards institutional arrangements, formal agreements on the delivery of data have been signed for the largest part of the inventory. It is planned to arrange agreements for the remainder part.

In conclusion, considerations have been made of all of the review reports' suggestions, comments, recommendations and corrections. Certain improvements relating to the items pointed out by reviewers were able to be made to the inventories in a rather short timeframe. However, many of the suggestions regarded as important will require further work before implementation. The timeframe for considering and implementing suggestions with regard to the data and data improvements should be seen in light of the date for delivery to the European Commission for data in the CRF-format, i.e. January 15, 2006. Only the filling of gaps, etc. in data could be carried out before March 15, 2006.

Annexes to Denmark's NIR 1990 – 2004

Annex 1	Key Source Analyses
Annex 2	Detailed discussion of methodology and data for estimating CO_2 emission from fossil fuel combustion
Annex 3	Other detailed methodological descriptions for individual source or sink categories (where relevant) 3A Stationary combustion plants 3B Transport 3C Industry - no annexes to industry for 2004 3D Agriculture 3E Waste 3F Solvents
Annex 4	CO_2 reference approach and comparison with sectoral approach, and relevant information on the national energy balance
Annex 5	Assessment of completeness and (potential) sources and sinks of greenhouse gas emissions and removals excluded
Annex 6.1	Additional information to be considered as part of the NIR submission (where relevant) or other useful reference information
Annex 6.2	Additional information to be considered as part of the NIR submission (where relevant) or other useful reference information - Greenland/Faroe Islands
Annex 7	Tables 6.1 and 6.2 of the IPCC good practice guidance
Annex 8	Other annexes – (Any other relevant information)
Annex 9	Annual emission inventories 1990-2004 CRF tables for Denmark

Annex 1 Key source analyses

Description of the methodology used for identifying key sources

The key source analysis is carried out according to the IPCC Good Practice Guidance (GPG). 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 not adjusted for electricity import/export. The analysis was made for the inventory for the year 2004.

The present key source analysis follows the same approach as the analyses for the years 2000, 2001, 2002 and 2003 as presented in NIR 2002, 2003, 2004 and 2005 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 relative contribution 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 the list and of which the 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-equivalents, from the base year to the year under consideration. The trend of the source category is calculated relative to that of the national totals and the trend is then weighted with the contribution, according to the level assessment. The ranking is in descending order. As for the level assessment, the cut-off point for the sum of contribution to the trend is 95% and the source categories from the top of the list to the cut-off line are trend key sources.

The level of disaggregation

The starting point for the choice of source categories is presented in the GPG as Table 7.1. This table constitutes a suggested list of source categories for the key source analysis. It is mentioned in the GPG that categories for the key source analysis should be chosen in a way so that emissions from a single category are estimated with the same method and the same emission factor. Therefore, for categories in Table 7.1, which in our Corinair database are composed of activities with different emission factors or estimated with different methods, splits were made accordingly. It is in the energy sector, with its major emission contributions, that further splits are made as compared to 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 for year 2004 are as follows:

CO_2 emission factors, fossil	kg/GJ
COAL	95
COKE OVEN COKE	108
PETROLEUM COKE	92
PLASTIC WASTE	17.6
RESIDUAL OIL	78
GAS OIL	74
KEROSENE	72
ORIMULSION	80
NATURAL GAS	57.12
LPG	65
REFINERY GAS	56.9

For Energy and stationary, combustion categories in the key source analyses are composed according to the fuels mentioned. The split made in the analyses for year 2003 between brown coal and coke-oven coke is, in this analysis, not of importance since brown coal, according to the Energy Statistics, is not used in 2004.

For energy and mobile combustion, the basis for the source categories is the activities:

1 Mobile combustion	Civil aviation
2 Mobile combustion	Road transportation
3 Mobile combustion	Railways
4 Mobile combustion	Navigation
5 Mobile combustion	Military
6 Mobile combustion	National fishing
7 Mobile combustion	Agriculture
8 Mobile combustion	Forestry
9 Mobile combustion	Other mobile and machinery/industry
10 Mobile combustion	Household and gardening

The categories above, numbered 1 - 5, are directly found in the CRF-tables, while numbers 6 – 8 are found under CRF category 1.A.c., number 9 under 1.A.2.f and number 10 under 1.A.4.b. These categories have been chosen as source categories for the analysis due to differences in the use of fuels and fuel types and resulting differences in emission factors.

For the sectors Industry, Agriculture and Waste, the source categories in the key source analyses are activities found in the CRF source categorisation.

The selection of key source categorisation made for the key source analysis is well argued in relation to the intentions of the analysis in the GPG and the decision to keep the selection has been made in order not to lose the ability to make comparisons with the key source analysis performed for the years 2000, 2001, 2002 and 2003. Our choice of categories for the analysis identifies 71 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 analysis made for year 2003 (refer NIR 2005) with 67 categories, 5 additional categories have been identified and 1 was deleted. Three new categories appeared in the industrial sector: CO_2 emissions from limestone and dolomite use, CO_2 emissions from road paving with asphalt and CO_2 emissions from asphalt roofing. In the waste sector, two additional categories were identified as CO_2 from gasification of biogas and N_2O from gasification of biogas. Fugitive CH_4 emissions from solid fuels have, for the 2006 submissions of inventories, been removed.

The result of the key source analyses for Denmark for the year 2004

The entries in the results of the key source analyses in Table 1 and Table 2 for the years 1990 and 2004 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. Due to late implementation of the new CRF and the CRF software, these analyses are carried out on the basis of the old CRF used up until now in the process for 2006 submissions. However, since the submission of inventories linked to the submission of this report will be in the new CRF, some deviations from the data in this section representing the key-source analyses might occur. These deviations will be minor and of negligible importance to the results of the key source analyses. It is important to mention here that the minor deviations occur due to reasons other than the intended changes in the inventories.

The result of the key source level assessment for Denmark for 2004 is shown in Table 1. 21 key sources were identified and marked as shaded in the table. In 2003 and 2002, the number of key sources was also 21, in 2001 and 2000 the number was 20.

The result of the key source trend assessment for Denmark for 2004 is shown in Table 2. A number of 21 key sources (21 in 2003, 17 in 2002 and 2001and 16 in 2000) were identified and marked as shaded in the table. Note that according to the GPG, the analysis implies that contributions to the trend are all calculated as mathematically positive to be able to perform the ranking.

Following the reporting suggestion of the GPG, the key source analysis is summarised in Table 3. The information in this table is given in an order to allow **reference to the key source table** (Table 7) in the new 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 71 source categories chosen for this analysis, 24 are identified as key source categories either in the level or in the trend analysis or in both. In 2003, this number was 25 out of 67 categories and in 2002 25 out of 63 categories. In 2001 and 2000 out of 59 categories 23 and 22 were key sources, respectively. In the key source analysis for 2004, 18 key sources were key in both level and trend as was the case in 2003. In 2002 this number was 15, and 14 in both 2001 and 2000. In 2004, 3 sources were key sources for level only as for 2003 (7 in 2002 and 6 in 2001 and in 2000). In 2004, 3 sources were key in trend only compared with 4 in 2003 (3 in 2002, 3 in 2001 and 2 in 2000).

The **Energy Sector and CO_2 emission from Stationary Combustion** contribute with 6 key source categories in 2004 with respect to level and trend (also 6 in 2003, 7 in 2002, 7 in 2001 and 5 in 2000). These 6 key sources are, as in 2003, the major fuels coal, Petroleum Coke, Plastic Waste, Residual Oil, Gas Oil and Natural gas. For these key sources the trend in emission estimates, comparing 1990 and 2004, Coal, Residual Oil and Gas Oil are seen to decrease, while Plastic Waste and Petroleum Coke and especially Natural Gas increase. According to the key source level assessment Coal is the most contributing category in 2004 with 25.5% of the national total (Table 1). Also in 2003, 2002 and 2001, Coal was the most contributing category. This contribution was at a maximum in 2003 where it was 30.5%, compared with 2002 where it was 24.4% and where it had increased from 24.0% in 2001 and 23.0% in 2000. Natural gas is, in

2004 as in 2003, 2002 and in 2001, the third largest contributor with 16.4% (15.1% in 2003, 16.6% in 2002, 16.0% in 2001 and 15.5% in 2000). Gas Oil is, in 2004, the 6th largest contributor with 4.0% (in 2003 3.9%, in 2002 4.3%, in 2001 4.4% and in 2000 4.2%). The rest of the categories mentioned in this paragraph as level and trend key sources each contribute below 2.7% of the national total in 2004. Kerosene is still, as in 2003, a key source with regard only to trend, due to the falling emission estimate from 1990 to 2004. Refinery gas is, as in 2003, a key source according to level only and contributes, in 2004, with 1.3% with a slight increasing emission estimate from 1990 to 2004.

The **Energy Sector and CO_2 emission from Mobile Combustion** contributes with the category Road Transportation as a key source for level and trend with increasing emission estimates from year 1990 to 2004. This category is in year 2004, as in 2003, 2002, 2001 and in 2000, the second largest contributor to the national total among the categories in this analysis, with a level contribution of 17.7% in 2004 as compared to 16.0% in 2003, 16.6% in 2002, 16.2% in 2001 and 16.4% in 2000. The source CO_2 from Mobile Combustion Agriculture is in 2004, as in 2003, a key source with respect to both level and trend. For this source the trend in emission estimates from 1990 to 2004 is falling and the contribution to the national total in 2004 is 1.5%. The source CO_2 from Mobile Combustion National Fishing is in 2004 a key source with respect to trend, with a falling emission estimate from 1990 to 2004 and no longer, as in 2003, a key source with regard to both level and trend. The contribution is down to 0.7% in 2004. The source CO_2 from Mobile Combustion Navigation is no longer a key source according to level as it was in 2003, in 2004 contributing only 0.7%. The source CO_2 from Mobile Combustion, Other Mobile and Machinery is a key source according to level only with a contribution of 1.3% in 2004 and a slight increase in emission estimates from 1990 to 2004.

The source CO_2 from Fugitive Emissions Oil and Natural Gas has, for the 2004 analysis, become a key source for level and trend, whereas this source was key for trend only in 2003. The contribution in 2004 is 0.9% and the emission estimates from 1990 to 2004 are increasing.

The source CH_4 as Non-CO_2 Emission from Stationary Combustion has, for the 2004 analysis, become a key source for level and trend, whereas it was for trend only in 2003. The contribution in 2004 is 0.8% and the emission estimates from 1990 to 2004 increase markedly.

In the **Industrial Sector**, 3 sources are, as in 2003 and 2002, keys with respect to both level and trend in 2004. The 3 keys in 2004 (and in 2003 and 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 trends from year 1990 to 2004 for these sources are increasing emissions from Cement Production and from Substitutes for the Ozone Depleting Substances (HFCs and PFCs) (trend from 1995), while N_2O emissions from Nitric Acid Production decrease. As regards the level assessment, Cement Production contributes with 2.3% (1.9% in 2003 and 2.1% in 2002), Nitric Acid Production with 0.8% (1.0% in 2003 and 1.1% in 2002) and Substitutes for Ozone Depleting substances (HFCs and PFCs) with 1.1% (1% in 2003 and in 2002).

For the **Agricultural Sector** the analysis includes 5 sources. Of those are 4 keys to both level and trend, while in 2003 they were all keys to both level and trend. The change since 2003 is that, in 2004, N_2O emission from agriculture soils is a key source with regard to level only. In 2002, 2001 and 2000, only 3 of those sources were keys. These 3 key categories, which are the dominant sources also in 2004, 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 1990 to 2004. According to the level assessment, these 3 sources are among the 7 most contributing sources, with direct N_2O emissions from agriculture soils contributing 4.3% (in 2003 3.9%, in 2002 4.3% and in 2001 6.5%), indirect N_2O emissions from nitrogen used in agriculture contributing 4.1% (in 2003 3.7%, in 2002 4.1% and in 2001 4.3%) and CH_4 from enteric fermentation 4.0% (in 2003 3.7%, in 2002 4.1% and in 2001 4.0%). The emission estimates for CH_4 from manure management represent an increasing trend for the year 1990 to 2004 and the emission estimates of N_2O from manure management represent a decreasing trend. According to the level assessment, the contribution in 2004 from these two sources is 1.5% and 0.8%, respectively (compared with 1.3% and 0.8% in 2003).

In the **Waste Sector,** one source – CH_4 emissions from solid disposal of waste – is a key source both with respect to level and trend. The emission estimates decrease over the period from 1990 to 2004 , the contribution to national total being 1.6% in 2004 as in 2003.

Tables 7.A1 – 7.A3 of the Good Practice Guidance

Table 1. Key source analysis 1990-2004, level assessment.

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 2004 Estimate Mt CO2-eq	E Year 2004 Level Assess-ment	F Year 2004 Cumul. total of Col. E
Energy	CO2 Emission from stationary Combustion	Coal	CO2	24,077	17,337	0,255	0,25
Energy	Mobile combustion	Road Transportation	CO2	9,241	12,024	0,177	0,43
Energy	CO2 Emission from stationary Combustion	Natural gas	CO2	4,330	11,143	0,164	0,60
Agriculture	Direct N2O emissions from Agriculture soils		N2O	4,225	2,942	0,043	0,64
Agriculture	Indirect N2O emissions from Nitrogen used in agriculture		N2O	4,127	2,758	0,041	0,68
Energy	CO2 Emission from stationary Combustion	Gas oil	CO2	4,547	2,712	0,040	0,72
Agriculture	Enteric fermentation		CH4	3,259	2,711	0,040	0,76
Energy	CO2 Emission from stationary Combustion	Residual oil	CO2	2,505	1,832	0,027	0,79
Industrial Processes	CO2 emissions from Cement production		CO2	0,882	1,539	0,023	0,81
Waste	Emission from Solid Waste Disposal sites		CH4	1,334	1,074	0,016	0,82
Energy	Mobile combustion	agriculture	CO2	1,272	1,017	0,015	0,84
Agriculture	Manure management		CH4	0,742	1,003	0,015	0,85
Energy	Mobile combustion	other mobil and machinery	CO2	0,842	0,912	0,013	0,87
Energy	CO2 Emission from stationary Combustion	Refinery gas	CO2	0,806	0,904	0,013	0,88
Energy	CO2 Emission from stationary Combustion	Petroleum coke	CO2	0,410	0,817	0,012	0,89
Industrial Processes	Emission from substitutes for ODS (Consumption..)		HFC and	0,218	0,765	0,011	0,90
Energy	CO2 Emission from stationary Combustion	Plastic waste	CO2	0,349	0,676	0,010	0,91
Energy	Fugitive emissions	Oil and Natural Gas	CO2	0,263	0,608	0,009	0,92
Agriculture	N2O from Manure management		N2O	0,685	0,560	0,008	0,93
Industrial Processes	Nitric Acid Production		N2O	1,043	0,531	0,008	0,94
Energy	Non-CO2 Emission from stationary Combustion		CH4	0,121	0,522	0,008	0,95
Energy	Mobile combustion	Navigation	CO2	0,555	0,490	0,007	0,95
Energy	Mobile combustion	national fishing	CO2	0,771	0,473	0,007	0,96
Energy	Mobile combustion	Road Transportation	N2O	0,125	0,421	0,006	0,97
Energy	Mobile combustion	household and gardening	CO2	0,138	0,298	0,004	0,97
Energy	Non-CO2 Emission from stationary Combustion		N2O	0,240	0,268	0,004	0,97
Waste	Emission from Waste Water Handling		CH4	0,126	0,265	0,004	0,98
Energy	Mobile combustion	Military	CO2	0,119	0,239	0,004	0,98
Energy	Mobile combustion	Railways	CO2	0,297	0,216	0,003	0,99
Energy	Mobile combustion	Civil Aviation	CO2	0,243	0,128	0,002	0,99
Energy	CO2 Emission from stationary Combustion	Coke Oven Coke	CO2	0,138	0,123	0,002	0,99
Solvent and Other Product Use			CO2	0,134	0,111	0,002	0,99
Industrial Processes	CO2 emissions from Lime production		CO2	0,152	0,110	0,002	0,99
Energy	CO2 Emission from stationary Combustion	LPG	CO2	0,169	0,108	0,002	0,99
Energy	Fugitive emissions	Oil and Natural Gas	CH4	0,040	0,102	0,001	1,00
Industrial Processes	CO2 emissions from Limestone and Dolomite use		CO2	0,018	0,064	0,001	1,00
Waste	Emission from Waste Water Handling		N2O	0,088	0,053	0,001	1,00
Energy	Mobile combustion	Road Transportation	CH4	0,052	0,053	0,001	1,00
Industrial Processes	Emissions of SF6 from (1) window plate prod. (2) laboratories		SF6	0,068	0,023	<0,001	1,00
Energy	Mobile combustion	forestry	CO2	0,036	0,017	<0,001	1,00
Energy	CO2 Emission from stationary Combustion	Kerosene	CO2	0,366	0,015	<0,001	1,00
Industrial Processes	CO2 emissions Glass/Glass Woll Production		CO2	0,017	0,013	<0,001	1,00
Energy	Mobile combustion	agriculture	N2O	0,015	0,013	<0,001	1,00
Energy	Mobile combustion	other mobil and machinery	N2O	0,011	0,012	<0,001	1,00
Industrial Processes	SF6 from electrical equipment		SF6	0,004	0,010	<0,001	1,00
Energy	Mobile combustion	national fishing	N2O	0,015	0,009	<0,001	1,00
Energy	Mobile combustion	Navigation	N2O	0,010	0,009	<0,001	1,00
Energy	Mobile combustion	household and gardening	CH4	0,004	0,006	<0,001	1,00
Energy	Mobile combustion	Military	N2O	0,001	0,004	<0,001	1,00
Energy	Fugitive emissions	Oil and Natural Gas	N2O	0,001	0,003	<0,001	1,00
Industrial Processes	CO2 emissions Catalysts/Fertilizers and Pesticides		CO2	0,001	0,003	<0,001	1,00
Energy	Mobile combustion	Civil Aviation	N2O	0,003	0,002	<0,001	1,00
Waste	Gasification of biogas		CO2	0,000	0,002	<0,001	1,00
Energy	Mobile combustion	Railways	N2O	0,003	0,002	<0,001	1,00
Industrial Processes	CO2 emissions from Road paving with asphalt		CO2	0,002	0,002	<0,001	1,00
Energy	CO2 Emission from stationary Combustion	Orimulsion	CO2	0,000	0,001	<0,001	1,00
Energy	Mobile combustion	household and gardening	N2O	0,001	0,001	<0,001	1,00
Energy	Mobile combustion	agriculture	CH4	0,002	0,001	<0,001	1,00
Energy	Mobile combustion	other mobil and machinery	CH4	0,001	0,001	<0,001	1,00
Energy	Mobile combustion	Navigation	CH4	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	Military	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	forestry	N2O	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	forestry	CH4	0,000	0,000	<0,001	1,00
Industrial Processes	CO2 emissions from Asphalt roofing		CO2	0,000	0,000	<0,001	1,00
Waste	Gasification of biogas		N2O	0,000	0,000	<0,001	1,00
Energy	CO2 Emission from stationary Combustion	Brown Coal Bri	CO2	0,011	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				69,32	68,06	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. Key source analysis 1990-2004, trend assessment.

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 2004 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	Natural gas	CO2	4,33	11,14	0,1031	24,7	24,7
Energy	CO2 Emission from stationary Combustion	Coal	CO2	24,08	17,34	0,0943	22,6	47,4
Energy	Mobile combustion	Road Transportation	CO2	9,24	12,02	0,0442	10,6	58,0
Energy	CO2 Emission from stationary Combustion	Gas oil	CO2	4,55	2,71	0,0262	6,3	64,2
Agriculture	Indirect N2O emissions from Nitrogen used in agriculture		N2O	4,13	2,76	0,0194	4,6	68,9
Agriculture	Direct N2O emissions from Agriculture soils		N2O	4,22	2,94	0,0181	4,3	73,2
Industrial Processes	CO2 emissions from Cement production		CO2	0,88	1,54	0,0101	2,4	75,6
Energy	CO2 Emission from stationary Combustion	Residual oil	CO2	2,51	1,83	0,0094	2,3	77,9
Industrial Processes	Emission from substitutes for ODS (Consumption..)		HFC and	0,22	0,76	0,0082	2,0	79,9
Industrial Processes	Nitric Acid Production		N2O	1,04	0,53	0,0074	1,8	81,6
Agriculture	Enteric fermentation		CH4	3,26	2,71	0,0073	1,8	83,4
Energy	CO2 Emission from stationary Combustion	Petroleum coke	CO2	0,41	0,82	0,0062	1,5	84,9
Energy	Non-CO2 Emission from stationary Combustion		CH4	0,12	0,52	0,0060	1,4	86,3
Energy	Fugitive emissions	Oil and Natural Gas	CO2	0,26	0,61	0,0052	1,3	87,6
Energy	CO2 Emission from stationary Combustion	Kerosene	CO2	0,37	0,02	0,0051	1,2	88,8
Energy	CO2 Emission from stationary Combustion	Plastic waste	CO2	0,35	0,68	0,0050	1,2	90,0
Energy	Mobile combustion	Road Transportation	N2O	0,12	0,42	0,0045	1,1	91,1
Energy	Mobile combustion	national fishing	CO2	0,77	0,47	0,0042	1,0	92,1
Agriculture	Manure management		CH4	0,74	1,00	0,0041	1,0	93,1
Waste	Emission from Solid Waste Disposal sites		CH4	1,33	1,07	0,0035	0,8	93,9
Energy	Mobile combustion	agriculture	CO2	1,27	1,02	0,0035	0,8	94,8
Energy	Mobile combustion	household and gardening	CO2	0,14	0,30	0,0024	0,6	95,4
Waste	Emission from Waste Water Handling		CH4	0,13	0,26	0,0021	0,5	95,9
Energy	Mobile combustion	Military	CO2	0,12	0,24	0,0018	0,4	96,3
Agriculture	N2O from Manure management		N2O	0,68	0,56	0,0017	0,4	96,7
Energy	CO2 Emission from stationary Combustion	Refinery gas	CO2	0,81	0,90	0,0017	0,4	97,1
Energy	Mobile combustion	Civil Aviation	CO2	0,24	0,13	0,0016	0,4	97,5
Energy	Mobile combustion	other mobil and machinery	CO2	0,84	0,91	0,0013	0,3	97,8
Energy	Mobile combustion	Railways	CO2	0,30	0,22	0,0011	0,3	98,1
Energy	Fugitive emissions	Oil and Natural Gas	CH4	0,04	0,10	0,0009	0,2	98,3
Energy	CO2 Emission from stationary Combustion	LPG	CO2	0,17	0,11	0,0009	0,2	98,5
Energy	Mobile combustion	Navigation	CO2	0,56	0,49	0,0008	0,2	98,7
Industrial Processes	CO2 emissions from Limestone and Dolomite use		CO2	0,02	0,06	0,0007	0,2	98,9
Industrial Processes	Emissions of SF6 from (1) window plate prod. (2) laboratories		SF6	0,07	0,02	0,0007	0,2	99,0
Industrial Processes	CO2 emissions from Lime production		CO2	0,15	0,11	0,0006	0,1	99,2
Industrial Processes	SF6 from magnesium Production		SF6	0,04	0,00	0,0005	0,1	99,3
Waste	Emission from Waste Water Handling		N2O	0,09	0,05	0,0005	0,1	99,4
Energy	Non-CO2 Emission from stationary Combustion		N2O	0,24	0,27	0,0005	0,1	99,5
Industrial Processes	CO2 emissions Iron and Steel Production		CO2	0,03	0,00	0,0004	0,1	99,6
Solvent and Other Product Use			CO2	0,13	0,11	0,0003	0,1	99,7
Energy	Mobile combustion	forestry	CO2	0,04	0,02	0,0003	0,1	99,8
Energy	CO2 Emission from stationary Combustion	Coke Oven Coke	CO2	0,14	0,12	0,0002	0,0	99,8
Energy	CO2 Emission from stationary Combustion	Brown Coal Bri	CO2	0,01	0,00	0,0002	0,0	99,9
Industrial Processes	SF6 from electrical equipment		SF6	0,00	0,01	0,0001	0,0	99,9
Energy	Mobile combustion	national fishing	N2O	0,02	0,01	0,0001	0,0	99,9
Industrial Processes	CO2 emissions Glass/Glass Woll Production		CO2	0,02	0,01	0,0001	0,0	99,9
Energy	Mobile combustion	Military	N2O	0,00	0,00	<0,0001	0,0	99,9
Energy	Mobile combustion	Road Transportation	CH4	0,05	0,05	<0,0001	0,0	99,9
Energy	Mobile combustion	household and gardening	CH4	0,00	0,01	<0,0001	0,0	99,9
Industrial Processes	CO2 emissions Catalysts/Fertilizers and Pesticides		CO2	0,00	0,00	<0,0001	0,0	99,9
Waste	Gasification of biogas		CO2	0,00	0,00	<0,0001	0,0	100,0
Energy	Fugitive emissions	Oil and Natural Gas	N2O	0,00	0,00	<0,0001	0,0	100,0
Energy	Mobile combustion	agriculture	N2O	0,02	0,01	<0,0001	0,0	100,0
Energy	Mobile combustion	other mobil and machinery	N2O	0,01	0,01	<0,0001	0,0	100,0
Energy	CO2 Emission from stationary Combustion	Orimulsion	CO2	0,00	0,00	<0,0001	0,0	100,0
Energy	Mobile combustion	Navigation	N2O	0,01	0,01	<0,0001	0,0	100,0
Energy	Mobile combustion	agriculture	CH4	0,00	0,00	<0,0001	0,0	100,0
Energy	Mobile combustion	household and gardening	N2O	0,00	0,00	<0,0001	0,0	100,0
Energy	Mobile combustion	Civil Aviation	N2O	0,00	0,00	<0,0001	0,0	100,0
Energy	Mobile combustion	Railways	N2O	0,00	0,00	<0,0001	0,0	100,0
Energy	Mobile combustion	forestry	CH4	0,00	0,00	<0,0001	0,0	100,0
Energy	Mobile combustion	other mobil and machinery	CH4	0,00	0,00	<0,0001	0,0	100,0
Energy	Mobile combustion	national fishing	CH4	0,00	0,00	<0,0001	0,0	100,0
Energy	Mobile combustion	Military	CH4	0,00	0,00	<0,0001	0,0	100,0
Energy	Mobile combustion	Railways	CH4	0,00	0,00	<0,0001	0,0	100,0
Industrial Processes	CO2 emissions from Road paving with asphalt		CO2	0,00	0,00	<0,0001	0,0	100,0
Energy	Mobile combustion	Civil Aviation	CH4	0,00	0,00	<0,0001	0,0	100,0
Waste	Gasification of biogas		N2O	0,00	0,00	<0,0001	0,0	100,0
Energy	Mobile combustion	forestry	N2O	0,00	0,00	<0,0001	0,0	100,0
Industrial Processes	CO2 emissions from Asphalt roofing		CO2	0,00	0,00	<0,0001	0,0	100,0
Energy	Mobile combustion	Navigation	CH4	0,00	0,00	<0,0001	0,0	100,0
total				69,32	68,06	0,42	100	

(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. Key source analysis 1990-2004, summary.

Table 7.A3 (of Good Practice Guidance)
Source Category Analysis Summary (DK-inventory)

Quantitative method used: Tier 1

IPCC Source Categories (LULUCF not included)		**B** Direct Greenh. Gas	**C** Key Source 2004	**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	Brown Coal Bri	CO2	No		
CO2 Emission from stationary Combustion	Coke Oven Coke	CO2	No		
CO2 Emission from stationary Combustion	Petroleum coke	CO2	Yes	Level, Trend	*See text*
CO2 Emission from stationary Combustion	Plastic waste	CO2	Yes	Level, Trend	*See text*
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	
CO2 Emission from stationary Combustion	Orimulsion	CO2	NO		
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	*See text*
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	Trend	*See text*
Mobile combustion	agriculture	CO2	Yes	Level, Trend	*See text*
Mobile combustion	forestry	CO2	No		
Mobile combustion	other mobil and machinery/industry	CO2	Yes	Level	*See text*
Mobile combustion	household and gardening	CO2	No		
Fugitive emissions	Oil and Natural Gas	CO2	Yes	Level, Trend	*See text*
Non-CO2 Emission from stationary Combustion		CH4	Yes	Level, 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	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	
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	Oil and Natural Gas	N2O	No		
Industrial Processes					
CO2 emissions from Cement production		CO2	Yes	Level, Trend	*See text*
CO2 emissions from Lime production		CO2	No		
CO2 emissions from Limestone and Dolomite use		CO2	No		
CO2 emissions from Asphalt roofing		CO2	No		
CO2 emissions from Road paving with asphalt		CO2	No		
CO2 emissions Glass/Glass Woll Production		CO2	No		
CO2 emissions Catalysts/Fertilizers and Pesticides		CO2	No		
CO2 emissions Iron and Steel Production		CO2	No		
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 and F	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, Trend	*See text*
N2O from Manure management		N2O	Yes	Level	*See text*
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, Trend	*See text*
Emission from Waste Water Handling		CH4	No		
Emission from Waste Water Handling		N2O	No		
Gasification of biogas		CO2	No		
Gasification of biogas		N2O	No		

Annex 2 Detailed discussion of methodology and data for estimation CO_2 emission from fossil fuel combustion

Please refer to Annex 3.

Annex 3 Other detailed methodological descriptions for individual source of sink categories (where relevant)

Annex 3A Energy

Stationary combustion plants

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.

Contents

1 Introduction

The Danish atmospheric emission inventories are prepared on an annual basis and the results are reported to the *UN Framework Convention on Climate Change* (UNFCCC or Climate Convention) and to the UNECE *Convention on Long-Range Transboundary Air Pollution* (LRTAP Convention). Furthermore, a greenhouse gas emission inventory is reported to the EU, due to the EU – as well as the individual Member States – party to the Climate Convention. The Danish atmospheric emission inventories are calculated by the Danish National Environmental Research Institute (NERI).

This annex provides a summary of the emission inventories for stationary combustion reported to the Climate Convention and background documentation for the estimates. Stationary combustion plants include power plants, district heating plants, non-industrial and industrial combustion plants, industrial process burners, petroleum-refining plants, as well as combustion in oil/gas extraction and in pipeline compressors. Emissions from flaring in oil/gas production and from flaring carried out in refineries are not covered in this annex.

This annex presents detailed emission inventories and time-series for emissions from stationary combustion plants. Furthermore, emissions from stationary combustion plants are compared with total Danish emissions. The methodology and references for the emission inventories for stationary combustion plants are described. Furthermore, uncertainty estimates are provided.

2 Methodology and references

The Danish emission inventory is based on the CORINAIR (CORe INventory on AIR emissions) system, which is a European programme 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 2004). Emission data are stored in an Access database, from which data are transferred to the reporting formats.

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

2.1 Emission source categories

In the Danish emission database, all activity rates and emissions are defined in SNAP sector categories (Selected Nomenclature for Air Pollution) according the CORINAIR system. The emission inventories are prepared from a complete emission database based on the SNAP sectors. Aggregation to the sector codes used for the Climate Convention is based on a correspondence list between SNAP and IPCC enclosed in Appendix 3A-2.

The sector codes applied in the reporting activity will be referred to as IPCC sectors. The IPCC sectors define 6 main source categories, listed in Table 3A-1, and a number of subcategories. Stationary combustion is part of the IPCC ector 1, *Energy*. Table 3A-2 presents subsectors in the IPCC energy sector. The table also presents the sector in which the NERI documentation is included. Though industrial combustion is part of stationary combustion, detailed documentation for some of the specific industries is discussed in the industry chapters/annexes. Stationary combustion is defined as combustion activities in the SNAP sectors 01-03.

Table 3A-1 IPCC main sectors.

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

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

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

The CO_2 from calcination is not part of the energy sector. This emission is included in the IPCC sector 2, Industrial Processes.

2.2 Large point sources

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

In the inventory for the year 2004, 72 stationary combustion plants are specified as large point sources. These point sources include:

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

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

- All centralised power plants, including smaller units.
- All units with a capacity of above 25 MW_e.
- All district heating plants with an installed effect of 50 MW or above and a significant fuel consumption
- All waste incineration plants included under the Danish law "Bekendtgørelse om visse listevirksomheders pligt til at udarbejde grønt regnskab".
- Industrial plants
  - With an installed effect of 50 MW or above and significant fuel consumption.
  - With a significant process-related emission.

The fuel consumption of stationary combustion plants registered as large point sources is 361 PJ (2004). This corresponds to 64% of the overall fuel consumption for stationary combustion.

A list of the large point sources for 2004 and the fuel consumption rates is provided in Appendix 3A-5. The number of large point sources registered in the databases increased from 1990 to 2004.

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

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 legislatory requirements
- Emission data reported by Elsam and E2, the two major electricity suppliers
- Emission data reported by industrial plants

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

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

2.3 Area sources

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

2.4 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 2005a). 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)* is not disaggregated into specific industries in the NERI emission database. Disaggregation into specific industries is estimated for the reporting to the Climate Convention. The disaggregation of fuel consumption and emissions from the industrial sector is discussed in Chapter 3.6.

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

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

The Danish Energy Authority (DEA) compiles a database for the fuel consumption of each district heating and power-producing plant, based on data reported by plant operators. The fuel consumption of large point sources specified in the Danish emission database is based on the DEA database (DEA 2005c).

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

Emissions from the non-energy use of fuels have not been included in the Danish inventory, to date, but the non-energy use of fuels is, however, included in the reference approach for Climate Convention reporting. The Danish energy statistics include three fuels used for non-energy purposes: bitumen, white spirit and lube oil. The fuels used for non-energy purposes add up to less than 2% of the total fuel consumption in Denmark.

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 4.

2.5 Emission factors

For each fuel and SNAP category (sector and e.g. type of plant) a set of general area source emission factors has been determined. The emission factors are either nationally referenced or based on the international guidebooks: EMEP/Corinair Guidebook (EMEP/Corinair, 2004) and IPCC Reference Manual (IPCC 1996).

A complete list of emission factors, including time-series and references, is provided in Appendix 3A-4.

2.5.1 CO_2

The CO_2 emission factors applied for 2004 are presented 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 1990-2004.

In reporting for the Climate Convention, the CO_2 emission is aggregated to five fuel types: Solid fuel, Liquid fuel, Gas, Biomass and Other fuels. The correspondence list between the NERI fuel categories and the IPCC fuel categories is also provided in Table 3A-3.

Only emissions from fossil fuels are included in the national total CO_2 emission. The biomass emission factors are also included in the table, because emissions from biomass are reported to the Climate Convention as a memo item.

The CO_2 emission from the incineration of municipal waste (94,5 + 17,6 kg/GJ) is divided into 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, which is reported as a memo item. In the IPCC reporting, the CO_2 emission from combustion of the plastic content of the waste is reported in the fuel category, *Other fuels*. However, this split is not applied in either in the case of fuel consumption or other emissions, because it is only relevant for CO_2. Thus, the full consumption of municipal waste is included in the fuel category, *Biomass,* and non-CO_2 emissions from municipal waste combustion are also included in full in the *Biomass* category.

The CO_2 emission factors have been confirmed by the two major power plant operators, 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 by accepting use of the NERI factors in Danish legislation.

The current Danish legislation concerning CO_2 emission from power plants in 2003 and 2004 (Lov nr. 376 1999) is based on standard CO_2 emission factors for each fuel. Thus, to date, power plant operators have not been encouraged to estimate CO_2 emission factors based on their own fuel analysis. In future legislation (Lov nr. 493 2004), operators of large power plants are obliged to verify the applied emission factors, which will lead to the availability in future of improved emission factors for national emission inventories. The plants will report CO_2 emissions for 2005 according to this legislation.

Table 3A-3 CO_2 emission factors 2004.

Fuel	Emission factor		Unit	Reference type	IPCC fuel
	Biomass	Fossil fuel			Category
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	74		kg/GJ	Country-specific	Biomass
Orimulsion		80	kg/GJ	Country-specific	Liquid
Natural gas		57,12	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 operators in 1996 (Christiansen 1996 and Andersen 1996). Elsam reconfirmed the factor in 2001 (Christiansen 2001). The same emission factor is applied for 1990-2004.

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·(12+2·16)/12 = 94.6 kg CO_2/GJ assuming full oxidation. The same emission factor is applied for 1990-2004.

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 29.5 t C/TJ, corresponding to 29.5·(12+2·16)/12 = 108 kg CO_2/GJ assuming full oxidation. The same emission factor is applied for 1990-2004.

Petroleum coke

The emission factor 92 kg/GJ has been estimated by SK Energy (a former major power plant operator in eastern Denmark) in 1999 based on a fuel analysis carried out by dk-Teknik in 1993 (Bech 1999). The emission factor level was confirmed by a new fuel analysis which, however, is considered confidential. The same emission factor is applied for 1990-2004.

Wood

The emission factor for wood, 102 kg/GJ, refers to Fenhann & Kilde 1994. The factor is based on the interval stated in a former edition of the EMEP/Corinair Guidebook and the actual value is the default value from the Collector database. The same emission factor is applied for 1990-2004.

Municipal waste

The CO_2 emission from incineration of municipal waste is divided into 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 – which is reported as a memo item.

The plastic content of waste was 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 various 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, A.M.M. 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, 2003), 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.

Thus, in 2003, the CO_2 emission factor for the plastic content of waste was estimated to be 185g/kg municipal waste (Table 3A-4). The CO_2 emission per GJ of waste is calculated based on the lower heating values for waste listed in Table 3A-5 (DEA 2005b). It has been assumed that the plastic content as a percentage (weight) is constant, resulting in a decreasing energy percentage since the lower heating value (LHV) is increasing. However, the increasing LHV may be a result of an increase in the plastic content in the municipal waste. Time-series for the CO_2 emission factor for plastic content in waste are included in Table 3A-5.

Emission data from four waste incineration plants (Jørgensen & Johansen 2003) demonstrate the fraction of the carbon content of the waste not oxidised to be approximately 0.3%. The un-oxidised fraction of the carbon content is assumed to originate from the biomass content, and all carbon originating from plastic is assumed to be oxidised.

Table 3A-5 CO_2 emission factor for municipal waste, plastic content and biomass content.

Year	Lower heating value of municipal waste 1)	Plastic content	CO_2 emission factor for plastic 3)	CO_2 emission factor for plastic	CO_2 emission factor for municipal waste, total 2)	CO_2 emission factor for biomass content of waste
	[GJ/Mg]	[% of energy]	[g/kg waste]	[kg/GJ waste]	[kg/GJ 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
2003	10.50	22.3	185	17.6	112.1	94.5
2004	10.50	22.3	185	17.6	112.1	94.5

1) DEA 2005b
2) Based on data from Jørgensen & Johansen 2003
3) From Table 3A-4

Straw

The emission factor for straw, 102 kg/GJ, is from Fenhann & Kilde, 1994. The factor is based on the interval stated in the EMEP/Corinair Guidebook (EMEP/Corinair, 2004) and the actual value is the default value from the Collecter database. The same emission factor is applied for 1990-2004.

Residual oil

The emission factor 78 kg/GJ comes from Fenhann & Kilde, 1994. The factor is based on the interval stated in the EMEP/Corinair Guidebook (EMEP/Corinair; 2004). The factor is slightly 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 operators in 1996 (Christiansen 1996 and Andersen 1996). The same emission factor is applied for 1990-2004.

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, 2004). 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 operators in 1996 (Christiansen 1996 and Andersen 1996). The same emission factor is applied for 1990-2004.

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 1990-2004.

Fish & rape oil

The emission factor is assumed to be the same as for gas oil – 74 kg/GJ. The consumption of fish and 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 operator using orimulsion (Andersen 1996). The same emission factor is applied for 1990-2004.

Natural gas

The emission factor for natural gas is estimated by the Danish gas transmission company, Energinet.dk. Only natural gas from the Danish gas fields is utilised in Denmark. The calculation is based on gas analysis carried out daily by Energinet.dk. Energinet.dk and the Danish Gas Technology Centre have calculated emission factors for 2000-2004. The emission factor applied for 1990-1999 refers to Fenhann & Kilde 1994. This emission factor was confirmed by the two major power plant operators in 1996 (Christiansen 1996 and Andersen 1996). The time-series for the CO_2 emission factors is provided in Table 3A-6.

Table 3A-6 CO_2 emission factor for natural gas.

Year	CO_2 emission factor
1990-1999	56.9 kg/GJ
2000	57.1 kg/GJ
2001	57.25 kg/GJ
2002	57.28 kg/GJ
2003	57.19 kg/GJ
2004	57.12 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, 2004). 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 1990-2004.

Refinery gas

The emission factor applied for refinery gas is the same as 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, 2004). The same emission factor is applied for 1990-2004.

Biogas

The emission factor 83,6 kg/GJ is based on a biogas with 65% (vol.) CH_4 and 35% (vol.) CO_2. The Danish Gas Technology Centre has stated that this is typical manure-based biogas as utilised in stationary combustion plants (Kristensen 2001). The same emission factor is applied for 1990-2004.

2.5.2 CH_4

The CH_4 emission factors applied for 2004 are presented in Table 3A-7. In general, the same emission factors have been applied for 1990-2004. However, time-series have been estimated for both natural gas fuelled engines and biogas fuelled engines.

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, 2004).

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 1990-2004.

Fuel	ipcc_id	SNAP_id	Emission factor [g/GJ]	Reference
COAL	1A1a	010101, 010102, 010103	1.5	EMEP/Corinair 2004
COAL	1A1a, 1A2f, 1A4b, 1A4c	010202, 010203, 0301, 0202, 0203	15	EMEP/Corinair 2004
BROWN COAL BRI.	all	all	15	EMEP/Corinair 2004, assuming same emission factor as for coal
COKE OVEN COKE	all	all	15	EMEP/Corinair 2004, assuming same emission factor as for coal
PETROLEUM COKE	all	all	15	EMEP/Corinair 2004
WOOD AND SIMIL.	1A1a	010102, 010103, 010104	2	Nielsen & Illerup 2003
WOOD AND SIMIL.	1A4a, 1A4b, 1A4c	0201, 0202, 0203	200	EMEP/Corinair 2004
WOOD AND SIMIL.	1A1a, 1A2f	010105, 010202, 010203, 0301, 030102, 030103	32	EMEP/Corinair 2004
MUNICIP. WASTES	1A1a	010102, 010103, 010104, 010105	0.59	Nielsen & Illerup 2003
MUNICIP. WASTES	1A1a, 1A2f, 1A4a	all other	6	EMEP/Corinair 2004
STRAW	1A1a	010102, 010103	0.5	Nielsen & Illerup 2003
STRAW	1A1a, 1A2f, 1A4c	010202, 010203, 020302, 030105	32	EMEP/Corinair 2004
STRAW	1A4b, 1A4c	0202, 0203	200	EMEP/Corinair 2004
RESIDUAL OIL	all	all	3	EMEP/Corinair 2004
GAS OIL	all	all	1.5	EMEP/Corinair 2004
KEROSENE	all	all	7	EMEP/Corinair 2004
FISH & RAPE OIL	all	all	1.5	EMEP/Corinair 2004, assuming same emission factor as gas oil
ORIMULSION	1A1a	010101	3	EMEP/Corinair 2004, 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, 1Ac, 1A2f, 1A4a, 1A4c	Gas turbines: 010104, 010504, 030104, 020104, 020303	1.5	Nielsen & Illerup 2003
NATURAL GAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4b, 1A4c	Gas engines: 010105, 010205, 010505, 030105, 020105, 020204, 020304	1) 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 2004
REFINERY GAS	1A1b	010304	1.5	EMEP/Corinair 2004
BIOGAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4c	Gas engines: 010105, 010505, 030105, 020105, 020304	1) 323	Nielsen & Illerup 2003
BIOGAS	1A1a, 1A2f, 1A4a, 1A4c	all other	4	EMEP/Corinair 2004

1) 2004 emission factor. Time-series is shown below

CHP plants

A considerable portion of the electricity production in Denmark is based on decentralised CHP plants and well-documented emission factors for these plants are, therefore, of importance. In a project carried out for the electricity transmission company in Western Denmark, Eltra, emission factors have been estimated for CHP plants <25MW_e. 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 refer 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 datasets was comprehensive. Emission factors for subgroups of each plant type were estimated, e.g. the CH_4 emission factor for different gas engine types has been determined.

Gas engines, natural gas

SNAP 010105, 010205, 010505, 030105, 020105, 020204 and 020304

The emission factor for natural gas engines was determined as 520 g/GJ in 2000 and the same emission factor has been applied for 2001 - 2004. The emission factor for natural gas engines was based on 291 emission measurements in 114 different plants. The plants from which emission measurements were available represented 44% of the total gas consumption in gas engines (year 2000). The emission factor was estimated based on fuel consumption for each gas engine type and the emission factor for each engine type. The majority of emission measurements that were not performed within the project related solely to the emission of total unburned hydrocarbon (CH_4 + NMVOC). A constant disaggregation factor was estimated based on a number of emission measurements including both CH_4 and NMVOC.

The emission factor for lean-burn gas engines is relatively high, especially for pre-chamber engines, which account for more than half the gas consumption in Danish gas engines. However, the emission factors for different pre-chamber engine types differ considerably.

The installation of natural gas engines in decentralised CHP plants in Denmark has taken place since 1990. The first engines installed were relatively small open-chamber engines and, in later years, mainly pre chamber engines were installed. As mentioned above, pre-chamber engines have a higher emission factor than open-chamber engines; therefore, the emission factor has changed during the period 1990-2004. A time-series for the emission factor has been estimated and is presented 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 2003)
- 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
2003	520
2004	520

Gas engines, biogas

SNAP 010105, 010505, 020105, 020304 and 030105

The emission factor for biogas engines was estimated to be 323 g/GJ in 2000 and the same emission factor has been applied for 2001 - 2004. The emission factor for biogas engines was based on 18 emission measurements on 13 different plants. The plants from which emission measurements were available represented 18% of the total gas consumption in gas engines (year 2000).

The emission factor is lower than the factor for natural gas, mainly because most engines are lean-burn open-chamber engines - not pre-chamber engines. A time-series for the emission factor has been estimated (Nielsen & Illerup 2003).

Table 3A-9 Time-series for the CH_4 emission factor for biogas fuelled engines.

Year	Emission factor [g/GJ]
1990	239
1991	251
1992	264
1993	276
1994	289
1995	301
1996	305
1997	310
1998	314
1999	318
2000	323
2001	323
2002	323
2003	323
2004	323

Gas turbines, natural gas

SNAP 010104, 010504, 020104, 020303 and 030104

The emission factor for gas turbines was estimated to be below 1.5g/GJ and the emission factor of 1.5 g/GJ has been applied for all years. The emission factor was based on emission measurements in 9 plants.

CHP, wood

SNAP 010102 and, 010103 and 010104

The emission factor for CHP plants combusting wood was estimated to be below 2.1 g/GJ and the emission factor of 2 g/GJ has been applied for all years. The emission factor was based on emission measurements in 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 of 0.5g/GJ has been applied for all years. The emission factor was based on emission measurements in 4 plants.

CHP, municipal waste

SNAP 010102, 010103, 010104 and 010105

The emission factor for CHP plants combusting municipal waste was estimated to be below 0.59g/GJ and the emission factor of 0.59g/GJ has been applied for all years. The emission factor was based on emission measurements in 16 plants.

Other stationary combustion plants

Emission factors for other plants refer to the EMEP/Corinair Guidebook (EMEP/Corinair 2004), the Danish Gas Technology Centre (DGC 2001) or Gruijthuijsen & Jensen 2000. The same emission factors are applied for 1990-2004.

2.5.3 N_2O

The N_2O emission factors applied for the 2004 inventory are listed in Table 3A-10. The same emission factors have been applied for 1990-2004.

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). For coal-powered plants in the public power sector, research conducted by Elsam has led to a new emission factor being implemented for the entire time-series. Other emission factors refer to the EMEP/Corinair Guidebook (EMEP/Corinair 2004).

Table 3A-10 N_2O emission factors 1990-2004.

Fuel	ipcc_id	SNAP_id	Emission factor [g/GJ]	Reference
COAL	1A1a	0101**	0.8	Elsam 2005
COAL	1A1a, 1A1c, 1A2f, 1A4a, 1A4b, 1A4c	All except 0101**	3	EMEP/Corinair 2004
BROWN COAL BRI.	all	all	3	EMEP/Corinair 2004
COKE OVEN COKE	all	all	3	EMEP/Corinair 2004
PETROLEUM COKE	all	all	3	EMEP/Corinair 2004
WOOD AND SIMIL.	1A1a	010102, 010103, 010104	0.8	Nielsen & Illerup 2003
WOOD AND SIMIL.	1A1a	010105, 010202, 010203	4	EMEP/Corinair 2004
WOOD AND SIMIL.	1A2f, 1A4a, 1A4b, 1A4c	all	4	EMEP/Corinair 2004
MUNICIP. WASTES	1A1a	010102, 010103, 010104, 010105	1.2	Nielsen & Illerup 2003
MUNICIP. WASTES	1A1a	010203	4	EMEP/Corinair 2004
MUNICIP. WASTES	1A2f, 1A4a	030102, 0201, 020103	4	EMEP/Corinair 2004
STRAW	1A1a	010102, 010103	1.4	Nielsen & Illerup 2003
STRAW	1A1a	010202, 010203	4	EMEP/Corinair 2004
STRAW	1A2f, 1A4b, 1A4c	all	4	EMEP/Corinair 2004
RESIDUAL OIL	all	all	2	EMEP/Corinair 2004
GAS OIL	all	all	2	EMEP/Corinair 2004
KEROSENE	all	all	2	EMEP/Corinair 2004
FISH & RAPE OIL	all	all	2	EMEP/Corinair 2004, assuming same emission factor as gas oil
ORIMULSION	1A1a	010101	2	EMEP/Corinair 2004, assuming same emission factor as residual oil
NATURAL GAS	1A1a	0101, 010101, 010102,	1	EMEP/Corinair 2004

		010103, 010202, 010203		
NATURAL GAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4c	Gas turbines: 010104, 010504, 030104, 020104, 020303	2.2	Nielsen & Illerup 2003
NATURAL GAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4b, 1A4c	Gas engines: 010105, 010205, 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 2004
LPG	all	all	2	EMEP/Corinair 2004
REFINERY GAS	all	all	2.2	EMEP/Corinair 2004
BIOGAS	1A1a	010102, 010103, 010203	2	EMEP/Corinair 2004
BIOGAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4c	Gas engines: 010105, 010505, 030105, 020105, 020304	0.5	Nielsen & Illerup 2003
BIOGAS	1A2f, 1A4a, 1A4c	0301, 030102, 0201, 020103, 0203	2	EMEP/Corinair 2004

2.5.4 SO_2, NO_x, NMVOC and CO

Emission factors for SO_2, NO_x, NMVOC and CO are listed in Appendix 3A-4. The appendix includes references and time-series.

The emission factors refer to:

- The EMEP/Corinair Guidebook (EMEP/Corinair 2004)
- The IPCC Guidelines, Reference Manual (IPCC 1996)
- Danish legislation:
  - Miljøstyrelsen 2001 (Danish Environmental Protection Agency)
  - Miljøstyrelsen 1990 (Danish Environmental Protection Agency)
  - Miljøstyrelsen 1998 (Danish Environmental Protection Agency)
- Danish research reports including:
  - An emission measurement program for decentralised CHP plants (Nielsen & Illerup 2003)
  - Research and emission measurements programs for biomass fuels:
    - Nikolaisen et al., 1998
    - Jensen & Nielsen, 1990
    - Dyrnum et al., 1990
    - Hansen et al., 1994
    - Serup et al., 1999
  - Research and environmental data from the gas sector:
    - Gruijthuijsen & Jensen 2000
    - Danish Gas Technology Centre 2001
- Calculations based on plant-specific emissions from a considerable number of power plants (Nielsen 2003).
- Calculations based on plant-specific emission data from a considerable number of municipal waste incineration plants. These data refer to annual environmental reports published by plant operators.
- Sulphur content data from oil companies and the Danish gas transmission company.
- Additional personal communication.

Emission factor time-series have been estimated for a considerable number of the emission factors. These are provided in Appendix 3A-4.

2.6 Disaggregation to specific industrial subsectors

The national statistics on which the emission inventories are based do not include a direct disaggregation to specific industrial subsectors. However, separate national statistics from Statistics Denmark include a disaggregation to industrial subsectors. This part of the energy statistics is also included in the official energy statistics from the Danish Energy Authority.

Every other year, Statistics Denmark collects fuel consumption data for all industrial companies of considerable size. The deviation between the total fuel consumption from the Danish Energy Authority and the data collected by Statistics Denmark is rather small. Thus, the disaggregation to industrial subsectors available from Statistics Denmark can be applied for estimating disaggregation keys for fuel consumption and emissions.

The industrial fuel consumption is considered in respect of three aspects:

- Fuel consumption for transport. This part of the fuel consumption is not disaggregated to subsectors.
- Fuel consumption applied in power or district heating plants. Disaggregation of fuel and emissions is plant specific.
- Fuel consumption for other purposes. The total fuel consumption and the total emissions are disaggregated to subsectors.

All pollutants included in the Climate Convention reporting have been disaggregated to industrial subsectors.

3 Fuel consumption data

In 2004, total fuel consumption for stationary combustion plants was 564 PJ, of which 466 PJ related to fossil fuels. The fuel consumption rates are shown in Appendix 3A-3.

Fuel consumption distributed on the stationary combustion subsectors is shown in Figure 3A-1 and Figure 3A-2. The majority (60%) of all fuels is combusted in the sector, *Public electricity and heat production.* Other sectors with high fuel consumption are *Residential* and *Industry*. The energy consumption in category 1A1c is mainly natural gas used in gas turbines in the offshore industry.

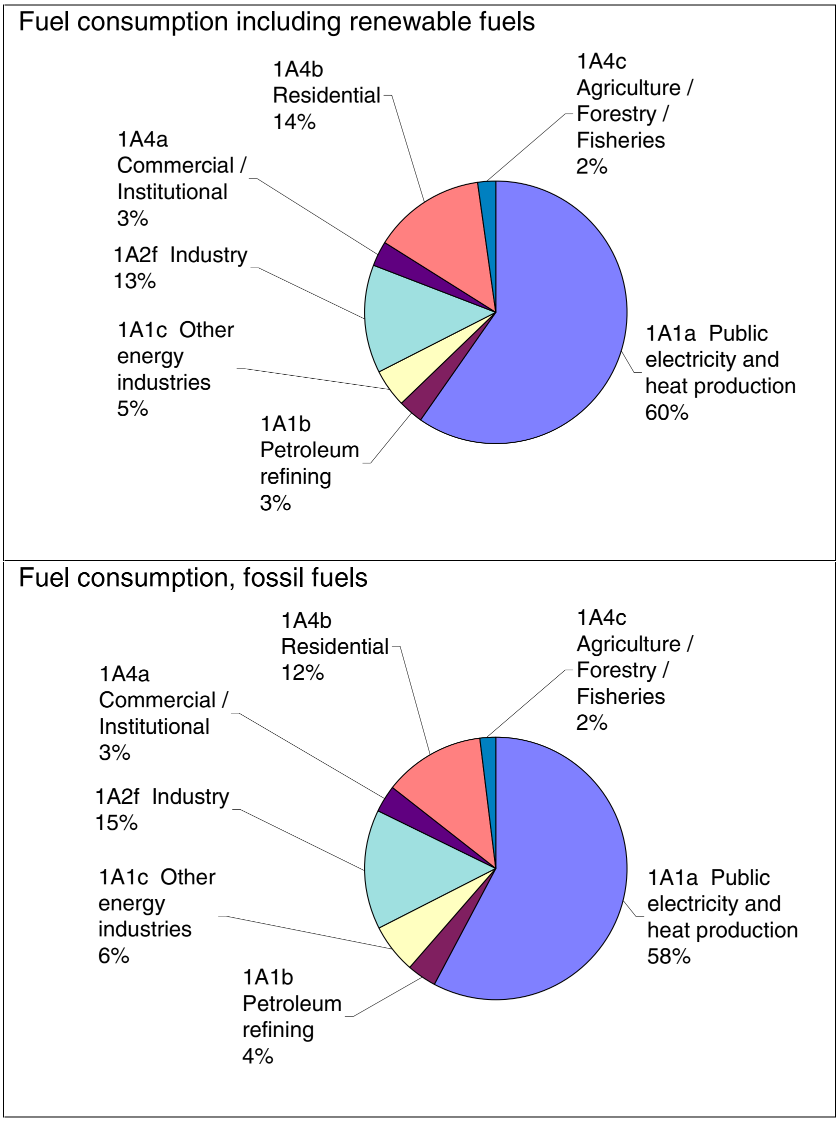

Figure 3A-1 Fuel consumption rate of stationary combustion, 2004 (based on DEA 2005a).

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.

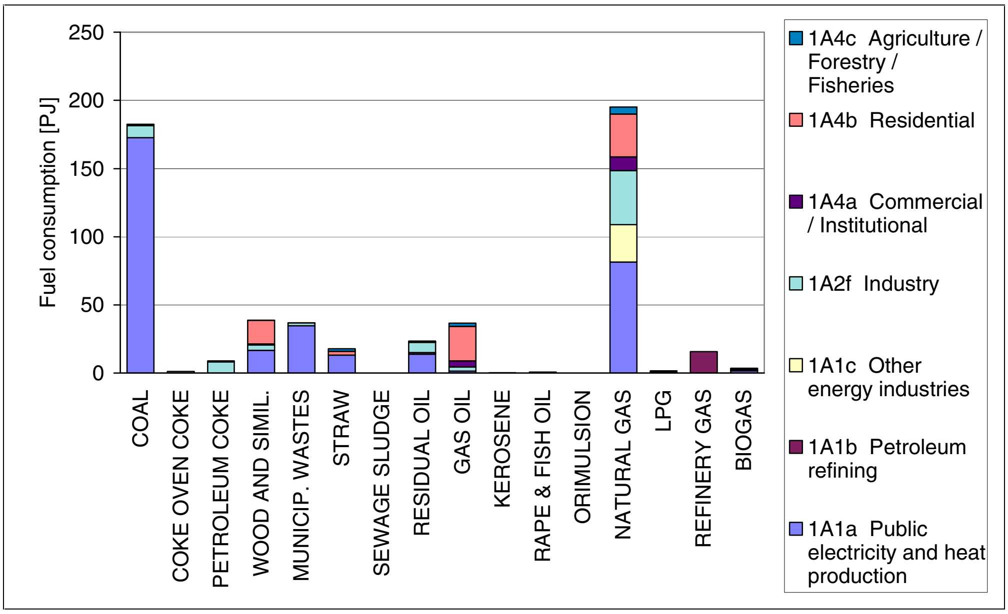

Figure 3A-2 Fuel consumption of stationary combustion plants 2004 (based on DEA 2005a).

Fuel consumption time-series for stationary combustion plants are presented in Figure 3A-3. The total fuel consumption has increased by 13% from 1990 to 2004, while the fossil fuel consumption has only increased by 4.2%. The consumption of natural gas and renewable fuels has increased since 1990, whereas coal consumption has decreased.

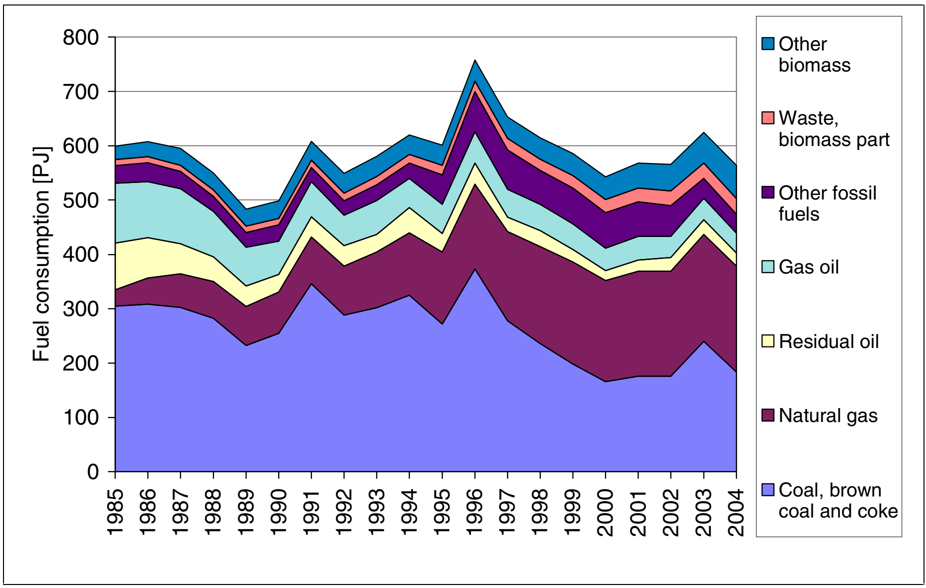

Figure 3A-3 Fuel consumption time-series, stationary combustion (based on DEA 2005a).

The fluctuations in the time-series for fuel consumption are mainly a result of electricity import/export, but also of outdoor temperature variations from year to year. This, in turn, leads to fluctuations in emission levels. The fluctuations in electricity trade, fuel consumption and NO_x emission are illustrated and compared in Figure 3A-4. In 1990 the Danish electricity import was large, causing relatively low fuel consumption, whereas the fuel consumption was high in 1996 due to a large electricity export. In 2004, the net electricity export was 10340 TJ which is lower than in 2003. The electricity export in 2004 is a result of low rainfall in Norway and Sweden causing insufficient hydropower production in both countries.

To be able to follow the national energy consumption, as well as for statistical and reporting purposes, the Danish Energy Authority produces a correction of the actual fuel consumption without random variations in electricity imports/exports and ambient temperature. This fuel consumption trend is also illustrated in Figure 3A-4. The corrections are included here to explain the fluctuations in the emission time-series.

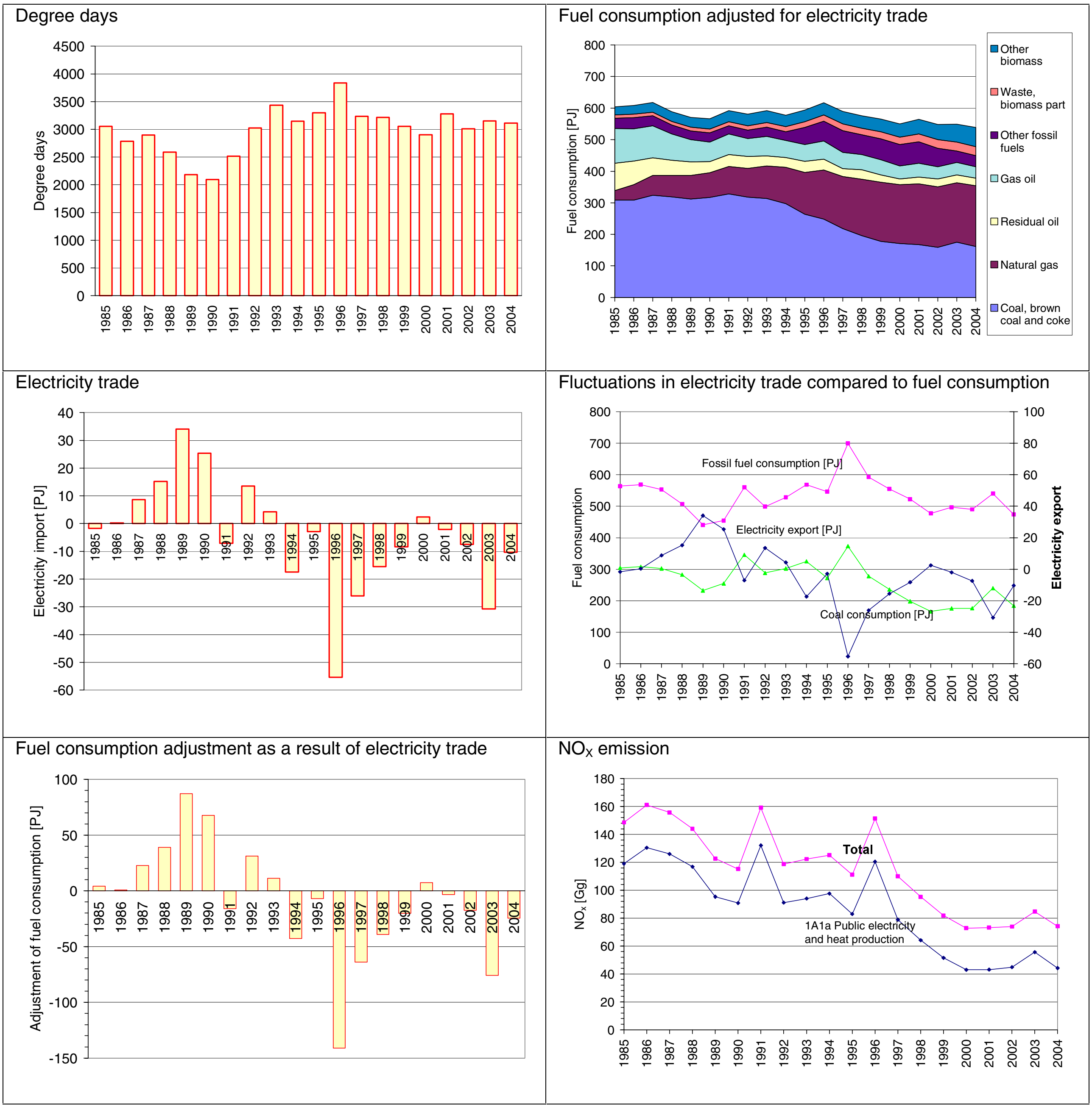

Figure 3A-4 Comparison of time-series fluctuations for electricity trade, fuel consumption and NO_x emission (DEA 2005b).

4 Greenhouse gas emission

The total Danish greenhouse gas (GHG) emission in the year 2004 was 68 062 Gg CO_2 equivalents, not including land-use change and forestry, or 65 812 Gg CO_2 equivalents including land-use change and forestry. The greenhouse gas pollutants HFCs, PFCs and SF_6 are not emitted from combustion plants and, as such, only the pollutants CO_2, CH_4 and N_2O are considered below.

The global warming potentials of CH_4 and N_2O applied in greenhouse gas inventories refer to 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 listed in Table 3A-11. The emission from stationary combustion accounts for 54% of the total Danish GHG emission.

The CO_2 emission from stationary combustion plants accounts for 66% of the total Danish CO_2 emission (not including land-use change and forestry). CH_4 accounts for 9% of the total Danish CH_4 emission and N_2O for only 4% of the total Danish N_2O emission. The total Danish emissions are calculated in the old CRF format. Due to structural changes there is not total compliance between the new and old CRF format.

Table 3A-11 Greenhouse gas emission for the year 2004 [1)].

	CO_2	CH_4	N_2O
	Gg CO_2 equivalent		
1A1 Fuel consumption, Energy industries	25 388	323	154
1A2 Fuel consumption, Manufacturing Industries and Construction[1)]	4 929	31	47
1A4 Fuel consumption, Other sectors [1)]	5 354	169	67
Total emission from stationary combustion plants	**35 670**	**522**	**268**
Total Danish emission (gross)	53 938	5 779	7 587
	%		
Emission share for stationary combustion	66	9	4

1) Only stationary combustion sources of the sector is included

CO_2 is the most important GHG pollutant and accounts for 97.7% 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 81% of the GHG emission (CO_2 eq.).

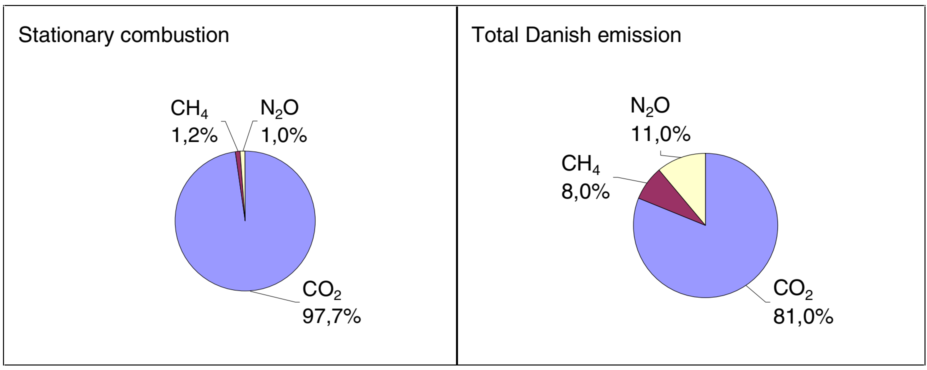

Figure 3A-5 GHG emission (CO_2 equivalent), contribution from each pollutant.

Figure 3A-6 depicts the time-series of GHG emission (CO_2 eq.) from stationary combustion and it can be seen that the GHG emission development follows the CO_2 emission development very closely. Both the CO_2 and the total GHG emission are lower in 2004 than in 1990, CO_2 by 5% and GHG by 4%. However, fluctuations in the GHG emission level are large.

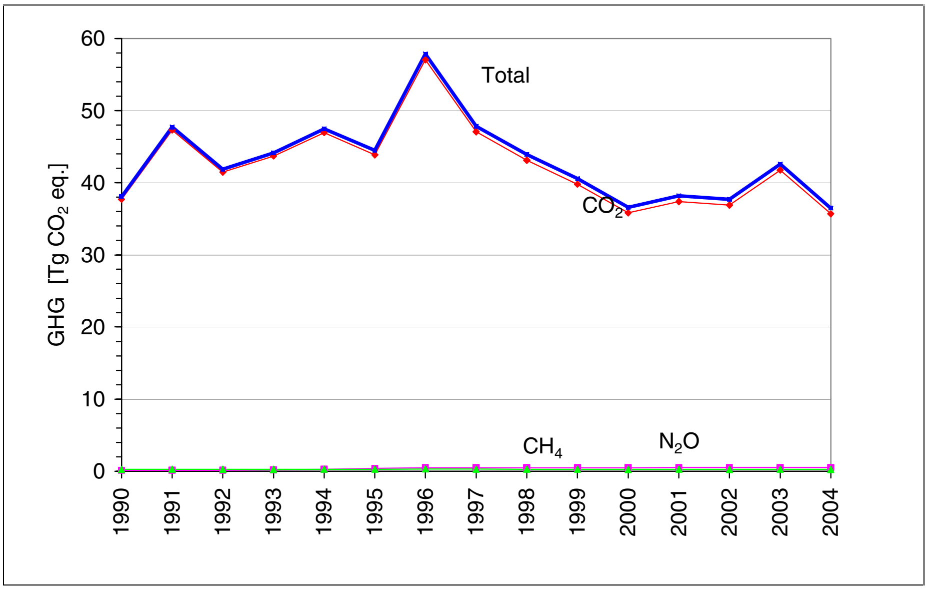

Figure 3A-6 GHG emission time-series for stationary combustion.

The fluctuations in the time-series are mainly a result of electricity import/export activity, but also of outdoor temperature variations from year to year. The fluctuations follow the fluctuations in fuel consumption discussed in Chapter 3.

Figure 3A-7 shows the corresponding time-series for degree days, electricity trade and CO_2 emission. As mentioned in Chapter 3, the Danish Energy Authority estimates 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 illustrated in Figure 3A-7. 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 23% since 1990, and the CO_2 emission by 24%.

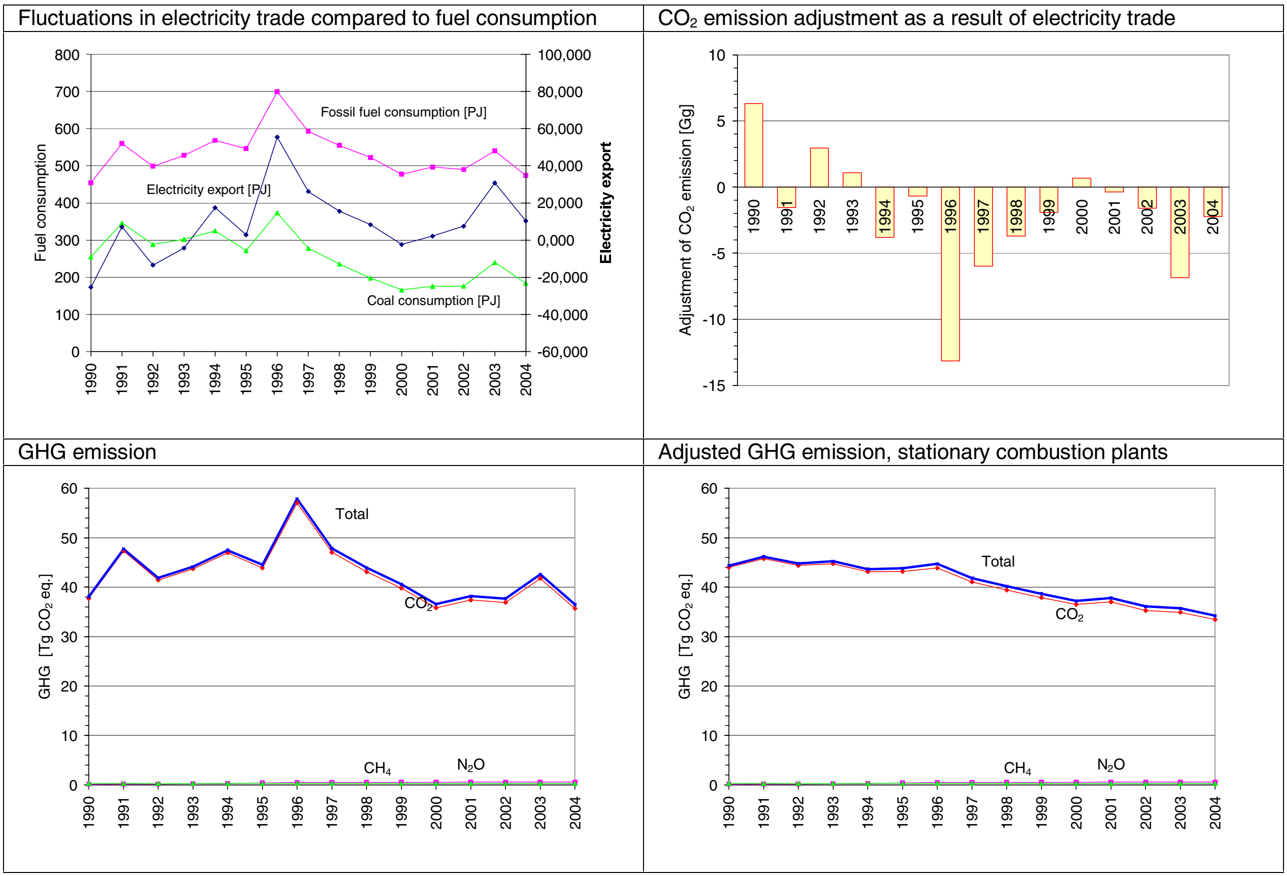

Figure 3A-7 GHG emission time-series for stationary combustion, adjusted for electricity import/export (DEA 2005b).

4.1 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 66% of the total Danish CO_2 emission. Table 3A-12 lists the CO_2 emission inventory for stationary combustion plants for 2004. Figure 3A-8 reveals that *Electricity and heat production* accounts for 63% of the CO_2 emission from stationary combustion. This share is somewhat higher than the fossil fuel consumption share for this sector, which is 60% (Figure 3A-1). Other large CO_2 emission sources are industrial plants and residential plants. These are the sectors which also account for a considerable share of fuel consumption.

Table 3A-12 CO_2 emission from stationary combustion plants 2004 [1)]

CO_2	**2004**	
1A1a Public electricity and heat production	22832	Gg
1A1b Petroleum refining	988	Gg
1A1c Other energy industries	1567	Gg
1A2 Industry	4929	Gg
1A4a Commercial / Institutional	956	Gg
1A4b Residential	3768	Gg
1A4c Agriculture / Forestry / Fisheries	631	Gg
Total	**35670**	**Gg**

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

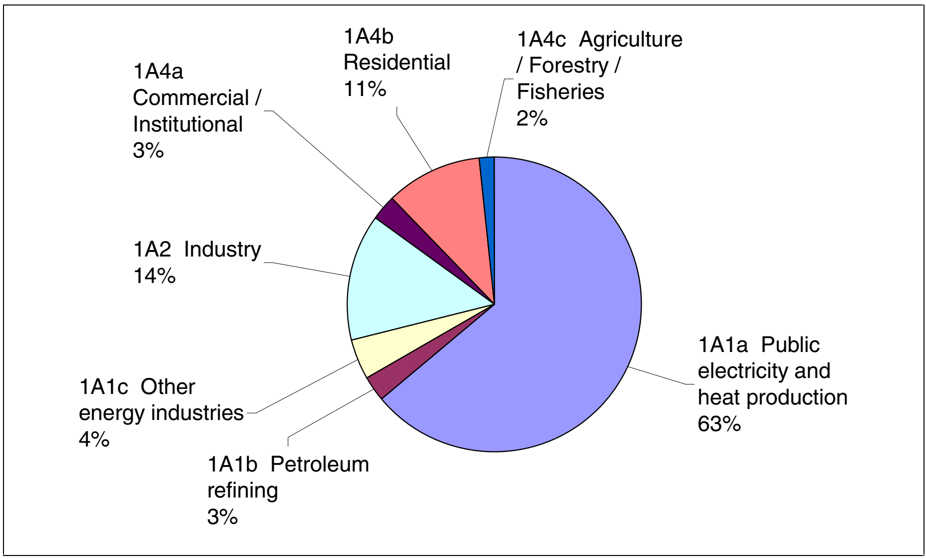

Figure 3A-8 CO_2 emission sources, stationary combustion plants, 2004.

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 listed in Table 3A-13. The most important subsector is power plant boilers >300MW.

Table 3A-13 CO_2 emission from subsectors to *1A1a Electricity and heat production*.

SNAP source	SNAP name	2004	
0101	Public power	0	Gg
010101	Combustion plants ≥ 300MW (boilers)	17 508	Gg
010102	Combustion plants ≥ 50MW and < 300 MW (boilers)	910	Gg
010103	Combustion plants <50 MW (boilers)	203	Gg
010104	Gas turbines	2 402	Gg
010105	Stationary engines	1 528	Gg
0102	District heating plants	-	Gg
010201	Combustion plants ≥ 300MW (boilers)	7	Gg
010202	Combustion plants ≥ 50MW and < 300 MW (boilers)	58	Gg
010203	Combustion plants <50 MW (boilers)	188	Gg
010204	Gas turbines	-	Gg
010205	Stationary engines	27	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 Climate Convention reporting. In 2004, the CO_2 emission from biomass combustion was 9 647 Gg.

In Figure 3A-9 the fuel consumption share (fossil fuels) is compared with the CO_2 emission share disaggregated to fuel origin. Due to the higher CO_2 emission factor for coal than oil and gas, the CO_2 emission share from coal combustion is higher than the fuel consumption share. Coal accounts for 39% of the fossil fuel consumption and for 49% of the CO_2 emission. Natural gas accounts for 41% of the fossil fuel consumption but only 31% of the CO_2 emission.

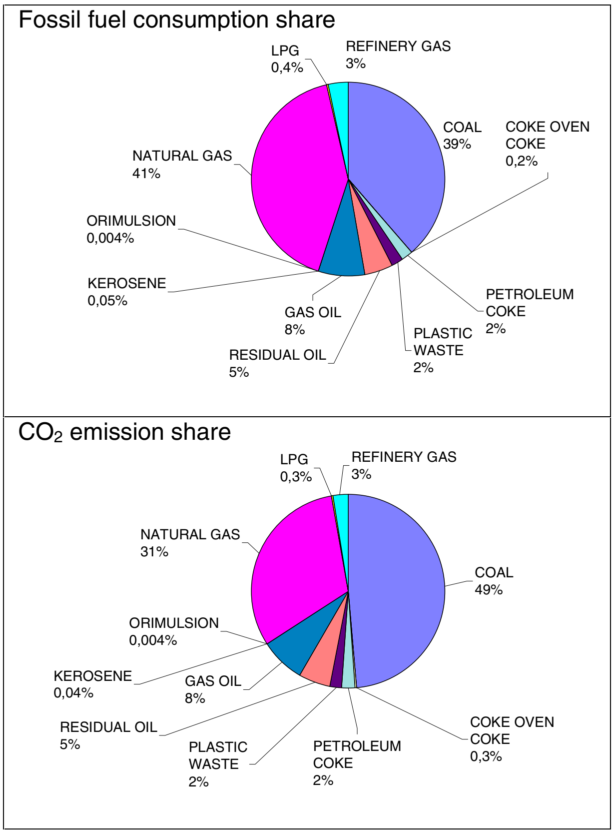

Figure 3A-9 CO_2 emission, fuel origin.

Time-series for the CO_2 emission are provided in Figure 3A-10. Despite an increase in fuel consumption of 13% since 1990 CO_2, the emission from stationary combustion has decreased by 5.4% because of the change of fuel type used.

The fluctuations in total CO_2 emission follow the fluctuations in CO_2 emission from *Electricity and heat production* (Figure 3A-10) and in coal consumption (Figure 3A-11). The fluctuations are the result of electricity import/export activity as discussed in Chapter 3.

Figure 3A-11 compares the time-series for fossil fuel consumption and the CO_2 emission. As mentioned above, the consumption of coal has decreased whereas the consumption of natural gas, with a lower CO_2 emission factor, has increased. Total fossil fuel use increased by 4% between 1990 and 2004.

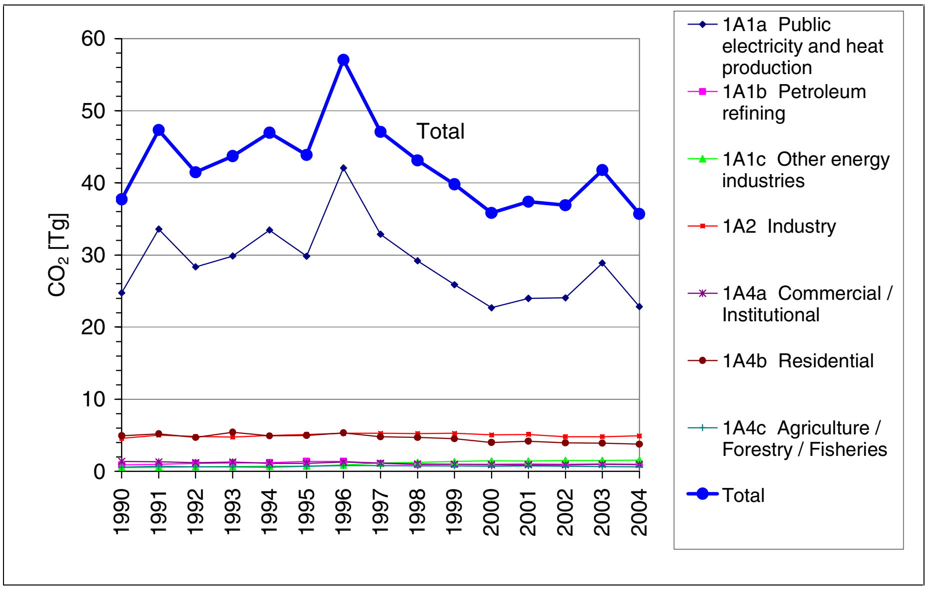

Figure 3A-10 CO_2 emission time-series for stationary combustion plants.

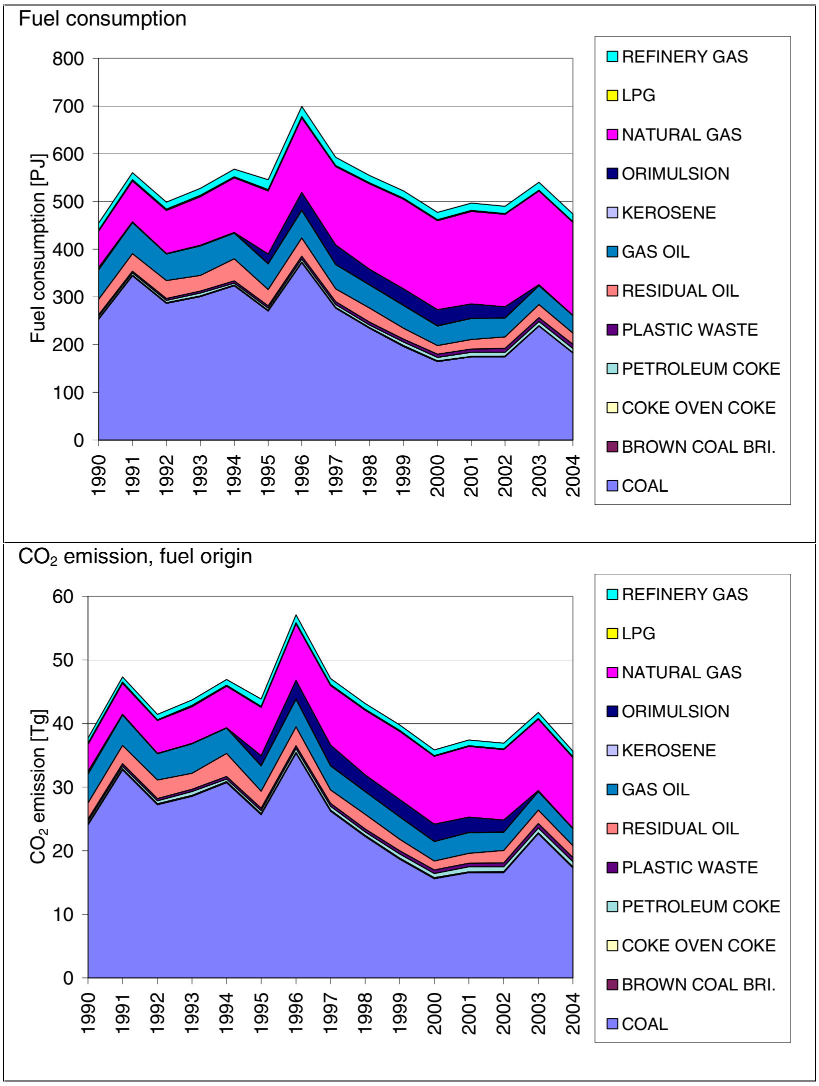

Figure 3A-11 Fossil fuel consumption and CO_2 emission time-series for stationary combustion.

4.2 CH_4

CH_4 emission from stationary combustion plants accounts for 9% of the total Danish CH_4 emission. Table 3A-14 lists the CH_4 emission inventory for stationary combustion plants in 2004. Figure 3A-12 reveals that *Electricity and heat production* accounts for 62% of the CH_4 emission from stationary combustion, this being closely aligned with fuel consumption share.

Table 3A-14 CH_4 emission from stationary combustion plants 2004 [1)].

CH_4	2004	
1A1a Public electricity and heat production	15294	Mg
1A1b Petroleum refining	2	Mg
1A1c Other energy industries	69	Mg
1A2 Industry	1464	Mg
1A4a Commercial / Institutional	906	Mg
1A4b Residential	5057	Mg
1A4c Agriculture / Forestry / Fisheries	2071	Mg
Total	24863	Mg

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

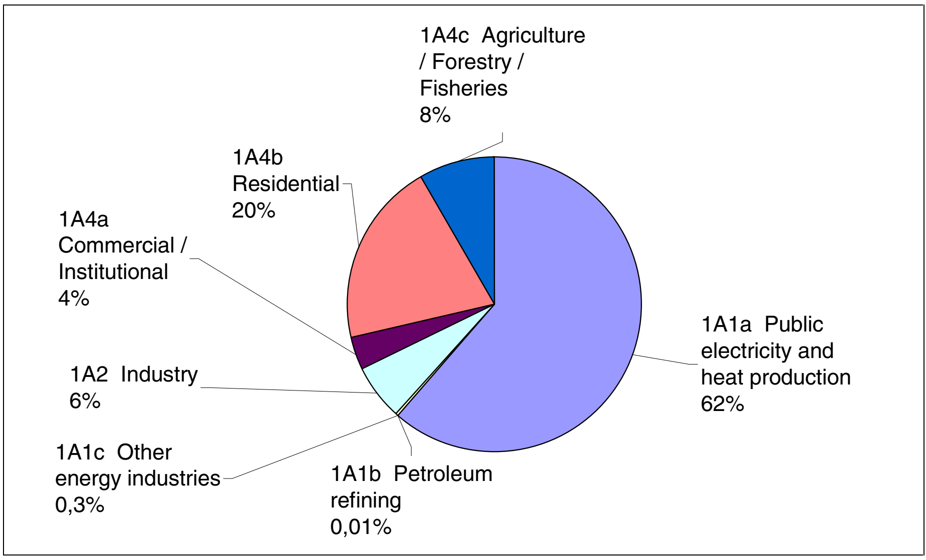

Figure 3A-12 CH_4 emission sources, stationary combustion plants, 2004.

The CH_4 emission factor for reciprocating gas engines is much higher than for other combustion plants due to the continuous ignition/burn-out of the gas. Lean-burn gas engines have an especially high emission factor, as discussed in Chapter 2.5.2. A considerable number of lean-burn gas engines are in operation in Denmark and these plants account for 74% of the CH_4 emission from stationary combustion plants (Figure 3A-13). The engines are installed in CHP plants and the fuel used is either natural gas or biogas.

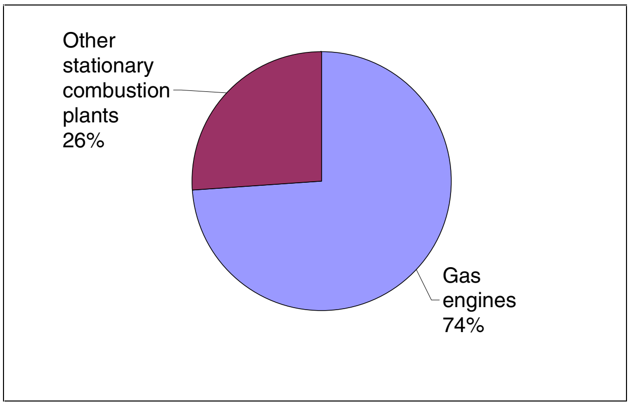

Figure 3A-13 Gas engine CH_4 emission share, 2004.

The CH_4 emission from stationary combustion increased by a factor of 4.3 since 1990 (Figure 3A-14). This results from the considerable number of lean-burn gas engines installed in CHP plants in Denmark in this period. Figure 3A-15 provides time-series for the fuel consumption rate in gas engines and the corresponding increase in the CH_4 emission.

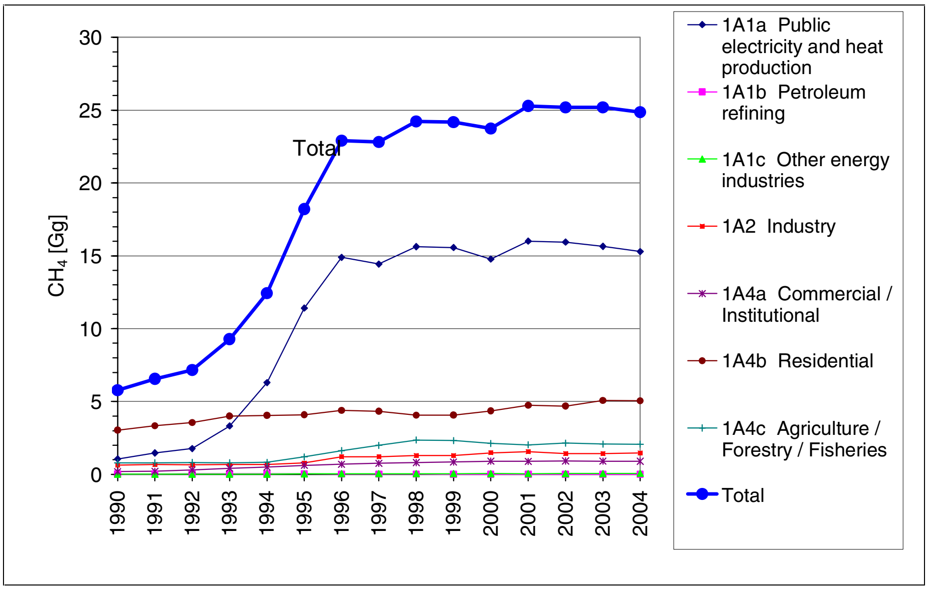

Figure 3A-14 CH_4 emission time-series for stationary combustion plants.

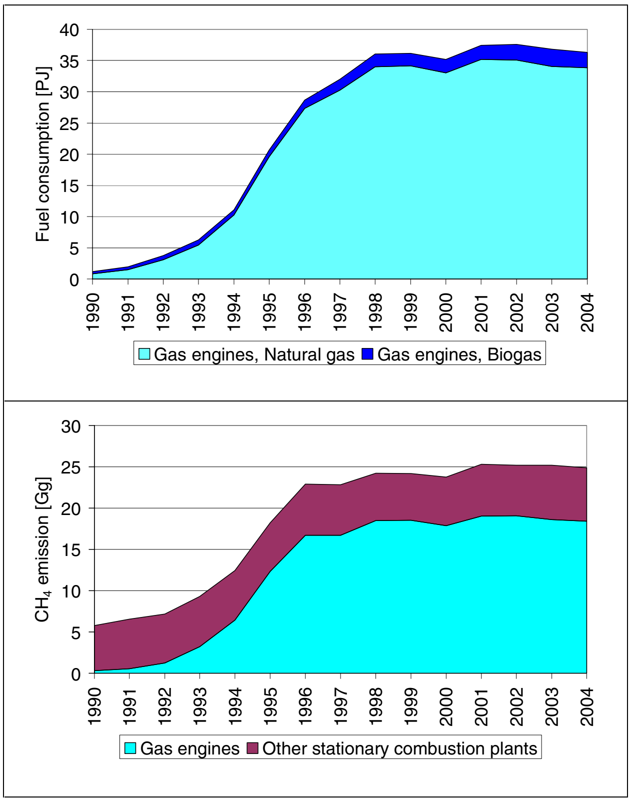

Figure 3A-15 Fuel consumption and CH_4 emission from gas engines, time-series.

4.3 N_2O

The N_2O emission from stationary combustion plants accounts for 4% of the total Danish N_2O emission. Table 3A-15 lists the N_2O emission inventory for stationary combustion plants in the year 2004. Since the last submission, the emission factor for coal-powered plants has been changed due to research by one of the major power plant operators in Denmark. Therefore, the emission for public power has significantly reduced. The emission factor is updated for the entire time-series. Figure 3A-16 reveals that *Electricity and heat production* accounts for 47% of the N_2O emission from stationary combustion.

Table 3A-15 N_2O emission from stationary combustion plants 2004 [1)].

N_2O	2004	
1A1a Public electricity and heat production	403	Mg
1A1b Petroleum refining	35	Mg
1A1c Other energy industries	60	Mg
1A2 Industry	150	Mg
1A4a Commercial / Institutional	25	Mg
1A4b Residential	167	Mg
1A4c Agriculture / Forestry / Fisheries	25	Mg
Total	**864**	Mg

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

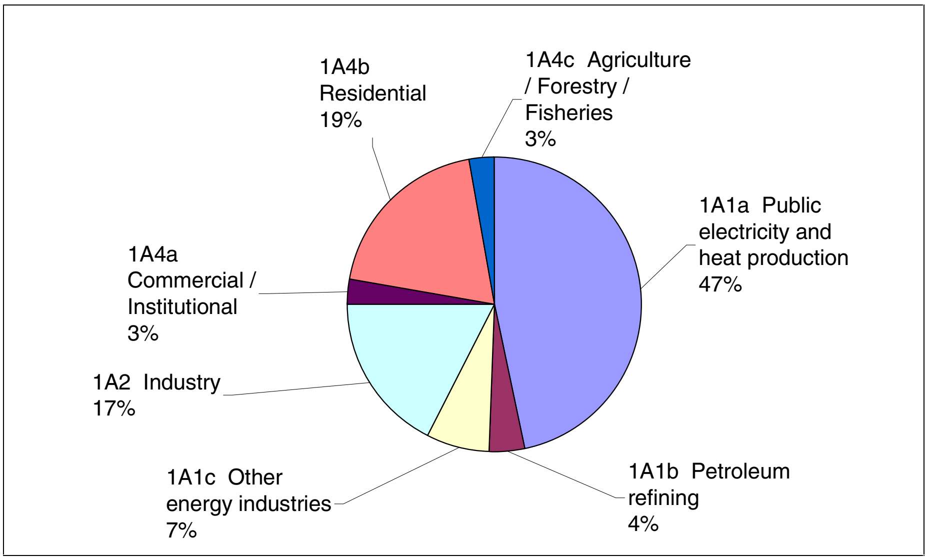

Figure 3A-16 N_2O emission sources, stationary combustion plants, 2004.

Figure 3A-17 shows time-series for N_2O emission. The N_2O emission from stationary combustion increased by 10% from 1990 to 2004, but again fluctuations in emission level due to electricity import/export are considerable.

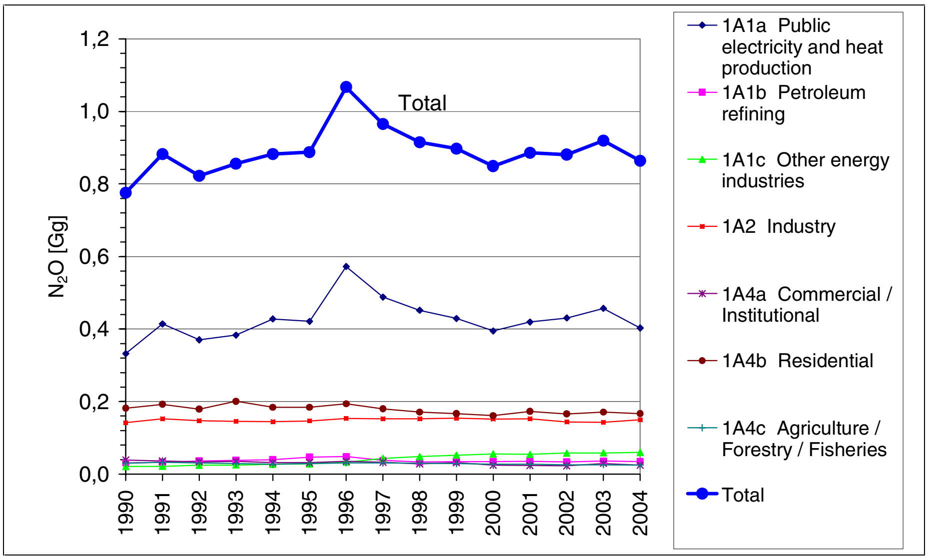

Figure 3A-17 N_2O emission time-series for stationary combustion plants.

5 SO_2, NO_X, NMVOC and CO

The emissions of SO_2, NO_X, NMVOC and CO from Danish stationary combustion plants 2004 are presented in Table 3A-16. The emission of these pollutants are also included in the report 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 41%, 35% and 17% of total Danish emissions, respectively.

Table 3A-16 SO_2, NO_X, NMVOC and CO emission from stationary combustion 2004 [1)].

Pollutant	NO_X Gg	CO Gg	NMVOC Gg	SO_2 Gg
1A1 Fuel consumption, Energy industries	52.7	12.1	4.1	10.2
1A2 Fuel consumption, Manufacturing Industries and Construction (Stationary combustion)	14.3	12.9	0.7	6.9
1A4 Fuel consumption, Other sectors (Stationary combustion)	7.3	180.3	14.7	3.2
Total emission from stationary combustion plants	**74.2**	**205.4**	**19.5**	**20.3**
Total Danish emission	181.3	587.3	116.5	24.4
		%		
Emission share for stationary combustion	41	35	17	83

1) Only emissions from stationary combustion plants in the sectors are included

5.1 SO_2

Stationary combustion is the most important emission source for SO_2, accounting for 83% of the total Danish emission. Table 3A-17 and Figure 3A-18 present 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. However, the SO_2 emission share is lower than the fuel consumption share for this sector, which is 60%. This is possibly due to effective flue gas desulphurisation equipment installed in power plants combusting coal. Figure 3A-19 shows the SO_2 emission from *Electricity and heat production* on a disaggregated level. Power plants >300MW_{th} represent the main emission source, accounting for 72% of the emission.

The fuel origin of the SO_2 emission is shown in Figure 3A-20. Disaggregation of total emissions from point sources using several fuels is based on emission factors. As expected, the emission from natural gas is negligible and the emission from coal combustion is considerable (51%). Most remarkable is the emission share from residual oil combustion, which is 25%. This emission is very high compared with the fuel consumption share of 4%. The emission factor for residual oil combusted in the industrial sector is uncertain because knowledge of the applied flue gas cleaning technology in this sector is insufficient.

The SO_2 emission from *Industry* is 34%, a remarkably high emission share compared with fuel consumption. The main emission sources in the industrial sector are combustion of coal and residual oil, but emissions from the cement industry also represent a considerable emission source. Some years ago, the SO_2 emission from the industrial sector only accounted for a small portion of the total emission, but as a result of reduced emissions from power plants the share has now increased.

Time-series for SO_2 emission from stationary combustion are shown in Figure 3A-21. The SO_2 emission from stationary combustion plants has decreased by 95% from 1980 and 84% from 1995. The large emission decrease is mainly a result of the reduced emission from *Electricity and heat production*, made possible due to installation of desulphurisation plants and due to the use of fuels with lower sulphur content. Despite the considerable reduction in emission from electricity and heat production plants, these still account for 48% of the total emission from stationary combustion, as mentioned above. The emission from other sectors also decreased considerably since 1980.

Table 3A-17 SO_2 emission from stationary combustion plants 2004 [1)].

SO_2	2004	
1A1a Public electricity and heat production	9765	Mg
1A1b Petroleum refining	422	Mg
1A1c Other energy industries	9	Mg
1A2 Industry	6927	Mg
1A4a Commercial / Institutional	264	Mg
1A4b Residential	1739	Mg
1A4c Agriculture / Forestry / Fisheries	1172	Mg
Total	20299	Mg

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

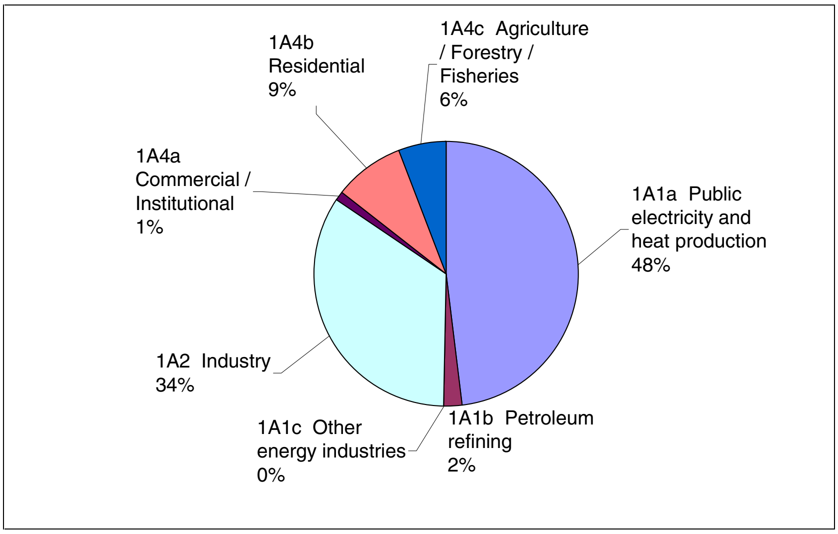

Figure 3A-18 SO_2 emission sources, stationary combustion plants, 2004.

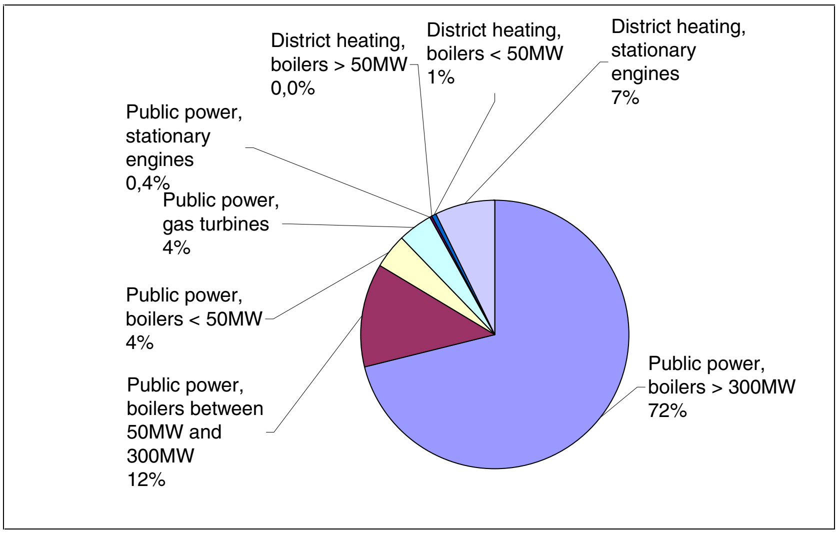

Figure 3A-19 Disaggregated SO_2 emissions from *Energy and heat production*.

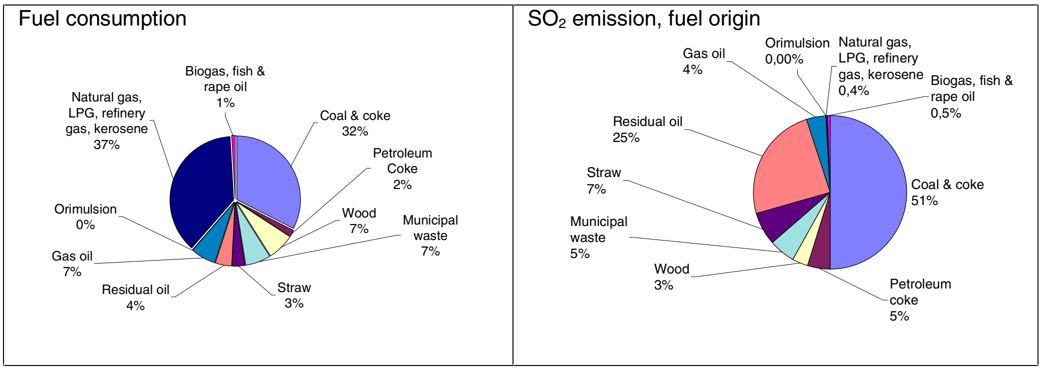

Figure 3A-20 Fuel origin of the SO_2 emission from stationary combustion plants.

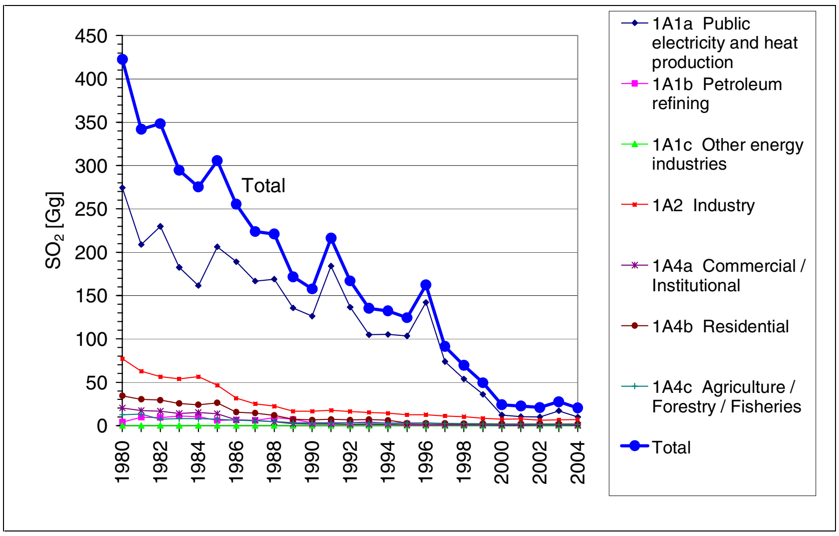

Figure 3A-21 SO_2 emission time-series for stationary combustion.

5.2 NO_X

Stationary combustion accounts for 41% of the total Danish NO_X emission. Table 3A-18 and Figure 3A-22 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.

Figure 3A-23 shows fuel origin of the NO_x emission from sector 1A1a Electricity and heat production. The fuel origin of the NO_x emission is almost the same as the fuel consumption in this plant category. The emission from coal combustion is, however, somewhat higher than the fuel consumption share.

Industrial combustion plants are also an important emission source, accounting for 19% of the emission. The main industrial emission source is cement production, accounting for 66% 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 43%, 27% and 23% of the residential plant emission, respectively.

Time-series for NO_x emission from stationary combustion are shown in Figure 3A-24. The NO_x emission from stationary combustion plants has decreased by 50% from 1985 and 33% from 1995. The reduced emission is largely 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 in the time-series follow the fluctuations in *Electricity and heat production*, which, in turn, result from electricity trade fluctuations.

Table 3A-18 NO_x emission from stationary combustion plants 2004 [1)].

	2004	
1A1a Public electricity and heat production	44 209	Mg
1A1b Petroleum refining	1 608	Mg
1A1c Other energy industries	6 843	Mg
1A2 Industry	14 265	Mg
1A4a Commercial / Institutional	1 087	Mg
1A4b Residential	4 881	Mg
1A4c Agriculture / Forestry / Fisheries	1 301	Mg
Total	**74 194**	Mg

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

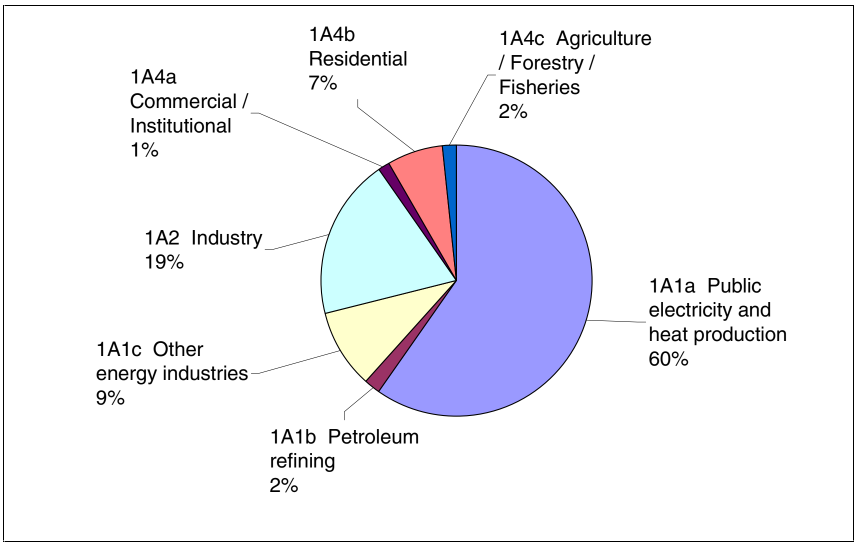

Figure 3A-22 NO_x emission sources, stationary combustion plants, 2004.

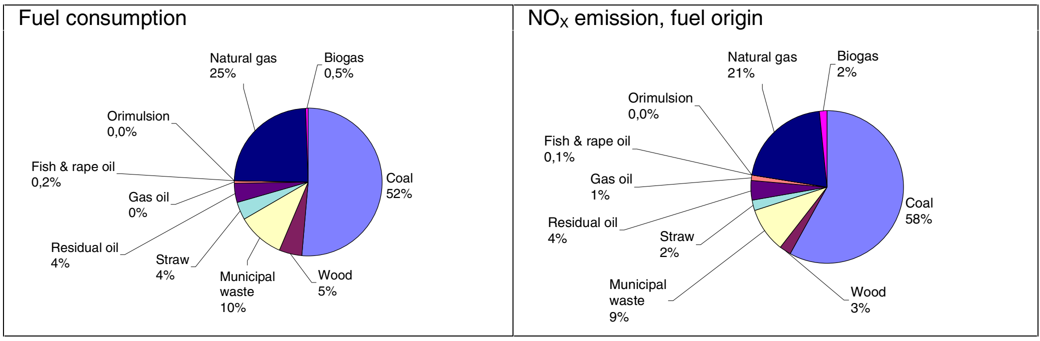

Figure 3A-23 NO_x emissions from 1A1a Electricity and heat production, fuel origin.

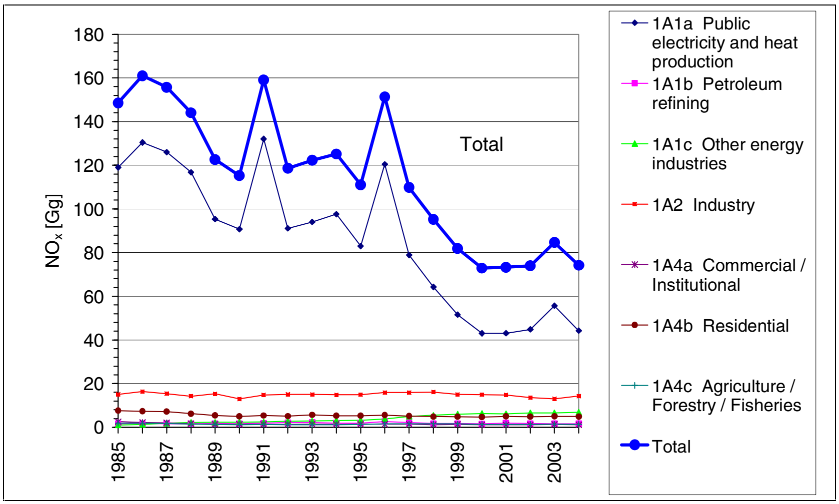

Figure 3A-24 NO_x emission time-series for stationary combustion.

5.3 NMVOC

Stationary combustion plants account for 17% of the total Danish NMVOC emission. Table 3A-19 and Figure 3A-25 present the NMVOC emission inventory for the stationary combustion subsectors.

Residential plants are the largest emission source accounting for 65% of the total emission from stationary combustion plants. For residential plants, NMVOC is mainly emitted from wood and straw combustion, see Figure 3A-26.

Electricity and heat production is also a considerable emission source, accounting for 21% of the total emission. Lean-burn gas engines have a relatively high NMVOC emission factor and are the most important emission source in this subsector (see Figure 3A-26). The gas engines are either natural gas or biogas fuelled.

Time-series for NMVOC emission from stationary combustion are shown in Figure 3A-27. The emission has increased by 51% from 1985 and 22% 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 7.2.

The emission from residential plants is 45% higher in 2004 than in 1990, but the NMVOC emission from wood combustion almost doubled since 1990 due to increased wood consumption. However the emission from straw combustion in farmhouse boilers has decreased over this period.

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

Table 3A-19 NMVOC emission from stationary combustion plants 2004 [1)].

	2004	
1A1a Public electricity and heat production	4 085	Mg
1A1b Petroleum refining	2	Mg
1A1c Other energy industries	41	Mg
1A2 Industry	652	Mg
1A4a Commercial / Institutional	573	Mg
1A4b Residential	12 558	Mg
1A4c Agriculture / Forestry / Fisheries	1 609	Mg
Total	19 519	Mg

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

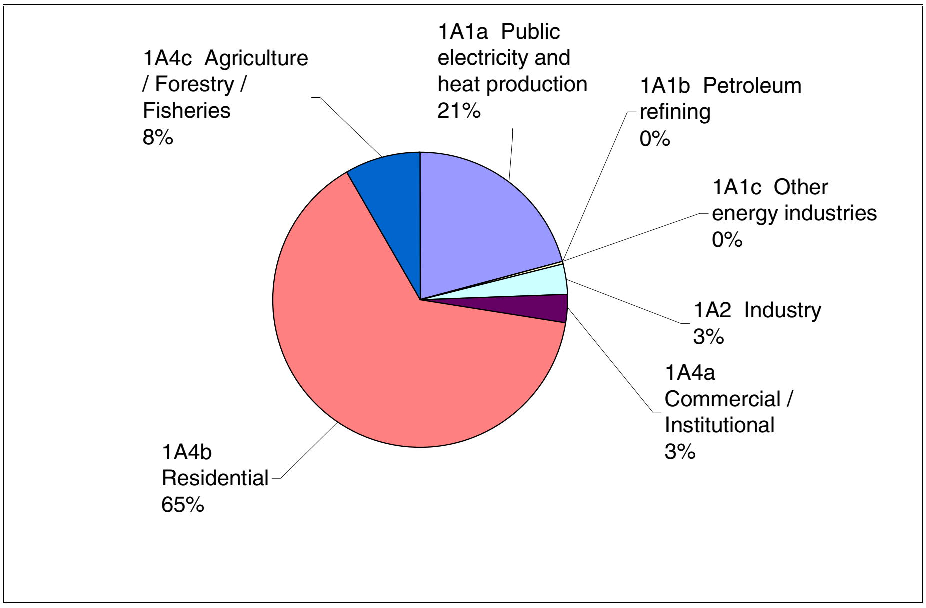

Figure 3A-25 NMVOC emission sources, stationary combustion plants, 2004.

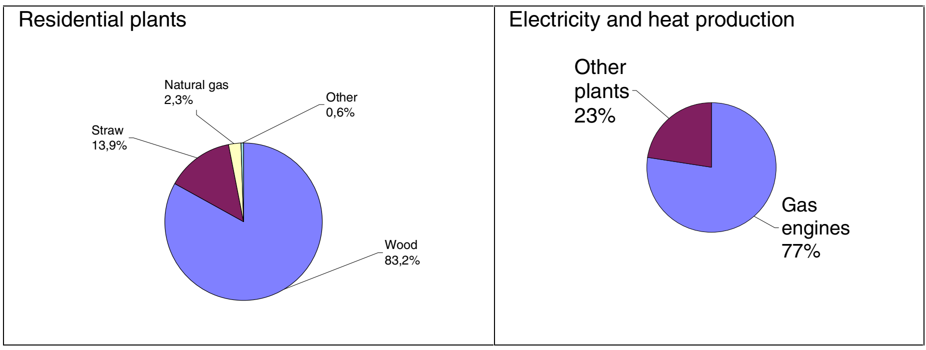

Figure 3A-26 NMVOC emission from residential plants and from electricity and heat production, 2004.

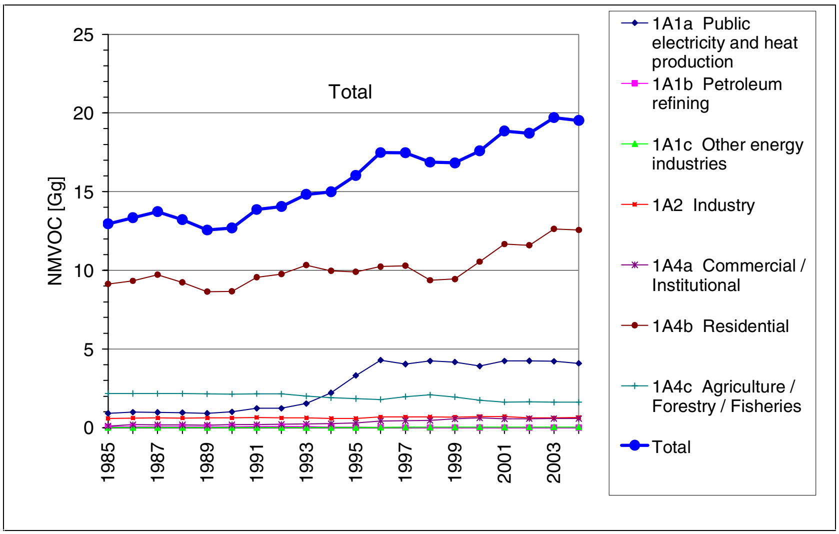

Figure 3A-27 NMVOC emission time-series for stationary combustion.

5.4 CO

Stationary combustion accounts for 35% of the total Danish CO emission. Table 3A-20 and Figure 3A-28 presents the CO emission inventory for stationary combustion subsectors.

Residential plants are the largest emission source, accounting for 84% of the emission. Wood combustion accounts for 92% of the emission from residential plants, see Figure 3A-29. This is in spite of the fact that the fuel consumption share is only 22%. Combustion of straw is also a considerable emission source, whereas the emission from other fuels used in residential plants is almost negligible.

Time-series for CO emission from stationary combustion are shown in Figure 3A-30. The emission has increased by 14% from 1985 and increased 9% from 1995. The time-series for CO from stationary combustion plants follows the time-series for CO emission from residential plants.

The consumption of wood in residential plants has increased by 94% since 1990 leading to an increase in the CO emission. The increase in the CO emission from residential plants is lower 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-20 CO emission from stationary combustion plants 2004 [1].

	2004	
1A1a Public electricity and heat production	11 708	Mg
1A1b Petroleum refining	237	Mg
1A1c Other energy industries	197	Mg
1A2 Industry	12 941	Mg
1A4a Commercial / Institutional	906	Mg
1A4b Residential	170 809	Mg
1A4c Agriculture / Forestry / Fisheries	8 561	Mg
Total	**205 360**	Mg

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

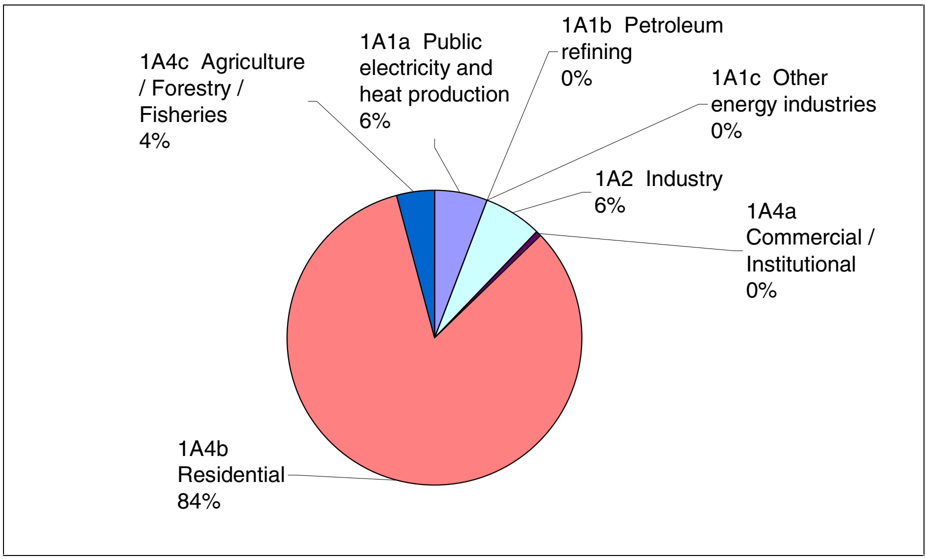

Figure 3A-28 CO emission sources, stationary combustion plants, 2004.

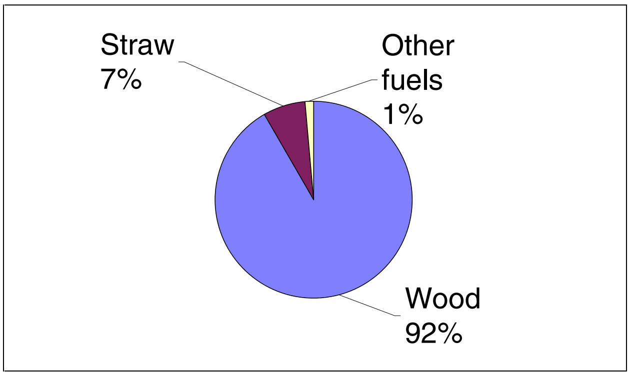

Figure 3A-29 CO emission sources, residential plants, 2004.

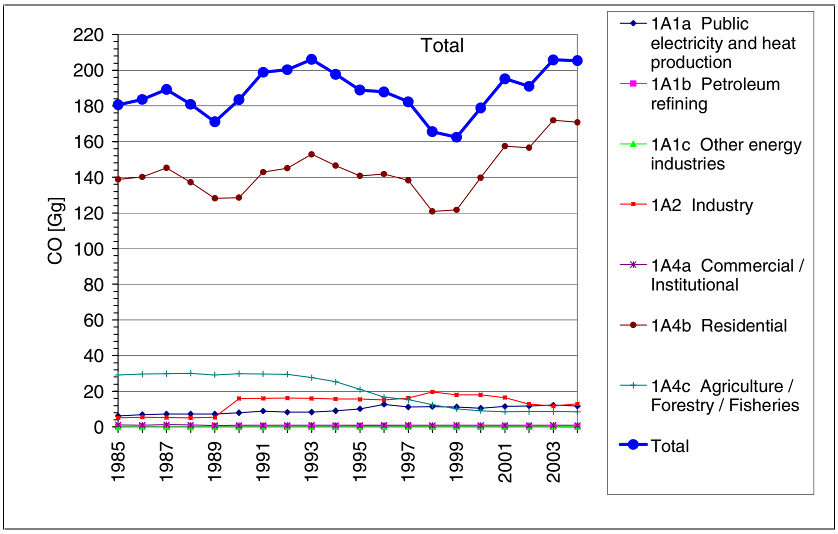

Figure 3A-30 CO emission time-series for stationary combustion.

6 QA/QC and validation

The elaboration of a formal QA/QC plan started in 2004. A first version is now available, Sørensen et al., 2005.

The quality manual describes the concepts of quality work and definitions of sufficient quality, critical control points and a list of Point for Measuring (PM). Please see the general chapter on QA/QC.

The QC is not fully implemented yet.

Data storage level 1

Table 3A-22 List of external data sources

Dataset	Description	AD or Emf.	Reference	Contact(s)	Data agreement/ Comment
Energiproducenttællingen.xls	Data set for all electricity and heat producing plants.	Activity data	The Danish Energy Authority (DEA)	Anders B. Hansen & Peter Dal	Data agreement in place
Gas consumption for gas engines and gas turbines 1990-1994		Activity data	DEA	Anders B. Hansen & Peter Dal	No data agreement. Historical data
Basic data (Grunddata.xls)	Data set used for IPCC reference approach	Activity data	DEA	Anders B. Hansen & Peter Dal	Not necessary. Published as part of national energy statistics
Energy statistics	The Danish energy statistics on SNAP level	Activity data	DEA	Anders B. Hansen & Peter Dal	Data agreement in place
SO_2 & NO_x data, plants>25 MW_e		Emissions	DEA	Marianne Nielsen	No data agreement in place
Emission factors	Emission factors stems from a large number of sources	Emission factors	See chapter regarding emission factors		
HM and PM from public power plants	Emissions from the two large power plant operator in DK Elsam & E2	Emissions	Elsam Energi E2	Helle M. Iversen & Egon Raun Hansen. Helle Herk-Hansen & Henrik Lous	No formal data agreement in place
Environmental reports	Emissions	Emissions	Various		No data

	from plants defined as large point sources		plants		agreement necessary. Plants are obligated by law.
Additional data	Fuel consumption and emissions from large industrial plants	AD & emissions	Aalborg Portland Statoil Shell	Henrik M. Thomsen Peder Nielsen Lis R. Rasmussen	No formal data agreement in place

Data Storage level 1	1. Accuracy	DS.1.1.1	General level of uncertainty for every dataset including the reasoning for the specific values

Since the DEA are responsible for the official Danish energy statistics as well as reporting to the IEA, NERI regards the data as being complete and in accordance with the official Danish energy statistics and IEA reporting. The uncertainties connected with estimating fuel consumption do not, therefore, influence the accordance between IEA data, the energy statistics and the dataset on SNAP level utilised by NERI. For the remainder of the datasets, it is assumed that the level of uncertainty is relatively low. For further comments regarding uncertainties, see Chapter 7.

Data Storage level 1	1. Accuracy	DS.1.1.2	Quantification of the uncertainty level of every single data value including the reasoning for the specific values.

The uncertainty for external data is not quantified. The uncertainties of activity data and emission factors are quantified see Chapter 7.

Data Storage level 1	2.Comparability	DS.1.2.1	Comparability of the data values with similar data from other countries, which are comparable with Denmark, and evaluation of discrepancy.

On the external data the comparability has not been checked. However, at CRF level a project has been carried out comparing the Danish inventories with those of other countries.

Data Storage level 1	3.Completeness	DS.1.3.1	Documentation showing that all possible national data sources are included by setting up the reasoning for the selection of datasets.

See the above table for an overview of external datasets.

Danish Energy Authority

Statistic on fuel consumption from district heating and power plants

A spreadsheet from DEA listing fuel consumption of all plants included as large point sources in the emission inventory. The statistic on fuel consumption from district heating and power plants is regarded as complete and with no significant uncertainty since the plants are bound by law to report their fuel consumption and other information.

Gas consumption for gas engines and gas turbines 1990-1994

For the years 1990-1994 DEA has estimated consumption of natural gas and biogas in gas engines and gas turbines. NERI assesses that the estimation by the DEA are the best available data.

Basic data
A spreadsheet from DEA used for the CO_2 emission calculation in accordance with the IPCC reference approach. It is published annually on DEA's webpage; therefore, a formal data delivery agreement is not deemed necessary.

Energy statistics on SNAP level
The DEA reports fuel consumption statistics on SNAP level based on a correspondence table developed in co-operation with NERI. Both traded and non-traded fuels are included in the Danish energy statistics. Thus, for example, estimation of the annual consumption of non-traded wood is included. Petroleum coke, purchased abroad and combusted in Danish residential plants (border trade), is added to the apparent consumption of petroleum coke and the emissions are included in the inventory.

Emissions from non-energy use of fuels have not been included in the Danish inventory, to date, but the non-energy use of fuels is, however, included in the reference approach for Climate Convention reporting.

SO_2 and NO_x emission data from electricity producing plants > 25MWe
Plants larger than 25 MW_e are obligated to report emission data for SO_2 and NO_x to the DEA annually. Data is on block level and are classified. The data on plant level are part of the plants annually environmental reports. NERI's QC of the data consists of a comparison with data from previous years and with data from the plants' annual environmental reports.

Emission factors from a wide range of sources
For specific references, see the chapter regarding emission factors.

Data for emission of heavy metals and particles from central power plants, Elsam and Energi E2
The two major Danish power plant operators assess heavy metal emissions from their plants using model calculations based on fuel data and type of flue gas cleaning. NERI's QC of the data consists of a comparison with data from previous years and with data from the plants' annual environmental reports.

Annual environmental reports from plants defined as large point sources
A large number of plants are obligated by law to publish an environmental report annually with information on, among other things, emissions. NERI compares data with those from previous years large discrepancies are checked.

Supplementing data from large industrial combustion plants
Fuel consumption and emissions from a few large industrial combustion plants are obtained directly from the plants. NERI compares the data with those from previous years and large discrepancies are checked.

Data Storage level 1	4.Consistency	DS.1.4.1	The origin of external data has to be preserved whenever possible without explicit arguments (referring to other PM's)

It is ensured that all external data are archived at NERI. Subsequent data processing takes place in other spreadsheets or databases. The datasets are archived annually in order to ensure that the basic data for a given report are always available in their original form.

Data Stor-age level 1	6.Robustness	DS.1.6.1	Explicit agreements between the external institution of data delivery and NERI about the condition of delivery

For stationary combustion a data delivery agreement is made with the DEA. Most of the other external data sources are available due to legislatory requirements. See table.

Data Stor-age level 1	7.Transparency	DS.1.7.1	Summary of each dataset including the reasoning for selecting the specific dataset

See DS 1.3.1

Data Stor-age level 1	7.Transparency	DS.1.7.3	References for citation for any external data set have to be available for any single number in any dataset.

See table 3A-22 for general references. Much documentation already exists. However, some of the information used is classified and therefore not publicly available.

Data Stor-age level 1	7.Transparency	DS.1.7.4	Listing of external contacts for every dataset

See Table 3A-22.

Data Processing Level 1

Data Processing level 1	1. Accuracy	DP.1.1.1	Uncertainty assessment for every data source as input to Data Stor-age level 2 in relation to type of variability. (Distribution as: normal, log normal or other type of variability)

The uncertainty assessment of activity data and emission factors and discussed in the chapter concerning uncertainties.

Data Processing level 1	1. Accuracy	DP.1.1.2	Uncertainty assessment for every data source as input to Data Stor-age level 2 in relation to scale of variability (size of variation inter-vals)

The uncertainty assessment of activity data and emission factors are discussed in the chapter concerning uncertainties.

Data Processing level 1	1. Accuracy	DP.1.1.3	Evaluation of the methodological approach using international guidelines

The methodological approach is consistent with international guidelines.

Data Processing level 1	1. Accuracy	DP.1.1.4	Verification of calculation results using guideline values

Calculated emission factors are compared with guideline emission factors to ensure that they are within reason.

Data Processing level 1	2.Comparabilit y	DP.1.2.1	The inventory calculation has to follow the international guidelines suggested by UNFCCC and IPCC.

The calculations follow the principle in international guidelines.

Data Processing level 1	3.Completeness	DP.1.3.1	Assessment of the most important quantitative knowledge which is lacking.

Regarding the distribution of energy consumption for industrial sources, a more detailed and frequently updated data material would be preferred. There is ongoing work to increase the accuracy and completeness of this sector. It is not assessed that this has any influence on the emission of greenhouse gases.

Data Processing level 1	3.Completeness	DP.1.3.2	Assessment of the most important cases where accessibility to critical data sources that could improve quantitative knowledge is missing.

There is no missing accessibility to critical data sources.

Data Processing level 1	4.Consistency	DP.1.4.1	In order to keep consistency at a higher level, an explicit description of the activities needs to accompany any change in the calculation procedure.

A change in calculation procedure would entail that an updated description would be elaborated.

Data Processing level 1	5.Correctness	DP.1.5.1	Show at least once, by independent calculation, the correctness of every data manipulation.

During data processing it is checked that calculations are done correctly. However, documentation for this needs to be elaborated.

Data Processing level 1	5.Correctness	DP.1.5.2	Verification of calculation results using time-series

A time-series for activity data on SNAP level, as well as emission factors, is used to identify possible errors in the calculation procedure.

Data Processing level 1	5.Correctness	DP.1.5.3	Verification of calculation results using other measures

The IPCC reference approach validates the fuel consumption rates and CO_2 emissions of fuel combustion. Fuel consumption rates and CO_2 emissions differ by less than 1.55% (1990-2004). The reference approach is further discussed below.

Data Processing level 1	5.Correctness	DP.1.5.4	Show one-to-one correctness between external data sources and the databases at Data Storage level 2.

There is a direct line between the external datasets, the calculation process and the input data used to Data Storage level 2. During the calculation process numerous controls are in place to ensure correctness, e.g. sum checks of the various stages in the calculation procedure.

Data Processing level 1	7.Transparency	DP.1.7.1	The calculation principle and equations used must be described.
Data Processing level 1	7.Transparency	DP.1.7.2	The theoretical reasoning for all methods must be described.
Data Processing level 1	7.Transparency	DP.1.7.3	Explicit listing of assumptions behind all methods

Where appropriate, this is included in the present report with annexes.

Data Processing level 1	7.Transparency	DP.1.7.4	Clear reference to dataset at Data Storage level 1

There is a clear line between the external data and the data processing.

Data Processing level 1	7.Transparency	DP.1.7.5	A manual log to collect information about recalculations

At present, a manual log table is not in place on this level. However, this feature will be implemented in the future. A manual log table is incorporated in the national emission database, Data Storage level 2.

Data Storage level 2	5.Correctness	DS.2.5.1	Documentation of a correct connection between all data types at level 2 to data at level 1

To ensure a correct connection between data on level 2 to data on level 1, different controls are in place, e.g. control of sums and random tests.

Data Storage level 2	5.Correctness	DS.2.5.2	Check if a correct data import to level 2 has been made.

Data import is checked by use of sum control and random testing. The same procedure is applied every year in order to minimise the risk of data import errors.

Other QC procedures

- The emission from each large point source is compared with the emission reported the previous year.
- Some automated checks have been prepared for the emission databases:
  - Check of units for fuel rate, emission factors and plant-specific emissions
  - Check of emission factors for large point sources. Emission factors for pollutants that are not plant-specific should be the same as those defined for area sources.
  - Additional checks on database consistency
- Most emission factor references are now incorporated in the emissions database, itself.
- Annual environmental reports are kept for subsequent control of plant-specific emission data.
- QC checks of the country-specific emission factors have not been performed, but most factors are based on input from companies that have implemented some QA/QC work. The two major power plant owners / operators in Denmark, E2 and Elsam, both obtained the ISO 14001 certification for an environmental management system. The Danish Gas Technology Centre and Force both run accredited laboratories for emission measurements.

Suggested QA/QC plan for stationary combustion

The following points make up the list of QA/QC tasks to be carried out directly in relation to the stationary combustion part of the Danish emission inventories. The time plan for the individual tasks has not yet been made.

Data storage level 1

- A fully comprehensive list of references for emission factors and activity data.
- A comparison with external data from other countries in order to evaluate discrepancies.

Data processing level 1

- Documentation list of model and independent calculations to test every single mathematical relation

6.1 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 originate from the annual "basic data" table prepared by the Danish Energy Authority and published on their homepage (DEA 2004b). 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, this approach being for the purposes of verification.

The Climate Convention reporting tables include a comparison of the national approach and the reference approach estimates. To make results comparable, the CO_2 emission from incineration of the plastic content of municipal waste is added in the reference approach. Further consumption for non-energy purposes is subtracted in the reference approach, because non-energy use of fuels is not, as yet, included in the Danish national approach. In the new CRF table format, it is no longer possible to add the CO2 emission from combustion of the plastic part of municipal waste to the reference approach, nor is it possible to subtract fuel consumption for non-energy use of fuels. Therefore, the results will no longer be directly comparable. The results presented in this year's inventory use the old method. From next year onwards, this will be changed to reflect the new CRF table format.

Three fuels are used for non-energy purposes: lube oil, bitumen and white spirit. The total consumption for non-energy purposes is relatively low – 12.2 PJ in 2004.

In 2004, the fuel consumption rates in the two approaches differ by 0.04% and the CO_2 emission differs by 0.04%. In the period 1990-2004 fuel consumption and the CO_2 emission differ by less than 1.55%. The differences are below 1% for all years except 1998. According to IPCC Good Practice Guidance (IPCC 2000), the difference should be within 2%. The reference approach for 2004 and the comparison with the Danish national approach are provided in Appendix 3A-10. The appendix also includes a correspondence list for the fuel categories (Danish Energy Authority/IPCC reference approach).

A comparison of the national approach and the reference approach is illustrated in Figure 3A-32.

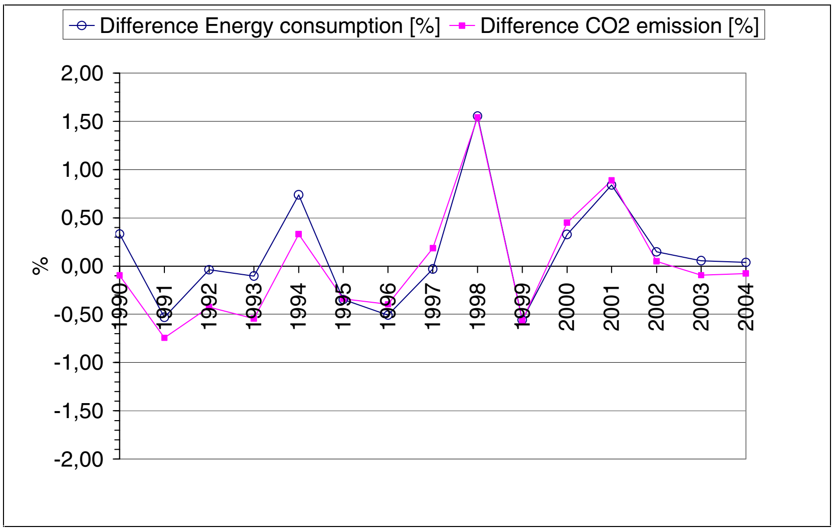

Figure 3A-32 Comparison of the reference approach and the national approach.

6.2 External review

The second national external review of the annually updated sector report for stationary combustion was performed in 2005 by Bo Sander, Elsam Engineering. The review was performed after the reporting in 2005 and, thus, the improvements suggested by Bo Sander have only partly been included in the inventory presented in this report. In next year's report, the recommendations by Bo Sander are expected to be fully implemented.

6.3 Key source analysis

As part of the reporting for the Climate Convention a key source analysis for the Danish emission inventory has been performed. A key source has a significant influence on a country's total inventory of greenhouse gases in terms of the absolute level of emission, the trend in emissions, or both.

Stationary combustion key sources for greenhouse gases are shown in Table 3A-23. The CO_2 emission from eight different fuels is a key source in the Danish inventory. Furthermore, CH_4 emission is a level and trend key source due to the increase in the production of electricity from gas engines.

The key source analysis will be considered in the future QC for stationary combustion.

Table 3A-23 Key sources, stationary combustion

Source		Pollutant	Key source	Level or trend
CO_2 Emission from Stationary Combustion	Coal	CO_2	Yes	Level, Trend
CO_2 Emission from Stationary Combustion	Petroleum coke	CO_2	Yes	Level, Trend
CO_2 Emission from Stationary Combustion	Plastic waste	CO_2	Yes	Level, Trend
CO_2 Emission from Stationary Combustion	Residual oil	CO_2	Yes	Level, Trend
CO_2 Emission from Stationary Combustion	Gas oil	CO_2	Yes	Level, Trend
CO_2 Emission from Stationary Combustion	Kerosene	CO_2	Yes	Trend
CO_2 Emission from Stationary Combustion	Natural gas	CO_2	Yes	Level, Trend
CO_2 Emission from Stationary Combustion	Refinery gas	CO_2	Yes	Level
Non-CO_2 Emission from Stationary Combustion		CH_4	Yes	Level, Trend

7 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 with regard to the total emission inventory as well as uncertainty with regard to trends. The GHG emission from stationary combustion plants has been estimated with an uncertainty interval of ±7.8% and the decrease in the GHG emission since 1990 has been estimated to be 4.3% ± 2 %-age-points.

7.1 Methodology

The Danish uncertainty estimates for GHGs are based on a methodology included in IPCC Good Practice Guidance (IPCC 2000). The estimates are based on uncertainties for emission factors and fuel consumption rates, respectively. The input data required for the uncertainty calculations are:

- Emission data for the base year and the last year
- Uncertainty for activity rates
- Uncertainty for emission factors

7.1.1 Greenhouse gases

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

- CO_2 emission from each of the fuel categories applied
- 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 the CH_4 emission from gas engines and CH_4 emission from other plants does not follow the recommendations in the IPCC Good Practice Guidance. Disaggregation is applied, because the CH_4 emission from gas engines is much larger in Denmark than the emission from other stationary combustion plants, and the CH_4 emission factor for gas engines is estimated with a much smaller uncertainty level than for other stationary combustion plants.

Most of the uncertainty estimates applied 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. A country-specific uncertainty estimate will be estimated for future reporting.

Table 3A-24 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, BKB	CO_2	3 [1)]	5 [1)]
Stationary Combustion, Coke oven coke	CO_2	3 [1)]	5 [1)]
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 Good Practice Guidance (default value)
2) Kristensen (2001)
3) Jensen & Lindroth (2002)
4) NERI assumption

7.1.2 Other pollutants

With regard to other pollutants, IPCC methodologies for uncertainty estimates have been adopted for the LRTAP Convention reporting activities (Pulles & Aardenne 2003). The Danish uncertainty estimates are based on the simple Tier 1 approach.

The uncertainty estimates are based on emission data for the base year and year 2004 as well as on uncertainties for fuel consumption and emission factors for each of the main SNAP sectors. The base year is 1990. The applied uncertainties for activity rates and emission factors are default values referring to Pulles & Aardenne 2003. The default uncertainties for emission factors are given in letter codes representing an uncertainty range. It has been assumed that the uncertainties were in the lower end of the range for all sources and pollutants. The applied uncertainties for emission factors are listed in Table 3A-25. The uncertainty for fuel consumption in stationary combustion plants was assumed to be 2%.

Table 3A-25 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

7.2 Results

The uncertainty estimates for stationary combustion emission inventories are shown in Table 3A-26. Detailed calculation sheets are provided in Appendix 3A-7.

The uncertainty interval for GHG is estimated to be ±7.8% and the uncertainty for the trend in GHG emission is ±2%-age points. The main sources of uncertainty for the GHG emission are N_2O emission (all plants) and CO_2 emission from coal combustion. The main source of uncertainty in the trend in the GHG emission is the CO_2 emission from the combustion of coal and natural gas.

The total emission uncertainty is 7% for SO_2, 16% for NO_x, 39% for NMVOC and 44% for CO.

Table 3A-26 Danish uncertainty estimates, 2004.

Pollutant	Uncertainty Total emission [%]	Trend 1990-2004 [%]	Uncertainty Trend [%-age points]
GHG	7.8	-4.3	± 2.0
CO_2	2.7	-5.4	± 1.7
CH_4	39	331	± 316
N_2O	1 000	11.4	± 3.5
SO_2	7	-87.1	±0.6
NO_X	16	-36	±2.0
NMVOC	39	54	±13
CO	44	19	±4.1

8 Improvements/recalculations since reporting in 2005

Improvements and recalculations since the 2004 emission inventory include:

- Update of fuel rates according to the latest energy statistics. The update included the years 1980-2003.
- The emission factor for N_2O for coal-powered plants in SNAP categories 0101xx has been updated based on new research.
- White spirit has been relocated to its own category instead of using the fuel category Other oil in the IPCC reference approach.
- The criteria for including a plant as a point source has been defined and included in this submission.

9 Future improvements

Some planned improvements of the emission inventories are discussed below.

1) Improved documentation for CO_2 emission factors

The CO_2 emission factors applied for the Danish inventories are considered accurate, but documentation will be improved in future inventories. The documentation will be improved when the large plants start reporting CO_2 emissions based on plant-specific CO_2 emission factors (2006).

2) QA/QC and validation

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

4) Uncertainty estimates

Uncertainty estimates are based mainly on default uncertainty levels for activity rates and emission factors. More country-specific uncertainty estimates will be incorporated in future inventories.

10 Conclusion

The annual Danish emission inventories are prepared and reported by NERI. The inventories are based on the Danish energy statistics and on a set of emission factors for various sectors, technologies and fuels. Plant-specific emissions for large combustion sources are incorporated in the inventories.

Since 1990 fuel consumption has increased by 13% – fossil fuel consumption, however, has only increased by 4.2%. The use of coal has decreased, whereas the use of natural gas and renewable fuels has increased. The Danish fuel consumption fluctuates due to variation in the import/export of electricity from year to year.

Stationary combustion plants account for 54% of the total Danish GHG emission. 66% of the Danish CO_2 emission originates from stationary combustion plants, whereas stationary combustion plants account for 9% of the CH_4 emission and 4% of the N_2O emission.

Public power plants represent the most important stationary combustion emission source for CO_2, SO_2 and NO_X.

Lean-burn gas engines installed in decentralised CHP plants are the largest stationary combustion emission source for CH_4. Furthermore, these plants are also a considerable emission source for NMVOC.

Residential plants represent the most important stationary combustion source for CO and NMVOC. Wood combustion in residential plants is the predominant emission source.

The greenhouse gas emission (GHG) development follows the CO_2 emission development closely. Both the CO_2 and the total GHG emission was lower in 2004 than in 1990, CO_2 by 5% and GHG by 4%. However, fluctuations in the GHG emission level are large. The fluctuations in the time-series are a result of electricity import/export and of outdoor temperature variations from year to year.

The CH_4 emission from stationary combustion has increased by a factor of 4.3 since 1990. This is a result of the considerable number of lean-burn gas engines installed in CHP plants in Denmark during this period.

The SO_2 emission from stationary combustion plants has decreased by 84% since 1995. The considerable emission decrease is largely a result of the reduced emission from electricity and heat production due to installation of desulphurisation technology and the use of fuels with lower sulphur content.

The NO_X emission from stationary combustion plants has decreased by 33% since 1995. The reduced emission is mainly a result of the reduced emission from electricity and heat production. The fluctuations in the emission time-series follow fluctuations in electricity import/export.

The uncertainty level for the Danish greenhouse gas emission from stationary combustion is estimated to be within a range of ±7.8% and the trend uncertainty within a range of ±2.0%-age points. The sources contributing the most to the uncertainty estimates are the N_2O emission (all plants) and the CO_2 emission from coal combustion.

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Appendix

Appendix 3A-1: The Danish emission inventory for the year 2003 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-10: Emission inventory 2003 based on SNAP sectors

Appendix 3A-1 The Danish emission inventory for the year 2004 reported to the Climate Convention

Table 3A-25 The Danish emission inventory for the year 2004 reported to the Climate Convention in 2006.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES		CO2 emissions	CO2 removals	CH4	N2O	HFCs(1)		PFCs(1)		SF6	
						P	A	P	A	P	A
		(Gg)		CO2 equivalent (Gg)						(Gg)	
Total National Emissions and Removals		**53.938,31**	**-2.279,62**	**273,28**	**24,47**	**1.437,66**	**748,96**	**2,11**	**15,90**	**0,00**	**0,00**
1. Energy		**52.093,87**		**32,70**	**2,40**						
A. Fuel Combustion	Reference Approach (2)	50.735,33									
	Sectoral Approach (2)	51.485,49		27,86	2,39						
1. Energy Industries		25.387,80		15,37	0,50						
2. Manufacturing Industries and Construction		5.841,04		1,51	0,19						
3. Transport		12.858,60		2,57	1,40						
4. Other Sectors		7.159,03		8,40	0,29						
5. Other		239,02		0,01	0,01						
B. Fugitive Emissions from Fuels		608,39		4,84	0,01						
1. Solid Fuels		0,00		0,00	0,00						
2. Oil and Natural Gas		608,39		4,84	0,01						
2. Industrial Processes		**1.731,23**		**0,00**	**1,71**	**1.437,66**	**748,96**	**2,11**	**15,90**	**0,00**	**0,00**
A. Mineral Products		1.728,22		0,00	0,00						
B. Chemical Industry		3,01		0,00	1,71	0,00	0,00	0,00	0,00	0,00	0,00
C. Metal Production		0,00		0,00	0,00				0,00		0,00
D. Other Production (3)		NE									
E. Production of Halocarbons and SF6							0,00		0,00		0,00
F. Consumption of Halocarbons and SF6						1.437,66	748,96	2,11	15,90	0,00	0,00
G. Other		0,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
3. Solvent and Other Product Use		111,17			0						
4. Agriculture		0	0	176,85	20,19						
A. Enteric Fermentation				129,07							
B. Manure Management				47,78	1,81						
C. Rice Cultivation				0							
D. Agricultural Soils				0	18,38						
E. Prescribed Burning of Savannas				0	0						
F. Field Burning of Agricultural Residues				0	0						
G. Other				0	0						
5. Land-Use Change and Forestry		0	-2279,6218	0	0						
A. Changes in Forest and Other Woody Biomass Stocks		0	-3449,4167								
B. Forest and Grassland Conversion		0		0	0						
C. Abandonment of Managed Lands		0	0								
D. CO_2 Emissions and Removals from Soil		1028,17	0								
E. Other		141,62	0	0	0						
6. Waste		2,04		63,73	0,17						
A. Solid Waste Disposal on Land		0		51,13							
B. Wastewater Handling				12,61	0,17						
C. Waste Incineration		0		0	0						
D. Other		2,04		0,00	0,00						
7. Other *(please specify)*		0	0	0	0	0	0	0	0	0	0

Memo Items: (7)											
International Bunkers		4991,90		0,10	0,25						
Aviation		2447,40		0,05	0,08						
Marine		2544,50		0,06	0,16						
Multilateral Operations		0,00		0	0						
CO2 Emissions from Biomass		9646,95									

Appendix 3A-2 IPCC/SNAP source correspondence list

Table 3A-26 Correspondence list for IPCC source categories 1A1, 1A2 and 1A4 and SNAP (EMEP/Corinair 2004).

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 [2)]	Other equipments (stoves, fireplaces, cooking,...) [2)]	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 industry)(f)	1A2f
030313	Asphalt concrete plants	1A2f
030314	Flat glass (f)	1A2f
030315	Container glass (f)	1A2f
030316	Glass wool (except binding) (f)	1A2f
030317	Other glass (f)	1A2f
030318	Mineral wool (except binding)	1A2f
030319	Bricks and tiles	1A2f
030320	Fine ceramic materials	1A2f
030321	Paper-mill industry (drying processes)	1A2d
030322	Alumina production	1A2b
030323	Magnesium production (dolomite treatment)	1A2b
030324	Nickel production (thermal process)	1A2b
030325	Enamel production	1A2f
030326	Other	1A2f
08 1)	Other mobile sources and machinery	
0804 1)	Maritime activities	
080403 1)	National fishing	1A4c
0806 1)	Agriculture	1A4c
0807 1)	Forestry	1A4c
0808 1)	Industry	1A2f
0809 1)	Household and gardening	1A4b

1) Not stationary combustion. Included in a IPCC sector that also includes stationary combustion plants
2) Stoves, fireplaces and cooking is included in the sector 0202 or 020202 in the Danish inventory. It is not possible based on the Danish energy statistics to split the residential fuel consumption between stoves/fireplaces/cooking and residential boilers.

Appendix 3A-3 Fuel rate

Table 3A-27 Fuel consumption rate of stationary combustion plants [GJ].

fuel	fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
102	COAL	253443653	344299909	286838436	300798816	323397473	270346013	371908020	276277338	234284903	196471582	164707937	174308631	174654028	238978034	182496587
106	BROWN COAL BRI.	115931	166823	95324	128246	91500	74609	56053	54331	47745	37606	25748	32903	18922	3056	0
107	COKE OVEN COKE	1275912	1449734	1181054	1154538	1226146	1272909	1226000	1253015	1346306	1422574	1187177	1109591	1068454	995409	1143051
110	PETROLEUM COKE	4459523	4403568	4814028	6179382	4308897	4849824	6381422	6523131	5797915	7283513	7291583	8313464	8281655	8465315	8878130
111	WOOD AND SIMIL.	18246813	20042437	21030660	22220198	21939961	21844810	23389205	23459225	22937838	24402569	26744717	29277912	29370315	35670110	38918149
114	MUNICIP. WASTES	15499033	16744033	17797251	19409907	20312344	22906324	24952440	26770061	26590826	29138335	30351595	32233660	35056955	36493642	36931453
117	STRAW	12481150	13306150	13880150	13366000	12662374	13053145	13545634	13911770	13903701	13668183	12219993	13698193	15651212	16718510	17938819
118	SEWAGE SLUDGE											40162	0	64508	55369	58266
203	RESIDUAL OIL	32115776	37019676	37331786	32498181	46701347	34069407	38484606	26693239	29479704	22987285	18049577	20248975	24751387	27208796	23488761
204	GAS OIL	61449256	64998154	56102476	62025402	53930105	53698269	58018611	51071033	48425146	47555370	41259963	43814958	38918286	39377307	36649389
206	KEROSENE	5086021	943393	783765	771272	649577	580777	539748	436636	417009	255606	169963	286786	256128	338430	214577
210	NAPHTA															
215	RAPE & FISH OIL	744000	744000	744000	800000	245419	250912	60409	13751	13619	27148	49046	191475	126772	258882	650447
225	ORIMULSION						19913113	36766527	40488416	32580001	34190632	34148181	30243677	23846404	1921399	18719
301	NATURAL GAS	76092457	86106669	90466659	102475053	114585627	132698559	156276599	164489313	178706886	187876815	186121970	193826826	193608713	196444240	195076156
303	LPG	2597544	2550099	2316450	2371906	2399717	2639678	2869571	2362592	2412781	2176932	1885313	1609877	1477458	1554215	1668540
308	REFINERY GAS	14169000	14537000	14865000	15405000	16359999	20837864	21476000	16945381	15225340	15723812	15556268	15755428	15197000	16554512	15890576
309	BIOGAS	752001	910000	898999	1077001	1279488	1753645	1985110	2390005	2635029	2612573	2870670	3020152	3331898	3551061	3634921
Total		**498528069**	**608221645**	**549146038**	**580680902**	**620089974**	**600789857**	**757935954**	**653139237**	**614804749**	**585830535**	**542679863**	**567972508**	**565680095**	**624588287**	**563656541**

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	2003	2004
1A1a	102	COAL	0101	8523090	12892052	10175750	8221270											
1A1a	102	COAL	010101	219780959	303105248	252745120	269458670	295430108	244510483	347251766	252648133	211429498	176640613	146911420	158990462	161608390	225396935	167930883
1A1a	102	COAL	010102	2118951	2653700	2250130	2269060	8604699	8380814	9032905	8671429	9022776	8238010	6224846	4970502	4684578	4578267	4511500
1A1a	102	COAL	010103					837469	526213	149470	38928	24300	33747	35480	24354	15476	33831	23637
1A1a	102	COAL	010104					272428	269521	301136	74422							
1A1a	102	COAL	010105					20360										
1A1a	102	COAL	0102	6017000	6635000	5173000	3581000	0	0	0	0							
1A1a	102	COAL	010201					153003	20286									
1A1a	102	COAL	010202					1112251	789684	199724	64713	17914	371	371	1494	363	371	636
1A1a	102	COAL	010203					377837	316754	228340	48919	48071	6562	3551	439	0	0	0
1A1a	110	PETROLEUM COKE	0101				1239000											
1A1a	110	PETROLEUM COKE	010102															7130
1A1a	111	WOOD AND SIMIL.	0101			172000	515000											
1A1a	111	WOOD AND SIMIL.	010101					42966				263719	0		920	65930	304980	231380
1A1a	111	WOOD AND SIMIL.	010102			0	0	1053223	865377	861821	1001257	1371873	2377322	2274825	2186568	3175531	5854505	5626990
1A1a	111	WOOD AND SIMIL.	010103					623575	671570	578451	644712	575350	732058	669817	747047	780123	446474	1061917
1A1a	111	WOOD AND SIMIL.	010104					78890	4410							120031	1656898	4488031
1A1a	111	WOOD AND SIMIL.	010105										1674	53468	60394	61748	369	0
1A1a	111	WOOD AND SIMIL.	0102	3217000	3648000	4096000	3751000	0	0	0	0							
1A1a	111	WOOD AND SIMIL.	010201					8537										
1A1a	111	WOOD AND SIMIL.	010202					44	43575	164768	190941	207278	193907	179937	249689	164347	196112	620370
1A1a	111	WOOD AND SIMIL.	010203					3337730	3490933	3857403	3795439	3971995	3928219	3882223	4297719	4650874	5066279	4798365
1A1a	114	MUNICIP. WASTES	0101	990000	3563000	5578000	8433000											
1A1a	114	MUNICIP. WASTES	010101									1288015	1278184	1230861	2809020	3502130	143440	0
1A1a	114	MUNICIP. WASTES	010102		0	0	0	5110126	6527009	7152947	10831534	11715082	16937780	18305718	17902293	19002825	22524122	24730336
1A1a	114	MUNICIP. WASTES	010103					2909656	3755268	5002562	3074395	1957053	4039009	8361289	8343163	8321439	7848203	7885256
1A1a	114	MUNICIP. WASTES	010104					1665338	2027577	3191968	3025187	2806452	2452693	416975	0	0	625367	0
1A1a	114	MUNICIP. WASTES	010105											0	0	0	0	0
1A1a	114	MUNICIP. WASTES	0102	13567000	12142000	11111000	9839000	0	0	0	0							
1A1a	114	MUNICIP. WASTES	010201					6980										
1A1a	114	MUNICIP. WASTES	010202					3472288	3703267	4646064	4649086	4617704						
1A1a	114	MUNICIP. WASTES	010203					5908716	5559213	3698956	3978326	3458148	2915393	1395589	2195038	2430354	2570284	2282380
1A1a	117	STRAW	0101	479000	985000	1487000	1643000											
1A1a	117	STRAW	010101					100254	82215	610290	740153	1013770	1339800	1119600	1587710	2643060	3191917	4366424
1A1a	117	STRAW	010102	0	0	0	0	621557	1286956	1704388	1845052	1751935	1819429	1826796	1746166	1640945	1712033	1815157
1A1a	117	STRAW	010103					1126908	1297258	1361686	1174181	1180826	1058038	640340	1905033	1754340	1927521	1336411
1A1a	117	STRAW	010104												101730	1215692	1706623	2476858
1A1a	117	STRAW	0102	3524000	3843000	3915000	3806000	0	0	0	0							
1A1a	117	STRAW	010201					22040										
1A1a	117	STRAW	010202					57304	179930	114376	95990	136488	141564	150510	97600	0	0	95414
1A1a	117	STRAW	010203					3378461	3409001	3699694	3564019	3525786	3565456	3290636	3418313	3555625	3338866	3007005
1A1a	203	RESIDUAL OIL	0101	774830	364138	1742448	741228							0	0	0	0	0
1A1a	203	RESIDUAL OIL	010101	7171573	10052580	8691120	8420050	22142392	11174241	16072213	7736420	11557361	7213503	4045724	5950549	5018057	7329328	5577981
1A1a	203	RESIDUAL OIL	010102	42265	16950	27100	24390	180490	253891	443479	420683	510374	762923	513002	253635	278953	334256	595816
1A1a	203	RESIDUAL OIL	010103					252297	173028	201180	159318	115535	101551	108599	117384	120150	106040	17155
1A1a	203	RESIDUAL OIL	010104					320163	347198	237194	302167	355440	118177	117319	1767903	6694775	9358988	7484444
1A1a	203	RESIDUAL OIL	010105	9332	9332	9332	9332	11554	4323	4888	2415	5984	4136	17206	533	656	5900	1681
1A1a	203	RESIDUAL OIL	0102	2006000	2236000	1141000	879000	0	0	0	0							
1A1a	203	RESIDUAL OIL	010202					134116	172981	171395	140565	102376	135957	58729	86854	122795	83920	34421
1A1a	203	RESIDUAL OIL	010203					858909	938696	1201058	874538	779146	961623	625296	611665	547566	323210	208183
1A1a	204	GAS OIL	0101	239170	416396	641323	245263							0	0	0	0	0
1A1a	204	GAS OIL	010101					12386	51300	41614	194854	108730	258004	135602	122718	92395	956997	220146
1A1a	204	GAS OIL	010102	0	0	0	0	42898	30019	153012	113506	82184	158532	278595	366847	279069	114717	138782
1A1a	204	GAS OIL	010103					59149	40405	78104	41727	44468	61232	0	34258	36567	16629	14604
1A1a	204	GAS OIL	010104	43987	43987	43987	43987	43987	75632	81094	54042	146795	60385	103191	40026	75242	79241	80590
1A1a	204	GAS OIL	010105	16843	32617	34690	34750	116493	136913	99083	100449	133710	108002	68733	84634	66390	63501	106919
1A1a	204	GAS OIL	0102	1941000	813000	744000	947000	0	0	0	0							
1A1a	204	GAS OIL	010201					27268	7000									92649

1A1a	204	GAS OIL	010202					174046	360676	799818	514978	418139	257831	694229	830045	166763	256178	418842
1A1a	204	GAS OIL	010203					843648	444369	554844	509625	652349	296296	233116	354842	306816	1125856	492537
1A1a	204	GAS OIL	010205					717					1055	0	0	0	0	5416
1A1a	215	RAPE & FISH OIL	010102															521
1A1a	215	RAPE & FISH OIL	010103					33707	24000	21799	188	5212	6974				2168	54570
1A1a	215	RAPE & FISH OIL	010105															1819
1A1a	215	RAPE & FISH OIL	0102	744000	744000	744000	800000											
1A1a	215	RAPE & FISH OIL	010202														18807	4662
1A1a	215	RAPE & FISH OIL	010203					211712	226912	38610	13563	8407	20174	48900	190810	126336	237665	588875
1A1a	225	ORIMULSION	010101						19913113	36766527	40488416	32580001	34190632	34148181	30243677	23846404	1921399	18719
1A1a	301	NATURAL GAS	0101								5511	21264	16787	14558	11364	2	1188	1521
1A1a	301	NATURAL GAS	010101	4005028	4394781	3279455	4422200	8437973	10453816	12217008	14600070	20808855	21307826	23541558	20514966	19246614	20165293	19287200
1A1a	301	NATURAL GAS	010102	0	0	0	0	295111	299964	1346036	5620044	5987198	2416146	1589836	4250088	2893468	1877463	1581768
1A1a	301	NATURAL GAS	010103					2487008	1775265	1558418	1138214	958646	716525	683789	733694	657392	1057907	837246
1A1a	301	NATURAL GAS	010104	1859206	2396900	4806049	7327221	7776734	8547638	14500109	12220262	13002948	21614378	22973678	25003005	30030786	29928352	30713112
1A1a	301	NATURAL GAS	010105	677767	1291319	2199496	4168579	8358415	16419956	22162423	24109208	26700713	26833951	25639911	27865345	27701651	27012113	26392308
1A1a	301	NATURAL GAS	0102	11033000	13655000	12350000	11420000	0	0	0	0	0						
1A1a	301	NATURAL GAS	010202					1072469	1017168	844253	660506	539227	282207	217700	286968	291201	278471	428248
1A1a	301	NATURAL GAS	010203					6160497	5525191	3803076	2420020	1988837	1873511	1427019	1768484	1482319	1849960	1611725
1A1a	301	NATURAL GAS	010205					131795	338556	377124	230400	235829	226189	203414	228049	207211	171691	473922
1A1a	303	LPG	0101		1000	1000	3000											
1A1a	303	LPG	010103						736	0								
1A1a	303	LPG	0102	9000	13000	10000	0	0	0		0							
1A1a	303	LPG	010203					2732					9	246	0	0	0	0
1A1a	308	REFINERY GAS	010101							35204	40077							
1A1a	309	BIOGAS	0101	141178	218984	29049	41826											
1A1a	309	BIOGAS	010101					16910	419	24075	19550							
1A1a	309	BIOGAS	010102	0	0	0	0	9835	0	94326	40561	50269	29597	25771	23338	20466	21787	16857
1A1a	309	BIOGAS	010103					54324	118012	79237	111449	86924	103711	134968	123991	90125	97272	78245
1A1a	309	BIOGAS	010104			78865	89233	199961	169040	6536								
1A1a	309	BIOGAS	010105	94822	175016	251085	405941	415191	599387	826301	1229745	1548936	1500477	1548734	1589322	1686300	1704661	1435085
1A1a	309	BIOGAS	0102	30000	30000	53000	53000	0	0	0	0							
1A1a	309	BIOGAS	010203					45538	43775	54145	33623	31287	25003	21733	11129	12650	17130	23466
1A1a	309	BIOGAS	010205					40607										36380
1A1b	203	RESIDUAL OIL	010306	1309202	2038140	3568653	3490237	3336717	2333787	2244019	1622382	1106086	1089501	1322995	1442929	1362640	907082	1071635
1A1b	204	GAS OIL	010306		40029	44476	29125	49319	33321	21879	87482						3085	9469
1A1b	303	LPG	010306		0	4600		8004	15042	20654	18492							
1A1b	308	REFINERY GAS	0103	458000	926000	1526000	15917											
1A1b	308	REFINERY GAS	010304				2067083	2355000	2289700	5069590	4081532	2996106	4172606	3907567	3978922	3855200	3804097	3796653
1A1b	308	REFINERY GAS	010306	13520108	13485940	13236820	13213580	14004999	18548164	16336522	12771044	12202506	11551206	11648701	11776506	11341800	12750415	12093923
1A1c	204	GAS OIL	010505													151	116	114
1A1c	301	NATURAL GAS	010502	0	0	0	0	0	399247	390587	417415	413342	409043	340514	352650	379362	322831	360596
1A1c	301	NATURAL GAS	010504	9482284	9703068	11118697	11235480	12267791	12506433	14849859	19454575	21636547	23561526	25015663	24413386	26179968	26247274	27068915
1A1c	301	NATURAL GAS	010505	1760	3520	3520	3520	2570	4494	7551	4939	15340	13883	13889	11887	11473	12396	12395
1A1c	309	BIOGAS	010505	6803	6803	6803	6803	5946	51779	60257	57462	31144	29028	32507	28627	31216	31791	61257
1A2f	102	COAL	0301	8850301	8977254	6751419	7698631	5866929	4832666	4460978	4494493	4676030	3714902	3667193	3358610	2126818	2826288	3735874
1A2f	102	COAL	030102					614624	1051344	1449890	1466575	1405667	1411682	1063375	997381	998229	1569871	1498728
1A2f	102	COAL	030103					190179	182609	192925	192444	0						
1A2f	102	COAL	030311	5018873	6048697	6577274	6602369	6913652	7224934	7067609	7209034	6627624	5638061	5708047	4718458	4348589	3368675	3754171
1A2f	106	BROWN COAL BRI.	0301	4374	6680	3806	17714	2745	2031	1464	1025							
1A2f	107	COKE OVEN COKE	0301	1169318	1351052	1077654	1073318	1163151	286685	303658	295421	319382	380768	238247	223280	279401	276382	302127
1A2f	107	COKE OVEN COKE	030318						937440	885600	930960	1006560	1030320	943920	883440	786240	693360	814320
1A2f	110	PETROLEUM COKE	0301	300247	0	56107	122868	0	98156	110026	33598	25842	38999	285426	127924	223785	229902	180642
1A2f	110	PETROLEUM COKE	030311	2499252	2991306	3234048	3230652	3469025	3707398	4966161	5229890	4774684	6398880	6474743	7656733	7543476	7714392	8187958
1A2f	111	WOOD AND SIMIL.	0301	5783743	5690367	5750550	5821715	4464819	4254327	4097885	4166034	4273637	4250138	4450170	4596137	3313464	3523061	3530934
1A2f	111	WOOD AND SIMIL.	030102									1776	1496	955	950	0	0	0
1A2f	111	WOOD AND SIMIL.	030103					481414	412555	623748	523545	412235	413749	439542	430608	410827	294774	342172
1A2f	114	MUNICIP. WASTES	0301	28033	28033	37251	38907	26336	28516	27942	23857	28854	35287					
1A2f	114	MUNICIP. WASTES	030102									0				0	4602	0
1A2f	114	MUNICIP. WASTES	030311											505233	795492	1787613	1406393	1926563
1A2f	117	STRAW	0301									446	446					
1A2f	117	STRAW	030103						3085									

1A2f	117	STRAW	030105											386	91	0	0	0
1A2f	118	SEWAGE SLUDGE	030311											40162	0	64508	55369	58266
1A2f	203	RESIDUAL OIL	0301	16528584	17769972	17383144	14202407	13060233	11277994	11328646	9336208	8615100	7973673	7362935	7287922	7207646	5381688	5112335
1A2f	203	RESIDUAL OIL	030102					741775	911133	788578	789663	663124	695536	714099	791893	808652	1644621	1690130
1A2f	203	RESIDUAL OIL	030103					200248	207326	165590	122783	121633	135661	140375	89987	0	0	0
1A2f	203	RESIDUAL OIL	030104								54439		0	0	0	0	0	0
1A2f	203	RESIDUAL OIL	030105												22	10	787	302
1A2f	203	RESIDUAL OIL	030311	1762853	2152997	2366678	2397243	2618777	2840311	1771379	1863965	2538540	885967	858853	784	591804	587464	817378
1A2f	204	GAS OIL	0301	537931	1369948	1430556	951740	812691	1460371	2251856	1895198	1799389	2477807	2184410	3090543	2496543	2891632	2957087
1A2f	204	GAS OIL	030102						3438			440	1327	3138	5071	199	3574	2830
1A2f	204	GAS OIL	030103					1678	1453	11390	1015	1623	64	82107	19	0	0	0
1A2f	204	GAS OIL	030104								244	377	6787	51	0	897	0	0
1A2f	204	GAS OIL	030105			1447	1578	1578						103	511	0	0	0
1A2f	204	GAS OIL	030106	6098	6636	8644	2762	9433	7030	6743	8178	15603	70265	8070	9828	7066	6887	8716
1A2f	204	GAS OIL	030315								1040	603	4950	1650	2009	681	933	3802
1A2f	206	KEROSENE	0301	69635	45692	38315	35461	30485	24464	30937	27840	16078	8909	7552	25543	65146	48233	19836
1A2f	215	RAPE & FISH OIL	030105													334	242	0
1A2f	301	NATURAL GAS	0301	22280195	23780869	23887554	25535326	29248293	30317635	29252137	29423362	29114015	31167462	28607521	30958244	29348181	28485704	27524037
1A2f	301	NATURAL GAS	030102					862925	2661779	2464665	2971625	2961903	3100115	2690206	2869052	1190136	2273628	2295787
1A2f	301	NATURAL GAS	030103					300216	64308	146812	169825	131608	126872	116411	117965	14707	118562	124427
1A2f	301	NATURAL GAS	030104	506337	608907	664092	729919	761202	909952	2562511	3366152	5106083	6501018	6756339	6138931	6724144	6526151	6632596
1A2f	301	NATURAL GAS	030105	187	187	187	187	11210	172920	873431	960232	1157405	1160055	1556394	1641970	1545466	1543942	1570267
1A2f	301	NATURAL GAS	030106	136059	24239	37695	70154	53489	24415	15283	5288	31735	38608	50809	53712	25558	17229	22029
1A2f	301	NATURAL GAS	030315								924066	903336	1005440	1101274	1089048	1016242	945777	911205
1A2f	301	NATURAL GAS	030318						624960	590400	620640	671040	686880	629280	588960	524160	552240	606880
1A2f	303	LPG	0301	1577575	1690755	1590314	1452076	1559182	1739094	1920315	1596586	1623548	1355035	1019122	761460	677846	730090	749425
1A2f	308	REFINERY GAS	0301	190892	125060	102180	108420	0	0	34684	52728	26728						
1A2f	309	BIOGAS	0301	0	0	0	0	13014	126131	96199	117439	73558	32726	32593	27929	37953	33614	45593
1A2f	309	BIOGAS	030102					6534	16370	16478	19080	16361	16116	15755	59220	71672	95546	112700
1A2f	309	BIOGAS	030104						1052	1265	1137							
1A2f	309	BIOGAS	030105									381	269	1487	23805	18459	14205	16947
1A4a	102	COAL	0201	87539	9010	95877	75870	90286	66064	41260	43062	2306						1298
1A4a	106	BROWN COAL BRI.	0201	1025	1720		8217	769	622	421	309							
1A4a	110	PETROLEUM COKE	0201	62023	104190	90150	96354	91988	70415	90528	97770	70544	50434	12070	12086	5355	9003	0
1A4a	111	WOOD AND SIMIL.	0201	204488	204488	204488	204488	216160	273035	449435	471415	492803	642041	775926	665349	672399	673803	680953
1A4a	111	WOOD AND SIMIL.	020105									2096	2057		97	796	0	110
1A4a	114	MUNICIP. WASTES	0201	914000	1011000	1071000	1099000	1182354	1274551	1222406	1179697	709930	1472645	122160	175985	0	1296406	31068
1A4a	114	MUNICIP. WASTES	020103					30550	30923	9595	7979	9588	7344	13770	12669	12594	74825	75850
1A4a	203	RESIDUAL OIL	0201	1070494	865011	600545	517393	718786	677072	717757	729305	383913	450237	343022	173185	478286	174366	107544
1A4a	203	RESIDUAL OIL	020103					87533	78081									
1A4a	204	GAS OIL	0201	11794783	10622868	9062255	9007046	7156617	6556065	6619841	6093376	5442142	5781168	4957566	4685349	4031236	4288708	4411382
1A4a	204	GAS OIL	020102					190782		215		75						
1A4a	204	GAS OIL	020103					72		57796	58202	53618	39101	71306	44010	43890	29646	19369
1A4a	204	GAS OIL	020105			1361	1485	733	20330	1754	294	21	66	1277	673	743	727	756
1A4a	206	KEROSENE	0201	569083	209843	206978	188910	154647	124344	103314	96459	127964	117233	63008	79642	69668	74131	76734
1A4a	301	NATURAL GAS	0201	6376293	6934201	7382035	8908566	7343015	8436587	11247402	9106736	8661696	7525335	7233923	7323256	7623549	9190345	8942521
1A4a	301	NATURAL GAS	020103					2177			2434	49460	10801	43211	67208	165296	11053	50446
1A4a	301	NATURAL GAS	020104		0			11946	25798	31397	25514	22995	30739	23335	31001	42862	33669	22070
1A4a	301	NATURAL GAS	020105	45985	88875	278287	350372	473892	609395	681480	866185	959184	985839	1033132	1044813	1079590	1023163	1033012
1A4a	303	LPG	0201	82757	77097	76519	122201	125183	131001	137989	128417	116413	109573	121621	119345	136552	169985	214880
1A4a	303	LPG	020103									9						
1A4a	303	LPG	020105									803	771					21
1A4a	309	BIOGAS	0201	199072	179112	83895	64492	112893	169712	173026	271951	225094	292653	310904	354917	424989	321897	510454
1A4a	309	BIOGAS	020103							14474	39396	71226	74379	86680	84512	74286	85295	101260
1A4a	309	BIOGAS	020104						27092									
1A4a	309	BIOGAS	020105	270479	290438	386655	406059	349088	410626	389678	404594	439292	436918	506512	504222	528119	531465	517152
1A4b	102	COAL	0202	589051	1125243	866285	785646	618696	376644	85595	86470	127147	79262	14442	12906	15370	318	292
1A4b	106	BROWN COAL BRI.	0202	50600	66685	39107	80209	75963	62403	47324	48550	43847	37606	25748	32903	18922	3056	0
1A4b	107	COKE OVEN COKE	0202	106594	98682	103400	81220	62995	48784	36742	26634	20364	11486	5010	2871	2813	25667	26604
1A4b	110	PETROLEUM COKE	0202	760877	697484	961122	990337	747884	734273	928841	839269	725791	705961	513190	513393	509008	511264	502400
1A4b	111	WOOD AND SIMIL.	0202	8954432	10412432	10720472	11859632	11564240	11760665	12668890	12569082	11134265	11615182	13847545	15894835	15807245	17525175	17409247
1A4b	117	STRAW	0202	5086890	5086890	5086890	4750200	4413510	4076820	3633120	3891945	3773190	3442590	3111555	2901450	2901450	2901450	2901450

1A4b	203	RESIDUAL OIL	0202	216927	218605	167748	129878	95249	62794	66254	45933	43266	50365	35611	26881	148870	47430	44417
1A4b	204	GAS OIL	0202	46463224	50638393	42913606	49967084	43678618	43287857	45295557	39595464	37849748	35675468	30275667	31506271	28997757	27027087	25290533
1A4b	206	KEROSENE	0202	4404777	659635	512024	520836	437788	410845	382564	287211	251843	118954	91190	159051	110143	205243	110525
1A4b	301	NATURAL GAS	0202	17362132	20432645	21439693	24903983	24736624	26947401	30412122	28361811	29137977	28981613	27568914	29262248	28081591	30022155	29858709
1A4b	301	NATURAL GAS	020202							25676	24503	18059	31289	55319	69007	30105	63281	63692
1A4b	301	NATURAL GAS	020204	0	7932	499046	776351	1022812	1094868	1448246	1488432	1575546	1554382	1439173	1450266	1392257	1451228	1475531
1A4b	303	LPG	0202	669665	521639	442269	672725	588599	628367	653211	510109	545681	624403	650995	648947	607682	596053	650748
1A4c	102	COAL	0203	2457889	2853705	2203581	2106300	2294953	1797998	1446423	1238716	903570	708372	1079212	1234026	856215	1203478	1039568
1A4c	106	BROWN COAL BRI.	0203	59932	91738	52411	22106	12023	9553	6844	4447	3898						
1A4c	110	PETROLEUM COKE	0203	837124	610588	472601	500171	0	239582	285866	322604	201054	89239	6154	3328	31	754	0
1A4c	111	WOOD AND SIMIL.	0203	87150	87150	87150	68363	68363	68363	86804	96800	230244	230875	170093	147164	147000	127680	127680
1A4c	111	WOOD AND SIMIL.	020304									567	13851	216	435			
1A4c	117	STRAW	0203	3391260	3391260	3391260	3166800	2942340	2717880	2422080	2594630	2515460	2295060	2074370	1934300	1934300	1934300	1934300
1A4c	117	STRAW	020302								5800	5800	5800	5800	5800	5800	5800	5800
1A4c	203	RESIDUAL OIL	0203	1223716	1295951	1634018	1687023	1942109	2616552	3070976	2492455	2563430	2396266	1778526	1640210	1365228	914218	720074
1A4c	203	RESIDUAL OIL	020302									9051	1105	3269	2069	1964	6081	5265
1A4c	203	RESIDUAL OIL	020304									9345	11104	4017	4570	3335	3417	0
1A4c	204	GAS OIL	0203	406220	1014280	1176131	793582	707992	1182090	1940156	1799028	1675132	2297030	2156378	2634581	2311036	2505478	2374846
1A4c	204	GAS OIL	020302								7							
1A4c	204	GAS OIL	020304							3855	2324			4774	2723	4846	6315	0
1A4c	206	KEROSENE	0203	42526	28223	26448	26065	26657	21124	22933	25126	21124	10510	8213	22550	11171	10823	7482
1A4c	215	RAPE & FISH OIL	020304											146	665	102	0	0
1A4c	301	NATURAL GAS	0203	2222000	2680002	2385006	2462538	2485322	2559680	2666407	2644836	2476128	2241939	2383877	2687167	2543009	2351781	2256591
1A4c	301	NATURAL GAS	020303						0	5959	26127	65805	77171	61906	59503	64374	53821	53805
1A4c	301	NATURAL GAS	020304	104224	104224	135847	160657	282141	961133	1796227	2620381	3354165	3379285	3109418	2934589	3116038	2855572	2863595
1A4c	303	LPG	0203	258547	246608	191748	121904	116017	125438	137402	108988	126327	87141	93329	80125	55378	58087	53466
1A4c	309	BIOGAS	0203					2750	4455	132108	26121	34614	30392	76487	80321	96277	140632	268187
1A4c	309	BIOGAS	020304	9647	9647	9647	9647	6897	15795	17005	17897	25943	41304	76539	108819	239386	455766	411338
Total				498528069	608221645	549146038	580680902	620089974	600789857	757935954	653139237	614804749	585830535	542679863	567972508	565680095	624588287	563656541

Appendix 3A-4 Emission factors

Table 3A-29 CO_2 emission factors.

Fuel	Emission factor Biomass	Emission factor Fossil fuel	Unit	Reference type	IPCC fuel Category
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	74		kg/GJ	Country specific	Biomass
Orimulsion		80	kg/GJ	Country specific	Liquid
Natural gas		57.12	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 1990-2003.

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	56.9	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
2003	57.19	17.6	+94.5
2004	57.12	17.6	+94.5

Table 3A-31 CH_4 emission factors and references 2004.

Fuel	ipcc_id	SNAP_id	Emission factor [g/GJ]	Reference
COAL	1A1a	010101, 010102, 010103	1.5	EMEP/Corinair 2004
COAL	1A1a, 1A2f, 1A4b, 1A4c	010202, 010203, 0301, 0202, 0203	15	EMEP/Corinair 2004
BROWN COAL BRI.	all	all	15	EMEP/Corinair 2004, assuming same emission factor as for coal
COKE OVEN COKE	all	all	15	EMEP/Corinair 2004, assuming same emission factor as for coal
PETROLEUM COKE	all	all	15	EMEP/Corinair 2004
WOOD AND SIMIL.	1A1a	010102, 010103, 010104	2	Nielsen & Illerup 2003
WOOD AND SIMIL.	1A4a, 1A4b, 1A4c	0201, 0202, 0203	200	EMEP/Corinair 2004
WOOD AND SIMIL.	1A1a, 1A2f	010105, 010202, 010203, 0301, 030102, 030103	32	EMEP/Corinair 2004
MUNICIP. WASTES	1A1a	010102, 010103, 010104, 010105	0.59	Nielsen & Illerup 2003
MUNICIP. WASTES	1A1a, 1A2f, 1A4a	all other	6	EMEP/Corinair 2004
STRAW	1A1a	010102, 010103	0.5	Nielsen & Illerup 2003
STRAW	1A1a, 1A2f, 1A4c	010202, 010203, 020302, 030105	32	EMEP/Corinair 2004
STRAW	1A4b, 1A4c	0202, 0203	200	EMEP/Corinair 2004
RESIDUAL OIL	all	all	3	EMEP/Corinair 2004
GAS OIL	all	all	1.5	EMEP/Corinair 2004
KEROSENE	all	all	7	EMEP/Corinair 2004
FISH & RAPE OIL	all	all	1.5	EMEP/Corinair 2004, assuming same emission factor as gas oil
ORIMULSION	1A1a	010101	3	EMEP/Corinair 2004, 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, 1Ac, 1A2f, 1A4a, 1A4c	Gas turbines: 010104, 010504, 030104, 020104, 020303	1.5	Nielsen & Illerup 2003
NATURAL GAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4b, 1A4c	Gas engines: 010105, 010205, 010505, 030105, 020105, 020204, 020304	1) 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 2004
REFINERY GAS	1A1b	010304	1.5	EMEP/Corinair 2004
BIOGAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4c	Gas engines: 010105, 010505, 030105, 020105, 020304	1) 323	Nielsen & Illerup 2003
BIOGAS	1A1a, 1A2f, 1A4a, 1A4c	all other	4	EMEP/Corinair 2004

1) 2004 emission factor. Time-series is shown below

Time-series for CH_4 emission factors for gas engines are shown below. All other CH_4 emission factors are the same for 1990-2004.

Table 3A-32 CH_4 emission factors, time-series.

Year	Natural gas fuelled engines Emission factor [g/GJ]	Biogas fuelled engines Emission factor [g/GJ]
1990	257	239
1991	299	251
1992	347	264
1993	545	276
1994	604	289
1995	612	301
1996	596	305
1997	534	310
1998	525	314
1999	524	318
2000	520	323
2001	520	323
2002	520	323
2003	520	323
2004	520	323

Table 3A-33 N_2O emission factors and references 2004.

Fuel	ipcc_id	SNAP_id	Emission factor [g/GJ]	Reference
COAL	1A1a	0101**	0.8	Elsam 2005
COAL	1A1a, 1A1c, 1A2f, 1A4a, 1A4b, 1A4c	All except 0101**	3	EMEP/Corinair 2004
BROWN COAL BRI.	all	all	3	EMEP/Corinair 2004
COKE OVEN COKE	all	all	3	EMEP/Corinair 2004
PETROLEUM COKE	all	all	3	EMEP/Corinair 2004
WOOD AND SIMIL.	1A1a	010102, 010103, 010104	0.8	Nielsen & Illerup 2003
WOOD AND SIMIL.	1A1a	010105, 010202, 010203	4	EMEP/Corinair 2004
WOOD AND SIMIL.	1A2f, 1A4a, 1A4b, 1A4c	all	4	EMEP/Corinair 2004
MUNICIP. WASTES	1A1a	010102, 010103, 010104, 010105	1.2	Nielsen & Illerup 2003
MUNICIP. WASTES	1A1a	010203	4	EMEP/Corinair 2004
MUNICIP. WASTES	1A2f, 1A4a	030102, 0201, 020103	4	EMEP/Corinair 2004
STRAW	1A1a	010102, 010103	1.4	Nielsen & Illerup 2003
STRAW	1A1a	010202, 010203	4	EMEP/Corinair 2004
STRAW	1A2f, 1A4b, 1A4c	all	4	EMEP/Corinair 2004
RESIDUAL OIL	all	all	2	EMEP/Corinair 2004
GAS OIL	all	all	2	EMEP/Corinair 2004
KEROSENE	all	all	2	EMEP/Corinair 2004
FISH & RAPE OIL	all	all	2	EMEP/Corinair 2004, assuming same emission factor as gas oil
ORIMULSION	1A1a	010101	2	EMEP/Corinair 2004, assuming same emission factor as residual oil
NATURAL GAS	1A1a	0101, 010101, 010102, 010103, 010202, 010203	1	EMEP/Corinair 2004
NATURAL GAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4c	Gas turbines: 010104, 010504, 030104, 020104, 020303	2.2	Nielsen & Illerup 2003
NATURAL GAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4b, 1A4c	Gas engines: 010105, 010205, 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 2004
LPG	all	all	2	EMEP/Corinair 2004
REFINERY GAS	all	all	2.2	EMEP/Corinair 2004
BIOGAS	1A1a	010102, 010103, 010203	2	EMEP/Corinair 2004
BIOGAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4c	Gas engines: 010105, 010505, 030105, 020105, 020304	0.5	Nielsen & Illerup 2003
BIOGAS	1A2f, 1A4a, 1A4c	0301, 030102, 0201, 020103, 0203	2	EMEP/Corinair 2004

The same N_2O emission factors are applied for 1990-2004.

Table 3A-34 SO_2, NO_X, NMVOC and CO emission factors and references 2004.

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	42	18	131	18	1.5	1	10	3
COAL	1A1a, 1A2f, 1A4c	010202, 010203, 0301, 0203	574	19	95	4	15	1	10	1
COAL	1A4b	0202	574	19	95	4	15	1	2000	32
BROWN COAL BRI.	1A4b	0202	574	29	95	29	15	29	2000	29
COKE OVEN COKE	1A2f	0301	574	29	95	29	15	29	10	29
COKE OVEN COKE	1A4b	0202	574	29	95	29	15	29	2000	29
PETROLEUM COKE	1A2f	0301	605	20	95	29	1.5	1	61	4
PETROLEUM COKE	1A4a, 1A4b, 1A4c	0201, 0202, 0203	605	20	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, 21	90	22, 21, 4	48	1	50	3
WOOD AND SIMIL.	1A1a, 1A2f	010202, 010203, 0301, 030102, 030103	25	22, 21	90	22, 21, 4	48	1	240	4
WOOD AND SIMIL.	1A4a, 1A4c	0201, 020105, 0203	25	22, 21	90	22, 21, 4	600	1	240	4
WOOD AND SIMIL.	1A4b	0202	25	22, 21	120	22	600	1, 32	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, 1A4c	010202, 010203, 030105, 020302	130	5	90	4, 28	50	1	325	4, 5
STRAW	1A4b, 1A4c	0201, 0203	130	5	90	4, 28	600	1	4000	1,6,7
RESIDUAL OIL	1A1a	0101, 010101, 010102, 010103, 010104, 010105	349	18	131	18	3	1	15	3
RESIDUAL OIL	1A1a, 1A4a, 1A4b, 1A4c	010202, 010203, 0201, 0202, 0203, 020302	344	25, 10, 24	142	4	3	1	30	1
RESIDUAL OIL	1A1b	010306	537	33	142	4	3	1	30	1
RESIDUAL OIL	1A2f	0301, 030102, 030103	344	25, 10, 24	130	28	3	1	30	1
RESIDUAL OIL	1A2f	030104	344	25, 10, 24	130	28	3	1	15	1
RESIDUAL OIL	1A2f	030105	344	25, 10, 24	130	28	3	1	100	1
RESIDUAL OIL	1A4c	020304	344	25, 10, 24	142	4	3	1	100	1
GAS OIL	1A1a	0101, 010101, 010102	23	27	249	18	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	1	100	1	100	1
GAS OIL	1A1a	010103	23	27	65	28	1.5	1	15	3
GAS OIL	1A1a, 1A1b, 1A2f	010202, 010203, 010306, 0301, 030102, 030103, 030106	23	27	65	28	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	010103	1	37	220	38	1.5	15	15	15
FISH & RAPE OIL	1A1a	010202, 010203	1	37	65	15	1.5	15	15	15
FISH & RAPE OIL	1A2f, 1A4c	030105, 020304	1	37	700	15	100	15	100	15
ORIMULSION	1A1a	010101	12	34	86	34	3	16	15	16
NATURAL GAS	1A1a	0101, 010101, 010102	0.3	17	97	9	2	14	15	3
NATURAL GAS	1A1a, 1A2f, 1A4a, 1A4c	Gas turbines: 010104, 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, 010205, 010505, 030105, 020105, 020204, 020304	0.3	17	168	31	117	31	175	31
NATURAL GAS	1A1a, 1A2f	010103, 010202, 010203, 0301, 030103, 030106	0.3	17	42	36	2	14	28	4
NATURAL GAS	1A1c	010504	0.3	17	250	1, 8, 32	1.4	31	6.2	31
NATURAL GAS	1A4a, 1A4c	0201, 020103, 0203	0.3	17	30	1, 4, 11	2	14	28	4
NATURAL GAS	1A4b	0202, 020202	0.3	17	30	1, 4, 11	4	11	20	11
LPG	1A1a, 1A2f	010203, 0301	0.13	23	96	32	2	1	25	1
LPG	1A4a, 1A4c	0201, 0203	0.13	23	71	32	2	1	25	1
LPG	1A4b	0202	0.13	23	47	32	2	1	25	1
REFINERY GAS	1A1b	010304	1	2	170	9	1.4	35	6.2	35
BIOGAS	1A1a, 1A2f, 1A4a, 1A4c	010102, 010103, 010203, 0301, 0201, 020103, 0203	25	26	28	4	4	1	36	4
BIOGAS	1A1a, 1A1c, 1A2f, 1A4a, 1A4c	Gas engines: 010105, 010505, 030105, 020105, 020304	19.2	31	540	31	14	31	273	31
BIOGAS	1A2f	030102	25	26	59	4	4	1	36	4

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Time-series for emission factors for SO_2, NO_X, NMVOC and CO that are not the same in 1990-2004 are shown below. All other factors are constant in 1990-2004.

Table 3A-35 SO_2, NO_X, NMVOC and CO emission factors time-series [g/GJ].

pol.	fuel	snap_id	ipcc_id	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
SO2	COAL	0101	1A1a	506	571	454	386											
SO2	COAL	010101	1A1a	506	571	454	386	343	312	420	215	263	193	64	47	45	61	42
SO2	COAL	010102	1A1a	506	571	454	386	343	312	420	215	263	193	64	47	45	61	42
SO2	COAL	010103	1A1a					343	312	420	215	263	193	64	47	45	61	42
SO2	COAL	010104	1A1a					343	312	420	215							
SO2	PETROLEUM COKE	0201	1A4a	787	787	787	787	787	787	787	787	787	787	787	605	605	605	605
SO2	PETROLEUM COKE	0202	1A4b	787	787	787	787	787	787	787	787	787	787	787	605	605	605	605
SO2	PETROLEUM COKE	0203	1A4c	787	787	787	787	787	787	787	787	787	787	787	605	605	605	605
SO2	PETROLEUM COKE	0301	1A2f	787	787	787	787	787	787	787	787	787	787	787	605	605	605	605
SO2	MUNICIP. WASTES	0101	1A1a	138	116	95	73											
SO2	MUNICIP. WASTES	010102	1A1a		116	95	73	52	30			26	25	23,9	23,9	23,9	23,9	23,9
SO2	MUNICIP. WASTES	010103	1A1a					52	30	29	28	26	25	23,9	23,9	23,9	23,9	23,9
SO2	MUNICIP. WASTES	010104	1A1a					52	30	29	28	26	25	23,9	23,9	23,9	23,9	23,9
SO2	MUNICIP. WASTES	010105	1A1a											23,9	23,9	23,9	23,9	23,9
SO2	MUNICIP. WASTES	0102	1A1a	138	131	124	117	110	103	95	88							
SO2	MUNICIP. WASTES	010202	1A1a					110	103									
SO2	MUNICIP. WASTES	010203	1A1a					110	103	95	88	81	74	67	67	67	67	67
SO2	MUNICIP. WASTES	0201	1A4a	138	131	124	117	110	103	95	88	81	74	67	67	67	67	67
SO2	MUNICIP. WASTES	020103	1A4a					110	103	95	88	81	74	67	67	67	67	67
SO2	MUNICIP. WASTES	0301	1A2f	138	131	124	117	110	103	95	88	81	74					
SO2	RESIDUAL OIL	0101	1A1a	446	470	490	475							403	315	290	334	349
SO2	RESIDUAL OIL	010101	1A1a						351	408	344	369	369	403	315	290	334	349
SO2	RESIDUAL OIL	010102	1A1a	446	470	490	475	1564	351	408	344	369	369	403	315	290	334	349
SO2	RESIDUAL OIL	010103	1A1a					1564	351	408	344	369	369	403	315	290	334	349
SO2	RESIDUAL OIL	010104	1A1a					1564	351	408	344	369	369	403	315	290	334	349
SO2	RESIDUAL OIL	010105	1A1a	446	470	490	475	1564	351	408	344	369	369	403	315	290	334	349
SO2	RESIDUAL OIL	0102	1A1a	495	495	495	495	495	495	495	344							
SO2	RESIDUAL OIL	010202	1A1a					495	495	495	344	344	344	344	344	344	344	344
SO2	RESIDUAL OIL	010203	1A1a					495	495	495	344	344	344	344	344	344	344	344

SO2	RESIDUAL OIL	010306	1A1b	643	38	222	389				537	537	537	537	537	537	537	537
SO2	RESIDUAL OIL	0201	1A4a	495	495	495	495	495	495	495	344	344	344	344	344	344	344	344
SO2	RESIDUAL OIL	020103	1A4a					495	495									
SO2	RESIDUAL OIL	0202	1A4b	495	495	495	495	495	495	495	344	344	344	344	344	344	344	344
SO2	RESIDUAL OIL	0203	1A4c	495	495	495	495	495	495	495	344	344	344	344	344	344	344	344
SO2	RESIDUAL OIL	020302	1A4c									344	344	344	344	344	344	344
SO2	RESIDUAL OIL	020304	1A4c									344	344	344	344	344	344	344
SO2	RESIDUAL OIL	0301	1A2f	495	495	495	495	495	495	495	344	344	344	344	344	344	344	344
SO2	RESIDUAL OIL	030102	1A2f					495	495	495	344	344	344	344	344	344	344	344
SO2	RESIDUAL OIL	030103	1A2f					495	495	495	344	344	344	344	344	344	344	344
SO2	GAS OIL	0101	1A1a	94	94	94	94							23	23	23	23	23
SO2	GAS OIL	010101	1A1a					94	23	23	23	23	23	23	23	23	23	23
SO2	GAS OIL	010102	1A1a	94	94	94	94	94	23	23	23	23	23	23	23	23	23	23
SO2	GAS OIL	010103	1A1a					94	23	23	23	23	23	23	23	23	23	23
SO2	GAS OIL	010104	1A1a	94	94	94	94	94	23	23	23	23	23	23	23	23	23	23
SO2	GAS OIL	010105	1A1a	94	94	94	94	94	23	23	23	23	23	23	23	23	23	23
SO2	GAS OIL	0102	1A1a	94	94	94	94	94	23	23	23							
SO2	GAS OIL	010201	1A1a					94	23									23
SO2	GAS OIL	010202	1A1a					94	23	23	23	23	23	23	23	23	23	23
SO2	GAS OIL	010203	1A1a					94	23	23	23	23	23	23	23	23	23	23
SO2	GAS OIL	010205	1A1a					94					23	23	23	23	23	23
SO2	GAS OIL	010306	1A1b		94	94	94	94	23	23	23						23	23
SO2	GAS OIL	010505	1A1c													23	23	23
SO2	GAS OIL	0201	1A4a	94	94	94	94	94	23	23	23	23	23	23	23	23	23	23
SO2	GAS OIL	020102	1A4a					94		23		23						
SO2	GAS OIL	020103	1A4a					94		23	23	23	23	23	23	23	23	23
SO2	GAS OIL	020105	1A4a			94	94	94	23	23	23	23	23	23	23	23	23	23
SO2	GAS OIL	0202	1A4b	94	94	94	94	94	23	23	23	23	23	23	23	23	23	23
SO2	GAS OIL	0203	1A4c	94	94	94	94	94	23	23	23	23	23	23	23	23	23	23
SO2	GAS OIL	0301	1A2f	94	94	94	94	94	23	23	23	23	23	23	23	23	23	23
SO2	GAS OIL	030103	1A2f					94	23	23	23	23	23	23	23	23	23	23
SO2	GAS OIL	030105	1A2f			94	94	94						23	23	23	23	23
SO2	GAS OIL	030106	1A2f	94	94	94	94	94	23	23	23	23	23	23	23	23	23	23
SO2	ORIMULSION	010101	1A1a							147	149				10	12	12	12
NOX	COAL	0101	1A1a	342	384	294	289											
NOX	COAL	010101	1A1a	342	384	294	289	267	239	250	200	177	152	129	122	130	144	131
NOX	COAL	010102	1A1a	342	384	294	289	267	239	250	200	177	152	129	122	130	144	131
NOX	COAL	010103	1A1a					267	239	250	200	177	152	129	122	130	144	131
NOX	COAL	010104	1A1a					267	239	250	200							
NOX	COAL	010202	1A1a					200	200	200	200	200	200	95	95	95	95	95
NOX	COAL	010203	1A1a					200	200	200	200	200	200	95	95	95	95	95
NOX	COAL	0201	1A4a	200	200	200	200	200	200	200	200	200						95
NOX	COAL	0202	1A4b	200	200	200	200	200	200	200	200	200	200	95	95	95	95	95
NOX	COAL	0203	1A4c	200	200	200	200	200	200	200	200	200	200	95	95	95	95	95
NOX	COAL	0301	1A2f	200	200	200	200	200	200	200	200	200	200	95	95	95	95	95
NOX	BROWN COAL BRI.	0202	1A4b	200	200	200	200	200	200	200	200	200	200	95	95	95	95	95
NOX	COKE OVEN COKE	0202	1A4b	200	200	200	200	200	200	200	200	200	200	95	95	95	95	95
NOX	COKE OVEN COKE	0301	1A2f	200	200	200	200	200	200	200	200	200	200	95	95	95	95	95
NOX	PETROLEUM COKE	0301	1A2f	200	200	200	200	200	200	200	200	200	200	95	95	95	95	95
NOX	WOOD AND SIMIL.	010202	1A1a					130	130	130	130	130	90	90	90	90	90	90
NOX	WOOD AND SIMIL.	010203	1A1a					130	130	130	130	130	90	90	90	90	90	90
NOX	WOOD AND SIMIL.	0201	1A4a	130	130	130	130	130	130	130	130	130	90	90	90	90	90	90
NOX	WOOD AND SIMIL.	020105	1A4a									130	90		90	90	90	90
NOX	WOOD AND SIMIL.	0203	1A4c	130	130	130	130	130	130	130	130	130	90	90	90	90	90	90
NOX	WOOD AND SIMIL.	020304	1A4c									130	90	90	90			
NOX	WOOD AND SIMIL.	0301	1A2f	130	130	130	130	130	130	130	130	130	90	90	90	90	90	90
NOX	WOOD AND SIMIL.	030102	1A2f									130	90	90	90	90	90	90
NOX	WOOD AND SIMIL.	030103	1A2f					130	130	130	130	130	90	90	90	90	90	90
NOX	RESIDUAL OIL	0101	1A1a	342	384	294	289							129	122	130	144	131
NOX	RESIDUAL OIL	010101	1A1a						239	250	200	177	152	129	122	130	144	131
NOX	RESIDUAL OIL	010102	1A1a	342	384	294	289	267	239	250	200	177	152	129	122	130	144	131
NOX	RESIDUAL OIL	010103	1A1a					267	239	250	200	177	152	129	122	130	144	131
NOX	RESIDUAL OIL	010104	1A1a					267	239	250	200	177	152	129	122	130	144	131
NOX	RESIDUAL OIL	010105	1A1a	342	384	294	289	267	239	250	200	177	152	129	122	130	144	131
NOX	GAS OIL	010103	1A1a					80	75	65	65	65	65	65	65	65	65	65
NOX	GAS OIL	0102	1A1a	100	95	90	85	80	75	70	65							
NOX	GAS OIL	010201	1A1a					80	75									65
NOX	GAS OIL	010202	1A1a					80	75	70	65	65	65	65	65	65	65	65
NOX	GAS OIL	010203	1A1a					80	75	70	65	65	65	65	65	65	65	65
NOX	GAS OIL	010306	1A1b		95	90	85	80	75	70	65						65	65
NOX	GAS OIL	0301	1A2f	100	95	90	85	80	75	70	65	65	65	65	65	65	65	65
NOX	GAS OIL	030102	1A2f						75			65	65	65	65	65	65	65
NOX	GAS OIL	030103	1A2f					80	75	70	65	65	65	65	65	65	65	65
NOX	GAS OIL	030106	1A2f	100	95	90	85	80	75	70	65	65	65	65	65	65	65	65
NOX	FISH & RAPE OIL	0102	1A1a	100	95	90	85											
NOX	FISH & RAPE OIL	010203	1A1a					80	75	70	65	65	65	65	65	65	65	65
NOX	ORIMULSION	010101	1A1a							139	138				88	86	86	86
NOX	NATURAL GAS	0101	1A1a								115	115	115	115	115	115	115	97
NOX	NATURAL GAS	010101	1A1a					115			115				115	115	115	97
NOX	NATURAL GAS	010102	1A1a	115	115	115	115	115	115			115	115	115	115	115	115	97
NOX	NATURAL GAS	010104	1A1a	161	157	153	149	145	141	138	134	131	127	124	124	124	124	124
NOX	NATURAL GAS	010105	1A1a	276	241	235	214	199	194	193	170	167	167	168	168	168	168	168
NOX	NATURAL GAS	010205	1A1a					199	194	193	170	167	167	168	168	168	168	168
NOX	NATURAL GAS	010505	1A1c	276	241	235	214	199	194	193	170	167	167	168	168	168	168	168
NOX	NATURAL GAS	020104	1A4a		157			145	141	138	134	131	127	124	124	124	124	124
NOX	NATURAL GAS	020105	1A4a	276	241	235	214	199	194	193	170	167	167	168	168	168	168	168
NOX	NATURAL GAS	020204	1A4b	276	241	235	214	199	194	193	170	167	167	168	168	168	168	168
NOX	NATURAL GAS	020303	1A4c						141	138	134	131	127	124	124	124	124	124
NOX	NATURAL GAS	020304	1A4c	276	241	235	214	199	194	193	170	167	167	168	168	168	168	168
NOX	NATURAL GAS	030104	1A2f	161				145	141	138	134	131	127	124	124	124	124	124
NOX	NATURAL GAS	030105	1A2f	276	241	235	214	199	194	193	170	167	167	168	168	168	168	168
NOX	BIOGAS	010105	1A1a	711	696	681	665	650	635	616	597	578	559	540	540	540	540	540
NOX	BIOGAS	010505	1A1c	711	696	681	665	650	635	616	597	578	559	540	540	540	540	540
NOX	BIOGAS	020105	1A4a	711	696	681	665	650	635	616	597	578	559	540	540	540	540	540
NOX	BIOGAS	020304	1A4c	711	696	681	665	650	635	616	597	578	559	540	540	540	540	540

NOX	BIOGAS	030105	1A2f									578	559	540	540	540	540	540
NMVOC	NATURAL GAS	010105	1A1a	58	67	78	122	136	137	134	120	118	118	117	117	117	117	117
NMVOC	NATURAL GAS	010205	1A1a					136	137	134	120	118	118	117	117	117	117	117
NMVOC	NATURAL GAS	010505	1A1c	58	67	78	122	136	137	134	120	118	118	117	117	117	117	117
NMVOC	NATURAL GAS	020105	1A4a	58	67	78	122	136	137	134	120	118	118	117	117	117	117	117
NMVOC	NATURAL GAS	020204	1A4b	58	67	78	122	136	137	134	120	118	118	117	117	117	117	117
NMVOC	NATURAL GAS	020304	1A4c	58	67	78	122	136	137	134	120	118	118	117	117	117	117	117
NMVOC	NATURAL GAS	030105	1A2f	58	67	78	122	136	137	134	120	118	118	117	117	117	117	117
CO	WOOD AND SIMIL.	0102	1A1a	400	373	347	320	293	267	240	240							
CO	WOOD AND SIMIL.	010202	1A1a					293	267	240	240	240	240	240	240	240	240	240
CO	WOOD AND SIMIL.	010203	1A1a					293	267	240	240	240	240	240	240	240	240	240
CO	WOOD AND SIMIL.	0201	1A4a	400	373	347	320	293	267	240	240	240	240	240	240	240	240	240
CO	WOOD AND SIMIL.	0203	1A4c	400	373	347	320	293	267	240	240	240	240	240	240	240	240	240
CO	WOOD AND SIMIL.	0301	1A2f	400	373	347	320	293	267	240	240	240	240	240	240	240	240	240
CO	WOOD AND SIMIL.	030103	1A2f					293	267	240	240	240	240	240	240	240	240	240
CO	MUNICIP. WASTES	0102	1A1a	100	85	70	55	40	25	10	10							
CO	MUNICIP. WASTES	010201	1A1a					40										
CO	MUNICIP. WASTES	010202	1A1a					40	25									
CO	MUNICIP. WASTES	010203	1A1a					40	25	10	10	10	10	10	10	10	10	10
CO	MUNICIP. WASTES	0201	1A4a	100	85	70	55	40	25	10	10	10	10	10	10	10	10	10
CO	MUNICIP. WASTES	020103	1A4a					40	25	10	10	10	10	10	10	10	10	10
CO	MUNICIP. WASTES	0301	1A2f	100	85	70	55	40	25	10	10	10	10					
CO	STRAW	0102	1A1a	600	554	508	463	417	371	325	325							
CO	STRAW	010202	1A1a					417	371	325	325	325	325	325	325	325	325	325
CO	STRAW	010203	1A1a					417	371	325	325	325	325	325	325	325	325	325
CO	STRAW	0202	1A4b	8500	8500	8500	8500	8500	7500	6500	5500	4500	4000	4000	4000	4000	4000	4000
CO	STRAW	0203	1A4c	8500	8500	8500	8500	8500	7500	6500	5500	4500	4000	4000	4000	4000	4000	4000
CO	NATURAL GAS	010105	1A1a	181	202	203	217	216	212	211	174	174	174	175	175	175	175	175
CO	NATURAL GAS	010205	1A1a					216	212	211	174	174	174	175	175	175	175	175
CO	NATURAL GAS	010505	1A1c	181	202	203	217	216	212	211	174	174	174	175	175	175	175	175
CO	NATURAL GAS	020105	1A4a	181	202	203	217	216	212	211	174	174	174	175	175	175	175	175
CO	NATURAL GAS	020204	1A4b	181	202	203	217	216	212	211	174	174	174	175	175	175	175	175
CO	NATURAL GAS	020304	1A4c	181	202	203	217	216	212	211	174	174	174	175	175	175	175	175
CO	NATURAL GAS	030105	1A2f	181	202	203	217	216	212	211	174	174	174	175	175	175	175	175
CO	BIOGAS	010105	1A1a	230	234	239	243	248	252	256	260	265	269	273	273	273	273	273
CO	BIOGAS	010505	1A1c	230	234	239	243	248	252	256	260	265	269	273	273	273	273	273
CO	BIOGAS	020105	1A4a	230	234	239	243	248	252	256	260	265	269	273	273	273	273	273
CO	BIOGAS	020304	1A4c	230	234	239	243	248	252	256	260	265	269	273	273	273	273	273
CO	BIOGAS	030105	1A2f									265	269	273	273	273	273	273

Appendix 3A-5 Large point sources

Table 3A-38 Large point sources, fuel consumption in 2003 (1A1, 1A2 and 1A4).

lps_id	lps name	part_id	SNAP_id	fuel_id	fuel	fuel con-sumption [GJ]	IPCC source
001	Amagervaerket	01	010101	102	COAL	1778930	1A1a
001	Amagervaerket	01	010101	203	RESIDUAL OIL	39853	1A1a
001	Amagervaerket	02	010101	117	STRAW	708764	1A1a
001	Amagervaerket	02	010101	203	RESIDUAL OIL	298759	1A1a
001	Amagervaerket	03	010101	102	COAL	14104740	1A1a
001	Amagervaerket	03	010101	203	RESIDUAL OIL	107521	1A1a
002	Svanemoellevaerket	05	010101	203	RESIDUAL OIL	23130	1A1a
002	Svanemoellevaerket	05	010101	301	NATURAL GAS	1685480	1A1a
002	Svanemoellevaerket	07	010104	204	GAS OIL	1775	1A1a
002	Svanemoellevaerket	07	010104	301	NATURAL GAS	4725000	1A1a
003	H.C.Oerstedsvaerket	03	010101	203	RESIDUAL OIL	504818	1A1a
003	H.C.Oerstedsvaerket	03	010101	301	NATURAL GAS	1159470	1A1a
003	H.C.Oerstedsvaerket	07	010101	203	RESIDUAL OIL	612405	1A1a
003	H.C.Oerstedsvaerket	07	010101	301	NATURAL GAS	1988930	1A1a
003	H.C.Oerstedsvaerket	08	010101	301	NATURAL GAS	1456810	1A1a
004	Kyndbyvaerket	21	010101	203	RESIDUAL OIL	228510	1A1a
004	Kyndbyvaerket	21	010101	204	GAS OIL	16350	1A1a
004	Kyndbyvaerket	22	010101	203	RESIDUAL OIL	173990	1A1a
004	Kyndbyvaerket	26	010101	203	RESIDUAL OIL	235060	1A1a
004	Kyndbyvaerket	28	010101	203	RESIDUAL OIL	52590	1A1a
004	Kyndbyvaerket	41	010105	204	GAS OIL	3450	1A1a
004	Kyndbyvaerket	52	010104	204	GAS OIL	25480	1A1a
005	Masnedoevaerket	12	010102	111	WOOD AND SIMIL.	115573	1A1a
005	Masnedoevaerket	12	010102	117	STRAW	466528	1A1a
005	Masnedoevaerket	12	010102	204	GAS OIL	1130	1A1a
005	Masnedoevaerket	31	010104	204	GAS OIL	13320	1A1a
007	Stigsnaesvaerket	01	010101	102	COAL	298700	1A1a
007	Stigsnaesvaerket	01	010101	203	RESIDUAL OIL	76757	1A1a
007	Stigsnaesvaerket	02	010101	102	COAL	8815360	1A1a
007	Stigsnaesvaerket	02	010101	203	RESIDUAL OIL	201853	1A1a
007	Stigsnaesvaerket	03	010101	203	RESIDUAL OIL	66040	1A1a
008	Asnaesvaerket	01	010101	203	RESIDUAL OIL	61874	1A1a
008	Asnaesvaerket	02	010101	102	COAL	6516440	1A1a
008	Asnaesvaerket	02	010101	203	RESIDUAL OIL	78681	1A1a
008	Asnaesvaerket	04	010101	102	COAL	680640	1A1a
008	Asnaesvaerket	04	010101	203	RESIDUAL OIL	103566	1A1a
008	Asnaesvaerket	05	010101	102	COAL	13435970	1A1a
008	Asnaesvaerket	05	010101	203	RESIDUAL OIL	1219298	1A1a
008	Asnaesvaerket	05	010101	225	ORIMULSION	18719	1A1a
009	Statoil Raffinaderi	01	010306	203	RESIDUAL OIL	84893	1A1b
009	Statoil Raffinaderi	01	010306	308	REFINERY GAS	7886864	1A1b
010	Avedoerevaerket	01	010101	102	COAL	16086390	1A1a
010	Avedoerevaerket	01	010101	203	RESIDUAL OIL	55916	1A1a
010	Avedoerevaerket	01	010101	204	GAS OIL	8436	1A1a
010	Avedoerevaerket	02	010104	111	WOOD AND SIMIL.	4483061	1A1a
010	Avedoerevaerket	02	010104	117	STRAW	1861866	1A1a
010	Avedoerevaerket	02	010104	203	RESIDUAL OIL	7387153	1A1a
010	Avedoerevaerket	02	010104	301	NATURAL GAS	7990914	1A1a
011	Fynsvaerket	03	010101	102	COAL	1932860	1A1a
011	Fynsvaerket	03	010101	203	RESIDUAL OIL	106960	1A1a
011	Fynsvaerket	03	010101	301	NATURAL GAS	742490	1A1a
011	Fynsvaerket	07	010101	102	COAL	17705230	1A1a
011	Fynsvaerket	07	010101	203	RESIDUAL OIL	204110	1A1a
011	Fynsvaerket	08	010102	114	MUNICIP. WASTES	2819230	1A1a
011	Fynsvaerket	08	010102	204	GAS OIL	23711	1A1a
012	Studstrupvaerket	03	010101	102	COAL	8508190	1A1a
012	Studstrupvaerket	03	010101	203	RESIDUAL OIL	282050	1A1a
012	Studstrupvaerket	04	010101	102	COAL	17612220	1A1a
012	Studstrupvaerket	04	010101	117	STRAW	1879810	1A1a
012	Studstrupvaerket	04	010101	203	RESIDUAL OIL	164060	1A1a
014	Vendsysselvaerket	02	010101	102	COAL	2193960	1A1a
014	Vendsysselvaerket	02	010101	203	RESIDUAL OIL	94310	1A1a
014	Vendsysselvaerket	03	010101	102	COAL	17847660	1A1a
014	Vendsysselvaerket	03	010101	203	RESIDUAL OIL	249490	1A1a
014	Vendsysselvaerket	03	010101	204	GAS OIL	28400	1A1a
016	Kemira Danmark	03	030104	301	NATURAL GAS	375920	1A2f
017	Shell Raffinaderi	01	010306	203	RESIDUAL OIL	986742	1A1b
017	Shell Raffinaderi	01	010306	308	REFINERY GAS	4207059	1A1b
017	Shell Raffinaderi	05	010304	308	REFINERY GAS	2442200	1A1b
018	Skaerbaekvaerket	03	010101	204	GAS OIL	125060	1A1a
018	Skaerbaekvaerket	03	010101	301	NATURAL GAS	12254020	1A1a
019	Enstedvaerket	03	010101	102	COAL	23986250	1A1a
019	Enstedvaerket	03	010101	203	RESIDUAL OIL	210800	1A1a
019	Enstedvaerket	04	010101	111	WOOD AND SIMIL.	231380	1A1a
019	Enstedvaerket	04	010101	117	STRAW	1777850	1A1a
019	Enstedvaerket	04	010101	204	GAS OIL	18770	1A1a
020	Esbjergvaerket	03	010101	102	COAL	16427340	1A1a
020	Esbjergvaerket	03	010101	203	RESIDUAL OIL	125580	1A1a
022	Oestkraft	05	010102	203	RESIDUAL OIL	122580	1A1a
022	Oestkraft	06	010102	102	COAL	710750	1A1a
022	Oestkraft	06	010102	111	WOOD AND SIMIL.	37457	1A1a
022	Oestkraft	06	010102	203	RESIDUAL OIL	24962	1A1a
023	Danisco Ingredients	01	030102	102	COAL	558750	1A2f
023	Danisco Ingredients	01	030102	301	NATURAL GAS	8303	1A2f

024	Dansk Naturgas Behandlingsanlaeg	01	010502	301	NATURAL GAS	360596,14	1A1c
025	Horsens Kraftvarmevaerk	01	010102	111	WOOD AND SIMIL.	4970	1A1a
025	Horsens Kraftvarmevaerk	01	010102	114	MUNICIP. WASTES	930050	1A1a
025	Horsens Kraftvarmevaerk	02	010104	301	NATURAL GAS	884320	1A1a
026	Herningvaerket	01	010102	111	WOOD AND SIMIL.	2446570	1A1a
026	Herningvaerket	01	010102	203	RESIDUAL OIL	130580	1A1a
026	Herningvaerket	01	010102	301	NATURAL GAS	1133060	1A1a
027	Vestforbraendingen	01	010102	114	MUNICIP. WASTES	2431742	1A1a
027	Vestforbraendingen	01	010102	204	GAS OIL	14778	1A1a
027	Vestforbraendingen	01	010102	301	NATURAL GAS	26170	1A1a
027	Vestforbraendingen	02	010102	114	MUNICIP. WASTES	2721440	1A1a
028	Amagerforbraendingen	01	010102	114	MUNICIP. WASTES	4220210	1A1a
029	Randersvaerket	01	010102	102	COAL	2624200	1A1a
029	Randersvaerket	01	010102	110	PETROLEUM COKE	7130	1A1a
029	Randersvaerket	01	010102	111	WOOD AND SIMIL.	523635	1A1a
029	Randersvaerket	01	010102	309	BIOGAS	16857	1A1a
029	Randersvaerket	02	010102	204	GAS OIL	61660	1A1a
030	Grenaavaerket	01	010102	102	COAL	1176550	1A1a
030	Grenaavaerket	01	010102	111	WOOD AND SIMIL.	52289	1A1a
030	Grenaavaerket	01	010102	117	STRAW	888219	1A1a
030	Grenaavaerket	01	010102	203	RESIDUAL OIL	121017	1A1a
030	Grenaavaerket	01	010102	204	GAS OIL	14082	1A1a
031	Hilleroedvaerket	01	010104	301	NATURAL GAS	3128230	1A1a
032	Helsingoervaerket	01	010104	301	NATURAL GAS	1797475	1A1a
032	Helsingoervaerket	02	010105	301	NATURAL GAS	10938	1A1a
033	Staalvalsevaerket	01	030102	301	NATURAL GAS	1247994	1A2f
034	Stora Dalum	01	030102	301	NATURAL GAS	1039490	1A2f
035	Assens Sukkerfabrik	01	030102	102	COAL	280258	1A2f
035	Assens Sukkerfabrik	01	030102	203	RESIDUAL OIL	361300	1A2f
035	Assens Sukkerfabrik	01	030102	309	BIOGAS	8370	1A2f
036	Kolding Kraftvarmevaerk	01	010103	114	MUNICIP. WASTES	694280	1A1a
036	Kolding Kraftvarmevaerk	02	010103	114	MUNICIP. WASTES	257790	1A1a
037	Maabjergvaerket	02	010102	111	WOOD AND SIMIL.	364650	1A1a
037	Maabjergvaerket	02	010102	114	MUNICIP. WASTES	1666000	1A1a
037	Maabjergvaerket	02	010102	117	STRAW	460410	1A1a
037	Maabjergvaerket	02	010102	301	NATURAL GAS	183690	1A1a
038	Soenderborg Kraftvarmevaerk	01	010102	114	MUNICIP. WASTES	681744	1A1a
038	Soenderborg Kraftvarmevaerk	02	010104	301	NATURAL GAS	1230540	1A1a
039	Kara Affaldsforbraendingsanlaeg	01	010102	114	MUNICIP. WASTES	2123340	1A1a
039	Kara Affaldsforbraendingsanlaeg	01	010102	301	NATURAL GAS	9489	1A1a
040	Viborg Kraftvarmevaerk	01	010104	301	NATURAL GAS	2227010	1A1a
042	Nordforbraendingen	01	010102	114	MUNICIP. WASTES	1149670	1A1a
045	Aalborg Portland	01	030311	102	COAL	3754171	1A2f
045	Aalborg Portland	01	030311	110	PETROLEUM COKE	8187958	1A2f
045	Aalborg Portland	01	030311	114	MUNICIP. WASTES	1926563	1A2f
045	Aalborg Portland	01	030311	118	SEWAGE SLUDGE	58266	1A2f
045	Aalborg Portland	01	030311	203	RESIDUAL OIL	817378	1A2f
046	Aarhus Nord	01	010102	114	MUNICIP. WASTES	1921990	1A1a
047	Reno Nord	01	010103	114	MUNICIP. WASTES	1442080	1A1a
048	Silkeborg Kraftvarmevaerk	01	010104	301	NATURAL GAS	3397950	1A1a
049	Rensningsanlægget Lynetten	01	020103	114	MUNICIP. WASTES	75850	1A4a
049	Rensningsanlægget Lynetten	01	020103	204	GAS OIL	19369	1A4a
049	Rensningsanlægget Lynetten	01	020103	309	BIOGAS	101260	1A4a
050	I/S Fasan	01	010203	114	MUNICIP. WASTES	701750	1A1a
051	AVV Forbrændingsanlæg	01	010103	114	MUNICIP. WASTES	615260	1A1a
052	I/S REFA Kraftvarmeværk	01	010103	114	MUNICIP. WASTES	1084990	1A1a
053	Svendborg Kraftvarmeværk	01	010102	114	MUNICIP. WASTES	503590	1A1a
053	Svendborg Kraftvarmeværk	01	010102	301	NATURAL GAS	2090	1A1a
054	Kommunekemi	01	010102	114	MUNICIP. WASTES	723930	1A1a
054	Kommunekemi	01	010102	203	RESIDUAL OIL	114652	1A1a
054	Kommunekemi	01	010102	204	GAS OIL	7245	1A1a
054	Kommunekemi	02	010102	114	MUNICIP. WASTES	545460	1A1a
054	Kommunekemi	02	010102	203	RESIDUAL OIL	39316	1A1a
054	Kommunekemi	02	010102	204	GAS OIL	7209	1A1a
054	Kommunekemi	03	010102	114	MUNICIP. WASTES	384770	1A1a
054	Kommunekemi	03	010102	203	RESIDUAL OIL	21652	1A1a
054	Kommunekemi	03	010102	204	GAS OIL	8967	1A1a
055	I/S Fælles Forbrænding	01	010203	114	MUNICIP. WASTES	270020	1A1a
056	Vestfyns Forbrænding	01	010203	114	MUNICIP. WASTES	216560	1A1a
058	I/S Reno Syd	01	010103	114	MUNICIP. WASTES	624280	1A1a
059	I/S Kraftvarmeværk Thisted	01	010103	111	WOOD AND SIMIL.	3627	1A1a
059	I/S Kraftvarmeværk Thisted	01	010103	114	MUNICIP. WASTES	535010	1A1a
059	I/S Kraftvarmeværk Thisted	01	010103	117	STRAW	6931	1A1a
060	Knudmoseværket	01	010103	114	MUNICIP. WASTES	413080	1A1a
060	Knudmoseværket	01	010103	301	NATURAL GAS	39766	1A1a
061	Kavo I/S Energien	01	010103	114	MUNICIP. WASTES	879586	1A1a
062	VEGA (Vestforbraending Taastrup)	01	010203	114	MUNICIP. WASTES	590120	1A1a
065	Haderslev Kraftvarmeværk	01	010103	114	MUNICIP. WASTES	583600	1A1a
065	Haderslev Kraftvarmeværk	01	010103	301	NATURAL GAS	550	1A1a
066	Frederiskhavn Affaldskraftvarmeværk	01	010103	114	MUNICIP. WASTES	370600	1A1a
066	Frederiskhavn Affaldskraftvarmeværk	01	010103	204	GAS OIL	775	1A1a
067	Vejen Kraftvarmeværk	01	010103	114	MUNICIP. WASTES	384700	1A1a
068	Bofa I/S	01	010203	114	MUNICIP. WASTES	201000	1A1a
069	DTU	01	010104	301	NATURAL GAS	1358840	1A1a
070	Næstved Kraftvarmeværk	01	010104	301	NATURAL GAS	224304	1A1a
071	Maricogen	01	030104	301	NATURAL GAS	1863340	1A2f
072	Hjørring KVV	01	010104	301	NATURAL GAS	1228030	1A1a
075	Rockwool A/S Hedehusene	01	030318	301	NATURAL GAS	64000	1A2f
076	Rockwool A/S Vamdrup	01	030318	107	COKE OVEN COKE	438480	1A2f
076	Rockwool A/S Vamdrup	01	030318	301	NATURAL GAS	292320	1A2f
077	Rockwool A/S Doense	01	030318	107	COKE OVEN COKE	375840	1A2f
077	Rockwool A/S Doense	01	030318	301	NATURAL GAS	250560	1A2f
078	Rexam Glass Holmegaard A/S	01	030315	204	GAS OIL	3802	1A2f
078	Rexam Glass Holmegaard A/S	01	030315	301	NATURAL GAS	911205	1A2f
081	Haldor Topsøe	02	0301	301	NATURAL GAS	478700	1A2f

081	Haldor Topsøe	02	0301	303	LPG	100	1A2f
082	Danisco Sugar Nakskov	02	030102	102	COAL	659720	1A2f
082	Danisco Sugar Nakskov	02	030102	203	RESIDUAL OIL	561380	1A2f
082	Danisco Sugar Nakskov	02	030102	204	GAS OIL	2830	1A2f
082	Danisco Sugar Nakskov	02	030102	309	BIOGAS	45966	1A2f
083	Danisco Sugar Nykøbing	02	030102	203	RESIDUAL OIL	767450	1A2f
083	Danisco Sugar Nykøbing	02	030102	309	BIOGAS	58364	1A2f
085	L90 Affaldsforbrænding	01	010102	114	MUNICIP. WASTES	1907170	1A1a
085	L90 Affaldsforbrænding	01	010102	203	RESIDUAL OIL	21057	1A1a
086	Hammel Fjernvarme	01	010203	114	MUNICIP. WASTES	302930	1A1a
086	Hammel Fjernvarme	01	010203	203	RESIDUAL OIL	20920	1A1a

Table 3A-39 Large point sources, plant-specific emissions (IPCC 1A1, 1A2 and 1A4)[1)].

LPS_id	LPS name	LPS part	Sector (IPCC)	Sector (SNAP)	SO_2	NO_x	NMVOC	CO
001	Amagervaerket	01	1A1a	010101	x	x		
001	Amagervaerket	02	1A1a	010101	x	x		
001	Amagervaerket	03	1A1a	010101	x	x		
002	Svanemoellevaerket	05	1A1a	010101	x	x		
002	Svanemoellevaerket	07	1A1a	010104		x		
003	H.C.Oerstedsvaerket	03	1A1a	010101	x	x		
003	H.C.Oerstedsvaerket	07	1A1a	010101	x	x		
003	H.C.Oerstedsvaerket	08	1A1a	010101		x		
004	Kyndbyvaerket	21	1A1a	010101	x	x		
004	Kyndbyvaerket	22	1A1a	010101	x	x		
004	Kyndbyvaerket	26	1A1a	010101	x	x		
004	Kyndbyvaerket	28	1A1a	010101	x	x		
004	Kyndbyvaerket	51	1A1a	010104	x	x		
004	Kyndbyvaerket	52	1A1a	010104	x	x		
005	Masnedoevaerket	12	1A1a	010102	x			
005	Masnedoevaerket	31	1A1a	010104	x	x		
007	Stigsnaesvaerket	01	1A1a	010101	x	x		
007	Stigsnaesvaerket	02	1A1a	010101	x	x		
007	Stigsnaesvaerket	03	1A1a	010101	x	X		
008	Asnaesvaerket	02	1A1a	010101	x	x		
008	Asnaesvaerket	03	1A1a	010101	x	x		
008	Asnaesvaerket	04	1A1a	010101	x	x		
008	Asnaesvaerket	05	1A1a	010101	x	x		
009	Statoil Raffinaderi	01	1A1b	010306	x			
010	Avedoerevaerket	01	1A1a	010101	x	x		
010	Avedoerevaerket	02	1A1a	010104	x	x		
011	Fynsvaerket	03	1A1a	010101	x	x		
011	Fynsvaerket	07	1A1a	010101	x	x		
011	Fynsvaerket	08	1A1a	010102	x	x		x
012	Studstrupvaerket	03	1A1a	010101	x	x		
012	Studstrupvaerket	04	1A1a	010101	x	x		
014	Vendsysselvaerket	02	1A1a	010101	x	x		
014	Vendsysselvaerket	03	1A1a	010101	x	x		
017	Shell Raffinaderi	01	1A1b	010306	x	x		
017	Shell Raffinaderi	05	1A1b	010304	x	x		
018	Skaerbaekvaerket	01	1A1a	010101	x	x		
018	Skaerbaekvaerket	03	1A1a	010101	x	x		
019	Enstedvaerket	03	1A1a	010101	x	x		
019	Enstedvaerket	04	1A1a	010101	x	x		
020	Esbjergvaerket	03	1A1a	010101	x	x		
022	Oestkraft	05	1A1a	010102	x	x		
022	Oestkraft	06	1A1a	010102	x	x		
023	Danisco Ingredients	01	1A2f	030102	x			
024	Dansk Naturgas Behandlingsanlaeg	01	1A1c	010502		x		
025	Horsens Kraftvarmevaerk	01	1A1a	010102	x	x		x
025	Horsens Kraftvarmevaerk	02	1A1a	010104		x		
026	Herningvaerket	01	1A1a	010102	x	x		x
027	Vestforbraendingen	01	1A1a	010102	x	x		
027	Vestforbraendingen	02	1A1a	010102	x	x		
028	Amagerforbraendingen	01	1A1a	010102	x	x	x	x
029	Randersvaerket	01	1A1a	010102	x	x		
030	Grenaavaerket	01	1A1a	010102	x	x		x
031	Hilleroedvaerket	01	1A1a	010104		x		
032	Helsingoervaerket	01	1A1a	010104		x		
032	Helsingoervaerket	02	1A1a	010105		x		
033	Staalvalsevaerket	01	1A2f	030102		x		
034	Stora Dalum	01	1A2f	030102		x		
035	Assens Sukkerfabrik	01	1A2f	030102	x			
036	Kolding Kraftvarmevaerk	01	1A1a	010103	x		x	x
036	Kolding Kraftvarmevaerk	02	1A1a	010103	x		x	x
037	Maabjergvaerket	02	1A1a	010102	x	x		x
038	Soenderborg Kraftvarmevaerk	01	1A1a	010102	x	x		x
038	Soenderborg Kraftvarmevaerk	02	1A1a	010104		x		
039	Kara Affaldsforbraendingsanlaeg	01	1A1a	010102	x			x
040	Viborg Kraftvarmevaerk	01	1A1a	010104		x		
042	Nordforbraendingen	01	1A1a	010102	x			x
045	Aalborg Portland	01/03	1A2f	030311	x	x		x
046	Aarhus Nord	01	1A1a	010102	x			
047	Reno Nord	01	1A1a	010103	x			x
048	Silkeborg Kraftvarmevaerk	01	1A1a	010104		x		

049	Rensningsanlægget Lynetten	01	1A4a	020103	x			
050	I/S Fasan	01	1A1a	010203	x	x		x
051	AVV Forbrændingsanlæg	01	1A1a	010103	x			x
053	Svendborg Kraftvarmeværk	01	1A1a	010102	x	x	x	x
054	Kommunekemi	01	1A1a	010102	x			x
054	Kommunekemi	02	1A1a	010102	x			x
054	Kommunekemi	03	1A1a	010102	x			x
056	Vestfyns Forbrænding	01	1A1a	010203	x	x		x
058	I/S Reno Syd	01	1A1a	010103	x			x
059	I/S Kraftvarmeværk Thisted	01	1A1a	010103	x			x
060	Knudmoseværket	01	1A1a	010103	x			x
061	Kavo I/S Energien	01	1A1a	010103	x		x	x
062	VEGA (Vestforbraending Taastrup)	01	1A1a	010203	x	x		x
065	Haderslev Kraftvarmeværk	01	1A1a	010103	x	x		x
066	Frederiskhavn Affaldskraftvarmeværk	01	1A1a	010103	x	x		x
067	Vejen Kraftvarmeværk	01	1A1a	010103	x	x		x
068	Bofa I/S	01	1A1a	010203	x			x
069	DTU	01	1A1a	010104		x		
070	Næstved Kraftvarmeværk	01	1A1a	010104		x		x
071	Maricogen	01	1A2f	030104		x		
072	Hjørring KVV	01	1A1a	010104		x		
075	Rockwool A/S Hedehusene	01	1A2f	030318	x		x	x
076	Rockwool A/S Vamdrup	01	1A2f	030318	x		x	x
077	Rockwool A/S Doense	01	1A2f	030318	x		x	x
078	Rexam Glass Holmegaard A/S	01	1A2f	030315		x		x
085	L90 Affaldsforbrænding	01	1A1a	010102	x	x		x
086	Hammel Fjernvarme	01	1A1a	010203	x	x		x
Total					**10105**	**36740**	**20**	**9701**

1) Emission of the pollutants marked with “x” is plant specific. Emission of other pollutants is estimated based on emission factors. The total shown *in this table* only includes plant-specific data.

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 in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		Gg CO_2 eq	Gg CO_2 eq	%	%	%	%	%	%	%	%	%
Stationary Combustion, Coal	CO_2	24077	17337	1	5	5.099	2.425	-0.149	0.455	-0.746	0.644	0.985
Stationary Combustion, BKB	CO_2	11	0	3	5	5.831	0.000	0.000	0.000	-0.001	0.000	0.001
Stationary Combustion, Coke	CO_2	138	123	3	5	5.831	0.020	0.000	0.003	-0.001	0.014	0.014
Stationary Combustion, Petroleum coke	CO_2	410	817	3	5	5.831	0.131	0.011	0.021	0.056	0.091	0.107
Stationary Combustion, Plastic waste	CO_2	349	676	5	5	7.071	0.131	0.009	0.018	0.045	0.126	0.133
Stationary Combustion, Residual oil	CO_2	2505	1832	2	2	2.828	0.142	-0.015	0.048	-0.030	0.136	0.139
Stationary Combustion, Gas oil	CO_2	4564	2712	4	5	6.403	0.476	-0.043	0.071	-0.217	0.403	0.458
Stationary Combustion, Kerosene	CO_2	366	15	4	5	6.403	0.003	-0.009	0.000	-0.044	0.002	0.044
Stationary Combustion, Orimulsion	CO_2	0	1	1	2	2.236	0.000	0.000	0.000	0.000	0.000	0.000
Stationary Combustion, Natural gas	CO_2	4330	11143	3	1	3.162	0.966	0.184	0.293	0.184	1.241	1.255
Stationary Combustion, LPG	CO_2	164	108	4	5	6.403	0.019	-0.001	0.003	-0.006	0.016	0.017
Stationary Combustion, Refinery gas	CO_2	806	904	3	5	5.831	0.145	0.003	0.024	0.017	0.101	0.102
Stationary combustion plants, gas engines	CH_4	6	386	2.2	40	40.060	0.424	0.010	0.010	0.399	0.032	0.400
Stationary combustion plants, other	CH_4	115	136	2.2	100	100.024	0.373	0.001	0.004	0.068	0.011	0.069
Stationary combustion plants	N_2O	240	268	2.2	1000	1000.002	7.344	0.001	0.007	0.988	0.022	0.988
Total		38082	36461				61.372					3.957

Total uncertainties **Overall uncertainty in the year (%):** **7.834** **Trend uncertainty (%):** **1.989**

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 in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		Gg CO_2	Gg CO_2	%	%	%	%	%	%	%	%	%
Stationary Combustion, Coal	CO_2	24077	17337	1	5	5.099	2.478	-0.143	0.460	-0,715	0,650	0.967
Stationary Combustion, BKB	CO_2	11	0	3	5	5.831	0.000	0.000	0.000	-0,001	0,000	0.001
Stationary Combustion, Coke	CO_2	138	123	3	5	5.831	0.020	0.000	0.003	-0,001	0,014	0.014
Stationary Combustion, Petroleum coke	CO_2	410	817	3	5	5.831	0.134	0.011	0.022	0,057	0,092	0.108
Stationary Combustion, Plastic waste	CO_2	349	676	5	5	7.071	0.134	0.009	0.018	0,046	0,127	0.135
Stationary Combustion, Residual oil	CO_2	2505	1832	2	2	2.828	0.145	-0.014	0.049	-0,028	0,137	0.140
Stationary Combustion, Gas oil	CO_2	4564	2712	4	5	6.403	0.487	-0.042	0.072	-0,212	0,407	0.459
Stationary Combustion, Kerosene	CO_2	366	15	4	5	6.403	0.003	-0.009	0.000	-0,044	0,002	0.044
Stationary Combustion, Orimulsion	CO_2	0	1	1	2	2.236	0.000	0.000	0.000	0,000	0,000	0.000
Stationary Combustion, Natural gas	CO_2	4330	11143	3	1	3.162	0.988	0.187	0.295	0,187	1,253	1.267
Stationary Combustion, LPG	CO_2	164	108	4	5	6.403	0.019	-0.001	0.003	-0,006	0,016	0.017
Stationary Combustion, Refinery gas	CO_2	806	904	3	5	5.831	0.148	0.004	0.024	0,019	0,102	0.103
Total	CO_2	37720	35671				7.434					2.813
Total uncertainties			**Overall uncertainty in the year (%):**				**2.727**		**Trend uncertainty (%):**			**1.677**

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 in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		Mg CH_4	Mg CH_4	%	%	%	%	%	%	%	%	%
Stationary combustion plants, gas engines	CH_4	305	18388	2.2	40	40.060	29.628	2.956	3.185	118.256	9.910	118.671
Stationary combustion plants, other	CH_4	5468	6475	2.2	100	100.024	26.049	-2.930	1.122	-293.021	3.490	293.041
Total	CH_4	5773	24863				1556.35					99955.9
Total uncertainties				**Overall uncertainty in the year (%):**			**39.451**		**Trend uncertainty (%):**			**316.158**

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 in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		Gg N_2O	Gg N_2O	%	%	%	%	%	%	%	%	%
Stationary combustion plants	N_2O	0,775	0,864	2,200	1000	1000,002	1000,002	0,000	1,114	0,000	3,466	3,466
Total	N_2O	0.775	0.864				1000005					12.010
Total uncertainties				**Overall uncertainty in the year (%):**			**1000,002**	**Trend uncertainty (%):**				**3,466**

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 year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		Mg SO_2	Mg SO_2	%	%	%	%	%	%	%	%	%
01	SO_2	129601	10196	2	10	10.198	5.123	-0.041	0.065	-0.409	0.183	0.448
02	SO_2	11491	3176	2	20	20.100	3.145	0.011	0.020	0.215	0.057	0.222
03	SO_2	16507	6927	2	10	10.198	3.480	0.030	0.044	0.304	0.124	0.329
Total	SO_2	157599	20299				48.240					0.358
Total uncertainties			Overall uncertainty in the year (%):				6.945			Trend uncertainty (%):		0.598

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 in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		Mg NO_x	Mg NO_x	%	%	%	%	%	%	%	%	%
01	NO_x	94738	52660	2	20	20.100	14.266	-0.072	0.4571	-1.438	1.293	1.934
02	NO_x	7518	7268	2	50	50.040	4.902	0.021	0.0631	1.053	0.178	1.068
03	NO_x	12954	14265	2	20	20.100	3.865	0.051	0.1238	1.027	0.350	1.085
Total	NO_x	115209	74194				242.487					6.056
Total uncertainties			Overall uncertainty in the year (%):				15.572			Trend uncertainty (%):		2.461

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 in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		Mg NMVOC	Mg NMVOC	%	%	%	%	%	%	%	%	%
01	NMVOC	1073	4128	2	50	50.040	10.583	0.195	0.3251	9.749	0.920	9.792
02	NMVOC	10996	14739	2	50	50.040	37.787	-0.169	1.1609	-8.456	3.283	9.071
03	NMVOC	627	652	2	50	50.040	1.670	-0.025	0.0513	-1.228	0.145	1.236
Total	NMVOC	12696	19519				1542.622					179.706
Total uncertainties			Overall uncertainty in the year (%):				39.276			Trend uncertainty (%):		13.405

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 in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		Mg CO	Mg CO	%	%	%	%	%	%	%	%	%
01	CO	8256	12142	2	20	20.100	1.188	0.013	0.070	0.269	0.199	0.334
02	CO	159295	180277	2	50	50.040	43.928	-0.053	1.044	-2.645	2.954	3.965
03	CO	5082	12941	2	20	20.100	1.267	0.040	0.075	0.799	0.212	0.826
Total	CO	172633	205360				1932.678					16.515
Total uncertainties				Overall uncertainty in the year (%):			**43.962**				Trend uncertainty (%):	**4.064**

Appendix 3A-7 Lower Calorific Value (LCV) of fuels

Table 3A-48 Time-series for calorific values of fuels (Danish Energy Authority, DEA 2005b).

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
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	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	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	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	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	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	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	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	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	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	43.80	43.80
		34.80	34.80	34.80	34.80	34.80	34.80	34.80	34.80	34.80	34.80	34.80	34.80	34.80	34.80	34.80
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	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	43.50	43.50
		35.87	35.87	35.87	35.87	35.87	35.87	35.87	35.87	35.87	35.87	35.87	35.87	35.87	35.87	35.87
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	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	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	27.65	27.65
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	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	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	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	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	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	39.94	39.77
Town Gas	GJ / 1000 m3							17.00	17.00	17.00	17.00	17.01	16.88	17.39	16.88	17.58
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	24.73	24.60
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	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	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	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	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	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	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	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	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	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	3.20	3.20
Biogas	GJ / 1000 m3								23.00	23.00	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	10.50	10.50
Liquid Biofuels											37.60	37.60	37.60	37.60	37.60	37.60
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	37.20	37.20

Table 3A-49 Fuel category correspondence list, Danish Energy Authority, NERI and Climate convention reportings (IPCC).

Danish Energy Authority	NERI Emission database	IPCC fuel category
Other Hard Coal	Coal	Solid
Coke	Coke oven coke	Solid
Electricity Plant Coal	Coal	Solid
Brown Coal Briquettes	Brown coal briq.	Solid
Orimulsion	Orimulsion	Liquid
Petroleum Coke	Petroleum coke	Liquid
Fuel Oil	Residual oil	Liquid
Waste Oil	Residual oil	Liquid
Gas/Diesel Oil	Gas oil	Liquid
Other Kerosene	Kerosene	Liquid
LPG	LPG	Liquid
Refinery Gas	Refinery gas	Liquid
Town Gas	Natural gas	Gas
Natural Gas	Natural gas	Gas
Straw	Straw	Biomass
Wood Waste	Wood and simil.	Biomass
Wood Pellets	Wood and simil.	Biomass
Wood Chips	Wood and simil.	Biomass
Firewood, Hardwood & Conifer	Wood and simil.	Biomass
Waste Combustion	Municip. wastes	Biomass 1)
Fish Oil	Fish & Rape oil	Biomass
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 Adjustment of CO_2 emission (ref. Danish Energy Authority).

Degree Days		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Actual Degree Days	Degree days	2093	2515	3022	3434	3148	3297	3837	3236	3217	3056	2902	3279	3011	3150	3113
Normal Degree Days	Degree days	2691	2691	3370	3370	3370	3370	3370	3370	3370	3370	3370	3370	3370	3370	3370
Net electricity import	TJ	25373	-7 099	13486	4 266	-17424	-2 858	-55444	-26107	-15552	-8 327	2 394	-2 071	-7 453	-30760	-10340
Actual CO_2 emission	1 000 000 tonnes	52.7	62.8	56.7	58.9	62.7	59.6	73.0	63.2	59.4	56.4	52.4	53.8	53.0	58.0	52.7
Adjusted CO_2 emission	1 000 000 tonnes	60.9	61.8	60.8	59.8	59.7	59.1	58.4	57.6	56.2	55.4	54.3	53.7	52.4	51.8	51.2

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	828.564,21	160.588,66	642.420,56		1.594,18	345.138,13
		Orimulsion	TJ	0,00	0,00	0,00		-55,94	55,94
		Natural Gas Liquids	TJ	0,00	0,00	0,00		0,00	0,00
	Secondary Fuels	Gasoline	TJ		38.457,38	41.952,69	24,60	-1.191,31	-2.328,61
		Jet Kerosene	TJ		30.841,26	18.306,19	33.983,35	1.522,19	-22.970,47
		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		78.409,31	49.845,90	16.152,08	-7.172,13	19.583,46
		Residual Fuel Oil	TJ		36.520,89	56.644,64	17.298,08	1.034,75	-38.456,57
		LPG	TJ		203,50	4.373,96		-133,49	-4.036,96
		Ethane	TJ		0,00	0,00		0,00	0,00
		Naphtha	TJ		0,00	201,90		77,03	-278,93
		Bitumen	TJ		9.134,58	105,11		-145,43	9.174,90
		Lubricants	TJ		1.870,79	68,38	83,38	-25,01	1.744,05
		Petroleum Coke	TJ		7.452,82	433,54		-1.373,66	8.392,94
		Refinery Feedstocks	TJ		5.224,26	4.717,33		1.022,37	-515,43
		Other Oil	TJ		1.044,00	55,03		0,00	988,97
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	187.862,03	3.874,10	0,00	2.753,55	181.234,38
		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		5,76	6,00		0,00	-0,24
		Coke Oven/Gas Coke	TJ		1.232,27	52,48		-40,14	1.219,93
Solid Fuel Totals									
Gaseous Fossil		Natural Gas (Dry)	TJ	355.529,91	0,00	154.549,78		6.972,59	194.007,54
Total									
Biomass total									
		Solid Biomass	TJ	84.230,73	10.265,02	0,00		0,00	94.495,75
		Liquid Biomass	TJ	2.444,00	0,00	2.444,00		0,00	0,00
		Gas Biomass	TJ	3.738,12	0,00	0,00		0,00	3.738,12

FUEL TYPES	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)
Crude Oil	1,00	NCV	345.138,13	20,00	6.902,76		6.902,76	1,00	25.310,13
Orimulsion	1,00	NCV	55,94	22,00	1,23		1,23	1,00	4,51
Natural Gas Liquids	1,00	NCV	0,00	17,20	0,00		0,00	1,00	0,00
Gasoline	1,00	NCV	-2.328,61	18,90	-44,01		-44,01	1,00	-161,37
Jet Kerosene	1,00	NCV	-22.970,47	19,50	-447,92		-447,92	1,00	-1.642,39
Other Kerosene	1,00	NCV	0,00	19,60	0,00		0,00	1,00	0,00
Shale Oil	1,00	NCV	0,00	20,00	0,00		0,00	1,00	0,00
Gas / Diesel Oil	1,00	NCV	19.583,46	20,20	395,59	0,00	395,59	1,00	1.450,48
Residual Fuel Oil	1,00	NCV	-38.456,57	21,10	-811,43		-811,43	1,00	-2.975,26
LPG	1,00	NCV	-4.036,96	17,20	-69,44	0,00	-69,44	1,00	-254,60
Ethane	1,00	NCV	0,00	16,80	0,00	0,00	0,00	1,00	0,00
Naphtha	1,00	NCV	-278,93	20,00	-5,58	0,00	-5,58	1,00	-20,45
Bitumen	1,00	NCV	9.174,90	22,00	201,85	213,80	-11,95	1,00	-43,82
Lubricants	1,00	NCV	1.744,05	20,00	34,88	18,34	16,54	1,00	60,63
Petroleum Coke	1,00	NCV	8.392,94	27,50	230,81		230,81	1,00	846,29
Refinery Feedstocks	1,00	NCV	-515,43	20,00	-10,31		-10,31	1,00	-37,80
Other Oil	1,00	NCV	988,97	20,00	19,78	9,30	10,48	1,00	38,44
Liquid Fossil Totals			316.491,41		6.398,20	241,44	6.156,76		22.574,80
Anthracite [2]	1,00	NCV	0,00	26,80	0,00		0,00	1,00	0,00
Coking Coal	1,00	NCV	0,00	25,80	0,00	0,00	0,00	1,00	0,00
Other Bit. Coal	1,00	NCV	181.234,38	25,80	4.675,85		4.675,85	1,00	17.144,77
Sub-bit. Coal	1,00	NCV	0,00	26,20	0,00		0,00	1,00	0,00
Lignite	1,00	NCV	0,00	27,60	0,00		0,00	1,00	0,00
Oil Shale	1,00	NCV	0,00	29,10	0,00		0,00	1,00	0,00
Peat	1,00	NCV	0,00	28,90	0,00		0,00	1,00	0,00
BKB & Patent Fuel	1,00	NCV	-0,24	25,80	-0,01		-0,01	1,00	-0,02
Coke Oven/Gas Coke	1,00	NCV	1.219,93	29,50	35,99		35,99	1,00	131,96
Solid Fuel Totals			182.454,07		4.711,83	0,00	4.711,83		17.276,71
Natural Gas (Dry)	1,00	NCV	194.007,54	15,30	2.968,32	0,00	2.968,32	1,00	10.883,82
Total			**692.953,02**		**14.078,35**	**241,44**	**13.836,91**		**50.735,33**
Biomass total			98.233,87		2.910,65	0,00	2.910,65		10.672,39
Solid Biomass	1,00	NCV	94.495,75	29,90	2.825,42		2.825,42	1,00	10.359,88
Liquid Biomass	1,00	NCV	0,00	20,00	0,00		0,00	1,00	0,00
Gas Biomass	1,00	NCV	3.738,12	22,80	85,23		85,23	1,00	312,51

TABLE 1.A(c) COMPARISON OF CO_2 EMISSIONS FROM FUEL COMBUSTION
(Sheet 1 of 1)

Denmark
2004
2006, Jan 13

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)	316,49	22.574,80	301,40	22.176,13	5,01	1,80
Solid Fuels (excluding international bunkers)	182,45	17.276,71	183,64	17.460,63	-0,65	-1,05
Gaseous Fuels	194,01	10.883,82	195,08	11.142,75	-0,55	-2,32
Other [3]	-12,17	676,45	0,40	705,98	-3.108,44	-4,18
Total [3]	**680,78**	**51.411,78**	**680,52**	**51.485,49**	**0,04**	**-0,14**

[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. 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 to make results comparable. (Other fuels of sources 1A1, 1A2 and 1A4)

Table 3A-51 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	Liquid Biomass	Liquid biofuels
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	Crude oil	Waste 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	Other oil	White Spirit
Liquid fossil	Naphtha	Naphtha (LVN)
Gaseous fossil	Natural gas	Natural Gas
Liquid fossil	Natural gas liquids	-
Liquid fossil	Orimulsion	Orimulsion
Liquid fossil	Other kerosene	Other Kerosene
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	Lignite	-
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	-

Appendix 3A-10 Emission inventory 2004 based on SNAP sectors

Table 3A-52 Emission inventory 2004 based on SNAP sectors.

SNAP 2)	SO2 [Mg]	NOX [Mg]	NMVOC [Mg]	CH4 [Mg]	CO [Mg]	CO_2 1) [Gg]	N2O [Mg]	TSP [Mg]	PM10 [Mg]	PM2,5 [Mg]	As [kg]	Cd [kg]	Cr [kg]	Cu [kg]	Hg [kg]	Ni [kg]	Pb [kg]	Se [kg]	Zn [kg]	Flouran-the [kg]	Benzo(b) [kg]	Benzo(k) [kg]	Benzo(a) [kg]	Benzo(g,,) [kg]	Indeno [kg]
Total 01	10196	52660	4128	15365	12142	31924	498	1464	1175	980	362	222	468	625	567	2782	2177	767	13716	220	29	14	7	17	7
101	-	0	-	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10101	6943	27881	312	387	2349	17977	172	731	584	481	127	17	222	146	148	1424	219	692	26	14	3	1	1	2	1
10102	1218	4603	57	45	714	4008	43	120	88	72	157	84	98	246	122	259	1330	45	9393	6	0	0	0	0	0
10103	422	1303	16	21	261	1204	13	60	37	30	47	41	20	98	96	45	411	1	2678	3	0	0	0	0	0
10104	391	3628	82	79	824	3112	90	209	206	171	3	2	5	3	1	80	7	5	12	18	4	1	1	2	1
10105	39	5282	3119	14188	5021	1648	35	24	6	5	0	0	0	0	0	1	0	1	1	4	1	1	0	0	0
102	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10201	2	6	0	0	3	7	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
10202	50	115	36	26	206	132	4	16	12	10	1	5	2	5	6	22	4	2	90	6	1	1	0	0	0
10203	700	1289	407	290	2238	1246	45	166	118	93	11	59	85	112	189	262	181	8	1512	167	19	11	5	11	3
10204	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10205	1	103	57	258	93	31	1	0	0	0	0	-	0	0	0	-	0	0	0	0	0	0	-	-	-
103	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10301	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10302	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10303	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10304	1	641	2	2	24	216	8	19	19	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10305	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10306	420	967	0	0	214	772	26	114	103	98	15	14	36	14	5	688	25	13	3	2	1	0	0	0	0
104	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10401	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10402	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10403	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10404	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10405	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10406	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10407	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
105	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10501	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10502	0	40	1	2	10	21	0	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10503	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10504	8	6767	38	41	168	1546	60	3	2	1	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0
10505	1	35	2	26	19	6	0	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10506	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total 02	3176	7268	14739	8033	180277	7867	216	13957	13237	12526	59	148	69	186	243	597	189	162	2951	15261	4177	1376	3204	4324	2334
201	174	613	443	200	578	1005	22	123	123	117	7	7	9	12	12	74	19	22	156	548	151	50	115	157	82
20101	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20102	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20103	80	18	1	2	6	21	1	8	7	5	4	1	2	2	40	2	2	0	27	1	0	-	0	-	-
20104	0	3	0	0	0	1	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20105	10	453	128	704	322	102	2	2	0	0	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0
20106	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
202	1738	4631	12385	4289	170550	5752	165	13308	12626	11952	32	127	28	153	169	49	132	119	2694	14227	3906	1301	2980	4035	2104

20201	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20202	0	2	0	1	1	4	0	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20203	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20204	0	248	173	767	258	84	2	1	0	0	-	-	-	-	-	-	-	-	-	0	0	0	-	0	0
20205	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
203	1161	589	1268	448	7945	696	20	511	480	450	16	12	30	18	22	469	35	20	74	483	119	25	109	132	148
20301	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20302	3	1	0	0	2	1	0	0	0	0	0	0	0	0	0	3	0	0	0	1	0	0	0	0	0
20303	0	7	0	0	0	3	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20304	9	703	341	1622	613	198	4	3	1	1	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0
20305	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total 03	6927	14265	652	1464	12941	5526	150	1047	699	405	205	152	373	168	242	4573	1345	799	1270	3681	96	15	28	9	9
301	4352	2806	307	362	1932	3026	72	239	177	125	89	94	183	107	57	3303	164	79	573	168	10	9	1	5	4
30101	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30102	1049	467	33	42	134	415	10	140	42	12	29	23	60	27	10	1092	49	22	20	26	1	2	0	1	1
30103	9	36	17	13	86	42	1	7	4	3	-	2	-	2	2	-	1	-	47	1	0	0	-	0	-
30104	2	672	9	10	41	379	15	1	0	0	-	-	-	-	-	-	-	-	-	0	-	0	-	0	0
30105	1	273	184	822	279	91	2	1	0	0	-	-	0	-	-	0	0	-	-	0	0	0	-	0	0
30106	0	1	0	0	1	2	0	0	0	0	0	-	0	0	0	0	0	0	0	0	-	-	-	-	-
302	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30203	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30204	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30205	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
303	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30301	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30302	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30303	-	-	-	-	-	-	-	181	54	8	27	13	100	-	-	118	652	453	453	-	-	-	-	-	-
30304	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30305	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30306	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30307	-	-	-	-	-	-	-	2	1	1	-	0	-	1	-	-	9	-	-	-	-	-	-	-	-
30308	-	-	-	-	-	-	-	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30309	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30310	-	-	-	-	-	-	-	20	18	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30311	992	9441	89	193	1240	1396	45	196	177	78	57	20	29	29	172	57	29	20	143	3473	83	4	26	3	3
30312	-	-	-	-	-	-	-	27	14	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30313	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30314	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30315	0	467	2	5	10	52	1	23	21	18	-	-	-	-	-	-	436	225	25	0	-	-	-	-	-
30316	-	-	-	-	-	-	-	99	89	69	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30317	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30318	522	103	11	16	9218	123	3	111	100	78	3	0	2	3	1	4	5	0	9	11	1	1	0	1	1
30319	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30320	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30321	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30322	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30323	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30324	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30325	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30326	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30327	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

1) Including CO_2 emission from biomass
2) SNAP sector codes are shown in Appendix 3A-2

Heavy metal emissions for 2004 distributed on IPCC categories

Pollutant	Pb Mg	Cd Mg	Hg Mg	As Mg	Cr Mg	Cu Mg	Ni Mg	Se Mg	Zn Mg
1A1 Fuel combustion. Energy industries	2.18	0.22	0.57	0.36	0.47	0.63	2.78	0.77	13.72
1A2 Fuel combustion. Manufacturing Industries and Construction (Stationary combustion)	1.34	0.15	0.24	0.20	0.37	0.17	4.57	0.80	1.27
1A4 Fuel combustion. Other sectors (Stationary combustion)	0.19	0.15	0.24	0.06	0.07	0.19	0.60	0.16	2.95
Total emission from stationary combustion plants	3.71	0.52	1.05	0.63	0.91	0.98	7.95	1.73	17.94
Total Danish emission	5.25	0.58	1.06	0.66	1.16	9.03	9.55	1.84	23.41
Emission share for stationary combustion	71%	90%	99%	95%	78%	11%	83%	94%	77%

Selected PAH emissions for 2004 distributed on IPCC categories

Pollutant	Benzo(a)-pyrene Mg	Benzo(b)fluoranthene Mg	Benzo(k)fluoranthene Mg	Indeno(1,2,3-c,d)pyrene Mg
1A1 Fuel combustion. Energy industries	0.01	0.03	0.01	0.01
1A2 Fuel combustion. Manufacturing Industries and Construction (Stationary combustion)	0.03	0.10	0.02	0.01
1A4 Fuel combustion. Other sectors (Stationary combustion)	3.20	4.18	1.38	2.33
Total emission from stationary combustion plants	3.24	4.30	1.41	2.35
Total Danish emission (gross)	3.30	4.39	1.50	2.42
Emission share for stationary combustion	98%	98%	94%	97%

Annex 3B Transport

Annex 3B-1: Fleet data 1990-2004 for road transport (No. vehicles)

Sector	Subsector	Tech	FYear	LYear	1985	1986	1987	1988	1989	1990	1991	1992	1993
Passenger Cars	Gasoline <1.4 l	PRE ECE	0	1969	80570	70965	61916	53661	49471	46208	44014	42804	36466
Passenger Cars	Gasoline <1.4 l	ECE 15/00-01	1970	1978	333714	319739	297370	247511	217970	187911	161642	139011	119423
Passenger Cars	Gasoline <1.4 l	ECE 15/02	1979	1980	104223	81798	75344	97293	92422	86056	79240	72588	65798
Passenger Cars	Gasoline <1.4 l	ECE 15/03	1981	1985	345946	374460	359056	308509	306989	301692	295678	288944	280769
Passenger Cars	Gasoline <1.4 l	ECE 15/04	1986	1990		46574	114381	206106	245261	282011	280180	278685	278152
Passenger Cars	Gasoline <1.4 l	Euro I	1991	1996							39608	73527	101489
Passenger Cars	Gasoline <1.4 l	Euro II	1997	2000									
Passenger Cars	Gasoline <1.4 l	Euro III	2001	2005									
Passenger Cars	Gasoline 1.4 - 2.0 l	PRE ECE	0	1969	61592	54869	48157	41737	38477	35940	34233	33292	28362
Passenger Cars	Gasoline 1.4 - 2.0 l	ECE 15/00-01	1970	1978	218181	211819	199591	168672	148280	127631	109640	94187	80843
Passenger Cars	Gasoline 1.4 - 2.0 l	ECE 15/02	1979	1980	60836	50077	46439	62263	59148	55063	50674	46402	42040
Passenger Cars	Gasoline 1.4 - 2.0 l	ECE 15/03	1981	1985	210573	222174	211067	178826	177843	174544	170748	166595	161592
Passenger Cars	Gasoline 1.4 - 2.0 l	ECE 15/04	1986	1990		31049	74328	131279	159911	190297	188948	187873	187524
Passenger Cars	Gasoline 1.4 - 2.0 l	Euro I	1991	1996							35647	75763	119561
Passenger Cars	Gasoline 1.4 - 2.0 l	Euro II	1997	2000									
Passenger Cars	Gasoline 1.4 - 2.0 l	Euro III	2001	2005									
Passenger Cars	Gasoline >2.0 l	PRE ECE	0	1969	5923	5243	4586	3975	3665	3423	3260	3171	2701
Passenger Cars	Gasoline >2.0 l	ECE 15/00-01	1970	1978	18531	17532	16672	14346	12566	10780	9234	7914	6782
Passenger Cars	Gasoline >2.0 l	ECE 15/02	1979	1980	8729	6326	4457	4966	4718	4392	4042	3702	3355
Passenger Cars	Gasoline >2.0 l	ECE 15/03	1981	1985	31066	33255	31913	25237	25111	24666	24157	23596	22911
Passenger Cars	Gasoline >2.0 l	ECE 15/04	1986	1990		4085	9932	19410	22965	25679	25524	25389	25338
Passenger Cars	Gasoline >2.0 l	Euro I	1991	1996							3961	8129	12434
Passenger Cars	Gasoline >2.0 l	Euro II	1997	2000									
Passenger Cars	Gasoline >2.0 l	Euro III	2001	2005									
Passenger Cars	Diesel <2.0 l	Euro I	1991	1996							4042	8018	11873
Passenger Cars	Diesel <2.0 l	Euro II	1997	2000									
Passenger Cars	Diesel <2.0 l	Euro III	2001	2005									
Passenger Cars	Diesel <2.0 l	Conventional	0	1990	75827	78430	79758	80200	80188	79714	75795	72294	68535
Passenger Cars	Diesel >2.0 l	Euro I	1991	1996							213	436	667
Passenger Cars	Diesel >2.0 l	Euro II	1997	2000									

Passenger Cars	Diesel >2.0 l	Euro III	2001	2005									
Passenger Cars	Diesel >2.0 l	Conventional	0	1990	3451	3566	3627	3647	3706	3704	3557	3423	3280

Sector	Subsector	Tech	FYear	LYear	1985	1986	1987	1988	1989	1990	1991	1992	1993
Passenger Cars	LPG	Euro I	1991	1996	0	0	0	0	0	0	0	0	0
Passenger Cars	LPG	Euro II	1997	2000	0	0	0	0	0	0	0	0	0
Passenger Cars	LPG	Euro III	2001	2005	0	0	0	0	0	0	0	0	0
Passenger Cars	LPG	Conventional	0	1990	287	287	287	287	287	286	286	288	289
Passenger Cars	2-Stroke	Conventional	0	9999	4823	5402	5997	6026	5853	5417	4804	4308	3747
Light Duty Vehicles	Gasoline <3.5t	Conventional	0	1994	33049	36810	39724	41321	41967	42333	43215	44179	45487
Light Duty Vehicles	Gasoline <3.5t	Euro I	1995	1998									
Light Duty Vehicles	Gasoline <3.5t	Euro II	1999	2001									
Light Duty Vehicles	Gasoline <3.5t	Euro III	2002	2006									
Light Duty Vehicles	Diesel <3.5 t	Conventional	0	1994	121431	135248	145954	151822	154198	155543	158782	162324	167129
Light Duty Vehicles	Diesel <3.5 t	Euro I	1995	1998									
Light Duty Vehicles	Diesel <3.5 t	Euro II	1999	2001									
Light Duty Vehicles	Diesel <3.5 t	Euro III	2002	2006									
Heavy Duty Vehicles	Gasoline >3.5 t	Conventional	0	9999	251	261	262	255	254	250	255	261	267
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Conventional	0	1993	5140	5338	5353	5228	5194	5108	5214	5331	5487
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Euro I	1994	1996									
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Euro II	1997	2001									
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Euro III	2002	2006									
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Conventional	0	1993	10350	10750	10779	10528	10460	10286	10500	10735	11052
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Euro I	1994	1996									
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Euro II	1997	2001									
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Euro III	2002	2006									
Heavy Duty Vehicles	Diesel 16 - 32 t	Conventional	0	1993	13115	13623	13659	13342	13255	13034	13306	13603	14006
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro I	1994	1996									
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro II	1997	2001									
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro III	2002	2006									
Heavy Duty Vehicles	Diesel >32t	Conventional	0	1993	11517	11962	11994	11715	11640	11446	11683	11944	12299
Heavy Duty Vehicles	Diesel >32t	Euro I	1994	1996									
Heavy Duty Vehicles	Diesel >32t	Euro II	1997	2001									
Heavy Duty Vehicles	Diesel >32t	Euro III	2002	2006									

Sector	Subsector	Tech	FYear	LYear	1985	1986	1987	1988	1989	1990	1991	1992	1993
Buses	Urban Buses	Conventional	0	1993	4712	4768	4771	4761	4724	4753	4561	4522	4489
Buses	Urban Buses	Euro I	1994	1996									
Buses	Urban Buses	Euro II	1997	2001									
Buses	Urban Buses	Euro III	2002	2006									
Buses	Coaches	Conventional	0	1993	3298	3337	3339	3332	3307	3327	2868	3007	3086
Buses	Coaches	Euro I	1994	1996									
Buses	Coaches	Euro II	1997	2001									
Buses	Coaches	Euro III	2002	2006									
Mopeds	<50 cm^3	Conventional	0	1999	151000	139000	133000	127000	124000	120000	118000	113000	109000
Mopeds	<50 cm^3	97/24/EC I	2000	2002									
Mopeds	<50 cm^3	97/24/EC II	2003	9999									
Motorcycles	2-stroke >50 cm^3	Conventional	0	1999	6209	6280	6368	6368	6488	6617	6804	6904	7111
Motorcycles	4-stroke <250 cm^3	Conventional	0	1999	7037	7118	7218	7217	7353	7499	7712	7824	8059
Motorcycles	4-stroke <250 cm^3	97/24/EC	2000	2003									
Motorcycles	4-stroke <250 cm^3	Stage II	2004	2006									
Motorcycles	4-stroke 250 - 750 cm^3	Conventional	0	1999	19352	19573	19848	19845	20222	20622	21207	21516	22162
Motorcycles	4-stroke 250 - 750 cm^3	97/24/EC	2000	2003									
Motorcycles	4-stroke 250 - 750 cm^3	Stage II	2004	2006									
Motorcycles	4-stroke >750 cm^3	Conventional	0	1999	8796	8897	9022	9021	9192	9374	9639	9780	10074
Motorcycles	4-stroke >750 cm^3	97/24/EC	2000	2003									
Motorcycles	4-stroke >750 cm^3	Stage II	2004	2006									

Sector	Subsector	Tech	FYear	LYear	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Passenger Cars	Gasoline <1.4 l	PRE ECE	0	1969	39959	37597	37130	3434	2761	2103	1744	1614	1475	1392	1313
Passenger Cars	Gasoline <1.4 l	ECE 15/00-01	1970	1978	80742	67991	53301	44337	31104	22513	17979	15837	14154	13149	12404
Passenger Cars	Gasoline <1.4 l	ECE 15/02	1979	1980	49613	42977	34748	25889	17457	10806	7298	5510	4177	3128	2433
Passenger Cars	Gasoline <1.4 l	ECE 15/03	1981	1985	262502	250449	233657	215509	183239	147179	118980	97964	79041	60724	45825
Passenger Cars	Gasoline <1.4 l	ECE 15/04	1986	1990	275858	272988	269954	275190	264791	254033	235890	219215	194543	171430	142491
Passenger Cars	Gasoline <1.4 l	Euro I	1991	1996	139813	169133	205235	210861	208282	206804	204184	201708	197423	192152	185489
Passenger Cars	Gasoline <1.4 l	Euro II	1997	2000				38465	74494	108508	135031	132813	130153	128898	126401
Passenger Cars	Gasoline <1.4 l	Euro III	2001	2005								21858	47428	70311	99658
Passenger Cars	Gasoline 1.4 - 2.0 l	PRE ECE	0	1969	31079	29242	28879	2671	2148	1635	1356	1255	1147	1083	1021
Passenger Cars	Gasoline 1.4 - 2.0 l	ECE 15/00-01	1970	1978	54600	45990	36078	30465	21519	15648	12537	11078	9923	9231	8708
Passenger Cars	Gasoline 1.4 - 2.0 l	ECE 15/02	1979	1980	31712	27445	22172	16510	11141	6870	4642	3500	2658	1987	1545
Passenger Cars	Gasoline 1.4 - 2.0 l	ECE 15/03	1981	1985	150612	143385	133411	122642	103931	83270	67222	55301	44572	34237	25811
Passenger Cars	Gasoline 1.4 - 2.0 l	ECE 15/04	1986	1990	186046	184195	182297	186155	179510	172582	160800	149915	133745	118448	99092
Passenger Cars	Gasoline 1.4 - 2.0 l	Euro I	1991	1996	201006	288095	375253	383871	378062	375137	370803	367135	359958	351646	340424
Passenger Cars	Gasoline 1.4 - 2.0 l	Euro II	1997	2000				95358	196046	274022	326267	320971	314678	311808	305622
Passenger Cars	Gasoline 1.4 - 2.0 l	Euro III	2001	2005								49700	105324	147067	195431
Passenger Cars	Gasoline >2.0 l	PRE ECE	0	1969	2960	2785	2750	254	205	156	129	120	109	103	97
Passenger Cars	Gasoline >2.0 l	ECE 15/00-01	1970	1978	4568	3849	3022	2619	1882	1367	1110	989	885	823	777
Passenger Cars	Gasoline >2.0 l	ECE 15/02	1979	1980	2531	2190	1770	1318	889	549	371	280	212	158	123
Passenger Cars	Gasoline >2.0 l	ECE 15/03	1981	1985	21429	20432	19054	17570	14933	12016	9723	8008	6459	4965	3744
Passenger Cars	Gasoline >2.0 l	ECE 15/04	1986	1990	25119	24845	24547	24976	23976	22975	21252	19699	17377	15265	12606
Passenger Cars	Gasoline >2.0 l	Euro I	1991	1996	20068	27915	35769	36617	36081	35807	35387	35024	34329	33515	32430
Passenger Cars	Gasoline >2.0 l	Euro II	1997	2000				12432	27315	44922	61899	60799	59506	58896	57816
Passenger Cars	Gasoline >2.0 l	Euro III	2001	2005								15179	30712	45080	65819
Passenger Cars	Diesel <2.0 l	Euro I	1991	1996	18305	24557	31178	31314	31728	35117	39313	43578	48670	53462	59969
Passenger Cars	Diesel <2.0 l	Euro II	1997	2000				7046	14640	23084	31540	34764	38841	43327	49262
Passenger Cars	Diesel <2.0 l	Euro III	2001	2005								5482	13338	21371	33648
Passenger Cars	Diesel <2.0 l	Conventional	0	1990	62145	58846	55003	48252	43894	43002	42599	42638	42101	40524	38623
Passenger Cars	Diesel >2.0 l	Euro I	1991	1996	1078	1499	1921	1929	1951	2161	2420	2683	2998	3294	3698
Passenger Cars	Diesel >2.0 l	Euro II	1997	2000				655	1478	2710	4232	4658	5196	5789	6592
Passenger Cars	Diesel >2.0 l	Euro III	2001	2005								1163	2681	4432	7505
Passenger Cars	Diesel >2.0 l	Conventional	0	1990	3041	2904	2749	2461	2267	2234	2228	2228	2190	2097	1977

Sector	Subsector	Tech	FYear	LYear	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Passenger Cars	LPG	Euro I	1991	1996	0	0	0	0	0	0	0	0	0	0	0
Passenger Cars	LPG	Euro II	1997	2000	0	0	0	0	0	0	0	0	0	0	0
Passenger Cars	LPG	Euro III	2001	2005	0	0	0	0	0	0	0	0	0	0	0
Passenger Cars	LPG	Conventional	0	1990	289	301	311	172	97	44	32	63	21	15	15
Passenger Cars	2-Stroke	Conventional	0	9999	3029	2443	1824	1248	761	400	300	200	150	100	50
Light Duty Vehicles	Gasoline <3.5t	Conventional	0	1994	47260	44601	41519	37209	34454	31490	28488	25423	21615	18838	14577
Light Duty Vehicles	Gasoline <3.5t	Euro I	1995	1998		4259	8524	12645	17212	16632	15979	15528	15050	13949	14793
Light Duty Vehicles	Gasoline <3.5t	Euro II	1999	2001						4705	9300	14017	13916	13805	14126
Light Duty Vehicles	Gasoline <3.5t	Euro III	2002	2006									5140	10719	16724
Light Duty Vehicles	Diesel <3.5 t	Conventional	0	1994	173650	163878	152553	142109	131572	122991	115694	105397	92990	82926	66760
Light Duty Vehicles	Diesel <3.5 t	Euro I	1995	1998		15648	31318	48292	65728	64964	64894	64370	64743	61407	67752
Light Duty Vehicles	Diesel <3.5 t	Euro II	1999	2001						18376	37766	58112	59870	60772	64698
Light Duty Vehicles	Diesel <3.5 t	Euro III	2002	2006									22112	47185	76596
Heavy Duty Vehicles	Gasoline >3.5 t	Conventional	0	9999	278	288	295	262	274	251	257	248	249	248	233
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Conventional	0	1993	5205	4891	4532	3999	3692	3079	2406	1978	1739	1407	1069
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Euro I	1994	1996	497	1004	1506	1440	1434	1269	1056	951	956	814	902
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Euro II	1997	2001				529	1088	1487	1702	1990	2064	1872	2036
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Euro III	2002	2006									484	941	1541
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Conventional	0	1993	10482	9850	9126	7801	6604	5613	5085	4211	3136	2571	1639
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Euro I	1994	1996	1001	2022	3034	2808	2565	2313	2234	2025	1724	1485	1384
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Euro II	1997	2001				1032	1945	2709	3601	4235	3724	3421	3123
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Euro III	2002	2006									872	1721	2364
Heavy Duty Vehicles	Diesel 16 - 32 t	Conventional	0	1993	13283	12481	11564	10719	9831	8982	7933	6815	5525	4571	3110
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro I	1994	1996	1268	2562	3844	3859	3821	3702	3486	3276	3037	2642	2627
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro II	1997	2001				1419	2896	4336	5616	6853	6560	6082	5926
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro III	2002	2006									1537	3058	4484
Heavy Duty Vehicles	Diesel >32t	Conventional	0	1993	11665	10961	10155	9337	8720	8180	7361	6527	5486	4716	3283
Heavy Duty Vehicles	Diesel >32t	Euro I	1994	1996	1114	2250	3375	3362	3389	3372	3234	3138	3016	2726	2772
Heavy Duty Vehicles	Diesel >32t	Euro II	1997	2001				1236	2568	3948	5211	6564	6513	6275	6253
Heavy Duty Vehicles	Diesel >32t	Euro III	2002	2006									1526	3155	4732

Sector	Subsector	Tech	FYear	LYear	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Buses	Urban Buses	Conventional	0	1993	4083	3635	3261	2946	2793	2542	2319	2158	1976	1860	1711
Buses	Urban Buses	Euro I	1994	1996	390	746	1084	1060	972	913	852	792	752	714	663
Buses	Urban Buses	Euro II	1997	2001				390	728	1053	1346	1596	1525	1446	1345
Buses	Urban Buses	Euro III	2002	2006									346	669	951
Buses	Coaches	Conventional	0	1993	2928	4507	4156	3662	3370	3006	2723	2444	2165	1962	1773
Buses	Coaches	Euro I	1994	1996	280	925	1381	1318	1174	1079	1001	896	823	752	688
Buses	Coaches	Euro II	1997	2001				485	879	1246	1580	1807	1670	1527	1394
Buses	Coaches	Euro III	2002	2006									379	706	986
Mopeds	<50 cm^3	Conventional	0	1999	105000	114167	123333	132500	141667	150833	143607	136249	128209	120305	112262
Mopeds	<50 cm^3	97/24/EC I	2000	2002							16393	28751	42791	40611	38395
Mopeds	<50 cm^3	97/24/EC II	2003	9999										8084	18343
Motorcycles	2-stroke >50 cm^3	Conventional	0	1999	7406	7672	8214	8980	9598	10385	11054	11367	11582	11850	12326
Motorcycles	2-stroke >50 cm^3	97/24/EC	2000	2003	0	0	0	0	0	0	0	0	0		0
Motorcycles	2-stroke >50 cm^3	Stage II	2004	9999											
Motorcycles	4-stroke <250 cm^3	Conventional	0	1999	8394	8695	9310	10177	10878	11769	11670	12487	12882	13380	14078
Motorcycles	4-stroke <250 cm^3	97/24/EC	2000	2003							858	918	1348	1806	1816
Motorcycles	4-stroke <250 cm^3	Stage II	2004	9999											604
Motorcycles	4-stroke 250 - 750 cm^3	Conventional	0	1999	23083	23911	25602	27986	29914	32365	32093	34338	35424	36794	38714
Motorcycles	4-stroke 250 - 750 cm^3	97/24/EC	2000	2003							2360	2525	3707	4967	4993
Motorcycles	4-stroke 250 - 750 cm^3	Stage II	2004	9999											1661
Motorcycles	4-stroke >750 cm^3	Conventional	0	1999	10492	10869	11637	12721	13597	14712	14588	15608	16102	16725	17597
Motorcycles	4-stroke >750 cm^3	97/24/EC	2000	2003							1073	1148	1685	2258	2270
Motorcycles	4-stroke >750 cm^3	Stage II	2004	9999											755

Annex 3B-2: Mileage data 1990-2004 for road transport (km)

Sector	Subsector	Tech	FYear	LYear	1985	1986	1987	1988	1989	1990	1991	1992	1993
Passenger Cars	Gasoline <1.4 l	PRE ECE	0	1969	9579	9371.7	9286.7	9480	9566.2	10410	11215	11916	11961
Passenger Cars	Gasoline <1.4 l	ECE 15/00-01	1970	1978	12134	11492	11034	10690	10079	10410	11215	11916	11961
Passenger Cars	Gasoline <1.4 l	ECE 15/02	1979	1980	16077	14937	13860	13562	13205	13297	12204	11916	11961
Passenger Cars	Gasoline <1.4 l	ECE 15/03	1981	1985	18829	17755	16960	16559	15737	16477	16988	17032	16112
Passenger Cars	Gasoline <1.4 l	ECE 15/04	1986	1990		20401	19818	19551	19317	20164	20649	20997	19980
Passenger Cars	Gasoline <1.4 l	Euro I	1991	1996							24415	25479	24809
Passenger Cars	Gasoline <1.4 l	Euro II	1997	2000									
Passenger Cars	Gasoline <1.4 l	Euro III	2001	2005									
Passenger Cars	Gasoline 1.4 - 2.0 l	PRE ECE	0	1969	9579	9371.7	9286.7	9480	9566.2	10410	11215	11916	11961
Passenger Cars	Gasoline 1.4 - 2.0 l	ECE 15/00-01	1970	1978	12052	11426	10978	10642	10052	10410	11215	11916	11961
Passenger Cars	Gasoline 1.4 - 2.0 l	ECE 15/02	1979	1980	16070	14949	13860	13560	13203	13291	12193	11916	11961
Passenger Cars	Gasoline 1.4 - 2.0 l	ECE 15/03	1981	1985	18912	17820	16975	16522	15701	16440	16953	16997	16053
Passenger Cars	Gasoline 1.4 - 2.0 l	ECE 15/04	1986	1990		20401	19825	19573	19366	20308	20805	21135	20127
Passenger Cars	Gasoline 1.4 - 2.0 l	Euro I	1991	1996							24415	25538	25030
Passenger Cars	Gasoline 1.4 - 2.0 l	Euro II	1997	2000									
Passenger Cars	Gasoline 1.4 - 2.0 l	Euro III	2001	2005									
Passenger Cars	Gasoline >2.0 l	PRE ECE	0	1969	9579	9371.7	9286.7	9480	9566.2	10410	11215	11916	11961
Passenger Cars	Gasoline >2.0 l	ECE 15/00-01	1970	1978	12071	11335	10877	10548	10019	10410	11215	11916	11961
Passenger Cars	Gasoline >2.0 l	ECE 15/02	1979	1980	16075	15017	13902	13563	13206	13300	12209	11916	11961
Passenger Cars	Gasoline >2.0 l	ECE 15/03	1981	1985	18863	17813	17033	16598	15766	16506	17015	17075	16182
Passenger Cars	Gasoline >2.0 l	ECE 15/04	1986	1990		20401	19821	19486	19280	20009	20515	20893	19826
Passenger Cars	Gasoline >2.0 l	Euro I	1991	1996							24415	25523	24981
Passenger Cars	Gasoline >2.0 l	Euro II	1997	2000									
Passenger Cars	Gasoline >2.0 l	Euro III	2001	2005									
Passenger Cars	Diesel <2.0 l	Euro I	1991	1996							44774	44798	43686
Passenger Cars	Diesel <2.0 l	Euro II	1997	2000									
Passenger Cars	Diesel <2.0 l	Euro III	2001	2005									
Passenger Cars	Diesel <2.0 l	Conventional	0	1990	30140	30143	30146	29412	29852	30226	30006	29506	28618
Passenger Cars	Diesel >2.0 l	Euro I	1991	1996							44774	44824	43778
Passenger Cars	Diesel >2.0 l	Euro II	1997	2000									
Passenger Cars	Diesel >2.0 l	Euro III	2001	2005									
Passenger Cars	Diesel >2.0 l	Conventional	0	1990	31387	31386	31387	30749	31224	31385	31124	30558	29450

Sector	Subsector	Tech	FYear	LYear	1985	1986	1987	1988	1989	1990	1991	1992	1993
Passenger Cars	LPG	Euro I	1991	1996	0	0	0	0	0	0	0	0	0
Passenger Cars	LPG	Euro II	1997	2000	0	0	0	0	0	0	0	0	0
Passenger Cars	LPG	Euro III	2001	2005	0	0	0	0	0	0	0	0	0
Passenger Cars	LPG	Conventional	0	1990	18862	17780	16967	16544	15723	16463	16974	17018	16091
Passenger Cars	2-Stroke	Conventional	0	9999	18862	17780	16967	16544	15723	16463	16974	17018	16091
Light Duty Vehicles	Gasoline <3.5t	Conventional	0	1994	19874	19443	19267	19668	19215	20316	20772	21385	20746
Light Duty Vehicles	Gasoline <3.5t	Euro I	1995	1998									
Light Duty Vehicles	Gasoline <3.5t	Euro II	1999	2001									
Light Duty Vehicles	Gasoline <3.5t	Euro III	2002	2006									
Light Duty Vehicles	Diesel <3.5 t	Conventional	0	1994	35513	37963	36672	36790	38329	40670	41136	39162	37638
Light Duty Vehicles	Diesel <3.5 t	Euro I	1995	1998									
Light Duty Vehicles	Diesel <3.5 t	Euro II	1999	2001									
Light Duty Vehicles	Diesel <3.5 t	Euro III	2002	2006									
Heavy Duty Vehicles	Gasoline >3.5 t	Conventional	0	9999	22450	21964	21765	22218	21707	24538	25088	25829	25057
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Conventional	0	1993	31444	33613	32470	32575	33937	41507	41982	39966	38412
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Euro I	1994	1996									
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Euro II	1997	2001									
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Euro III	2002	2006									
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Conventional	0	1993	43811	46833	45241	45387	47285	50173	50747	48311	46432
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Euro I	1994	1996									
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Euro II	1997	2001									
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Euro III	2002	2006									
Heavy Duty Vehicles	Diesel 16 - 32 t	Conventional	0	1993	60901	65102	62888	63092	65730	69745	70543	67157	64545
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro I	1994	1996									
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro II	1997	2001									
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro III	2002	2006									
Heavy Duty Vehicles	Diesel >32t	Conventional	0	1993	60901	65102	62888	63092	65730	69745	70543	67157	64545
Heavy Duty Vehicles	Diesel >32t	Euro I	1994	1996									
Heavy Duty Vehicles	Diesel >32t	Euro II	1997	2001									
Heavy Duty Vehicles	Diesel >32t	Euro III	2002	2006									

Sector	Subsector	Tech	FYear	LYear	1985	1986	1987	1988	1989	1990	1991	1992	1993
Buses	Urban Buses	Conventional	0	1993	91883	98221	94881	95188	99168	105226	108958	105212	104456
Buses	Urban Buses	Euro I	1994	1996									
Buses	Urban Buses	Euro II	1997	2001									
Buses	Urban Buses	Euro III	2002	2006									
Buses	Coaches	Conventional	0	1993	82367	89984	90154	90858	94640	94328	99821	99971	99704
Buses	Coaches	Euro I	1994	1996									
Buses	Coaches	Euro II	1997	2001									
Buses	Coaches	Euro III	2002	2006									
Mopeds	<50 cm^3	Conventional	0	1999	2017	1973	1955	1996	1950	2062	2158	2254	2258
Mopeds	<50 cm^3	97/24/EC I	2000	2002	0	0	0	0	0	0	0	0	0
Mopeds	<50 cm^3	97/24/EC II	2003	9999	0	0	0	0	0	0	0	0	0
Motorcycles	2-stroke >50 cm^3	Conventional	0	1999	5705	5582	5531	5646	5516	5832	6131	6425	6427
Motorcycles	2-stroke >50 cm^3	97/24/EC	2000	2003	0	0	0	0	0	0	0	0	0
Motorcycles	4-stroke <250 cm^3	Conventional	0	1999	5705	5582	5531	5646	5516	5832	6131	6425	6427
Motorcycles	4-stroke <250 cm^3	97/24/EC	2000	2003									
Motorcycles	4-stroke <250 cm^3	Stage II	2004	9999									
Motorcycles	4-stroke 250 - 750 cm^3	Conventional	0	1999	5705	5582	5531	5646	5516	5832	6131	6425	6427
Motorcycles	4-stroke 250 - 750 cm^3	97/24/EC	2000	2003									
Motorcycles	4-stroke 250 - 750 cm^3	Stage II	2004	9999									
Motorcycles	4-stroke >750 cm^3	Conventional	0	1999	5705	5582	5531	5646	5516	5832	6131	6425	6427
Motorcycles	4-stroke >750 cm^3	97/24/EC	2000	2003									
Motorcycles	4-stroke >750 cm^3	Stage II	2004	9999									

Sector	Subsector	Tech	FYear	LYear	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Passenger Cars	Gasoline <1.4 l	PRE ECE	0	1969	11947	12148	11930	11913	11873	11671	11563	11362	11487	11484	11497
Passenger Cars	Gasoline <1.4 l	ECE 15/00-01	1970	1978	11947	12148	11930	11913	11873	11671	11563	11362	11487	11484	11497
Passenger Cars	Gasoline <1.4 l	ECE 15/02	1979	1980	11947	12148	11930	11913	11873	11671	11563	11362	11487	11484	11497
Passenger Cars	Gasoline <1.4 l	ECE 15/03	1981	1985	15150	14269	12818	11913	11873	11671	11563	11362	11487	11484	11497
Passenger Cars	Gasoline <1.4 l	ECE 15/04	1986	1990	18877	18427	17364	16286	14812	13545	12675	11803	11487	11484	11497
Passenger Cars	Gasoline <1.4 l	Euro I	1991	1996	24465	24045	23055	22047	20728	19419	18242	17209	16501	15216	14295
Passenger Cars	Gasoline <1.4 l	Euro II	1997	2000				25933	25403	24304	23596	21890	20971	20039	18922
Passenger Cars	Gasoline <1.4 l	Euro III	2001	2005								24734	24632	25527	2369
Passenger Cars	Gasoline 1.4 - 2.0 l	PRE ECE	0	1969	11947	12148	11930	11913	11873	11671	11563	11362	11487	11484	11497
Passenger Cars	Gasoline 1.4 - 2.0 l	ECE 15/00-01	1970	1978	11947	12148	11930	11913	11873	11671	11563	11362	11487	11484	11497
Passenger Cars	Gasoline 1.4 - 2.0 l	ECE 15/02	1979	1980	11947	12148	11930	11913	11873	11671	11563	11362	11487	11484	11497
Passenger Cars	Gasoline 1.4 - 2.0 l	ECE 15/03	1981	1985	15080	14224	12800	11913	11873	11671	11563	11362	11487	11484	11497
Passenger Cars	Gasoline 1.4 - 2.0 l	ECE 15/04	1986	1990	18987	18548	17477	16395	14982	13730	12835	11886	11487	11484	11497
Passenger Cars	Gasoline 1.4 - 2.0 l	Euro I	1991	1996	24848	24782	23824	22740	21414	20014	18769	17719	17032	15922	15075
Passenger Cars	Gasoline 1.4 - 2.0 l	Euro II	1997	2000				25933	25429	24289	23491	21803	20844	19933	18874
Passenger Cars	Gasoline 1.4 - 2.0 l	Euro III	2001	2005								24734	24623	25273	23550
Passenger Cars	Gasoline >2.0 l	PRE ECE	0	1969	11947	12148	11930	11913	11873	11671	11563	11362	11487	11484	11497
Passenger Cars	Gasoline >2.0 l	ECE 15/00-01	1970	1978	11947	12148	11930	11913	11873	11671	11563	11362	11487	11484	11497
Passenger Cars	Gasoline >2.0 l	ECE 15/02	1979	1980	11947	12148	11930	11913	11873	11671	11563	11362	11487	11484	11497
Passenger Cars	Gasoline >2.0 l	ECE 15/03	1981	1985	15186	14290	12826	11913	11873	11671	11563	11362	11487	11484	11497
Passenger Cars	Gasoline >2.0 l	ECE 15/04	1986	1990	18775	18326	17264	16166	14623	13409	12568	11733	11487	11484	11497
Passenger Cars	Gasoline >2.0 l	Euro I	1991	1996	24775	24661	23694	22620	21297	19908	18680	17632	16939	15805	14945
Passenger Cars	Gasoline >2.0 l	Euro II	1997	2000				25933	25455	24485	23852	22229	21286	20301	19127
Passenger Cars	Gasoline >2.0 l	Euro III	2001	2005								24734	24605	25454	23717
Passenger Cars	Diesel <2.0 l	Euro I	1991	1996	45013	43827	42670	41081	38968	37769	35666	33848	32622	30618	29048
Passenger Cars	Diesel <2.0 l	Euro II	1997	2000				47363	46792	46335	45147	42127	40440	39001	37072
Passenger Cars	Diesel <2.0 l	Euro III	2001	2005								47735	47693	46789	46315
Passenger Cars	Diesel <2.0 l	Conventional	0	1990	28903	27774	26548	25802	24873	24478	23626	22534	22247	22433	22560
Passenger Cars	Diesel >2.0 l	Euro I	1991	1996	45168	44095	42927	41309	39200	37968	35855	34029	32806	30876	29333
Passenger Cars	Diesel >2.0 l	Euro II	1997	2000				47363	46854	46700	45781	42902	41224	39658	37540
Passenger Cars	Diesel >2.0 l	Euro III	2001	2005								47735	47653	46802	46550
Passenger Cars	Diesel >2.0 l	Conventional	0	1990	29540	28241	26855	25911	24753	24315	23450	22412	22247	22433	22560

Sector	Subsector	Tech	FYear	LYear	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Passenger Cars	LPG	Euro I	1991	1996	0	0	0	0	0	0	0	0	0		0
Passenger Cars	LPG	Euro II	1997	2000	0	0	0	0	0	0	0	0	0		0
Passenger Cars	LPG	Euro III	2001	2005	0	0	0	0	0	0	0	0	0		0
Passenger Cars	LPG	Conventional	0	1990	15123	14251	12811	11913	11873	11671	11563	11362	11487	11484	1149
Passenger Cars	2-Stroke	Conventional	0	9999	15123	14251	12811	11913	11873	11671	11563	11362	11487	11484	1149
Light Duty Vehicles	Gasoline <3.5t	Conventional	0	1994	19693	20175	19973	19783	18763	18198	18190	18247	18252	17408	1787
Light Duty Vehicles	Gasoline <3.5t	Euro I	1995	1998		20175	19973	19783	18763	18198	18190	18247	18252	17408	1787
Light Duty Vehicles	Gasoline <3.5t	Euro II	1999	2001						18198	18190	18247	18252	17408	1787
Light Duty Vehicles	Gasoline <3.5t	Euro III	2002	2006									18252	17408	1787
Light Duty Vehicles	Diesel <3.5 t	Conventional	0	1994	38875	37046	37446	37191	35122	34377	32931	32240	32281	33225	3517
Light Duty Vehicles	Diesel <3.5 t	Euro I	1995	1998		37046	37446	37191	35122	34377	32931	32240	32281	33225	3517
Light Duty Vehicles	Diesel <3.5 t	Euro II	1999	2001						34377	32931	32240	32281	33225	3517
Light Duty Vehicles	Diesel <3.5 t	Euro III	2002	2006									32281	33225	3517
Heavy Duty Vehicles	Gasoline >3.5 t	Conventional	0	9999	23785	24367	24124	21382	21560	21408	22116	25464	25159	25344	2434
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Conventional	0	1993	39673	37807	38216	30943	31912	33764	34395	44252	44011	49367	4658
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Euro I	1994	1996	39673	37807	38216	30943	31912	33764	34395	44252	44011	49367	4658
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Euro II	1997	2001				30943	31912	33764	34395	44252	44011	49367	4658
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Euro III	2002	2006									44011	49367	4658
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Conventional	0	1993	47957	45702	46194	43396	42485	39368	37712	21018	18001	19957	1969
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Euro I	1994	1996	47957	45702	46194	43396	42485	39368	37712	21018	18001	19957	1969
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Euro II	1997	2001				43396	42485	39368	37712	21018	18001	19957	1969
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Euro III	2002	2006									18001	19957	1969
Heavy Duty Vehicles	Diesel 16 - 32 t	Conventional	0	1993	66665	63530	64216	65012	65865	67197	64369	68491	67300	72548	7215
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro I	1994	1996	66665	63530	64216	65012	65865	67197	64369	68491	67300	72548	7215
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro II	1997	2001				65012	65865	67197	64369	68491	67300	72548	7215
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro III	2002	2006									67300	72548	7215
Heavy Duty Vehicles	Diesel >32t	Conventional	0	1993	66665	63530	64216	65012	65865	67197	64369	68491	67300	72548	7215
Heavy Duty Vehicles	Diesel >32t	Euro I	1994	1996	66665	63530	64216	65012	65865	67197	64369	68491	67300	72548	7215
Heavy Duty Vehicles	Diesel >32t	Euro II	1997	2001				65012	65865	67197	64369	68491	67300	72548	7215
Heavy Duty Vehicles	Diesel >32t	Euro III	2002	2006									67300	72548	7215

Sector	Subsector	Tech	FYear	LYear	1994	1995	1996	1997	1998	1999	2000	2001	2002		2003
Buses	Urban Buses	Conventional	0	1993	109250	103609	104411	103783	102642	100407	96179	93914	94414	101833	10570
Buses	Urban Buses	Euro I	1994	1996	109250	103609	104411	103783	102642	100407	96179	93914	94414	101833	10570
Buses	Urban Buses	Euro II	1997	2001				103783	102642	100407	96179	93914	94414	101833	10570
Buses	Urban Buses	Euro III	2002	2006									94414	101833	10570
Buses	Coaches	Conventional	0	1993	104261	90357	85396	83925	82776	81456	78186	76384	76791	82825	8597
Buses	Coaches	Euro I	1994	1996	104261	90357	85396	83925	82776	81456	78186	76384	76791	82825	8597
Buses	Coaches	Euro II	1997	2001				83925	82776	81456	78186	76384	76791	82825	8597
Buses	Coaches	Euro III	2002	2006									76791	82825	8597
Mopeds	<50 cm^3	Conventional	0	1999	2171	2213	2184	2165	2151	1806	1622	1290	1295	1295	130
Mopeds	<50 cm^3	97/24/EC I	2000	2002							1622	1290	1295	1295	130
Mopeds	<50 cm^3	97/24/EC II	2003	9999										1295	130
Motorcycles	2-stroke >50 cm^3	Conventional	0	1999	6174	6284	6210	6175	6168	6010	6058	6108	6179	6212	630
Motorcycles	2-stroke >50 cm^3	97/24/EC	2000	2003	0	0	0	0	0	0	0	0	0		[illegible]
Motorcycles	4-stroke <250 cm^3	Conventional	0	1999	6174	6284	6210	6175	6168	6010	6058	6108	6179	6212	630
Motorcycles	4-stroke <250 cm^3	97/24/EC	2000	2003							6058	6108	6179	6212	630
Motorcycles	4-stroke <250 cm^3	Stage II	2004	9999											630
Motorcycles	4-stroke 250 - 750 cm^3	Conventional	0	1999	6174	6284	6210	6175	6168	6010	6058	6108	6179	6212	630
Motorcycles	4-stroke 250 - 750 cm^3	97/24/EC	2000	2003							6058	6108	6179	6212	630
Motorcycles	4-stroke 250 - 750 cm^3	Stage II	2004	9999											630
Motorcycles	4-stroke >750 cm^3	Conventional	0	1999	6174	6284	6210	6175	6168	6010	6058	6108	6179	6212	630
Motorcycles	4-stroke >750 cm^3	97/24/EC	2000	2003							6058	6108	6179	6212	630
Motorcycles	4-stroke >750 cm^3	Stage II	2004	9999											630

Annex 3B-3: EU directive emission limits for road transportation vehicles

Private cars and light duty vehicles I (<1305 kg)

g/km		EURO 1	EURO 2	EURO 3[1)]	EURO 4
Normal temp.					
CO	Gasoline	2.72	2.2	2.3	1.0
	Diesel	2.72	1.0	0.64	0.5
HC	Gasoline	-	-	0.20	0.10
NO_x	Gasoline	-	-	0.15	0.08
	Diesel	-	-	0.5	0.25
$HC+NO_x$	Gasoline	0.97	0.5	-	-
	Diesel	0.97	0.7/0.9[2)]	0.56	0.30
Particulates	Diesel	0.14	0.08/0.10[2)]	0.05	0.025
Low temp.					
CO	Gasoline	-	-	-	15
HC	Gasoline	-	-	-	1.8
Evaporation					
HC[3)]	Gasoline	2.0	2.0	2.0	2.0

[1)] Changed test procedure at normal temperatures (40 s warm-up phase omitted) and for evaporation measurements
[2)] Less stringent emission limits for direct injection diesel engines
[3)] Unit: g/test

Light duty vehicles II (1305-1760 kg)

g/km		EURO 1	EURO 2	EURO 3[1)]	EURO 4
Normal temp.					
CO	Gasoline	5.17	4.0	4.17	1.81
	Diesel	5.17	1.25	0.80	0.63
HC	Gasoline	-	-	0.25	0.13
NO_x	Gasoline	-	-	0.18	0.10
	Diesel	-	-	0.65	0.33
$HC+NO_x$	Gasoline	1.4	0.6	-	-
	Diesel	1.4	1.0/1.3[2)]	0.72	0.39
Particulates	Diesel	0.19	0.12/0.14[2)]	0.07	0.04
Low temp.					
CO	Gasoline	-	-	-	24
HC	Gasoline	-	-		2.7
Evaporation					
HC[3)]	Gasoline	2.0	2.0	2.0	2.0

[1)] Changed test procedure at normal temperatures (40 s warm-up phase omitted) and for evaporation measurements
[2)] Less stringent emission limits for direct injection diesel engines
[3)] Unit: g/test

Light duty vehicles III (>1760 kg)

g/km		EURO 1	EURO 2	EURO 3[1)]	EURO 4
Normal temp.					
CO	Gasoline	6.9	5.0	5.22	2.27
	Diesel	6.9	1.5	0.95	0.74
HC	Gasoline	-	-	0.29	0.16
NO_x	Gasoline	-	-	0.21	0.11
	Diesel	-	-	0.78	0.39
$HC+NO_x$	Gasoline	1.7	0.7	-	-
	Diesel	1.7	1.2/1.6[2)]	0.86	0.46
Particulates	Diesel	0.25	0.17/0.20[2)]	0.10	0.06
Low temp.					
CO	Gasoline	-	-	-	30
HC	Gasoline	-	-	-	3.2
Evaporation					
HC[3)]	Gasoline	2.0	2.0	2.0	2.0

[1)] Changed test procedure at normal temperatures (40 s warm-up phase omitted) and for evaporation measurements
[2)] Less stringent emission limits for direct injection diesel engines
[3)] Unit: g/test

Heavy duty diesel vehicles

(g/kWh)		EURO 1	EURO 2	EURO 3	EURO 4	EURO 5	EEV[2]
	Test[1]	1993	1996	2001	2006	2009	2000
CO	ECE/ESC	4.5	4.0	2.1	1.5	1.5	1.5
	ETC	-	-	(5.45)	4.0	4.0	3.0
HC	ECE/ESC	1.1	1.1	0.66	0.46	0.46	0.25
	ETC	-	-	(0.78)	0.55	0.55	0.40
NO_x	ECE/ESC	8.0	7.0	5.0	3.5	2.0	2.0
	ETC	-	-	(5.0)	3.5	2.0	2.0
Particulates[3]	ECE/ESC	0.36/0.61	0.15/0.25	0.10/0.13	0.02	0.02	0.02
	ETC	-	-	(0.16/0.21)	0.03	0.03	0.02
	ELR	-	-	0.8	0.5	0.5	0.15

[1] Test procedure: Euro 1 and Euro 2: ECE (stationary)
Euro 3: ESC (stationary) + ELR (load response)
Euro 4, Euro 5 and EEV: ESC (stationary) + ETC (transient) + ELR (load response)

[2] EEV: Emission limits for extra environmental friendly vehicles, used as a basis for economical incentives (gas fuelled vehicles).

[3] For Euro 1, Euro 2 and Euro 3, less stringent emission limits apply for small engines:
Euro 1: <85 kW
Euro 2: <0,7 l
Euro 3: <0,75 l

Annex 3B-4: 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 - 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 >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	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	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	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	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
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 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 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 >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
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	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
Mopeds	<50 cm^3	Conventional	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 cm^3	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 cm^3	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 - 750 cm^3	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 >750 cm^3	Conventional	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 - 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 >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	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	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	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	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
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 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 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 >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
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	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
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 - 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 >750 cm^3	Conventional	14.880	18.030	24.300	0.148	0.266	0.392	2.320	1.410	0.990

Annex 3B-5: Reduction factors for road transport emission factors

Sector	Subsector	Tech	COuR	COrR	COhR	NOxuR	NOxrR	NOxhR	VOCuR	VOCrR	VOChR
Passenger Cars	Gasoline <1.4 l	Euro I - 91/441/EEC	0	0	0	0	0	0	0	0	0
Passenger Cars	Gasoline <1.4 l	Euro II - 94/12/EC	32	32	32	64	64	64	79	79	79
Passenger Cars	Gasoline <1.4 l	Euro III - 98/69/EC Stage2000	44	44	44	76	76	76	85	85	85
Passenger Cars	Gasoline <1.4 l	Euro IV - 98/69/EC Stage2005	66	66	66	87	87	87	97	97	97
Passenger Cars	Gasoline 1.4 - 2.0 l	Euro I - 91/441/EEC	0	0	0	0	0	0	0	0	0
Passenger Cars	Gasoline 1.4 - 2.0 l	Euro II - 94/12/EC	32	32	32	64	64	64	79	79	79
Passenger Cars	Gasoline 1.4 - 2.0 l	Euro III - 98/69/EC Stage2000	44	44	44	76	76	76	86	86	86
Passenger Cars	Gasoline 1.4 - 2.0 l	Euro IV - 98/69/EC Stage2005	66	66	66	87	87	87	97	97	97
Passenger Cars	Gasoline >2.0 l	Euro I - 91/441/EEC	0	0	0	0	0	0	0	0	0
Passenger Cars	Gasoline >2.0 l	Euro II - 94/12/EC	32	32	32	64	64	64	76	76	76
Passenger Cars	Gasoline >2.0 l	Euro III - 98/69/EC Stage2000	44	44	44	76	76	76	84	84	84
Passenger Cars	Gasoline >2.0 l	Euro IV - 98/69/EC Stage2005	65	65	65	87	87	87	95	95	95
Passenger Cars	Diesel <2.0 l	Euro I - 91/441/EEC	0	0	0	0	0	0	0	0	0
Passenger Cars	Diesel <2.0 l	Euro II - 94/12/EC	0	0	0	0	0	0	0	0	0
Passenger Cars	Diesel <2.0 l	Euro III - 98/69/EC Stage2000	0	0	0	23	23	23	15	15	15
Passenger Cars	Diesel <2.0 l	Euro IV - 98/69/EC Stage2005	0	0	0	62	62	62	31	31	31
Passenger Cars	Diesel >2.0 l	Euro I - 91/441/EEC	0	0	0	0	0	0	0	0	0
Passenger Cars	Diesel >2.0 l	Euro II - 94/12/EC	0	0	0	0	0	0	0	0	0
Passenger Cars	Diesel >2.0 l	Euro III - 98/69/EC Stage2000	0	0	0	23	23	23	15	15	15
Passenger Cars	Diesel >2.0 l	Euro IV - 98/69/EC Stage2005	0	0	0	62	62	62	31	31	31
Light Duty Vehicles	Gasoline <3.5t	Euro I - 93/59/EEC	0	0	0	0	0	0	0	0	0
Light Duty Vehicles	Gasoline <3.5t	Euro II - 96/69/EC	39	39	39	66	66	66	76	76	76
Light Duty Vehicles	Gasoline <3.5t	Euro III - 98/69/EC Stage2000	48	48	48	79	79	79	86	86	86
Light Duty Vehicles	Gasoline <3.5t	Euro IV - 98/69/EC Stage2005	72	72	72	90	90	90	94	94	94
Light Duty Vehicles	Diesel <3.5 t	Euro I - 93/59/EEC	0	0	0	0	0	0	0	0	0
Light Duty Vehicles	Diesel <3.5 t	Euro II - 96/69/EC	0	0	0	0	0	0	0	0	0
Light Duty Vehicles	Diesel <3.5 t	Euro III - 98/69/EC Stage2000	18	18	18	35	35	35	38	38	38
Light Duty Vehicles	Diesel <3.5 t	Euro IV - 98/69/EC Stage2005	35	35	35	67	67	67	77	77	77

Sector	Subsector	Tech	COuR	COrR	COhR	NOxuR	NOxrR	NOxhR	VOCuR	VOCrR	VOChR
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Conventional	0	0	0	0	0	0	0	0	0
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Euro I - 91/542/EEC Stage I	50	40	45	30	30	10	25	25	25
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Euro II - 91/542/EEC Stage II	60	45	50	50	45	35	30	30	30
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Euro III - 2000 Standards	72	61.5	65	65	61.5	54.5	51	51	51
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Euro IV - 2005 Standards	79.6	71.9	74.5	75.5	73.1	68.2	65.7	65.7	65.7
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Euro V - 2008 Standards	79.6	71.9	74.5	86	84.6	81.8	65.7	65.7	65.7
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Conventional	0	0	0	0	0	0	0	0	0
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Euro I - 91/542/EEC Stage I	50	40	45	30	30	10	25	25	25
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Euro II - 91/542/EEC Stage II	60	45	50	50	45	35	30	30	30
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Euro III - 2000 Standards	72	61.5	65	65	61.5	54.5	51	51	51
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Euro IV - 2005 Standards	79.6	71.9	74.5	75.5	73.1	68.2	65.7	65.7	65.7
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Euro V - 2008 Standards	79.6	71.9	74.5	86	84.6	81.8	65.7	65.7	65.7
Heavy Duty Vehicles	Diesel 16 - 32 t	Conventional	0	0	0	0	0	0	0	0	0
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro I - 91/542/EEC Stage I	45	40	35	45	40	45	50	35	25
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro II - 91/542/EEC Stage II	55	50	35	60	55	55	55	40	35
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro III - 2000 Standards	68.5	65	54.5	72	68.5	68.5	68.5	58	54.5
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro IV - 2005 Standards	77	74.5	66.8	80.4	78	78	78	70.6	68.2
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro V - 2008 Standards	77	74.5	66.8	88.8	87.4	87.4	78	70.6	68.2
Heavy Duty Vehicles	Diesel >32t	Conventional	0	0	0	0	0	0	0	0	0
Heavy Duty Vehicles	Diesel >32t	Euro I - 91/542/EEC Stage I	45	40	35	45	40	45	50	35	25
Heavy Duty Vehicles	Diesel >32t	Euro II - 91/542/EEC Stage II	55	50	35	60	55	55	55	40	35
Heavy Duty Vehicles	Diesel >32t	Euro III - 2000 Standards	68.5	65	54.5	72	68.5	68.5	68.5	58	54.5
Heavy Duty Vehicles	Diesel >32t	Euro IV - 2005 Standards	77	74.5	66.8	80.4	78	78	78	70.6	68.2
Heavy Duty Vehicles	Diesel >32t	Euro V - 2008 Standards	77	74.5	66.8	88.8	87.4	87.4	78	70.6	68.2
Buses	Urban Buses	Conventional	0	0	0	0	0	0	0	0	0
Buses	Urban Buses	Euro I - 91/542/EEC Stage I	50	40	45	30	30	10	25	25	25
Buses	Urban Buses	Euro II - 91/542/EEC Stage II	60	45	50	50	45	35	30	30	30
Buses	Urban Buses	Euro III - 2000 Standards	72	61.5	65	65	61.5	54.5	51	51	51
Buses	Urban Buses	Euro IV - 2005 Standards	79.6	71.9	74.5	75.5	73.1	68.2	65.7	65.7	65.7
Buses	Urban Buses	Euro V - 2008 Standards	79.6	71.9	74.5	86	84.6	81.8	65.7	65.7	65.7
Buses	Coaches	Conventional	0	0	0	0	0	0	0	0	0
Buses	Coaches	Euro I - 91/542/EEC Stage I	45	40	35	45	40	45	50	35	25
Buses	Coaches	Euro II - 91/542/EEC Stage II	55	50	35	60	55	55	55	40	35
Buses	Coaches	Euro III - 2000 Standards	68.5	65	54.5	72	68.5	68.5	68.5	58	54.5
Buses	Coaches	Euro IV - 2005 Standards	77	74.5	66.8	80.4	78	78	78	70.6	68.2

Buses	Coaches	Euro V - 2008 Standards	77	74.5	66.8	88.8	87.4	87.4	78	70.6	68.2

Sector	Subsector	Tech	COuR	COrR	COhR	NOxuR	NOxrR	NOxhR	VOCuR	VOCrR	VOChR
Mopeds	<50 cm³	Conventional	0	0	0	0	0	0	0	0	0
Mopeds	<50 cm³	97/24/EC Stage I	50	50	100	0	0	100	55	55	100
Mopeds	<50 cm³	97/24/EC Stage II	90	90	100	67	67	100	78	78	100
Motorcycles	2-stroke >50 cm³	97/24/EC	0	0	0	0	0	0	0	0	0
Motorcycles	2-stroke >50 cm³	97/24/EC Stage II (proposal)	31	31	31	-200	-200	-200	70	70	70
Motorcycles	2-stroke >50 cm³	97/24/EC Stage III (proposal)	75	75	75	-50	-50	-50	80	80	80
Motorcycles	4-stroke <250 cm³	97/24/EC	0	0	0	0	0	0	0	0	0
Motorcycles	4-stroke <250 cm³	97/24/EC Stage II (proposal)	58	58	58	0	0	0	67	67	67
Motorcycles	4-stroke <250 cm³	97/24/EC Stage III (proposal)	85	85	85	50	50	50	90	90	90
Motorcycles	4-stroke 250 - 750 cm³	97/24/EC	0	0	0	0	0	0	0	0	0
Motorcycles	4-stroke 250 - 750 cm³	97/24/EC Stage II (proposal)	58	58	58	0	0	0	67	67	67
Motorcycles	4-stroke 250 - 750 cm³	97/24/EC Stage III (proposal)	85	85	85	50	50	50	90	90	90
Motorcycles	4-stroke >750 cm³	97/24/EC	0	0	0	0	0	0	0	0	0
Motorcycles	4-stroke >750 cm³	97/24/EC Stage II (proposal)	58	58	58	0	0	0	67	67	67
Motorcycles	4-stroke >750 cm³	97/24/EC Stage III (proposal)	85	85	85	50	50	50	90	90	90

Annex 3B-6: Fuel use factors (MJ/km) and emission factors (g/km)

Sector	ForecastYear	FCu (MJ)	FCr (MJ)	FCh (MJ)	CO2u	CO2r	CO2h	CH4u	CH4r	CH4h	N2Ou	N2Or	N2Oh	SO2u	SO2r	SO2h	NOxu	NOxr	NOxh
Passenger Cars	1985	3.352	2.100	2.409	245	153	176	0.167	0.027	0.024	0.007	0.007	0.007	0.074	0.044	0.054	1.873	2.191	2.804
Passenger Cars	1986	3.317	2.090	2.391	242	153	175	0.164	0.027	0.024	0.007	0.007	0.007	0.048	0.029	0.035	1.865	2.191	2.814
Passenger Cars	1987	3.306	2.079	2.369	242	152	173	0.166	0.027	0.024	0.007	0.007	0.007	0.048	0.029	0.035	1.867	2.188	2.811
Passenger Cars	1988	3.227	2.068	2.345	236	151	171	0.157	0.027	0.024	0.007	0.007	0.007	0.046	0.028	0.034	1.848	2.188	2.816
Passenger Cars	1989	3.194	2.063	2.335	233	151	171	0.153	0.027	0.024	0.007	0.007	0.007	0.033	0.020	0.024	1.838	2.185	2.822
Passenger Cars	1990	3.180	2.062	2.327	232	151	170	0.153	0.027	0.024	0.007	0.007	0.007	0.032	0.020	0.023	1.844	2.198	2.845
Passenger Cars	1991	3.212	2.044	2.304	235	149	168	0.169	0.026	0.024	0.010	0.008	0.009	0.031	0.019	0.023	1.771	2.066	2.681
Passenger Cars	1992	3.197	2.027	2.283	234	148	167	0.174	0.026	0.023	0.013	0.008	0.011	0.022	0.014	0.016	1.690	1.944	2.531
Passenger Cars	1993	3.234	2.011	2.262	236	147	165	0.191	0.025	0.023	0.016	0.009	0.013	0.013	0.008	0.009	1.632	1.831	2.396
Passenger Cars	1994	3.229	1.990	2.234	236	145	163	0.198	0.024	0.022	0.021	0.010	0.016	0.013	0.008	0.009	1.513	1.642	2.166
Passenger Cars	1995	3.264	1.975	2.213	239	144	162	0.213	0.023	0.021	0.024	0.011	0.018	0.013	0.008	0.009	1.441	1.508	2.001
Passenger Cars	1996	3.319	1.959	2.191	243	143	160	0.236	0.022	0.021	0.028	0.012	0.020	0.013	0.008	0.009	1.378	1.379	1.841
Passenger Cars	1997	3.279	1.929	2.152	240	141	157	0.217	0.019	0.018	0.032	0.013	0.022	0.013	0.008	0.009	1.259	1.216	1.645
Passenger Cars	1998	3.305	1.917	2.136	242	140	156	0.214	0.017	0.016	0.035	0.013	0.024	0.013	0.008	0.009	1.160	1.073	1.463
Passenger Cars	1999	3.303	1.905	2.122	241	139	155	0.197	0.015	0.015	0.037	0.014	0.026	0.011	0.006	0.007	1.074	0.952	1.305
Passenger Cars	2000	3.298	1.897	2.112	241	139	154	0.189	0.014	0.014	0.039	0.015	0.027	0.008	0.004	0.005	1.011	0.862	1.187
Passenger Cars	2001	3.335	1.891	2.105	244	138	154	0.189	0.013	0.013	0.040	0.015	0.028	0.008	0.004	0.005	0.955	0.791	1.093
Passenger Cars	2002	3.309	1.885	2.098	242	138	153	0.168	0.012	0.012	0.041	0.016	0.029	0.008	0.004	0.005	0.883	0.713	0.988
Passenger Cars	2003	3.325	1.880	2.092	243	138	153	0.161	0.011	0.011	0.042	0.016	0.030	0.008	0.004	0.005	0.823	0.646	0.895
Passenger Cars	2004	3.274	1.874	2.086	240	137	153	0.138	0.010	0.010	0.043	0.017	0.030	0.008	0.004	0.005	0.759	0.580	0.804
Light Duty Vehicles	1985	4.030	2.790	3.000	298	206	222	0.049	0.010	0.008	0.016	0.016	0.016	0.802	0.573	0.627	2.056	1.143	1.171
Light Duty Vehicles	1986	4.007	2.792	3.006	296	206	222	0.045	0.009	0.007	0.016	0.016	0.016	0.485	0.348	0.381	2.037	1.121	1.146
Light Duty Vehicles	1987	4.020	2.791	3.005	297	206	222	0.046	0.009	0.008	0.016	0.016	0.016	0.485	0.347	0.379	2.045	1.127	1.153
Light Duty Vehicles	1988	3.963	2.791	3.003	293	206	222	0.044	0.009	0.008	0.016	0.016	0.016	0.477	0.346	0.379	2.011	1.132	1.158
Light Duty Vehicles	1989	3.938	2.792	3.008	291	206	222	0.041	0.009	0.007	0.016	0.016	0.016	0.319	0.233	0.255	1.992	1.116	1.140
Light Duty Vehicles	1990	3.932	2.792	3.008	290	206	222	0.041	0.009	0.007	0.016	0.016	0.016	0.319	0.233	0.255	1.988	1.115	1.139
Light Duty Vehicles	1991	3.968	2.792	3.007	293	206	222	0.043	0.009	0.007	0.016	0.016	0.016	0.321	0.233	0.254	2.011	1.117	1.142
Light Duty Vehicles	1992	3.952	2.790	3.002	292	206	222	0.044	0.010	0.008	0.016	0.016	0.016	0.206	0.150	0.164	2.006	1.137	1.164
Light Duty Vehicles	1993	3.989	2.790	3.001	295	206	222	0.046	0.010	0.008	0.016	0.016	0.016	0.081	0.058	0.063	2.028	1.139	1.167
Light Duty Vehicles	1994	3.957	2.792	3.007	292	206	222	0.043	0.009	0.007	0.016	0.016	0.016	0.081	0.059	0.064	2.005	1.118	1.143
Light Duty Vehicles	1995	3.955	2.771	2.980	292	205	220	0.045	0.009	0.007	0.016	0.016	0.016	0.080	0.058	0.063	1.957	1.120	1.149
Light Duty Vehicles	1996	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	1.918	1.100	1.130
Light Duty Vehicles	1997	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	1.826	1.077	1.108
Light Duty Vehicles	1998	3.883	2.714	2.918	287	200	216	0.041	0.008	0.007	0.018	0.016	0.017	0.078	0.056	0.062	1.770	1.064	1.097

Light Duty Vehicles	1999	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	1.701	1.042	1.076
Light Duty Vehicles	2000	3.816	2.681	2.882	282	198	213	0.036	0.008	0.007	0.018	0.016	0.017	0.009	0.006	0.007	1.640	1.027	1.061
Light Duty Vehicles	2001	3.833	2.665	2.864	283	197	212	0.036	0.007	0.006	0.019	0.016	0.018	0.009	0.006	0.007	1.602	1.011	1.047
Light Duty Vehicles	2002	3.779	2.647	2.845	279	196	210	0.031	0.007	0.006	0.019	0.016	0.018	0.009	0.006	0.007	1.487	0.962	0.998
Light Duty Vehicles	2003	3.765	2.629	2.830	278	194	209	0.028	0.006	0.006	0.019	0.017	0.018	0.009	0.006	0.007	1.404	0.914	0.948
Light Duty Vehicles	2004	3.686	2.605	2.806	272	192	207	0.023	0.006	0.005	0.019	0.017	0.018	0.009	0.006	0.007	1.279	0.868	0.903

Sector	ForecastYear	FCu (MJ)	FCr (MJ)	FCh (MJ)	CO2u	CO2r	CO2h	CH4u	CH4r	CH4h	N2Ou	N2Or	N2Oh	SO2u	SO2r	SO2h	NOxu	NOxr	NOxh
Heavy Duty Vehicles	1985	11.446	9.640	10.283	847	713	761	0.138	0.063	0.060	0.030	0.030	0.030	2.672	2.253	2.405	11.344	8.920	8.329
Heavy Duty Vehicles	1986	11.447	9.641	10.284	847	713	761	0.138	0.063	0.060	0.030	0.030	0.030	1.604	1.352	1.443	11.347	8.921	8.329
Heavy Duty Vehicles	1987	11.446	9.640	10.283	847	713	761	0.138	0.063	0.060	0.030	0.030	0.030	1.604	1.352	1.443	11.346	8.921	8.329
Heavy Duty Vehicles	1988	11.446	9.640	10.283	847	713	761	0.138	0.063	0.060	0.030	0.030	0.030	1.604	1.352	1.443	11.346	8.921	8.329
Heavy Duty Vehicles	1989	11.447	9.641	10.284	847	713	761	0.138	0.063	0.060	0.030	0.030	0.030	1.069	0.902	0.962	11.347	8.921	8.329
Heavy Duty Vehicles	1990	11.328	9.570	10.240	838	708	758	0.137	0.063	0.060	0.030	0.030	0.030	1.058	0.895	0.958	11.215	8.841	8.285
Heavy Duty Vehicles	1991	11.328	9.570	10.240	838	708	758	0.137	0.063	0.060	0.030	0.030	0.030	1.058	0.895	0.958	11.215	8.840	8.285
Heavy Duty Vehicles	1992	11.327	9.569	10.240	838	708	758	0.137	0.063	0.060	0.030	0.030	0.030	0.688	0.582	0.623	11.213	8.840	8.285
Heavy Duty Vehicles	1993	11.328	9.570	10.240	838	708	758	0.137	0.063	0.060	0.030	0.030	0.030	0.264	0.224	0.240	11.213	8.840	8.285
Heavy Duty Vehicles	1994	11.328	9.570	10.240	838	708	758	0.132	0.061	0.059	0.030	0.030	0.030	0.265	0.224	0.240	10.807	8.543	7.983
Heavy Duty Vehicles	1995	11.328	9.570	10.240	838	708	758	0.127	0.059	0.058	0.030	0.030	0.030	0.264	0.224	0.240	10.416	8.259	7.694
Heavy Duty Vehicles	1996	11.328	9.570	10.240	838	708	758	0.123	0.057	0.056	0.030	0.030	0.030	0.265	0.224	0.240	10.045	7.988	7.420
Heavy Duty Vehicles	1997	11.697	9.804	10.378	866	725	768	0.120	0.057	0.056	0.030	0.030	0.030	0.273	0.229	0.243	9.874	7.840	7.183
Heavy Duty Vehicles	1998	11.818	9.891	10.430	874	732	772	0.116	0.056	0.055	0.030	0.030	0.030	0.276	0.231	0.244	9.463	7.547	6.884
Heavy Duty Vehicles	1999	12.059	10.052	10.526	892	744	779	0.113	0.055	0.054	0.030	0.030	0.030	0.155	0.129	0.135	9.203	7.355	6.654
Heavy Duty Vehicles	2000	12.112	10.086	10.550	896	746	781	0.108	0.054	0.053	0.030	0.030	0.030	0.028	0.024	0.025	8.780	7.048	6.373
Heavy Duty Vehicles	2001	12.530	10.368	10.704	927	767	792	0.107	0.055	0.053	0.030	0.030	0.030	0.029	0.024	0.025	8.657	6.967	6.197
Heavy Duty Vehicles	2002	12.599	10.426	10.742	932	771	795	0.100	0.052	0.050	0.030	0.030	0.030	0.030	0.024	0.025	8.017	6.498	5.767
Heavy Duty Vehicles	2003	12.632	10.456	10.767	935	774	797	0.094	0.049	0.048	0.030	0.030	0.030	0.030	0.024	0.025	7.456	6.077	5.399
Heavy Duty Vehicles	2004	12.635	10.468	10.778	935	775	798	0.085	0.046	0.044	0.030	0.030	0.030	0.030	0.025	0.025	6.655	5.491	4.873
Buses	1985	13.074	10.124	8.802	967	749	651	0.175	0.080	0.070	0.030	0.030	0.030	3.062	2.371	2.061	14.418	10.279	8.603
Buses	1986	13.068	10.116	8.798	967	749	651	0.175	0.080	0.070	0.030	0.030	0.030	1.836	1.421	1.236	14.405	10.260	8.593
Buses	1987	13.057	10.101	8.790	966	747	650	0.175	0.080	0.070	0.030	0.030	0.030	1.835	1.419	1.235	14.382	10.229	8.576
Buses	1988	13.055	10.099	8.790	966	747	650	0.175	0.080	0.070	0.030	0.030	0.030	1.834	1.419	1.235	14.379	10.226	8.573
Buses	1989	13.055	10.099	8.789	966	747	650	0.175	0.080	0.070	0.030	0.030	0.030	1.223	0.946	0.823	14.379	10.225	8.573
Buses	1990	13.074	10.124	8.802	967	749	651	0.175	0.080	0.070	0.030	0.030	0.030	1.225	0.948	0.825	14.418	10.279	8.603
Buses	1991	13.099	10.158	8.820	969	752	653	0.175	0.080	0.070	0.030	0.030	0.030	1.227	0.952	0.826	14.471	10.350	8.644
Buses	1992	13.072	10.121	8.801	967	749	651	0.175	0.080	0.070	0.030	0.030	0.030	0.796	0.616	0.536	14.414	10.273	8.600
Buses	1993	13.061	10.106	8.793	966	748	651	0.175	0.080	0.070	0.030	0.030	0.030	0.306	0.237	0.206	14.390	10.241	8.582
Buses	1994	13.048	10.089	8.785	966	747	650	0.170	0.078	0.068	0.030	0.030	0.030	0.306	0.236	0.206	13.939	9.906	8.334
Buses	1995	12.897	9.901	8.699	954	733	644	0.165	0.076	0.067	0.030	0.030	0.030	0.302	0.232	0.204	13.200	9.231	7.879

Buses	1996	12.910	9.916	8.705	955	734	644	0.160	0.074	0.066	0.030	0.030	0.030	0.302	0.232	0.204	12.837	8.993	7.671
Buses	1997	12.923	9.931	8.711	956	735	645	0.154	0.072	0.064	0.030	0.030	0.030	0.303	0.233	0.204	12.239	8.618	7.352
Buses	1998	12.934	9.944	8.717	957	736	645	0.151	0.070	0.062	0.030	0.030	0.030	0.303	0.233	0.204	11.835	8.371	7.140
Buses	1999	12.939	9.950	8.720	957	736	645	0.147	0.069	0.061	0.030	0.030	0.030	0.167	0.128	0.112	11.376	8.080	6.896
Buses	2000	12.940	9.952	8.721	958	736	645	0.143	0.067	0.060	0.030	0.030	0.030	0.030	0.023	0.020	10.963	7.816	6.676
Buses	2001	12.952	9.967	8.727	958	738	646	0.141	0.066	0.059	0.030	0.030	0.030	0.030	0.023	0.020	10.661	7.634	6.521
Buses	2002	12.964	9.981	8.733	959	739	646	0.135	0.063	0.057	0.030	0.030	0.030	0.030	0.023	0.020	10.168	7.309	6.245
Buses	2003	12.976	9.996	8.740	960	740	647	0.131	0.062	0.055	0.030	0.030	0.030	0.030	0.023	0.020	9.780	7.055	6.028
Buses	2004	12.982	10.003	8.744	961	740	647	0.127	0.060	0.053	0.030	0.030	0.030	0.030	0.023	0.020	9.414	6.810	5.821

Sector	ForecastYear	FCu (MJ)	FCr (MJ)	FCh (MJ)	CO2u	CO2r	CO2h	CH4u	CH4r	CH4h	N2Ou	N2Or	N2Oh	SO2u	SO2r	SO2h	NOxu	NOxr	NOxh
Mopeds	1985	1.095	1.095		80	80		0.219	0.219		0.001	0.001		0.003	0.003		0.030	0.030	
Mopeds	1986	1.095	1.095		80	80		0.219	0.219		0.001	0.001		0.003	0.003		0.030	0.030	
Mopeds	1987	1.095	1.095		80	80		0.219	0.219		0.001	0.001		0.003	0.003		0.030	0.030	
Mopeds	1988	1.095	1.095		80	80		0.219	0.219		0.001	0.001		0.003	0.003		0.030	0.030	
Mopeds	1989	1.095	1.095		80	80		0.219	0.219		0.001	0.001		0.003	0.003		0.030	0.030	
Mopeds	1990	1.095	1.095		80	80		0.219	0.219		0.001	0.001		0.003	0.003		0.030	0.030	
Mopeds	1991	1.095	1.095		80	80		0.219	0.219		0.001	0.001		0.003	0.003		0.030	0.030	
Mopeds	1992	1.095	1.095		80	80		0.219	0.219		0.001	0.001		0.003	0.003		0.030	0.030	
Mopeds	1993	1.095	1.095		80	80		0.219	0.219		0.001	0.001		0.003	0.003		0.030	0.030	
Mopeds	1994	1.095	1.095		80	80		0.219	0.219		0.001	0.001		0.003	0.003		0.030	0.030	
Mopeds	1995	1.095	1.095		80	80		0.219	0.219		0.001	0.001		0.003	0.003		0.030	0.030	
Mopeds	1996	1.095	1.095		80	80		0.219	0.219		0.001	0.001		0.003	0.003		0.030	0.030	
Mopeds	1997	1.095	1.095		80	80		0.219	0.219		0.001	0.001		0.003	0.003		0.030	0.030	
Mopeds	1998	1.095	1.095		80	80		0.219	0.219		0.001	0.001		0.003	0.003		0.030	0.030	
Mopeds	1999	1.095	1.095		80	80		0.219	0.219		0.001	0.001		0.003	0.003		0.030	0.030	
Mopeds	2000	1.095	1.095		80	80		0.207	0.207		0.001	0.001		0.003	0.003		0.030	0.030	
Mopeds	2001	1.095	1.095		80	80		0.198	0.198		0.001	0.001		0.003	0.003		0.030	0.030	
Mopeds	2002	1.095	1.095		80	80		0.189	0.189		0.001	0.001		0.003	0.003		0.030	0.030	
Mopeds	2003	1.095	1.095		80	80		0.182	0.182		0.001	0.001		0.003	0.003		0.029	0.029	
Mopeds	2004	1.095	1.095		80	80		0.173	0.173		0.001	0.001		0.003	0.003		0.028	0.028	
Motorcycles	1985	1.307	1.318	1.578	95	96	115	0.193	0.193	0.193	0.002	0.002	0.002	0.003	0.003	0.004	0.122	0.228	0.340
Motorcycles	1986	1.307	1.318	1.578	95	96	115	0.193	0.193	0.193	0.002	0.002	0.002	0.003	0.003	0.004	0.122	0.228	0.340
Motorcycles	1987	1.307	1.318	1.578	95	96	115	0.193	0.193	0.193	0.002	0.002	0.002	0.003	0.003	0.004	0.122	0.228	0.340
Motorcycles	1988	1.307	1.318	1.578	95	96	115	0.192	0.192	0.192	0.002	0.002	0.002	0.003	0.003	0.004	0.122	0.228	0.340
Motorcycles	1989	1.307	1.318	1.578	95	96	115	0.193	0.193	0.193	0.002	0.002	0.002	0.003	0.003	0.004	0.122	0.228	0.340
Motorcycles	1990	1.307	1.318	1.578	95	96	115	0.192	0.192	0.192	0.002	0.002	0.002	0.003	0.003	0.004	0.122	0.228	0.340
Motorcycles	1991	1.307	1.318	1.578	95	96	115	0.193	0.193	0.193	0.002	0.002	0.002	0.003	0.003	0.004	0.122	0.228	0.340
Motorcycles	1992	1.307	1.318	1.578	95	96	115	0.192	0.192	0.192	0.002	0.002	0.002	0.003	0.003	0.004	0.122	0.228	0.340

Motorcycles	1993	1.307	1.318	1.578	95	96	115	0.192	0.192	0.192	0.002	0.002	0.002	0.003	0.003	0.004	0.122	0.228	0.340
Motorcycles	1994	1.307	1.318	1.578	95	96	115	0.193	0.193	0.193	0.002	0.002	0.002	0.003	0.003	0.004	0.122	0.228	0.340
Motorcycles	1995	1.307	1.318	1.578	95	96	115	0.193	0.193	0.193	0.002	0.002	0.002	0.003	0.003	0.004	0.122	0.228	0.340
Motorcycles	1996	1.307	1.318	1.578	95	96	115	0.193	0.193	0.193	0.002	0.002	0.002	0.003	0.003	0.004	0.122	0.228	0.340
Motorcycles	1997	1.307	1.318	1.578	95	96	115	0.192	0.192	0.192	0.002	0.002	0.002	0.003	0.003	0.004	0.122	0.228	0.340
Motorcycles	1998	1.307	1.318	1.578	95	96	115	0.193	0.193	0.193	0.002	0.002	0.002	0.003	0.003	0.004	0.122	0.228	0.340
Motorcycles	1999	1.307	1.318	1.578	95	96	115	0.192	0.192	0.192	0.002	0.002	0.002	0.003	0.003	0.004	0.122	0.228	0.340
Motorcycles	2000	1.307	1.318	1.578	95	96	115	0.193	0.193	0.193	0.002	0.002	0.002	0.003	0.003	0.004	0.122	0.228	0.340
Motorcycles	2001	1.307	1.317	1.578	95	96	115	0.193	0.193	0.193	0.002	0.002	0.002	0.003	0.003	0.004	0.122	0.229	0.341
Motorcycles	2002	1.307	1.317	1.578	95	96	115	0.193	0.193	0.193	0.002	0.002	0.002	0.003	0.003	0.004	0.123	0.230	0.342
Motorcycles	2003	1.307	1.316	1.577	95	96	115	0.193	0.193	0.193	0.002	0.002	0.002	0.003	0.003	0.004	0.124	0.231	0.343
Motorcycles	2004	1.307	1.315	1.577	95	96	115	0.189	0.189	0.189	0.002	0.002	0.002	0.003	0.003	0.004	0.124	0.232	0.344

Sector	ForecastYear	NMVOCu (exh)	NMVOCr (exh)	NMVOCh (exh)	NMVOCu (tot)	NMVOCr (tot)	NMVOCh (tot)	COu	COr	COh
Passenger Cars	1985	3.368	1.048	0.923	5.597	1.424	0.973	40.810	10.109	10.525
Passenger Cars	1986	3.256	1.026	0.898	5.490	1.403	0.948	38.410	9.606	9.893
Passenger Cars	1987	3.217	1.002	0.869	5.426	1.376	0.919	36.822	9.035	9.225
Passenger Cars	1988	2.958	0.974	0.833	5.260	1.363	0.885	32.048	8.298	8.333
Passenger Cars	1989	2.845	0.955	0.811	5.167	1.347	0.864	30.059	7.893	7.799
Passenger Cars	1990	2.802	0.944	0.797	5.139	1.339	0.850	29.076	7.606	7.398
Passenger Cars	1991	2.775	0.878	0.741	4.921	1.241	0.790	29.147	7.057	6.936
Passenger Cars	1992	2.593	0.816	0.689	4.621	1.159	0.735	27.232	6.547	6.560
Passenger Cars	1993	2.573	0.756	0.638	4.385	1.062	0.680	27.389	6.036	6.227
Passenger Cars	1994	2.308	0.659	0.556	3.934	0.934	0.593	24.650	5.245	5.631
Passenger Cars	1995	2.199	0.588	0.498	3.635	0.831	0.530	23.852	4.705	5.355
Passenger Cars	1996	2.157	0.520	0.441	3.374	0.726	0.468	23.919	4.182	5.079
Passenger Cars	1997	1.806	0.428	0.366	2.868	0.608	0.390	19.973	3.361	4.573
Passenger Cars	1998	1.644	0.362	0.310	2.506	0.508	0.330	18.882	2.904	4.268
Passenger Cars	1999	1.433	0.306	0.262	2.174	0.431	0.279	16.767	2.513	4.005
Passenger Cars	2000	1.303	0.265	0.228	1.799	0.349	0.239	15.681	2.247	3.841
Passenger Cars	2001	1.248	0.234	0.202	1.676	0.306	0.212	15.628	2.051	3.704
Passenger Cars	2002	1.085	0.202	0.175	1.457	0.265	0.183	13.970	1.838	3.504
Passenger Cars	2003	1.005	0.176	0.152	1.320	0.229	0.159	13.433	1.652	3.291
Passenger Cars	2004	0.845	0.149	0.130	1.114	0.195	0.136	11.564	1.465	3.059
Light Duty Vehicles	1985	0.685	0.178	0.139	0.958	0.221	0.147	6.399	1.679	1.897
Light Duty Vehicles	1986	0.642	0.172	0.136	0.896	0.212	0.143	5.948	1.629	1.834
Light Duty Vehicles	1987	0.657	0.174	0.137	0.914	0.214	0.144	6.108	1.643	1.852
Light Duty Vehicles	1988	0.622	0.175	0.137	0.893	0.217	0.145	5.803	1.653	1.864
Light Duty Vehicles	1989	0.587	0.171	0.135	0.846	0.211	0.143	5.448	1.617	1.820
Light Duty Vehicles	1990	0.582	0.171	0.135	0.841	0.211	0.142	5.404	1.615	1.818
Light Duty Vehicles	1991	0.610	0.172	0.135	0.868	0.212	0.143	5.655	1.621	1.825
Light Duty Vehicles	1992	0.621	0.177	0.138	0.902	0.220	0.146	5.805	1.665	1.879
Light Duty Vehicles	1993	0.649	0.177	0.138	0.922	0.220	0.146	6.066	1.670	1.886
Light Duty Vehicles	1994	0.604	0.172	0.135	0.867	0.213	0.143	5.604	1.623	1.827
Light Duty Vehicles	1995	0.615	0.170	0.134	0.871	0.210	0.142	5.764	1.568	1.777
Light Duty Vehicles	1996	0.615	0.164	0.130	0.836	0.198	0.137	5.754	1.466	1.668
Light Duty Vehicles	1997	0.550	0.156	0.126	0.751	0.187	0.132	5.144	1.356	1.548
Light Duty Vehicles	1998	0.533	0.151	0.123	0.709	0.178	0.128	5.022	1.273	1.461
Light Duty Vehicles	1999	0.491	0.144	0.119	0.650	0.168	0.123	4.574	1.175	1.354
Light Duty Vehicles	2000	0.462	0.138	0.116	0.574	0.156	0.119	4.313	1.097	1.271

Light Duty Vehicles	2001	0.460	0.133	0.112	0.557	0.148	0.115	4.267	1.018	1.187
Light Duty Vehicles	2002	0.403	0.123	0.105	0.484	0.136	0.108	3.749	0.912	1.070
Light Duty Vehicles	2003	0.367	0.113	0.098	0.430	0.123	0.100	3.350	0.809	0.954
Light Duty Vehicles	2004	0.305	0.103	0.091	0.351	0.110	0.092	2.770	0.692	0.826

Sector	ForecastYear	NMVOCu (exh)	NMVOCr (exh)	NMVOCh (exh)	NMVOCu (tot)	NMVOCr (tot)	NMVOCh (tot)	COu	COr	COh
Heavy Duty Vehicles	1985	1.654	1.054	0.802	1.654	1.054	0.802	3.405	2.315	1.871
Heavy Duty Vehicles	1986	1.652	1.053	0.802	1.652	1.053	0.802	3.384	2.303	1.863
Heavy Duty Vehicles	1987	1.653	1.053	0.802	1.653	1.053	0.802	3.390	2.307	1.866
Heavy Duty Vehicles	1988	1.653	1.053	0.802	1.653	1.053	0.802	3.394	2.309	1.867
Heavy Duty Vehicles	1989	1.652	1.052	0.802	1.652	1.052	0.802	3.380	2.300	1.862
Heavy Duty Vehicles	1990	1.653	1.053	0.803	1.653	1.053	0.803	3.390	2.307	1.867
Heavy Duty Vehicles	1991	1.654	1.054	0.803	1.654	1.054	0.803	3.393	2.309	1.867
Heavy Duty Vehicles	1992	1.655	1.054	0.803	1.655	1.054	0.803	3.412	2.320	1.875
Heavy Duty Vehicles	1993	1.655	1.055	0.803	1.655	1.055	0.803	3.413	2.320	1.875
Heavy Duty Vehicles	1994	1.598	1.025	0.785	1.598	1.025	0.785	3.264	2.233	1.810
Heavy Duty Vehicles	1995	1.546	0.998	0.769	1.546	0.998	0.769	3.159	2.172	1.763
Heavy Duty Vehicles	1996	1.495	0.972	0.753	1.495	0.972	0.753	3.037	2.100	1.709
Heavy Duty Vehicles	1997	1.423	0.935	0.728	1.423	0.935	0.728	2.844	1.984	1.635
Heavy Duty Vehicles	1998	1.362	0.904	0.706	1.362	0.904	0.706	2.712	1.904	1.586
Heavy Duty Vehicles	1999	1.301	0.873	0.686	1.301	0.873	0.686	2.570	1.817	1.534
Heavy Duty Vehicles	2000	1.254	0.849	0.668	1.254	0.849	0.668	2.474	1.759	1.500
Heavy Duty Vehicles	2001	1.185	0.819	0.648	1.185	0.819	0.648	2.395	1.700	1.469
Heavy Duty Vehicles	2002	1.102	0.772	0.614	1.102	0.772	0.614	2.236	1.594	1.394
Heavy Duty Vehicles	2003	1.034	0.731	0.583	1.034	0.731	0.583	2.081	1.494	1.323
Heavy Duty Vehicles	2004	0.941	0.679	0.545	0.941	0.679	0.545	1.870	1.361	1.229
Buses	1985	1.301	0.861	0.702	1.301	0.861	0.702	4.274	2.722	1.945
Buses	1986	1.303	0.863	0.703	1.303	0.863	0.703	4.268	2.716	1.941
Buses	1987	1.308	0.867	0.706	1.308	0.867	0.706	4.257	2.706	1.933
Buses	1988	1.308	0.867	0.707	1.308	0.867	0.707	4.256	2.705	1.932
Buses	1989	1.308	0.867	0.707	1.308	0.867	0.707	4.256	2.705	1.932
Buses	1990	1.301	0.861	0.702	1.301	0.861	0.702	4.274	2.722	1.945
Buses	1991	1.291	0.853	0.694	1.291	0.853	0.694	4.299	2.746	1.963
Buses	1992	1.301	0.862	0.702	1.301	0.862	0.702	4.272	2.720	1.944
Buses	1993	1.306	0.865	0.705	1.306	0.865	0.705	4.261	2.710	1.936
Buses	1994	1.271	0.846	0.693	1.271	0.846	0.693	4.067	2.604	1.861
Buses	1995	1.283	0.865	0.712	1.283	0.865	0.712	3.759	2.392	1.721
Buses	1996	1.238	0.839	0.695	1.238	0.839	0.695	3.613	2.320	1.670
Buses	1997	1.188	0.809	0.672	1.188	0.809	0.672	3.426	2.230	1.615

Buses	1998	1.155	0.789	0.656	1.155	0.789	0.656	3.307	2.174	1.582
Buses	1999	1.121	0.769	0.639	1.121	0.769	0.639	3.166	2.104	1.539
Buses	2000	1.091	0.751	0.625	1.091	0.751	0.625	3.039	2.041	1.501
Buses	2001	1.066	0.735	0.613	1.066	0.735	0.613	2.947	1.999	1.475
Buses	2002	1.020	0.705	0.588	1.020	0.705	0.588	2.801	1.918	1.419
Buses	2003	0.983	0.680	0.567	0.983	0.680	0.567	2.688	1.855	1.375
Buses	2004	0.950	0.658	0.549	0.950	0.658	0.549	2.581	1.794	1.332
Sector	ForecastYear	NMVOCu (exh)	NMVOCr (exh)	NMVOCh (exh)	NMVOCu (tot)	NMVOCr (tot)	NMVOCh (tot)	COu	COr	COh
Mopeds	1985	8.781	8.781		9.095	9.095		15.000	15.000	
Mopeds	1986	8.781	8.781		9.098	9.098		15.000	15.000	
Mopeds	1987	8.781	8.781		9.092	9.092		15.000	15.000	
Mopeds	1988	8.781	8.781		9.111	9.111		15.000	15.000	
Mopeds	1989	8.781	8.781		9.119	9.119		15.000	15.000	
Mopeds	1990	8.781	8.781		9.119	9.119		15.000	15.000	
Mopeds	1991	8.781	8.781		9.110	9.110		15.000	15.000	
Mopeds	1992	8.781	8.781		9.119	9.119		15.000	15.000	
Mopeds	1993	8.781	8.781		9.100	9.100		15.000	15.000	
Mopeds	1994	8.781	8.781		9.117	9.117		15.000	15.000	
Mopeds	1995	8.781	8.781		9.115	9.115		15.000	15.000	
Mopeds	1996	8.781	8.781		9.100	9.100		15.000	15.000	
Mopeds	1997	8.781	8.781		9.119	9.119		15.000	15.000	
Mopeds	1998	8.781	8.781		9.104	9.104		15.000	15.000	
Mopeds	1999	8.781	8.781		9.139	9.139		15.000	15.000	
Mopeds	2000	8.286	8.286		8.583	8.583		14.232	14.232	
Mopeds	2001	7.939	7.939		8.264	8.264		13.693	13.693	
Mopeds	2002	7.572	7.572		7.909	7.909		13.123	13.123	
Mopeds	2003	7.293	7.293		7.627	7.627		12.552	12.552	
Mopeds	2004	6.940	6.940		7.272	7.272		11.831	11.831	
Motorcycles	1985	2.639	2.014	2.011	3.464	2.236	2.045	20.029	22.185	27.917
Motorcycles	1986	2.639	2.014	2.011	3.470	2.237	2.045	20.029	22.185	27.917
Motorcycles	1987	2.639	2.014	2.011	3.458	2.234	2.045	20.029	22.185	27.917
Motorcycles	1988	2.639	2.015	2.011	3.495	2.244	2.047	20.029	22.185	27.917
Motorcycles	1989	2.639	2.014	2.011	3.509	2.248	2.047	20.029	22.185	27.917
Motorcycles	1990	2.639	2.014	2.011	3.511	2.248	2.047	20.029	22.185	27.917
Motorcycles	1991	2.639	2.014	2.011	3.493	2.243	2.046	20.029	22.185	27.917
Motorcycles	1992	2.639	2.015	2.011	3.509	2.248	2.047	20.029	22.185	27.917
Motorcycles	1993	2.639	2.014	2.011	3.472	2.238	2.046	20.029	22.185	27.917
Motorcycles	1994	2.639	2.014	2.011	3.506	2.247	2.047	20.029	22.185	27.917

Motorcycles	1995	2.639	2.014	2.011	3.502	2.246	2.047	20.029	22.185	27.917
Motorcycles	1996	2.639	2.014	2.011	3.472	2.238	2.045	20.029	22.185	27.917
Motorcycles	1997	2.639	2.014	2.011	3.511	2.248	2.047	20.029	22.185	27.917
Motorcycles	1998	2.639	2.014	2.011	3.481	2.240	2.046	20.029	22.185	27.917
Motorcycles	1999	2.639	2.014	2.011	3.509	2.248	2.047	20.029	22.185	27.917
Motorcycles	2000	2.639	2.014	2.011	3.325	2.198	2.039	20.029	22.185	27.917
Motorcycles	2001	2.600	1.978	1.975	3.276	2.159	2.003	20.010	22.166	27.919
Motorcycles	2002	2.562	1.941	1.938	3.252	2.126	1.967	19.990	22.146	27.922
Motorcycles	2003	2.523	1.904	1.902	3.207	2.088	1.930	19.970	22.127	27.924
Motorcycles	2004	2.453	1.848	1.846	3.147	2.034	1.874	19.591	21.708	27.410

Annex 3B-7: Fuel use (GJ) and emissions (tonnes) per vehicle category and as totals

Sector	Year	FC (PJ)	SO2	NOx	NMVOC	CH4	CO	CO2	N2O	NH3
Passenger Cars	1985	64	1395	54217	69102	1862	516779	4685	176	47
Passenger Cars	1986	64	916	54954	68768	1861	494176	4713	180	48
Passenger Cars	1987	65	930	55400	68330	1890	474552	4730	182	48
Passenger Cars	1988	65	912	56462	68016	1855	428732	4764	183	49
Passenger Cars	1989	64	658	56050	66506	1811	401081	4708	184	49
Passenger Cars	1990	68	669	59653	69953	1917	409520	4968	191	52
Passenger Cars	1991	72	690	60008	70514	2183	426126	5277	254	224
Passenger Cars	1992	76	513	59977	69855	2348	420560	5540	321	410
Passenger Cars	1993	76	295	56866	65494	2519	412178	5529	370	568
Passenger Cars	1994	77	304	52694	59616	2619	376184	5608	462	839
Passenger Cars	1995	81	318	51707	57508	2917	377712	5916	555	1103
Passenger Cars	1996	83	326	48919	53498	3227	375653	6043	632	1334
Passenger Cars	1997	85	334	45598	47178	3067	326831	6207	737	1641
Passenger Cars	1998	87	347	41900	41756	3064	311583	6357	821	1884
Passenger Cars	1999	88	286	38237	36461	2835	280381	6411	885	2048
Passenger Cars	2000	87	200	35106	30061	2702	260867	6385	924	2139
Passenger Cars	2001	86	198	32109	27213	2633	252270	6317	939	2166
Passenger Cars	2002	88	201	29798	24080	2401	231251	6404	986	2258
Passenger Cars	2003	89	203	27593	21836	2314	222391	6483	1019	2317
Passenger Cars	2004	89	204	25308	18651	2020	195780	6495	1051	2347
Light Duty Vehicles	1985	16	3285	7289	2323	114	16714	1195	77	6
Light Duty Vehicles	1986	19	2345	8454	2579	126	18552	1404	92	7
Light Duty Vehicles	1987	20	2447	8885	2745	135	19802	1470	96	7
Light Duty Vehicles	1988	21	2538	9235	2835	136	20072	1528	100	7
Light Duty Vehicles	1989	22	1789	9578	2844	135	20073	1600	105	8
Light Duty Vehicles	1990	23	1913	10234	3028	144	21356	1711	113	8
Light Duty Vehicles	1991	24	1983	10653	3202	154	22762	1776	116	8
Light Duty Vehicles	1992	24	1254	10553	3269	156	22970	1742	114	8
Light Duty Vehicles	1993	23	484	10523	3287	160	23446	1732	113	8
Light Duty Vehicles	1994	25	517	11002	3314	158	23405	1834	120	9
Light Duty Vehicles	1995	25	506	10823	3292	164	23426	1814	121	16
Light Duty Vehicles	1996	25	521	10964	3249	170	23630	1870	127	24
Light Duty Vehicles	1997	26	528	10842	3036	160	21869	1890	133	31

Light Duty Vehicles	1998	25	512	10394	2818	156	20641	1840	132	37
Light Duty Vehicles	1999	25	289	10293	2660	147	19264	1862	136	43
Light Duty Vehicles	2000	25	59	10181	2422	142	18370	1876	140	49
Light Duty Vehicles	2001	26	60	10214	2390	144	18209	1914	145	57
Light Duty Vehicles	2002	27	63	10078	2217	133	16886	1987	154	64
Light Duty Vehicles	2003	29	67	10229	2128	128	16135	2118	166	69
Light Duty Vehicles	2004	32	76	10959	2066	125	15515	2399	192	83
Heavy Duty Vehicles	1985	22	5083	19694	2356	168	5140	1609	63	6
Heavy Duty Vehicles	1986	24	3387	21863	2614	187	5675	1787	70	7
Heavy Duty Vehicles	1987	23	3280	21177	2532	181	5506	1731	68	7
Heavy Duty Vehicles	1988	23	3214	20752	2482	177	5400	1696	67	7
Heavy Duty Vehicles	1989	24	2218	21478	2567	183	5568	1755	69	7
Heavy Duty Vehicles	1990	25	2325	22486	2715	193	5900	1840	73	7
Heavy Duty Vehicles	1991	26	2400	23217	2803	199	6096	1900	75	8
Heavy Duty Vehicles	1992	25	1519	22599	2731	194	5964	1849	73	7
Heavy Duty Vehicles	1993	25	578	22364	2703	192	5903	1830	73	7
Heavy Duty Vehicles	1994	27	620	23151	2816	199	6087	1963	78	8
Heavy Duty Vehicles	1995	26	611	22016	2700	190	5826	1935	77	8
Heavy Duty Vehicles	1996	27	633	22009	2719	191	5825	2003	80	8
Heavy Duty Vehicles	1997	28	643	21357	2584	187	5454	2035	79	8
Heavy Duty Vehicles	1998	29	671	21204	2574	188	5413	2122	82	8
Heavy Duty Vehicles	1999	30	384	21132	2542	190	5302	2211	84	8
Heavy Duty Vehicles	2000	29	68	19521	2380	177	4959	2141	81	8
Heavy Duty Vehicles	2001	30	70	19192	2278	177	4806	2198	81	8
Heavy Duty Vehicles	2002	29	68	17358	2081	162	4390	2148	79	8
Heavy Duty Vehicles	2003	31	74	17486	2122	165	4443	2323	85	9
Heavy Duty Vehicles	2004	31	73	15621	1946	151	4023	2306	85	8
Buses	1985	8	1855	8363	727	85	2325	586	21	2
Buses	1986	9	1213	9107	795	92	2529	639	23	2
Buses	1987	8	1187	8904	782	90	2470	625	23	2
Buses	1988	8	1191	8927	784	91	2476	627	23	2
Buses	1989	9	821	9228	811	94	2560	648	23	2
Buses	1990	9	857	9661	840	98	2685	677	24	2
Buses	1991	9	828	9358	803	94	2609	654	23	2
Buses	1992	9	531	9210	802	93	2559	646	23	2
Buses	1993	9	204	9184	804	93	2549	645	23	2
Buses	1994	9	216	9419	831	96	2583	682	25	2
Buses	1995	10	242	10075	958	105	2697	766	28	3

Buses	1996	10	238	9624	911	100	2556	752	28	3
Buses	1997	10	236	9090	866	96	2412	744	27	3
Buses	1998	10	235	8769	840	93	2330	742	27	3
Buses	1999	10	126	8234	795	89	2187	723	27	3
Buses	2000	9	22	7613	743	83	2021	693	25	3
Buses	2001	9	21	7171	702	79	1904	670	25	2
Buses	2002	9	21	6864	674	76	1822	672	25	2
Buses	2003	10	23	7153	703	80	1898	727	27	3
Buses	2004	10	24	7073	698	79	1877	747	27	3
Mopeds	1985	0	1	9	2770	67	4568	24	0	0
Mopeds	1986	0	1	8	2496	60	4114	22	0	0
Mopeds	1987	0	1	8	2364	57	3901	21	0	0
Mopeds	1988	0	1	8	2310	56	3802	20	0	0
Mopeds	1989	0	1	7	2205	53	3627	19	0	0
Mopeds	1990	0	1	7	2256	54	3711	20	0	0
Mopeds	1991	0	1	8	2320	56	3820	20	0	0
Mopeds	1992	0	1	8	2322	56	3820	20	0	0
Mopeds	1993	0	1	7	2240	54	3692	20	0	0
Mopeds	1994	0	1	7	2078	50	3419	18	0	0
Mopeds	1995	0	1	8	2303	55	3790	20	0	0
Mopeds	1996	0	1	8	2452	59	4041	22	0	0
Mopeds	1997	0	1	9	2616	63	4304	23	0	0
Mopeds	1998	0	1	9	2774	67	4570	24	0	0
Mopeds	1999	0	1	8	2489	60	4085	22	0	0
Mopeds	2000	0	1	8	2227	54	3693	21	0	0
Mopeds	2001	0	1	6	1759	42	2914	17	0	0
Mopeds	2002	0	1	7	1752	42	2907	18	0	0
Mopeds	2003	0	1	6	1669	40	2746	17	0	0
Mopeds	2004	0	1	6	1602	38	2607	18	0	0
Motorcycles	1985	0	1	46	658	45	5190	23	0	0
Motorcycles	1986	0	1	45	652	45	5135	23	0	0
Motorcycles	1987	0	1	46	654	45	5160	23	0	0
Motorcycles	1988	0	1	46	672	46	5267	24	0	0
Motorcycles	1989	0	1	46	671	46	5243	24	0	0
Motorcycles	1990	0	1	50	724	50	5653	25	1	1
Motorcycles	1991	0	1	54	780	54	6111	27	1	1
Motorcycles	1992	0	1	57	832	57	6498	29	1	1
Motorcycles	1993	0	1	59	850	59	6695	30	1	1

Motorcycles	1994	0	1	59	857	59	6698	30	1	1
Motorcycles	1995	0	1	62	903	62	7063	32	1	1
Motorcycles	1996	0	1	66	949	65	7473	33	1	1
Motorcycles	1997	0	1	72	1040	71	8123	36	1	1
Motorcycles	1998	1	1	77	1104	76	8673	39	1	1
Motorcycles	1999	1	1	81	1170	80	9143	41	1	1
Motorcycles	2000	1	1	87	1208	86	9811	44	1	1
Motorcycles	2001	1	1	93	1275	92	10514	47	1	1
Motorcycles	2002	1	2	100	1346	99	11215	50	1	1
Motorcycles	2003	1	2	107	1413	105	11956	54	1	1
Motorcycles	2004	1	2	118	1514	113	12849	59	1	1
Total	1985	111	11620	89618	77938	2341	550715	8123	339	62
Total	1986	117	7861	94432	77903	2371	530183	8588	366	64
Total	1987	117	7846	94420	77406	2398	511392	8600	369	65
Total	1988	118	7856	95431	77098	2361	465749	8658	374	66
Total	1989	119	5486	96389	75603	2322	438153	8754	382	66
Total	1990	126	5766	102091	79517	2456	448826	9241	402	70
Total	1991	131	5902	103297	80422	2739	467522	9654	471	243
Total	1992	134	3819	102403	79811	2904	462370	9825	532	429
Total	1993	133	1562	99004	75378	3076	454463	9785	579	586
Total	1994	138	1658	96332	69511	3181	418376	10135	686	859
Total	1995	143	1679	94690	67664	3493	420514	10483	782	1131
Total	1996	146	1720	91590	63777	3813	419178	10723	868	1370
Total	1997	149	1743	86967	57320	3644	368994	10936	977	1684
Total	1998	151	1766	82353	51865	3644	353211	11124	1063	1933
Total	1999	153	1087	77984	46118	3400	320362	11270	1134	2104
Total	2000	152	351	72515	39042	3244	299720	11159	1172	2200
Total	2001	152	351	68785	35617	3167	290617	11163	1191	2234
Total	2002	154	355	64205	32150	2913	268471	11279	1244	2334
Total	2003	159	369	62574	29871	2832	259570	11722	1298	2398
Total	2004	164	378	59085	26477	2526	232650	12024	1357	2443

Annex 3B-8: COPERT III:DEA statistics fuel use ratios and mileage adjustment factors

		1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Fuel ratio	DEA:COPERT III	0.89	0.88	0.87	0.89	0.86	0.91	0.96	1.00	1.00	0.96	0.98	0.97	0.96	0.95	0.92	0.92	0.92	0.93	0.93	0.93
	DEA:COPERT III	1.50	1.59	1.55	1.55	1.61	1.70	1.75	1.69	1.68	1.75	1.67	1.68	1.67	1.65	1.61	1.54	1.50	1.49	1.58	1.61
Mileage factor	DEA:COPERT III	0.89	0.88	0.87	0.89	0.86	0.91	0.96	1.00	1.00	0.96	0.98	0.97	0.96	0.95	0.92	0.92	0.92	0.93	0.93	0.93
	DEA:COPERT III	1.60	1.71	1.65	1.66	1.72	1.83	1.90	1.83	1.82	1.90	1.80	1.82	1.81	1.79	1.75	1.67	1.63	1.64	1.77	1.84

Annex 3B-9: Basis fuel use and emission factors, deterioration factors, transient factors for non-road working machinery and equipment, and recreational craft

Basis factors for diesel fuelled non-road machinery

Engine size [P=kW]	Emission Level	NO_x	VOC	CO	N_2O	NH_3	TSP	Fuel
		[g/kWh]						
P<19	<1981	12.0	5.0	7	0.035	0.002	2.8	300
P<19	1981-1990	11.5	3.8	6	0.035	0.002	2.3	285
P<19	1991-Stage I	11.2	2.5	5	0.035	0.002	1.6	270
P<19	Stage I	11.2	2.5	5	0.035	0.002	1.6	270
P<19	Stage II	11.2	2.5	5	0.035	0.002	1.6	270
P<19	Stage IIIA	11.2	2.5	5	0.035	0.002	1.6	270
P<19	Stage IIIB	11.2	2.5	5	0.035	0.002	1.6	270
P<19	Stage IV	11.2	2.5	5	0.035	0.002	1.6	270
19<=P<37	<1981	18.0	2.5	6.5	0.035	0.002	2	300
19<=P<37	1981-1990	18.0	2.2	5.5	0.035	0.002	1.4	281
19<=P<37	1991-Stage I	9.8	1.8	4.5	0.035	0.002	1.4	262
19<=P<37	Stage I	9.8	1.8	4.5	0.035	0.002	1.4	262
19<=P<37	Stage II	6.5	0.6	2.2	0.035	0.002	0.4	262
19<=P<37	Stage IIIA	6.2	0.6	2.2	0.035	0.002	0.4	262
19<=P<37	Stage IIIB	6.2	0.6	2.2	0.035	0.002	0.4	262
19<=P<37	Stage IV	6.2	0.6	2.2	0.035	0.002	0.4	262
37<=P<56	<1981	7.7	2.4	6	0.035	0.002	1.8	290
37<=P<56	1981-1990	8.6	2.0	5.3	0.035	0.002	1.2	275
37<=P<56	1991-Stage I	11.5	1.5	4.5	0.035	0.002	0.8	260
37<=P<56	Stage I	7.7	0.6	2.2	0.035	0.002	0.4	260
37<=P<56	Stage II	5.5	0.4	2.2	0.035	0.002	0.2	260
37<=P<56	Stage IIIA	3.9	0.4	2.2	0.035	0.002	0.2	260
37<=P<56	Stage IIIB	3.9	0.4	2.2	0.035	0.002	0.0225	260
37<=P<56	Stage IV	3.9	0.4	2.2	0.035	0.002	0.0225	260
56<=P<75	<1981	7.7	2.0	5	0.035	0.002	1.4	290
56<=P<75	1981-1990	8.6	1.6	4.3	0.035	0.002	1	275
56<=P<75	1991-Stage I	11.5	1.2	3.5	0.035	0.002	0.4	260
56<=P<75	Stage I	7.7	0.4	1.5	0.035	0.002	0.2	260

56<=P<75	Stage II	5.5	0.3	1.5	0.035	0.002	0.2	260
56<=P<75	Stage IIIA	4.0	0.3	1.5	0.035	0.002	0.2	260
56<=P<75	Stage IIIB	3.0	0.2	1.5	0.035	0.002	0.0225	260
56<=P<75	Stage IV	0.4	0.2	1.5	0.035	0.002	0.0225	260
75<=P<130	<1981	10.5	2.0	5	0.035	0.002	1.4	280
75<=P<130	1981-1990	11.8	1.6	4.3	0.035	0.002	1	268
75<=P<130	1991-Stage I	13.3	1.2	3.5	0.035	0.002	0.4	255
75<=P<130	Stage I	8.1	0.4	1.5	0.035	0.002	0.2	255
75<=P<130	Stage II	5.2	0.3	1.5	0.035	0.002	0.2	255
75<=P<130	Stage IIIA	3.4	0.3	1.5	0.035	0.002	0.2	255
75<=P<130	Stage IIIB	3.0	0.2	1.5	0.035	0.002	0.0225	255
75<=P<130	Stage IV	0.4	0.2	1.5	0.035	0.002	0.0225	255
130<=P<560	<1981	17.8	1.5	2.5	0.035	0.002	0.9	270
130<=P<560	1981-1990	12.4	1.0	2.5	0.035	0.002	0.8	260
130<=P<560	1991-Stage I	11.2	0.5	2.5	0.035	0.002	0.4	250
130<=P<560	Stage I	7.6	0.3	1.5	0.035	0.002	0.2	250
130<=P<560	Stage II	5.2	0.3	1.5	0.035	0.002	0.1	250
130<=P<560	Stage IIIA	3.4	0.3	1.5	0.035	0.002	0.1	250
130<=P<560	Stage IIIB	3.0	0.2	1.5	0.035	0.002	0.0225	250
130<=P<560	Stage IV	0.4	0.2	1.5	0.035	0.002	0.0225	250

Basis factors for 4-stroke gasoline non-road machinery

Engine	Size code	Size classe [S=ccm]	Emission Level	NO_x	VOC	CO	N_2O [g/kWh]	NH_3	TSP	Fuel
4-stroke	SH2	20<=S<50	<1981	2.4	33	198	0.002	0.03	0.08	496
4-stroke	SH2	20<=S<50	1981-1990	3.5	27.5	165	0.002	0.03	0.08	474
4-stroke	SH2	20<=S<50	1991-Stage I	4.7	22	132	0.002	0.03	0.08	451
4-stroke	SH2	20<=S<50	Stage I	4.7	22	132	0.002	0.03	0.08	406
4-stroke	SH2	20<=S<50	Stage II	4.7	22	132	0.002	0.03	0.08	406
4-stroke	SH3	S>=50	<1981	2.4	33	198	0.002	0.03	0.08	496
4-stroke	SH3	S>=50	1981-1990	3.5	27.5	165	0.002	0.03	0.08	474
4-stroke	SH3	S>=50	1991-Stage I	4.7	22	132	0.002	0.03	0.08	451
4-stroke	SH3	S>=50	Stage I	4.7	22	132	0.002	0.03	0.08	406
4-stroke	SH3	S>=50	Stage II	4.7	22	132	0.002	0.03	0.08	406
4-stroke	SN1	S<66	<1981	1.2	26.9	822	0.002	0.03	0.08	603

4-stroke	SN1	S<66	1981-1990	1.8	22.5	685	0.002	0.03	0.08	603
4-stroke	SN1	S<66	1991-Stage I	2.4	18	548	0.002	0.03	0.08	603
4-stroke	SN1	S<66	Stage I	4.3	16.1	411	0.002	0.03	0.08	475
4-stroke	SN1	S<66	Stage II	4.3	16.1	411	0.002	0.03	0.08	475
4-stroke	SN2	66<=S<100	<1981	2.3	10.5	822	0.002	0.03	0.08	627
4-stroke	SN2	66<=S<100	1981-1990	3.5	8.7	685	0.002	0.03	0.08	599
4-stroke	SN2	66<=S<100	1991-Stage I	4.7	7	548	0.002	0.03	0.08	570
4-stroke	SN2	66<=S<100	Stage I	4.7	7	467	0.002	0.03	0.08	450
4-stroke	SN2	66<=S<100	Stage II	4.7	7	467	0.002	0.03	0.08	450
4-stroke	SN3	100<=S<225	<1981	2.6	19.1	525	0.002	0.03	0.08	601
4-stroke	SN3	100<=S<225	1981-1990	3.8	15.9	438	0.002	0.03	0.08	573
4-stroke	SN3	100<=S<225	1991-Stage I	5.1	12.7	350	0.002	0.03	0.08	546
4-stroke	SN3	100<=S<225	Stage I	5.1	11.6	350	0.002	0.03	0.08	546
4-stroke	SN3	100<=S<225	Stage II	5.1	9.4	350	0.002	0.03	0.08	546
4-stroke	SN4	S>=225	<1981	1.3	11.1	657	0.002	0.03	0.08	539
4-stroke	SN4	S>=225	1981-1990	2	9.3	548	0.002	0.03	0.08	514
4-stroke	SN4	S>=225	1991-Stage I	2.6	7.4	438	0.002	0.03	0.08	490
4-stroke	SN4	S>=225	Stage I	2.6	7.4	438	0.002	0.03	0.08	490
4-stroke	SN4	S>=225	Stage II	2.6	7.4	438	0.002	0.03	0.08	490

Basis factors for 2-stroke gasoline non road machinery

Engine	Size code	Size classe	Emission Level	NO_x	VOC	CO	N_2O	NH_3	TSP	Fuel
		[ccm]					[g/kWh]			
2-stroke	SH2	20<=S<50	<1981	1	305	695	0.002	0.01	7	882
2-stroke	SH2	20<=S<50	1981-1990	1	300	579	0.002	0.01	5.3	809
2-stroke	SH2	20<=S<50	1991-Stage I	1.1	203	463	0.002	0.01	3.5	735
2-stroke	SH2	20<=S<50	Stage I	1.5	188	379	0.002	0.01	3.5	720
2-stroke	SH2	20<=S<50	Stage II	1.5	44	379	0.002	0.01	3.5	500
2-stroke	SH3	S>=50	<1981	1.1	189	510	0.002	0.01	3.6	665
2-stroke	SH3	S>=50	1981-1990	1.1	158	425	0.002	0.01	2.7	609
2-stroke	SH3	S>=50	1991-Stage I	1.2	126	340	0.002	0.01	1.8	554
2-stroke	SH3	S>=50	Stage I	2	126	340	0.002	0.01	1.8	529
2-stroke	SH3	S>=50	Stage II	1.2	64	340	0.002	0.01	1.8	500
2-stroke	SN1	S<66	<1981	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN1	S<66	1981-1990	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN1	S<66	1991-Stage I	0.5	155	418	0.002	0.01	2.6	652

2-stroke	SN1	S<66	Stage I	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN1	S<66	Stage II	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN2	66<=S<100	<1981	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN2	66<=S<100	1981-1990	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN2	66<=S<100	1991-Stage I	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN2	66<=S<100	Stage I	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN2	66<=S<100	Stage II	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN3	100<=S<225	<1981	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN3	100<=S<225	1981-1990	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN3	100<=S<225	1991-Stage I	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN3	100<=S<225	Stage I	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN3	100<=S<225	Stage II	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN4	S>=225	<1981	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN4	S>=225	1981-1990	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN4	S>=225	1991-Stage I	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN4	S>=225	Stage I	0.5	155	418	0.002	0.01	2.6	652
2-stroke	SN4	S>=225	Stage II	0.5	155	418	0.002	0.01	2.6	652

Fuel use and emission factors LPG fork lifts

NO_x [g/kWh]	VOC [g/kWh]	CO [g/kWh]	NH_3 [g/kWh]	N_2O [g/kWh]	TSP [g/kWh]	FC [g/kWh]
19	2.2	1.5	0.003	0.05	0.07	311

Fuel use and emission factors for All Terrain Vehicles (ATV's)

ATV type	NO_x [g/GJ]	VOC [g/GJ]	CO [g/GJ]	NH_3 [g/GJ]	N_2O [g/GJ]	TSP [g/GJ]	Fuel [kg/hour]
Professional	108	1077	16306	2	2	32	1.125
Private	128	1527	22043	2	2	39	0.75

Fuel use and emission factors for recreational craft

Fuel type	Vessel type	Engine	Engine type	Direktiv	Engine size	CO	VOC	N_2O	NH_3	NO_x	TSP	Fuel
					[kW]	[g/kWh]						
Gasoline	Other boats (< 20 ft)	Out board	2-stroke	2003/44	8	202.5	45.9	0.01	0.002	2	10	791
Gasoline	Other boats (< 20 ft)	Out board	2-stroke	Konv.	8	427	257.0	0.01	0.002	2	10	791
Gasoline	Other boats (< 20 ft)	Out board	4-stroke	2003/44	8	202.5	24.0	0.03	0.002	7	0.08	426

Gasoline	Other boats (< 20 ft)	Out board	4-stroke	Konv.	8	520	24.0	0.03	0.002	7	0.08	426
Gasoline	Yawls and cabin boats	Out board	2-stroke	2003/44	20	162	36.5	0.01	0.002	3	10	791
Gasoline	Yawls and cabin boats	Out board	2-stroke	Konv.	20	374	172.0	0.01	0.002	3	10	791
Gasoline	Yawls and cabin boats	Out board	4-stroke	2003/44	20	162	14.0	0.03	0.002	10	0.08	426
Gasoline	Yawls and cabin boats	Out board	4-stroke	Konv.	20	390	14.0	0.03	0.002	10	0.08	426
Gasoline	Sailing boats (< 26 ft)	Out board	2-stroke	2003/44	10	189	43.0	0.01	0.002	2	10	791
Gasoline	Sailing boats (< 26 ft)	Out board	2-stroke	Konv.	10	427	257.0	0.01	0.002	2	10	791
Gasoline	Sailing boats (< 26 ft)	Out board	4-stroke	2003/44	10	189	24.0	0.03	0.002	7	0.08	426
Gasoline	Sailing boats (< 26 ft)	Out board	4-stroke	Konv.	10	520	24.0	0.03	0.002	7	0.08	426
Gasoline	Speed boats	In board	4-stroke	2003/44	90	141	10.0	0.03	0.002	12	0.08	426
Gasoline	Speed boats	In board	4-stroke	Konv.	90	346	10.0	0.03	0.002	12	0.08	426
Gasoline	Speed boats	Out board	2-stroke	2003/44	50	145.8	31.8	0.01	0.002	3	10	791
Gasoline	Speed boats	Out board	2-stroke	Konv.	50	374	172.0	0.01	0.002	3	10	791
Gasoline	Speed boats	Out board	4-stroke	2003/44	50	145.8	14.0	0.03	0.002	10	0.08	426
Gasoline	Speed boats	Out board	4-stroke	Konv.	50	390	14.0	0.03	0.002	10	0.08	426
Gasoline	Water scooters	Built in	2-stroke	2003/44	45	147	32.2	0.01	0.002	3	10	791
Gasoline	Water scooters	Built in	2-stroke	Konv.	45	374	172.0	0.01	0.002	3	10	791
Gasoline	Water scooters	Built in	4-stroke	2003/44	45	147	14.0	0.03	0.002	10	0.08	426
Gasoline	Water scooters	Built in	4-stroke	Konv.	45	390	14.0	0.03	0.002	10	0.08	426
Diesel	Motor boats (27-34 ft)	In board		2003/44	150	5	1.7	0.035	0.002	8.6	1	275
Diesel	Motor boats (27-34 ft)	In board		Konv.	150	5.3	2.0	0.035	0.002	8.6	1.2	275
Diesel	Motor boats (> 34 ft)	In board		2003/44	250	5	1.6	0.035	0.002	8.6	1	275
Diesel	Motor boats (> 34 ft)	In board		Konv.	250	5.3	2.0	0.035	0.002	8.6	1.2	275
Diesel	Motor boats (< 27 ft)	In board		2003/44	40	5	1.8	0.035	0.002	9.8	1	281
Diesel	Motor boats (< 27 ft)	In board		Konv.	40	5.5	2.2	0.035	0.002	18	1.4	281
Diesel	Motor sailors	In board		2003/44	30	5	1.9	0.035	0.002	9.8	1	281
Diesel	Motor sailors	In board		Konv.	30	5.5	2.2	0.035	0.002	18	1.4	281
Diesel	Sailing boats (> 26 ft)	In board		2003/44	30	5	1.9	0.035	0.002	9.8	1	281
Diesel	Sailing boats (> 26 ft)	In board		Konv.	30	5.5	2.2	0.035	0.002	18	1.4	281

CH_4 shares of VOC for diesel, gasoline and LPG

Fuel type	CH_4 share of VOC
Diesel	0.016
Gasoline 4-stroke	0.1
Gasoline 2-stroke	0.009
LPG	0.05

Deterioration factors for diesel machinery

Emission Level	NO_x	VOC	CO	TSP
<1981	0.024	0.047	0.185	0.473
1981-1990	0.024	0.047	0.185	0.473
1991-Stage I	0.024	0.047	0.185	0.473
Stage I	0.024	0.036	0.101	0.473
Stage II	0.009	0.034	0.101	0.473
Stage IIIA	0.008	0.027	0.151	0.473
Stage IIIB	0.008	0.027	0.151	0.473
Stage IV	0.008	0.027	0.151	0.473

Deterioration factors for gasoline 2-stroke machinery

Engine	Size code	Size classe	Emission Level	NO_x	VOC	CO	TSP
2-stroke	SH2	20<=S<50	<1981	0	0.2	0.2	0
2-stroke	SH2	20<=S<50	1981-1990	0	0.2	0.2	0
2-stroke	SH2	20<=S<50	1991-Stage I	0	0.2	0.2	0
2-stroke	SH2	20<=S<50	Stage I	0	0.29	0.24	0
2-stroke	SH2	20<=S<50	Stage II	0	0.29	0.24	0
2-stroke	SH3	S>=50	<1981	-0.031	0.2	0.2	0
2-stroke	SH3	S>=50	1981-1990	-0.031	0.2	0.2	0
2-stroke	SH3	S>=50	1991-Stage I	-0.031	0.2	0.2	0
2-stroke	SH3	S>=50	Stage I	0	0.266	0.231	0
2-stroke	SH3	S>=50	Stage II	0	0.266	0.231	0
2-stroke	SN1	S<66	<1981	-0.6	0.201	0.9	1.1
2-stroke	SN1	S<66	1981-1990	-0.6	0.201	0.9	1.1
2-stroke	SN1	S<66	1991-Stage I	-0.6	0.201	0.9	1.1
2-stroke	SN1	S<66	Stage I	-0.33	0.266	1.109	5.103
2-stroke	SN1	S<66	Stage II	-0.33	0	1.109	5.103
2-stroke	SN2	66<=S<100	<1981	-0.6	0.201	0.9	1.1
2-stroke	SN2	66<=S<100	1981-1990	-0.6	0.201	0.9	1.1
2-stroke	SN2	66<=S<100	1991-Stage I	-0.6	0.201	0.9	1.1
2-stroke	SN2	66<=S<100	Stage I	-0.33	0.266	1.109	5.103
2-stroke	SN2	66<=S<100	Stage II	-0.33	0	1.109	5.103
2-stroke	SN3	100<=S<225	<1981	-0.6	0.201	0.9	1.1
2-stroke	SN3	100<=S<225	1981-1990	-0.6	0.201	0.9	1.1

2-stroke	SN3	100<=S<225	1991-Stage I	-0.6	0.201	0.9	1.1
2-stroke	SN3	100<=S<225	Stage I	-0.33	0.266	1.109	5.103
2-stroke	SN3	100<=S<225	Stage II	-0.33	0	1.109	5.103
2-stroke	SN4	S>=225	<1981	-0.6	0.201	0.9	1.1
2-stroke	SN4	S>=225	1981-1990	-0.6	0.201	0.9	1.1
2-stroke	SN4	S>=225	1991-Stage I	-0.6	0.201	0.9	1.1
2-stroke	SN4	S>=225	Stage I	-0.274	0	0.887	1.935
2-stroke	SN4	S>=225	Stage II	-0.274	0	0.887	1.935

Deterioration factors for gasoline 4-stroke machinery

Engine	Size code	Size class	Emission Level	NO_x	VOC	CO	TSP
4-stroke	SN1	S<66	<1981	-0.6	1.1	0.9	1.1
4-stroke	SN1	S<66	1981-1990	-0.6	1.1	0.9	1.1
4-stroke	SN1	S<66	1991-Stage I	-0.6	1.1	0.9	1.1
4-stroke	SN1	S<66	Stage I	-0.3	1.753	1.051	1.753
4-stroke	SN1	S<66	Stage II	-0.3	1.753	1.051	1.753
4-stroke	SN2	66<=S<100	<1981	-0.6	1.1	0.9	1.1
4-stroke	SN2	66<=S<100	1981-1990	-0.6	1.1	0.9	1.1
4-stroke	SN2	66<=S<100	1991-Stage I	-0.6	1.1	0.9	1.1
4-stroke	SN2	66<=S<100	Stage I	-0.3	1.753	1.051	1.753
4-stroke	SN2	66<=S<100	Stage II	-0.3	1.753	1.051	1.753
4-stroke	SN3	100<=S<225	<1981	-0.6	1.1	0.9	1.1
4-stroke	SN3	100<=S<225	1981-1990	-0.6	1.1	0.9	1.1
4-stroke	SN3	100<=S<225	1991-Stage I	-0.6	1.1	0.9	1.1
4-stroke	SN3	100<=S<225	Stage I	-0.3	1.753	1.051	1.753
4-stroke	SN3	100<=S<225	Stage II	-0.3	1.753	1.051	1.753

4-stroke	SN4	S>=225	<1981	-0.6	1.1	0.9	1.1
4-stroke	SN4	S>=225	1981-1990	-0.6	1.1	0.9	1.1
4-stroke	SN4	S>=225	1991-Stage I	-0.6	1.1	0.9	1.1
4-stroke	SN4	S>=225	Stage I	-0.599	1.095	1.307	1.095
4-stroke	SN4	S>=225	Stage II	-0.599	1.095	1.307	1.095
4-stroke	SH2	20<=S<50	<1981	0	0	0	0
4-stroke	SH2	20<=S<50	1981-1990	0	0	0	0
4-stroke	SH2	20<=S<50	1991-Stage I	0	0	0	0
4-stroke	SH2	20<=S<50	Stage I	0	0	0	0
4-stroke	SH2	20<=S<50	Stage II	0	0	0	0
4-stroke	SH3	S>=50	<1981	0	0	0	0
4-stroke	SH3	S>=50	1981-1990	0	0	0	0
4-stroke	SH3	S>=50	1991-Stage I	0	0	0	0
4-stroke	SH3	S>=50	Stage I	0	0	0	0
4-stroke	SH3	S>=50	Stage II	0	0	0	0

Transient factors for diesel machinery

Emission Level	Load	NO_x	VOC	CO	TSP	Fuel
<1981	High	0.95	1.05	1.53	1.23	1.01
1981-1990	High	0.95	1.05	1.53	1.23	1.01
1991-Stage I	High	0.95	1.05	1.53	1.23	1.01
Stage I	High	0.95	1.05	1.53	1.23	1.01
Stage II	High	0.95	1.05	1.53	1.23	1.01
Stage IIIA	High	0.95	1.05	1.53	1.23	1.01
Stage IIIB	High	1	1	1	1	1

Stage IV	High	1	1	1	1	1
<1981	Low	1.1	2.29	2.57	1.97	1.18
1981-1990	Low	1.1	2.29	2.57	1.97	1.18
1991-Stage I	Low	1.1	2.29	2.57	1.97	1.18
Stage I	Low	1.1	2.29	2.57	1.97	1.18
Stage II	Low	1.1	2.29	2.57	1.97	1.18
Stage IIIA	Low	1.1	2.29	2.57	1.97	1.18
Stage IIIB	Low	1	1	1	1	1
Stage IV	Low	1	1	1	1	1

Annex 3B-10: Stock and activity data for non-road working machinery and equipment

Stock data for diesel tractors 1985-2004

Size (kW)	Emission Level	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
37	<1981	3882	3792	3542	3543	3403	3234	3106	2922	2861	2610	2605	2273	2193	1918	1796	1601	1442	1282	1121	961
37	1981-1990	635	731	760	835	855	879	889	883	915	887	945	883	918	869	888	871	871	871	871	871
37	1991-Stage I							25	107	153	201	278	354	445	496	554	568	569	569	569	569
37	Stage I																	33	55	81	81
37	Stage II																				26
45	<1981	25988	25387	23709	23718	22781	21650	20796	19563	19154	17475	17441	15219	14684	12840	12025	10715	9652	8580	7507	6435
45	1981-1990	5740	6808	7263	8075	8476	8770	8867	8805	9128	8848	9419	8807	9151	8668	8856	8681	8688	8688	8688	8688
45	1991-Stage I							203	202	209	203	216	202	210	199	203	199	199	199	199	199
49	1991-Stage I								154	281	485	602	618	702	749	765	750	750	750	750	750
52	1991-Stage I															247	358	359	359	359	359
52	Stage I																	132	239	368	368
52	Stage II																				129
56	1991-Stage I								201	338	428	747	943	1181	1280	1307	1281	1282	1282	1282	1282
60	<1981	54651	53387	49857	49877	47907	45529	43732	41140	40278	36747	36676	32004	30879	27001	25287	22533	20297	18042	15787	13532
60	1981-1990	11751	14613	15795	17797	19395	20542	20770	20624	21380	20725	22063	20628	21434	20304	20744	20333	20351	20351	20351	20351
60	1991-Stage I							863	857	888	861	917	857	891	844	862	845	846	846	846	846
63	1991-Stage I								468	855	1325	2014	2384	2837	3011	3076	3015	3018	3018	3018	3018
67	1991-Stage I															671	1343	1344	1344	1344	1344
67	Stage I																	530	824	1088	1088
67	Stage II																				263

71	1991-Stage I								411	715	1179	1949	2507	3344	3594	3672	3600	3603	3603	3603	3603
78	<1981	14558	14221	13281	13286	12761	12128	11649	10959	10729	9789	9770	8525	8226	7192	6736	6002	5407	4806	4205	3605
78	1981-1990	4592	6152	7196	8559	10026	11323	11448	11368	11785	11424	12162	11371	11815	11192	11434	11208	11218	11218	11218	11218
78	1991-Stage I							1233	1503	1713	1945	2429	2561	2946	2994	3287	3436	3709	3709	3709	3709
78	Stage I																		321	321	321
78	Stage II																			222	443
86	1991-Stage I								108	193	333	589	880	1364	1532	1718	1876	2013	2013	2013	2013
86	Stage I																		133	133	133
86	Stage II																			89	178
93	1991-Stage I															149	245	323	323	323	323
93	Stage I																		112	112	112
93	Stage II																			104	208
97	1991-Stage I								71	175	443	962	1556	2327	2638	2695	2642	2644	2644	2644	2644
101	<1981	4659	4551	4250	4252	4084	3881	3728	3507	3433	3132	3126	2728	2632	2302	2156	1921	1730	1538	1346	1153
101	1981-1990	1158	1434	1618	1921	2156	2377	2403	2387	2474	2398	2553	2387	2480	2350	2400	2353	2355	2355	2355	2355
101	1991-Stage I							266	264	274	266	283	264	275	260	696	1116	1559	1559	1559	1559
101	Stage I																		229	229	229
101	Stage II																			133	265
112	1991-Stage I								63	114	166	252	422	690	790	978	1265	1618	1618	1618	1618
112	Stage I																		459	459	459
112	Stage II																			329	659
127	1991-Stage I								12	36	81	193	279	408	457	590	707	843	843	843	843
127	Stage I																		150	150	150
127	Stage II																			77	153
131	<1981	798	780	728	728	700	665	639	601	588	537	536	467	451	394	369	329	296	263	231	198
131	1981-1990	288	421	500	651	753	887	897	890	923	895	952	890	925	876	895	878	878	878	878	878
131	1991-Stage I							97	97	100	97	103	97	100	95	97	95	95	95	95	95
157	1981-1990		2	3	6	11	15	15	15	16	15	16	15	16	15	15	15	15	15	15	15
157	1991-Stage I							9	23	39	102	232	357	545	648	784	900	901	901	901	901
157	Stage I																	88	88	88	88
157	Stage II																		147	406	665
186	1991-Stage I															23	53	53	53	53	53
186	Stage I																	47	47	47	47
186	Stage II																		67	202	337

Stock data for gasoline tractors 1985-2004

Size (kW)	Emission Level	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Certified	<1981	13176	12541	11906	11270	10635	10000	9053	8148	7285	6465	5687	4951	4258	3607	2998	2432	1908	1427	987	591
Non certified	<1981	26352	25082	23811	22541	21270	20000	19042	18041	16998	15913	14785	13616	12403	11149	9852	8512	7131	5707	4240	2732

Stock data for harvesters 1985-2004

Size Group	Emission Level	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
0<S<=50	<1981	26601	24394	22599	22144	19842	18915	17241	15607	14575	12673	10700	9491	6966	5446	3589	2873	1743	1169	659	217
0<S<=50	1981-1990	519	534	550	582	566	591	594	601	635	636	633	683	641	686	672	715	713	713	713	713
50<S<=60	<1981	2703	2648	2634	2785	2711	2828	2847	2876	3040	3044	3029	3271	3068	2930	2235	1999	1477	1155	784	316
50<S<=60	1981-1990	853	1102	1164	1275	1258	1333	1341	1355	1432	1434	1427	1541	1446	1548	1516	1612	1609	1609	1609	1609
50<S<=60	1991-Stage I							8	8	8	8	8	9	9	9	9	10	10	10	10	10
60<S<=70	<1981	1786	1750	1741	1841	1792	1869	1881	1901	2009	2012	2002	2162	2028	2171	2127	2073	1550	1228	857	390
60<S<=70	1981-1990	1138	1679	1943	2237	2213	2348	2363	2388	2524	2527	2515	2716	2547	2727	2671	2841	2834	2834	2834	2834
60<S<=70	1991-Stage I							8	16	18	21	22	24	23	24	24	25	25	25	25	25
70<S<=80	<1981	929	910	905	958	932	972	979	989	1045	1046	1041	1125	1055	1129	1106	1176	1174	1013	642	174
70<S<=80	1981-1990	383	699	1026	1165	1318	1493	1502	1518	1604	1606	1598	1726	1619	1733	1698	1806	1802	1802	1802	1802
70<S<=80	1991-Stage I							72	77	83	86	87	96	91	98	96	102	102	102	102	102
70<S<=80	Stage I															1	1	1	1	1	1
80<S<=90	<1981	323	317	315	333	324	338	340	344	363	364	362	391	367	393	385	409	408	408	408	174
80<S<=90	1981-1990	383	562	645	967	1107	1466	1475	1491	1575	1577	1570	1695	1590	1702	1667	1773	1769	1769	1769	1769
80<S<=90	1991-Stage I							61	158	181	200	200	217	207	222	217	231	231	231	231	231
80<S<=90	Stage I															1	1	1	1	1	1
90<S<=100	1981-1990	89	175	235	387	515	670	674	681	720	721	717	775	726	778	762	810	808	808	808	808
90<S<=100	1991-Stage I							180	257	320	329	351	382	367	393	385	410	409	409	409	409
90<S<=100	Stage I															1	1	1	1	1	1
100<S<=120	1981-1990		54	106	219	334	589	592	599	633	634	630	681	639	684	670	712	711	711	711	711
100<S<=120	1991-Stage I							129	253	316	375	440	567	586	673	660	702	700	700	700	700
100<S<=120	Stage I															2	2	2	2	2	2
120<S<=140	1981-1990				4	69	183	184	186	197	197	196	212	199	213	208	222	221	221	221	221
120<S<=140	1991-Stage I							70	148	189	215	319	484	626	804	860	918	920	920	920	920
120<S<=140	Stage I															21	26	30	30	30	30
120<S<=140	Stage II																		5	8	10
140<S<=160	1991-Stage I								8	36	69	112	271	354	554	632	715	747	747	747	747

140<S<=160	Stage II																		24	41	55
160<S<=180	1991-Stage I											26	69	200	374	440	534	566	566	566	566
160<S<=180	Stage II																		39	66	89
180<S<=200	1991-Stage I												20	67	117	193	249	282	282	282	282
180<S<=200	Stage II																		59	86	109
200<S<=220	1991-Stage I														45	92	143	175	175	175	175
200<S<=220	Stage II																		39	66	89
220<S<=240	1991-Stage I															3	48	142	142	142	142
220<S<=240	Stage II																		74	113	146
240<S<=260	1991-Stage I															3	71	133	133	133	133
240<S<=260	Stage II																		74	125	168
260<S<=280	1991-Stage I															14	61	123	123	123	123
260<S<=280	Stage II																		74	125	168
280<S<=300	1991-Stage I																	31	31	31	31
280<S<=300	Stage II																		74	125	168
300<S<=320	Stage II																			26	47

Stock data for fork lifts 1985-2004

Fuel type	Size (kW)	Emission Level	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Diesel	35	<1981	387	361	336	311	285	260	234	209	183	158	133	107	84	58	30					
Diesel	35	1981-1990	120	162	202	239	270	297	297	297	297	297	297	297	297	297	297	297	277	249	232	198
Diesel	35	1991-Stage I							26	49	65	93	131	168	218	247	275	304	304	304	304	304
Diesel	35	Stage II																	23	53	75	89
Diesel	45	<1981	1612	1506	1400	1294	1188	1082	976	870	764	658	552	446	349	243	126					
Diesel	45	1981-1990	499	674	839	994	1122	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1151	1036	964	820
Diesel	45	1991-Stage I							108	203	270	386	544	699	905	1063	1063	1063	1063	1063	1063	1063
Diesel	45	Stage I															151	303	422	524	664	664
Diesel	45	Stage II																				104
Diesel	50	<1981	2173	2031	1888	1745	1602	1459	1316	1174	1031	888	745	602	471	328	170					
Diesel	50	1981-1990	673	909	1131	1340	1512	1662	1662	1662	1662	1662	1662	1662	1662	1662	1662	1662	1551	1396	1299	1105
Diesel	50	1991-Stage I							145	273	363	519	732	940	1217	1469	1469	1469	1469	1469	1469	1469
Diesel	50	Stage I															240	461	682	897	1135	1135
Diesel	50	Stage II																				187
Diesel	75	<1981	497	465	432	399	367	334	301	269	236	203	170	138	108	75	39					
Diesel	75	1981-1990	154	208	259	307	347	382	382	382	382	382	382	382	382	382	382	382	357	321	299	255
Diesel	75	1991-Stage I							33	63	84	120	169	217	281	354	354	354	354	354	354	354
Diesel	75	Stage I															70	162	234	311	311	311
Diesel	75	Stage II																			58	129
Diesel	120	<1981	111	103	96	89	81	74	67	60	52	45	38	31	24	17	9					
Diesel	120	1981-1990	34	46	57	68	77	85	85	85	85	85	85	85	85	85	85	85	80	72	67	57
Diesel	120	1991-Stage I							7	14	19	27	38	49	63	97	97	97	97	97	97	97
Diesel	120	Stage I															32	71	89	118	118	118
Diesel	120	Stage II																			16	38
LPG	33		5420	5427	5390	5323	5265	5215	5156	5068	4947	4863	4835	4792	4732	4765	4712	4718	4677	4655	4595	4494
LPG	40		4917	4923	4889	4828	4775	4730	4676	4596	4486	4410	4384	4344	4289	4295	4223	4218	4214	4244	4224	4166
LPG	50		2149	2151	2137	2110	2087	2067	2044	2008	1960	1926	1915	1897	1874	1926	1941	1897	1938	2003	2020	2018
LPG	78		97	97	96	95	94	93	92	91	89	88	88	87	86	90	92	88	95	98	99	104
LPG	120															1	2	2	2	3	3	3

Stock data for construction machinery 1985-2004

EquipmentName (Eng)	Emission Level	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Track type dozers	<1981	125	100	75	50	25															
Track type dozers	1981-1990	125	150	175	200	225	250	221	193	166	139	114	89	66	43	21					
Track type dozers	1991-Stage I							25	48	71	93	114	134	153	172	189	206	201	177	154	132
Track type dozers	Stage II																		20	38	56
Track type loaders	<1981	50	40	30	20	10															
Track type loaders	1981-1990	50	60	70	80	90	100	89	79	68	58	48	38	28	19	9					
Track type loaders	1991-Stage I							10	20	29	39	48	57	66	75	83	91	91	81	71	62
Track type loaders	Stage II																		9	18	26
Wheel loaders (0-5 tons)	1981-1990							186	331	434	496	517	496	434	331	186					
Wheel loaders (0-5 tons)	1991-Stage I							21	83	186	331	517	744	1013	1323	1674	2067	2046	1984	1881	1736
Wheel loaders (0-5 tons)	Stage II																	227	496	806	1158
Wheel loaders (> 5,1 tons)	<1981	1250	1000	750	500	250															
Wheel loaders (> 5,1 tons)	1981-1990	1250	1500	1750	2000	2250	2500	2228	1960	1698	1441	1188	941	698	460	228					
Wheel loaders (> 5,1 tons)	1991-Stage I							248	490	728	960	1188	1411	1629	1841	1822	1802	1559	1322	1089	861
Wheel loaders (> 5,1 tons)	Stage I															228	450	668	881	871	861
Wheel loaders (> 5,1 tons)	Stage II																			218	431
Wheel type excavators	<1981	500	400	300	200	100															
Wheel type excavators	1981-1990	500	600	700	800	900	1000	862	732	611	498	394	298	211	132	62					
Wheel type excavators	1991-Stage I							96	183	262	332	394	447	491	528	493	459	372	293	223	162
Wheel type excavators	Stage I															62	115	160	196	179	162
Wheel type excavators	Stage II																			45	81
Track type excavators (0-5 t)	1981-1990							459	816	1071	1224	1275	1224	1071	816	459					
Track type excavators (0-5 t)	1991-Stage I							51	204	459	816	1275	1837	2500	3265	4132	5101	5050	4897	4642	4285
Track type excavators (0-5 t)	Stage II																	561	1224	1990	2857
Track type excavators (> 5,1 t)	<1981	1000	800	600	400	200															
Track type excavators (> 5,1 t)	1981-1990	1000	1200	1400	1600	1800	2000	1798	1596	1394	1194	993	794	594	396	198					
Track type excavators (> 5,1 t)	1991-Stage I							200	399	598	796	993	1190	1387	1583	1581	1579	1380	1181	983	785
Track type excavators (> 5,1 t)	Stage I															198	395	591	787	786	785
Track type excavators (> 5,1 t)	Stage II																			197	393
Excavators/Loaders	<1981	2100	1680	1260	840	420															
Excavators/Loaders	1981-1990	2100	2520	2940	3360	3780	4200	3807	3408	3003	2592	2175	1752	1323	888	447					
Excavators/Loaders	1991-Stage I							423	852	1287	1728	2175	2628	3087	3552	3575	3599	3170	2735	2295	1848
Excavators/Loaders	Stage I															447	900	1359	1824	2295	2310
Excavators/Loaders	Stage II																				462

Dump trucks	<1981	250	200	150	100	50															
Dump trucks	1981-1990	250	300	350	400	450	500	489	469	441	404	358	304	241	169	89					
Dump trucks	1991-Stage I							54	117	189	269	358	455	561	676	711	745	682	611	530	442
Dump trucks	Stage I															89	186	292	407	530	552
Dump trucks	Stage II																				110
Mini loaders	<1981	1800	1600	1400	1200	1000	800	635	447	235											
Mini loaders	1981-1990	1000	1200	1400	1600	1800	2000	2118	2237	2355	2473	2332	2168	1980	1768	1532	1273	990	684	354	
Mini loaders	1991-Stage I							212	447	706	989	1296	1626	1980	2357	2758	3183	3301	3419	3537	3656
Mini loaders	Stage II																	330	684	1061	1462
Telescopic loaders	1981-1990											149	265	348	398	414	398	348	265	149	
Telescopic loaders	1991-Stage I											83	199	348	530	746	994	1160	1326	1491	1657
Telescopic loaders	Stage II																	116	265	447	663

Stock data for machine pools 1985-2004

Name	FuelCode	Emission Level	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Tractors	205B	<1981	1236	627																		
Tractors	205B	1981-1990	3091	3763	4575	4515	4370	4100	3643	2808	2368	1786	1214	604								
Tractors	205B	1991-Stage I							607	1123	1776	2382	3035	3624	4324	4210	4336	3956	4069	3323	2566	2053
Tractors	205B	Stage I																		554	513	513
Tractors	205B	Stage II																			513	1027
Harvesters	205B	<1981	969	776	661	472	287	139														
Harvesters	205B	1981-1990	807	932	1157	1257	1294	1385	1385	1197	927	794	712	512	421	282	162	78				
Harvesters	205B	1991-Stage I							139	266	348	454	593	615	737	751	729	778	779	651	531	472
Harvesters	205B	Stage II																		65	118	177
Self-propelled vehicles	205B	1981-1990									72	61	38									
Self-propelled vehicles	205B	1991-Stage I									72	122	190	263	278	277	295	289	314	237	203	153
Self-propelled vehicles	205B	Stage II																		47	102	153

Stock data for household and gardening 1985-2004

Name	Emission Level	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Lawn movers (private)	<1981	253125	168750	84375																	
Lawn movers (private)	1981-1990	421875	506250	590625	675000	675000	675000	590625	506250	421875	337500	253125	168750	84375							
Lawn movers (private)	1991-Stage I							84375	168750	253125	337500	421875	506250	590625	675000	675000	675000	675000	675000	675000	675000
Lawn movers (professional)	1981-1990	25000	25000	25000	25000	25000	25000	18750	12500	6250											
Lawn movers (professional)	1991-Stage I							6250	12500	18750	25000	25000	25000	25000	25000	25000	25000	25000	25000	25000	25000
Cultivators (private-large)	1981-1990	110000	110000	110000	110000	110000	110000	88000	66000	44000	22000										
Cultivators (private-large)	1991-Stage I							22000	44000	66000	88000	110000	110000	110000	110000	110000	110000	110000	110000	110000	110000
Cultivators (private-small)	<1981	6667	6000	5333	4667	4000	3333	2667	2000	1333	667										
Cultivators (private-small)	1981-1990	3333	4000	4667	5333	6000	6667	6667	6667	6667	6667	6667	6000	5333	4667	4000	3333	2667	2000	1333	667
Cultivators (private-small)	1991-Stage I							667	1333	2000	2667	3333	4000	4667	5333	6000	6667	7333	8000	8667	9333
Cultivators (professional)	<1981	3750	2500	1250																	
Cultivators (professional)	1981-1990	6250	7500	8750	10000	10000	10000	8750	7500	6250	5000	3750	2500	1250							
Cultivators (professional)	1991-Stage I							1250	2500	3750	5000	6250	7500	8750	10000	10000	10000	10000	10000	10000	10000
Chain saws (private)	<1981	125000	100000	75000	50000	25000															
Chain saws (private)	1981-1990	125000	150000	175000	200000	225000	250000	227250	204000	180250	156000	131250	106000	80250	54000	27250					
Chain saws (private)	1991-Stage I							25250	51000	77250	104000	131250	159000	187250	216000	245250	275000	277003	279006	281009	298000
Chain saws (professional)	1981-1990	10000	10000	10000	10000	10000	10000	7333	4000												
Chain saws (professional)	1991-Stage I							3667	8000	13000	14000	15000	16000	17000	18000	19000	20000	27500	35000	42500	50000
Chain saws (forestry)	1981-1990	8000	8000	8000	8000	8000	8000	5048	2381												
Chain saws (forestry)	1991-Stage I							2524	4762	6714	6286	5857	5429	5000	4571	4143	3714	3286	2857	2429	2000
Riders (private)	<1981	40950	35100	29250	23400	17550	11700	6205													
Riders (private)	1981-1990	29250	35100	40950	46800	52650	58500	62050	65600	62235	58160	53375	47880	41675	34760	27135	18800	10696			
Riders (private)	1991-Stage I							6205	13120	20745	29080	38125	47880	58345	69520	81405	94000	117654	143900	159450	175000
Riders (professional)	1981-1990	4800	4800	4800	4800	4800	4800	4032	3168	2208	1152										
Riders (professional)	1991-Stage I							1008	2112	3312	4608	6000	6240	6480	6720	6960	7200	11650	16100	20550	25000
Shrub clearers (private)	<1981	24000	19200	14400	9600	4800															
Shrub clearers (private)	1981-1990	24000	28800	33600	38400	43200	48000	47520	46080	43680	40320	36000	30720	24480	17280	9120					
Shrub clearers (private)	1991-Stage I							5280	11520	18720	26880	36000	46080	57120	69120	82080	96000	107000	118000	129000	140000
Shrub clearers (profes-sional)	1981-1990	2000	2000	2000	2000	2000	2000	1650	1200	650											
Shrub clearers (profes-sional)	1991-Stage I							550	1200	1950	2800	3000	3200	3400	3600	3800	4000	5500	7000	8500	10000
Hedge cutters (private)	<1981	6850	5480	4110	2740	1370															
Hedge cutters (private)	1981-1990	6850	8220	9590	10960	12330	13700	15237	16128	16373	15972	14925	13232	10893	7908	4277					
Hedge cutters (private)	1991-Stage I							1693	4032	7017	10648	14925	19848	25417	31632	38493	46000	52900	59800	66700	73600

Hedge cutters (professional)	1981-1990	1300	1300	1300	1300	1300	1300	1178	920	528											
Hedge cutters (professional)	1991-Stage I							393	920	1583	2380	2650	2920	3190	3460	3730	4000	4600	5200	5800	6400
Trimmers (private)	<1981	25500	20400	15300	10200	5100															
Trimmers (private)	1981-1990	25500	30600	35700	40800	45900	51000	48086	44686	40800	36429	31571	26229	20400	14086	7286					
Trimmers (private)	1991-Stage I							5343	11171	17486	24286	31571	39343	47600	56343	65571	75286	77714	80143	82571	85000
Trimmers (professional)	1981-1990	9000	9000	9000	9000	9000	9000	7071	4929	2571											
Trimmers (professional)	1991-Stage I							2357	4929	7714	10714	11143	11571	12000	12429	12857	13286	13714	14143	14571	15000

Stock data for small boats and pleasure crafts 1985-2004

Motortype	Boat type	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Diesel	Motor boats (27-34 ft)	1550	1550	1719	1889	2058	2228	2397	2567	2736	2906	3075	3244	3414	3583	3753	3922	4092	4261	4431	4600
Diesel	Motor boats (> 34 ft)	450	450	503	556	608	661	714	767	819	872	925	978	1031	1083	1136	1189	1242	1294	1347	1400
Diesel	Motor boats <(27 ft)	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
Diesel	Motor sailors	3500	3500	3583	3667	3750	3833	3917	4000	4083	4167	4250	4333	4417	4500	4583	4667	4750	4833	4917	5000
Diesel	Sailing boats (> 26 ft)	7500	7500	7917	8333	8750	9167	9583	10000	10417	10833	11250	11667	12083	12500	12917	13333	13750	14167	14583	15000
2-takt	Other boats (< 20 ft)	4000	4000	4056	4111	4167	4222	4278	4333	4389	4444	4500	4556	4564.89	4526.99	4438.68	4300.2	4108.05	3862.31	3559.68	3200
2-takt	Yawls and cabin boats	4000	4000	4056	4111	4167	4222	4278	4333	4389	4444	4500	4556	4564.89	4526.99	4438.68	4300.2	4108.05	3862.31	3559.68	3200
2-takt	Sailing boats (< 26 ft)	19000	19000	18778	18556	18333	18111	17889	17667	17444	17222	17000	16778	16390.44	15843.01	15144.34	14300.1	13316.95	12200.76	10959.84	9600
2-takt	Speed boats	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	2970	2910	2820	2700	2550	2370	2160	1920
2-takt	Water scooters	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	990	970	940	900	850	790	720	640
4-takt	Other boats (< 20 ft)													46.11	140.01	283.32	477.8	724.95	1026.69	1384.32	1800
4-takt	Yawls and cabin boats													46.11	140.01	283.32	477.8	724.95	1026.69	1384.32	1800
4-takt	Sailing boats (< 26 ft)													165.56	489.99	966.66	1588.9	2350.05	3243.24	4262.16	5400
4-takt	Speed boats (in board eng.)	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
4-takt	Speed boats (out board eng.)													30	90	180	300	450	630	840	1080
4-takt	Water scooters													10	30	60	100	150	210	280	360
4-takt	Speed boats (out board eng.)													30	90	180	300	450	630	840	1080
4-takt	Water scooters													10	30	60	100	150	210	280	360

Engine sizes (kW) for small boats and pleasure crafts 1985-2004

Motor-type	Boat type	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Diesel	Motor boats (27-34 ft)	70	70	74	79	83	88	92	97	101	106	110	114	119	123	128	132	137	141	146	8
Diesel	Motor boats (> 34 ft)	120	120	127	134	142	149	156	163	171	178	185	192	199	207	214	221	228	236	243	20
Diesel	Motor boats <(27 ft)	20	20	21.1	22.2	23.3	24.4	25.6	26.7	27.8	28.9	30	31.1	32.2	33.3	34.4	35.6	36.7	37.8	38.9	10
Diesel	Motor sailors	20	20	21	21	22	22	23	23	24	24	25	26	26	27	27	28	28	29	29	50
Diesel	Sailing boats (> 26 ft)	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	45
4-takt	Other boats (< 20 ft)													8	8	8	8	8	8	8	8
4-takt	Yawls and cabin boats													20	20	20	20	20	20	20	20
4-takt	Sailing boats (< 26 ft)													10	10	10	10	10	10	10	10
4-takt	Speed boats (in board eng.)	45	45	47.5	50	52.5	55	57.5	60	62.5	65	67.5	70	72.5	75	77.5	80	82.5	85	87.5	90
4-takt	Speed boats (out board eng.)													40.3	41.7	43.1	44.4	45.8	47.2	48.6	50
4-takt	Water scooters													45	45	45	45	45	45	45	45

Annex 3B-11: Fuel use and emission factors, and fuel use and emissions for non-road working machinery and equipment

Fuel use and emissions (tons) for diesel tractors 1985-2004

Year	FC (TJ)	SO_2	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3	TSP
1985	12345	2891	8760	2048	33	8078	914	36	2	1907
1986	12842	1805	9267	2100	34	8322	950	37	2	1937
1987	12479	1754	9138	2018	33	8034	923	36	2	1851
1988	12892	1811	9576	2062	34	8248	954	38	2	1883
1989	12898	1208	9723	2041	33	8198	954	38	2	1854
1990	12739	1193	9742	1995	32	8048	943	37	2	1806
1991	12614	1182	9881	1942	32	7892	933	37	2	1737
1992	12050	1129	9592	1834	30	7502	892	36	2	1629
1993	11862	1111	9571	1789	29	7359	878	35	2	1582
1994	11063	1036	9096	1645	27	6812	819	33	2	1438
1995	11519	1079	9695	1680	27	7012	852	34	2	1443
1996	10660	250	9205	1522	25	6400	789	32	2	1277
1997	10999	258	9748	1533	25	6505	814	33	2	1252
1998	10106	237	9134	1382	22	5912	748	31	2	1104
1999	10066	236	9275	1350	22	5821	745	31	2	1052
2000	9712	227	9122	1276	21	5547	719	30	2	967
2001	9628	225	9140	1231	20	5392	713	30	2	910
2002	9596	225	8988	1165	19	5164	710	30	2	853
2003	9538	223	8714	1098	18	4940	706	30	2	799
2004	9467	222	8398	1031	17	4713	701	29	2	748

Emission factors (g/GJ) for diesel tractors 1985-2004

Year	SO_2	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3	TSP
1985	234	710	166	2.7	654	74	2.9	0.2	154
1986	141	722	164	2.7	648	74	2.9	0.2	151
1987	141	732	162	2.6	644	74	2.9	0.2	148
1988	141	743	160	2.6	640	74	2.9	0.2	146
1989	94	754	158	2.6	636	74	2.9	0.2	144
1990	94	765	157	2.5	632	74	2.9	0.2	142
1991	94	783	154	2.5	626	74	2.9	0.2	138

1992	94	796	152	2.5	623	74	3.0	0.2	135
1993	94	807	151	2.5	620	74	3.0	0.2	133
1994	94	822	149	2.4	616	74	3.0	0.2	130
1995	94	842	146	2.4	609	74	3.0	0.2	125
1996	23	864	143	2.3	600	74	3.0	0.2	120
1997	23	886	139	2.3	591	74	3.0	0.2	114
1998	23	904	137	2.2	585	74	3.0	0.2	109
1999	23	921	134	2.2	578	74	3.0	0.2	105
2000	23	939	131	2.1	571	74	3.1	0.2	100
2001	23	949	128	2.1	560	74	3.1	0.2	95
2002	23	937	121	2.0	538	74	3.1	0.2	89
2003	23	914	115	1.9	518	74	3.1	0.2	84
2004	23	887	109	1.8	498	74	3.1	0.2	79

Fuel use and emissions (tonnes) for gasoline tractors 1985-2004

EquipmentName (Eng)	Year	Emission Level	FC (TJ)	SO_2	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3	TSP
Tractors (gasoline-certified)	1985	<1981	373	1	11	356	33	17999	27	0	0	2
Tractors (gasoline-certified)	1986	<1981	355	1	10	340	32	17228	26	0	0	2
Tractors (gasoline-certified)	1987	<1981	337	1	9	325	30	16446	25	0	0	2
Tractors (gasoline-certified)	1988	<1981	319	1	9	309	29	15652	23	0	0	2
Tractors (gasoline-certified)	1989	<1981	301	1	8	293	28	14847	22	0	0	2
Tractors (gasoline-certified)	1990	<1981	283	1	7	277	26	14032	21	0	0	2
Tractors (gasoline-certified)	1991	<1981	256	1	7	252	24	12766	19	0	0	2
Tractors (gasoline-certified)	1992	<1981	231	1	6	228	21	11545	17	0	0	2
Tractors (gasoline-certified)	1993	<1981	206	0	5	204	19	10372	15	0	0	1
Tractors (gasoline-certified)	1994	<1981	183	0	5	182	17	9247	13	0	0	1
Tractors (gasoline-certified)	1995	<1981	161	0	4	161	15	8172	12	0	0	1
Tractors (gasoline-certified)	1996	<1981	140	0	3	141	13	7147	10	0	0	1
Tractors (gasoline-certified)	1997	<1981	121	0	3	122	11	6173	9	0	0	1
Tractors (gasoline-certified)	1998	<1981	102	0	2	103	10	5252	7	0	0	1
Tractors (gasoline-certified)	1999	<1981	85	0	2	86	8	4385	6	0	0	1
Tractors (gasoline-certified)	2000	<1981	69	0	2	70	7	3571	5	0	0	0
Tractors (gasoline-certified)	2001	<1981	54	0	1	55	5	2814	4	0	0	0
Tractors (gasoline-certified)	2002	<1981	40	0	1	42	4	2112	3	0	0	0
Tractors (gasoline-certified)	2003	<1981	28	0	1	29	3	1468	2	0	0	0
Tractors (gasoline-certified)	2004	<1981	17	0	0	17	2	881	1	0	0	0
Tractors (gasoline-non certified)	1985	<1981	373	1	11	357	33	17999	27	0	0	2

Tractors (gasoline-non certified)	1986	<1981		355	1	10	342	32	17228	26	0	0	2
Tractors (gasoline-non certified)	1987	<1981		337	1	9	326	30	16446	25	0	0	2
Tractors (gasoline-non certified)	1988	<1981		319	1	9	310	29	15652	23	0	0	2
Tractors (gasoline-non certified)	1989	<1981		301	1	8	294	28	14847	22	0	0	2
Tractors (gasoline-non certified)	1990	<1981		283	1	7	278	26	14032	21	0	0	2
Tractors (gasoline-non certified)	1991	<1981		270	1	7	266	25	13426	20	0	0	2
Tractors (gasoline-non certified)	1992	<1981		256	1	7	253	24	12782	19	0	0	2
Tractors (gasoline-non certified)	1993	<1981		241	1	6	240	22	12101	18	0	0	2
Tractors (gasoline-non certified)	1994	<1981		225	1	6	225	21	11381	16	0	0	2
Tractors (gasoline-non certified)	1995	<1981		209	0	5	210	20	10623	15	0	0	1
Tractors (gasoline-non certified)	1996	<1981		193	0	5	194	18	9827	14	0	0	1
Tractors (gasoline-non certified)	1997	<1981		176	0	4	178	17	8991	13	0	0	1
Tractors (gasoline-non certified)	1998	<1981		158	0	4	160	15	8117	12	0	0	1
Tractors (gasoline-non certified)	1999	<1981		140	0	3	142	13	7203	10	0	0	1
Tractors (gasoline-non certified)	2000	<1981		121	0	3	123	12	6250	9	0	0	1
Tractors (gasoline-non certified)	2001	<1981		101	0	2	104	10	5257	7	0	0	1
Tractors (gasoline-non certified)	2002	<1981		81	0	2	83	8	4224	6	0	0	1
Tractors (gasoline-non certified)	2003	<1981		60	0	1	62	6	3151	4	0	0	0
Tractors (gasoline-non certified)	2004	<1981		39	0	1	40	4	2038	3	0	0	0

Emission factors (g/GJ) for gasoline tractors 1985-2004

EquipmentName (Eng)	Year	Emission Level	SO_2	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3	TSP
Tractors (gasoline-certified)	1985	<1981	2.3	28	953	89	48219	73	1.3	0.1	6.4
Tractors (gasoline-certified)	1986	<1981	2.3	28	958	90	48492	73	1.3	0.1	6.5
Tractors (gasoline-certified)	1987	<1981	2.3	27	963	90	48759	73	1.3	0.1	6.5
Tractors (gasoline-certified)	1988	<1981	2.3	27	967	91	49021	73	1.3	0.1	6.5
Tractors (gasoline-certified)	1989	<1981	2.3	27	972	91	49278	73	1.3	0.1	6.6
Tractors (gasoline-certified)	1990	<1981	2.3	26	977	92	49529	73	1.3	0.1	6.6
Tractors (gasoline-certified)	1991	<1981	2.3	26	982	92	49776	73	1.3	0.1	6.7
Tractors (gasoline-certified)	1992	<1981	2.3	26	986	93	50019	73	1.3	0.1	6.7
Tractors (gasoline-certified)	1993	<1981	2.3	25	990	93	50258	73	1.3	0.1	6.7
Tractors (gasoline-certified)	1994	<1981	2.3	25	995	94	50493	73	1.3	0.1	6.8
Tractors (gasoline-certified)	1995	<1981	2.3	25	999	94	50724	73	1.3	0.1	6.8
Tractors (gasoline-certified)	1996	<1981	2.3	25	1003	95	50952	73	1.3	0.1	6.8
Tractors (gasoline-certified)	1997	<1981	2.3	24	1008	95	51177	73	1.3	0.1	6.9
Tractors (gasoline-certified)	1998	<1981	2.3	24	1012	96	51399	73	1.3	0.1	6.9
Tractors (gasoline-certified)	1999	<1981	2.3	24	1016	96	51618	73	1.3	0.1	6.9
Tractors (gasoline-certified)	2000	<1981	2.3	23	1020	97	51834	73	1.3	0.1	7.0
Tractors (gasoline-certified)	2001	<1981	2.3	23	1024	97	52047	73	1.3	0.1	7.0
Tractors (gasoline-certified)	2002	<1981	2.3	23	1028	97	52258	73	1.3	0.1	7.0
Tractors (gasoline-certified)	2003	<1981	2.3	23	1032	98	52466	73	1.3	0.1	7.1
Tractors (gasoline-certified)	2004	<1981	2.3	22	1035	98	52672	73	1.3	0.1	7.1
Tractors (gasoline-non certified)	1985	<1981	2.3	28	957	89	48219	73	1.3	0.1	6.4
Tractors (gasoline-non certified)	1986	<1981	2.3	28	962	90	48492	73	1.3	0.1	6.5
Tractors (gasoline-non certified)	1987	<1981	2.3	27	967	90	48759	73	1.3	0.1	6.5
Tractors (gasoline-non certified)	1988	<1981	2.3	27	972	91	49021	73	1.3	0.1	6.5
Tractors (gasoline-non certified)	1989	<1981	2.3	27	977	91	49278	73	1.3	0.1	6.6
Tractors (gasoline-non certified)	1990	<1981	2.3	26	981	92	49529	73	1.3	0.1	6.6
Tractors (gasoline-non certified)	1991	<1981	2.3	26	986	92	49776	73	1.3	0.1	6.7
Tractors (gasoline-non certified)	1992	<1981	2.3	26	990	93	50019	73	1.3	0.1	6.7
Tractors (gasoline-non certified)	1993	<1981	2.3	25	995	93	50258	73	1.3	0.1	6.7
Tractors (gasoline-non certified)	1994	<1981	2.3	25	999	94	50493	73	1.3	0.1	6.8
Tractors (gasoline-non certified)	1995	<1981	2.3	25	1004	94	50724	73	1.3	0.1	6.8
Tractors (gasoline-non certified)	1996	<1981	2.3	25	1008	95	50952	73	1.3	0.1	6.8
Tractors (gasoline-non certified)	1997	<1981	2.3	24	1012	95	51177	73	1.3	0.1	6.9
Tractors (gasoline-non certified)	1998	<1981	2.3	24	1016	96	51399	73	1.3	0.1	6.9
Tractors (gasoline-non certified)	1999	<1981	2.3	24	1020	96	51618	73	1.3	0.1	6.9

Tractors (gasoline-non certified)	2000	<1981	2.3	23	1024	97	51834	73	1.3	0.1	7.0
Tractors (gasoline-non certified)	2001	<1981	2.3	23	1028	97	52047	73	1.3	0.1	7.0
Tractors (gasoline-non certified)	2002	<1981	2.3	23	1032	97	52258	73	1.3	0.1	7.0
Tractors (gasoline-non certified)	2003	<1981	2.3	23	1036	98	52466	73	1.3	0.1	7.1
Tractors (gasoline-non certified)	2004	<1981	2.3	22	1040	98	52672	73	1.3	0.1	7.1

Fuel use and emissions (tons) for harvesters 1985-2004

Year	FC (TJ)	SO_2	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3	TSP
1985	2134	500	1376	398	6	1584	158	6	0	412
1986	2152	302	1424	392	6	1565	159	6	0	400
1987	2121	298	1430	380	6	1525	157	6	0	386
1988	2222	312	1536	393	6	1580	164	6	0	396
1989	2137	200	1512	372	6	1503	158	6	0	373
1990	2249	211	1642	385	6	1558	166	7	0	381
1991	2203	206	1655	369	6	1505	163	6	0	362
1992	2145	201	1651	352	6	1448	159	6	0	343
1993	2144	201	1676	348	6	1437	159	6	0	337
1994	2025	190	1606	324	5	1347	150	6	0	313
1995	1927	180	1561	301	5	1263	143	6	0	289
1996	2033	48	1688	305	5	1300	150	6	0	291
1997	1894	44	1614	269	4	1170	140	6	0	255
1998	2030	48	1776	270	4	1204	150	6	0	253
1999	1949	46	1740	244	4	1116	144	6	0	228
2000	2059	48	1868	244	4	1144	152	6	0	228
2001	2046	48	1892	227	4	1094	151	6	0	210
2002	2090	49	1863	212	3	1050	155	7	0	194
2003	2070	48	1803	195	3	990	153	6	0	176
2004	2019	47	1724	176	3	917	149	6	0	155

Emission factors (g/GJ) for harvesters 1985-2004

Year	SO_2	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3	TSP
1985	234	645	186	3.0	742	74	2.8	0.2	193
1986	141	662	182	3.0	727	74	2.9	0.2	186
1987	141	674	179	2.9	719	74	2.9	0.2	182
1988	141	691	177	2.9	711	74	2.9	0.2	178
1989	94	707	174	2.8	703	74	2.9	0.2	174

1990	94	730	171	2.8	693	74	2.9	0.2	169
1991	94	751	167	2.7	683	74	2.9	0.2	164
1992	94	769	164	2.7	675	74	2.9	0.2	160
1993	94	782	162	2.6	670	74	2.9	0.2	157
1994	94	793	160	2.6	665	74	2.9	0.2	155
1995	94	810	156	2.5	656	74	3.0	0.2	150
1996	23	830	150	2.4	639	74	3.0	0.2	143
1997	23	852	142	2.3	618	74	3.0	0.2	135
1998	23	875	133	2.2	593	74	3.0	0.2	125
1999	23	893	125	2.0	573	74	3.1	0.2	117
2000	23	907	119	1.9	555	74	3.1	0.2	111
2001	23	925	111	1.8	535	74	3.1	0.2	103
2002	23	892	101	1.6	502	74	3.1	0.2	93
2003	23	871	94	1.5	478	74	3.1	0.2	85
2004	23	854	87	1.4	454	74	3.1	0.2	77

Fuel use and emissions (tons) for machine pool machinery 1985-2004

Name	Year	FC (TJ)	SO_2	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3	TSP
Harvesters	1985	188	44	170	31	0	126	14	1	0	30
Harvesters	1986	192	27	176	31	1	127	14	1	0	30
Harvesters	1987	217	30	201	34	1	142	16	1	0	33
Harvesters	1988	211	30	249	22	0	78	16	1	0	24
Harvesters	1989	204	19	233	21	0	76	15	1	0	23
Harvesters	1990	207	19	228	20	0	78	15	1	0	23
Harvesters	1991	217	20	230	20	0	82	16	1	0	23
Harvesters	1992	219	21	231	19	0	83	16	1	0	23
Harvesters	1993	201	19	210	17	0	76	15	1	0	20
Harvesters	1994	206	19	214	16	0	78	15	1	0	19
Harvesters	1995	225	21	233	17	0	86	17	1	0	20
Harvesters	1996	203	5	210	14	0	78	15	1	0	17
Harvesters	1997	218	5	224	14	0	84	16	1	0	17
Harvesters	1998	203	5	207	13	0	78	15	1	0	15
Harvesters	1999	183	4	185	11	0	71	14	1	0	13
Harvesters	2000	183	4	184	10	0	71	14	1	0	12
Harvesters	2001	173	4	173	8	0	67	13	1	0	10
Harvesters	2002	166	4	158	8	0	63	12	1	0	9
Harvesters	2003	157	4	141	7	0	57	12	1	0	8
Harvesters	2004	157	4	134	7	0	55	12	1	0	7
Self-propelled vehicles	1993	154	14	160	11	0	59	11	0	0	14
Self-propelled vehicles	1994	195	18	199	13	0	76	14	1	0	15
Self-propelled vehicles	1995	241	23	244	14	0	94	18	1	0	17
Self-propelled vehicles	1996	276	6	277	14	0	109	20	1	0	16
Self-propelled vehicles	1997	292	7	292	14	0	115	22	1	0	17
Self-propelled vehicles	1998	291	7	291	14	0	114	22	1	0	17
Self-propelled vehicles	1999	310	7	310	15	0	122	23	1	0	18
Self-propelled vehicles	2000	304	7	304	15	0	119	22	1	0	18
Self-propelled vehicles	2001	330	8	330	16	0	130	24	1	0	19
Self-propelled vehicles	2002	299	7	272	14	0	110	22	1	0	16
Self-propelled vehicles	2003	321	8	264	14	0	110	24	1	0	15
Self-propelled vehicles	2004	321	8	235	13	0	101	24	1	0	12
Tractors	1985	1201	281	801	181	3	761	89	3	0	176
Tractors	1986	1224	172	835	180	3	764	91	4	0	171
Tractors	1987	1282	180	895	184	3	786	95	4	0	169

Tractors	1988	1285	181	897	184	3	788	95	4	0	169
Tractors	1989	1266	119	884	181	3	777	94	4	0	167
Tractors	1990	1212	114	846	173	3	743	90	4	0	160
Tractors	1991	1271	119	937	177	3	766	94	4	0	157
Tractors	1992	1185	111	921	160	3	702	88	4	0	135
Tractors	1993	1262	118	1032	165	3	732	93	4	0	131
Tractors	1994	1283	120	1102	163	3	729	95	4	0	119
Tractors	1995	1327	124	1196	163	3	737	98	4	0	108
Tractors	1996	1325	31	1507	160	3	733	98	4	0	93
Tractors	1997	1390	33	1619	161	3	749	103	4	0	79
Tractors	1998	1377	32	1604	159	3	741	102	4	0	78
Tractors	1999	1455	34	1695	168	3	784	108	5	0	83
Tractors	2000	1360	32	1584	157	3	732	101	4	0	77
Tractors	2001	1433	34	1669	166	3	772	106	5	0	81
Tractors	2002	1407	33	1548	148	2	700	104	4	0	75
Tractors	2003	1348	32	1348	125	2	613	100	4	0	67
Tractors	2004	1392	33	1251	112	2	572	103	4	0	64

Emission factors (g/GJ) for machine pool machinery 1985-2004

Name	Year	SO_2	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3	TSP
Harvesters	1985	234	901	163	2.6	668	74	3.0	0.2	162
Harvesters	1986	141	914	160	2.6	662	74	3.0	0.2	158
Harvesters	1987	141	928	158	2.6	655	74	3.0	0.2	153
Harvesters	1988	141	1179	106	1.7	372	74	3.1	0.2	113
Harvesters	1989	94	1141	103	1.7	373	74	3.1	0.2	113
Harvesters	1990	94	1103	99	1.6	374	74	3.1	0.2	111
Harvesters	1991	94	1059	91	1.5	377	74	3.1	0.2	107
Harvesters	1992	94	1053	87	1.4	378	74	3.1	0.2	103
Harvesters	1993	94	1047	83	1.3	380	74	3.2	0.2	98
Harvesters	1994	94	1042	79	1.3	381	74	3.2	0.2	94
Harvesters	1995	94	1036	75	1.2	382	74	3.2	0.2	89
Harvesters	1996	23	1030	70	1.1	384	74	3.2	0.2	85
Harvesters	1997	23	1024	66	1.1	385	74	3.2	0.2	80
Harvesters	1998	23	1018	62	1.0	386	74	3.2	0.2	74
Harvesters	1999	23	1012	58	0.9	388	74	3.2	0.2	69
Harvesters	2000	23	1006	54	0.9	389	74	3.2	0.2	63
Harvesters	2001	23	1000	49	0.8	391	74	3.2	0.2	57

Harvesters	2002	23	952	47	0.8	377	74	3.2	0.2	54
Harvesters	2003	23	903	46	0.7	364	74	3.2	0.2	51
Harvesters	2004	23	855	44	0.7	350	74	3.2	0.2	47
Self-propelled vehicles	1993	94	1034	73	1.2	385	74	3.2	0.2	88
Self-propelled vehicles	1994	94	1023	65	1.1	388	74	3.2	0.2	79
Self-propelled vehicles	1995	94	1012	57	0.9	390	74	3.2	0.2	69
Self-propelled vehicles	1996	23	1001	49	0.8	393	74	3.2	0.2	58
Self-propelled vehicles	1997	23	1001	49	0.8	393	74	3.2	0.2	58
Self-propelled vehicles	1998	23	1001	49	0.8	393	74	3.2	0.2	58
Self-propelled vehicles	1999	23	1001	49	0.8	393	74	3.2	0.2	58
Self-propelled vehicles	2000	23	1001	49	0.8	393	74	3.2	0.2	58
Self-propelled vehicles	2001	23	1001	49	0.8	393	74	3.2	0.2	58
Self-propelled vehicles	2002	23	912	46	0.7	368	74	3.2	0.2	52
Self-propelled vehicles	2003	23	823	43	0.7	342	74	3.2	0.2	45
Self-propelled vehicles	2004	23	733	39	0.6	315	74	3.2	0.2	38
Tractors	1985	234	667	151	2.5	634	74	2.9	0.2	147
Tractors	1986	141	682	147	2.4	624	74	2.9	0.2	139
Tractors	1987	141	698	143	2.3	613	74	3.0	0.2	132
Tractors	1988	141	698	143	2.3	613	74	3.0	0.2	132
Tractors	1989	94	698	143	2.3	613	74	3.0	0.2	132
Tractors	1990	94	698	143	2.3	613	74	3.0	0.2	132
Tractors	1991	94	737	139	2.3	603	74	3.0	0.2	123
Tractors	1992	94	777	135	2.2	592	74	3.0	0.2	114
Tractors	1993	94	818	131	2.1	580	74	3.0	0.2	104
Tractors	1994	94	859	127	2.1	568	74	3.0	0.2	93
Tractors	1995	94	901	123	2.0	555	74	3.1	0.2	81
Tractors	1996	23	1137	121	2.0	553	74	3.2	0.2	70
Tractors	1997	23	1165	116	1.9	538	74	3.2	0.2	57
Tractors	1998	23	1165	116	1.9	538	74	3.2	0.2	57
Tractors	1999	23	1165	116	1.9	538	74	3.2	0.2	57
Tractors	2000	23	1165	116	1.9	538	74	3.2	0.2	57
Tractors	2001	23	1165	116	1.9	538	74	3.2	0.2	57
Tractors	2002	23	1100	105	1.7	497	74	3.2	0.2	53
Tractors	2003	23	1000	93	1.5	455	74	3.2	0.2	50
Tractors	2004	23	898	80	1.3	411	74	3.2	0.2	46

Fuel use and emissions (tons) for other machinery in agriculture 1985-2004

Fuel type	Year	FC (TJ)	SO_2	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3	TSP
Diesel	1985	91	21	57	15	0	60	7	0	0	15
Diesel	1986	91	13	58	14	0	59	7	0	0	14
Diesel	1987	91	13	58	14	0	59	7	0	0	14
Diesel	1988	90	13	58	14	0	58	7	0	0	14
Diesel	1989	90	8	59	14	0	57	7	0	0	13
Diesel	1990	90	8	59	14	0	57	7	0	0	13
Diesel	1991	89	8	61	13	0	56	7	0	0	12
Diesel	1992	88	8	63	13	0	54	7	0	0	12
Diesel	1993	88	8	65	12	0	53	6	0	0	11
Diesel	1994	87	8	66	12	0	52	6	0	0	10
Diesel	1995	86	8	68	12	0	51	6	0	0	9
Diesel	1996	86	2	70	11	0	50	6	0	0	9
Diesel	1997	86	2	71	11	0	49	6	0	0	9
Diesel	1998	85	2	72	11	0	49	6	0	0	8
Diesel	1999	85	2	72	10	0	46	6	0	0	8
Diesel	2000	85	2	72	10	0	44	6	0	0	7
Diesel	2001	85	2	71	9	0	42	6	0	0	6
Diesel	2002	84	2	71	8	0	40	6	0	0	6
Diesel	2003	84	2	70	8	0	37	6	0	0	5
Diesel	2004	84	2	69	7	0	35	6	0	0	4
Gasoline	1985	168	0	7	149	14	7180	12	0	0	1
Gasoline	1986	162	0	7	142	13	6862	12	0	0	1
Gasoline	1987	157	0	7	136	12	6547	11	0	0	1
Gasoline	1988	152	0	7	130	12	6236	11	0	0	1
Gasoline	1989	147	0	7	124	11	5928	11	0	0	1
Gasoline	1990	142	0	7	118	11	5625	10	0	0	1
Gasoline	1991	137	0	8	113	10	5370	10	0	0	1
Gasoline	1992	132	0	8	108	10	5112	10	0	0	1
Gasoline	1993	128	0	8	103	9	4855	9	0	0	1
Gasoline	1994	123	0	8	98	9	4599	9	0	0	1
Gasoline	1995	118	0	7	93	8	4346	9	0	0	1
Gasoline	1996	113	0	7	88	8	4096	8	0	0	1
Gasoline	1997	109	0	7	83	7	3850	8	0	0	1
Gasoline	1998	104	0	7	78	7	3608	8	0	0	1
Gasoline	1999	99	0	7	73	6	3372	7	0	0	1

Gasoline	2000	95	0	7	69	6	3141	7	0	0	1
Gasoline	2001	91	0	6	66	6	3006	7	0	0	1
Gasoline	2002	87	0	6	63	5	2870	6	0	0	1
Gasoline	2003	83	0	6	60	5	2735	6	0	0	1
Gasoline	2004	79	0	6	57	5	2599	6	0	0	1

Emission factors (g/GJ) for other machinery in agriculture 1985-2004

Fuel type	Year	SO_2	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3	TSP
Diesel	1985	234	626	161	3	654	74	2.8	0.2	161
Diesel	1986	141	633	159	3	650	74	2.9	0.2	158
Diesel	1987	141	640	158	3	646	74	2.9	0.2	155
Diesel	1988	141	647	156	3	642	74	2.9	0.2	153
Diesel	1989	94	654	154	3	637	74	2.9	0.2	150
Diesel	1990	94	661	152	2	633	74	2.9	0.2	147
Diesel	1991	94	686	149	2	624	74	2.9	0.2	140
Diesel	1992	94	711	145	2	614	74	2.9	0.2	133
Diesel	1993	94	737	141	2	605	74	3.0	0.2	125
Diesel	1994	94	763	137	2	595	74	3.0	0.2	117
Diesel	1995	94	790	134	2	584	74	3.0	0.2	109
Diesel	1996	23	809	132	2	579	74	3.0	0.2	105
Diesel	1997	23	828	130	2	574	74	3.0	0.2	100
Diesel	1998	23	847	128	2	568	74	3.0	0.2	95
Diesel	1999	23	846	121	2	544	74	3.1	0.2	88
Diesel	2000	23	844	114	2	520	74	3.1	0.2	81
Diesel	2001	23	842	107	2	495	74	3.1	0.2	74
Diesel	2002	23	841	100	2	469	74	3.1	0.2	67
Diesel	2003	23	839	93	2	443	74	3.1	0.2	59
Diesel	2004	23	825	85	1	416	74	3.1	0.2	51
Gasoline	1985	2	44	886	81	42831	73	1.3	0.1	6
Gasoline	1986	2	46	876	80	42235	73	1.3	0.1	6
Gasoline	1987	2	47	866	79	41606	73	1.3	0.1	6
Gasoline	1988	2	49	855	77	40946	73	1.3	0.1	6
Gasoline	1989	2	51	844	76	40257	73	1.3	0.1	6
Gasoline	1990	2	52	832	75	39539	73	1.3	0.1	6
Gasoline	1991	2	55	825	74	39097	73	1.3	0.1	6
Gasoline	1992	2	57	816	73	38593	73	1.3	0.1	6
Gasoline	1993	2	59	807	72	38040	73	1.3	0.1	6

Gasoline	1994	2	61	797	71	37444	73	1.4	0.1	6
Gasoline	1995	2	63	786	70	36809	73	1.4	0.1	6
Gasoline	1996	2	65	775	68	36138	73	1.4	0.1	6
Gasoline	1997	2	67	762	67	35432	73	1.4	0.1	7
Gasoline	1998	2	68	750	66	34693	73	1.4	0.1	7
Gasoline	1999	2	70	736	64	33922	73	1.4	0.1	7
Gasoline	2000	2	71	722	63	33120	73	1.4	0.1	7
Gasoline	2001	2	71	722	63	33115	73	1.4	0.1	7
Gasoline	2002	2	71	723	63	33110	73	1.4	0.1	7
Gasoline	2003	2	71	723	63	33105	73	1.4	0.1	7
Gasoline	2004	2	72	723	63	33099	73	1.4	0.1	7

Fuel use and emissions (tons) for ATV's 1985-2004

FuelType	Year	Emission Level	FC (TJ)	SO_2	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3	TSP
Gasoline	1992	Conv. MC urban	5	0	0	5	1	74	0	0	0	0
Gasoline	1993	Conv. MC urban	10	0	1	10	2	159	1	0	0	0
Gasoline	1994	Conv. MC urban	16	0	2	17	3	262	1	0	0	1
Gasoline	1995	Conv. MC urban	24	0	3	25	4	387	2	0	0	1
Gasoline	1996	Conv. MC urban	32	0	4	35	5	530	2	0	0	1
Gasoline	1997	Conv. MC urban	42	0	5	45	7	691	3	0	0	1
Gasoline	1998	Conv. MC urban	54	0	6	58	9	887	4	0	0	2
Gasoline	1999	Conv. MC urban	70	0	8	75	11	1148	5	0	0	2
Gasoline	2000	Conv. MC urban	94	0	10	104	15	1576	7	0	0	3
Gasoline	2001	Conv. MC urban	116	0	13	132	19	1993	9	0	0	4
Gasoline	2002	Conv. MC urban	138	0	15	158	23	2393	10	0	0	5
Gasoline	2003	Conv. MC urban	158	0	18	183	26	2771	12	0	0	5
Gasoline	2004	Conv. MC urban	178	0	20	207	30	3130	13	0	0	6

Emission factors (g/GJ) for ATV's 1985-2004

FuelType	Year	Emission Level	SO_2	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3	TSP
Gasoline	1992	Conv. MC urban	2.3	108	1070	160	16306	73	1.6	1.6	32
Gasoline	1993	Conv. MC urban	2.3	108	1070	160	16306	73	1.6	1.6	32
Gasoline	1994	Conv. MC urban	2.3	108	1070	160	16306	73	1.6	1.6	32
Gasoline	1995	Conv. MC urban	2.3	108	1070	160	16306	73	1.6	1.6	32
Gasoline	1996	Conv. MC urban	2.3	108	1070	160	16306	73	1.6	1.6	32
Gasoline	1997	Conv. MC urban	2.3	108	1070	160	16306	73	1.6	1.6	32

Gasoline	1998	Conv. MC urban	2.3	108	1070	160	16306	73	1.6	1.6	32
Gasoline	1999	Conv. MC urban	2.3	108	1070	160	16306	73	1.6	1.6	32
Gasoline	2000	Conv. MC urban	2.3	110	1107	163	16808	73	1.6	1.6	33
Gasoline	2001	Conv. MC urban	2.3	111	1129	165	17115	73	1.6	1.6	33
Gasoline	2002	Conv. MC urban	2.3	112	1145	166	17329	73	1.7	1.7	33
Gasoline	2003	Conv. MC urban	2.3	113	1157	167	17496	73	1.7	1.7	33
Gasoline	2004	Conv. MC urban	2.3	113	1167	168	17633	73	1.7	1.7	34

Annex 3B-12: Emission factors and total emissions for 1990 and 2003 in CollectER format

Year	SNAP ID	Category	Fuel type	Mode	Fuel	SO2	NOx	NMVOC	CH4	CO	CO2	N2O
					[GJ]	[g/GJ]	[g/GJ]	[g/GJ]	[g/GJ]	[g/GJ]	[kg/GJ]	[g/GJ]
1990	070101	Passenger cars	Diesel	Highway driving	1026361.98	93.68	254.03	24.51	4.30	179.70	74	12.62
1990	070101	Passenger cars	Gasoline 2-stroke	Highway driving	42228.54	2.28	288.90	2357.34	10.03	3490.86	73	2.01
1990	070101	Passenger cars	Gasoline conventional	Highway driving	10933475.43	2.28	1317.10	364.60	11.09	3459.93	73	2.13
1990	070101	Passenger cars	LPG	Highway driving	2222.18	0.00	1151.70	187.09	10.06	3914.25	65	6.04
1990	070102	Passenger cars	Diesel	Rural driving	2044346.39	93.68	253.60	46.16	2.75	268.08	74	15.34
1990	070102	Passenger cars	Gasoline 2-stroke	Rural driving	118588.34	2.28	352.84	2476.82	13.84	2594.44	73	1.73
1990	070102	Passenger cars	Gasoline conventional	Rural driving	23583528.44	2.28	1140.07	483.50	13.92	3992.26	73	2.39
1990	070102	Passenger cars	LPG	Rural driving	4483.34	0.00	1248.46	305.18	16.91	1146.38	65	7.25
1990	070103	Passenger cars	Diesel	Urban driving	2553249.62	93.68	207.02	90.62	2.50	318.49	74	9.35
1990	070103	Passenger cars	Gasoline 2-stroke	Urban driving	191303.14	2.28	51.72	4548.72	44.74	7572.79	73	0.82
1990	070103	Passenger cars	Gasoline conventional	Urban driving	27472979.47	2.28	618.14	929.13	52.43	9975.92	73	1.56
1990	070103	Passenger cars	LPG	Urban driving	5612.94	0.00	615.87	430.04	34.34	1329.22	65	4.40
1990	070201	Light-duty vehicles	Diesel	Highway driving	2923030.83	93.68	270.67	31.16	1.62	344.14	74	5.52
1990	070201	Light-duty vehicles	Gasoline conventional	Highway driving	319077.58	2.28	1369.26	170.29	10.11	2987.40	73	2.43
1990	070202	Light-duty vehicles	Diesel	Rural driving	8905022.64	93.68	299.25	35.71	1.78	358.42	74	6.04
1990	070202	Light-duty vehicles	Gasoline conventional	Rural driving	1127865.12	2.28	1188.86	262.59	15.25	2316.18	73	2.29
1990	070203	Light-duty vehicles	Diesel	Urban driving	8528115.24	93.68	486.72	60.32	2.40	412.68	74	4.41
1990	070203	Light-duty vehicles	Gasoline conventional	Urban driving	1361243.26	2.28	624.03	697.98	60.64	7400.03	73	1.33
1990	070301	Heavy-duty vehicles	Diesel	Highway driving	8796092.68	93.68	826.66	78.10	6.08	178.52	74	2.98
1990	070301	Heavy-duty vehicles	Gasoline	Highway driving	9310.17	2.28	1037.78	474.61	9.69	7610.35	73	0.83
1990	070302	Heavy-duty vehicles	Diesel	Rural driving	14205820.64	93.68	946.46	102.84	6.87	237.23	74	3.09
1990	070302	Heavy-duty vehicles	Gasoline	Rural driving	18942.77	2.28	1141.55	820.40	16.74	8371.39	73	0.91
1990	070303	Heavy-duty vehicles	Diesel	Urban driving	10964874.28	93.68	1038.79	125.29	12.66	299.01	74	2.50
1990	070303	Heavy-duty vehicles	Gasoline	Urban driving	19345.80	2.28	456.62	696.09	14.21	7102.99	73	0.61

1990	0704	Mopeds	Gasoline	Mopeds and Motorcycles < 50 cm3	270914.31	2.28	27.40	8019.18	200.00	13698.63	73	0.91
1990	070501	Motorcycles	Gasoline	Highway driving	56842.05	2.28	215.21	1274.28	121.98	17689.89	73	1.27
1990	070502	Motorcycles	Gasoline	Rural driving	132229.46	2.28	173.17	1528.62	146.07	16834.36	73	1.52
1990	070503	Motorcycles	Gasoline	Urban driving	158064.73	2.28	93.28	2018.58	147.26	15322.43	73	1.53

Year	SNAP ID	Category	Fuel type	Mode	Fuel	SO2	NOx	NMVOC	CH4	CO	CO2	N2O
					[GJ]	[g/GJ]	[g/GJ]	[g/GJ]	[g/GJ]	[g/GJ]	[kg/GJ]	[g/GJ]
1990	0801	Military	Diesel		146162.10	93.68	684.30	80.01	5.79	291.62	74	4.56
1990	0801	Military	Jet fuel	< 3000 ft	149678.28	22.99	250.57	24.94	2.65	229.89	72	2.30
1990	0801	Military	Jet fuel	> 3000 ft	1347104.52	22.99	250.57	24.94	2.65	229.89	72	2.30
1990	0801	Military	Gasoline		985.50	2.28	927.71	1135.23	32.03	6553.48	73	1.96
1990	0801	Military	Aviation gasoline		4913.48	22.83	859.00	1242.60	21.90	6972.00	73	2.00
1990	0802	Railways	Diesel		4010006.53	93.68	1225.13	79.94	3.07	223.21	74	2.04
1990	0802	Railways	Kerosene		69.60	5.00	50.00	3.00	7.00	20.00	72	2.00
1990	0802	Railways	Gasoline		0.00	2.28	871.06	1129.29	33.78	6687.29	73	2.24
1990	0803	Inland waterways	Diesel		538329.24	93.68	942.01	171.10	2.78	453.27	74	2.96
1990	0803	Inland waterways	Gasoline		433014.39	2.28	327.19	3235.89	50.26	14293.02	73	0.86
1990	080402	Maritime activities	Residual oil		3559805.60	1466.99	1393.64	56.92	1.76	180.93	78	4.89
1990	080402	Maritime activities	Diesel		2782388.36	93.68	1334.89	54.52	1.69	173.30	74	4.68
1990	080402	Maritime activities	Kerosene		452.40	4.60	50.00	3.00	7.00	20.00	72	2.00
1990	080402	Maritime activities	LPG		1794.00		1249.00	384.90	20.30	443.00	65	2.00
1990	080403	Maritime activities	Residual oil		285426.00	1466.99	1393.64	56.92	1.76	180.93	78	4.89
1990	080403	Maritime activities	Diesel		10051142.58	93.68	1334.89	54.52	1.69	173.30	74	4.68
1990	080403	Maritime activities	Kerosene		25786.80	4.60	50.00	3.00	7.00	20.00	72	2.00
1990	080403	Maritime activities	Gasoline		0.00	2.28	64.34	10809.58	108.10	18485.08	73	0.52
1990	080403	Maritime activities	LPG		42320.00		1249.00	384.90	20.30	443.00	65	2.00
1990	080404	Maritime activities	Residual oil		28543367.60	1711.49	2127.14	56.92	1.76	180.93	78	4.89
1990	080404	Maritime activities	Diesel		11632673.89	468.38	2037.47	54.52	1.69	173.30	74	4.68
1990	080501	Air traffic	Jet fuel	Dom. < 3000 ft	422173.05	22.99	314.51	14.93	1.59	90.41	72	5.70
1990	080501	Air traffic	Aviation gasoline		104947.19	22.83	859.00	1242.60	21.90	6972.00	73	2.00
1990	080502	Air traffic	Jet fuel	Int. < 3000 ft	132339.29	22.99	309.25	16.47	1.75	168.98	72	7.10
1990	080502	Air traffic	Aviation gasoline		30659.59	22.83	859.00	1242.60	21.90	6972.00	73	2.00
1990	080503	Air traffic	Jet fuel	Dom. > 3000 ft	1026021.25	22.99	330.11	12.36	1.31	90.75	72	2.30
1990	080504	Air traffic	Jet fuel	Int. > 3000 ft	1611914.81	22.99	244.20	6.48	0.69	54.10	72	2.30
1990	0806	Agriculture	Diesel		16496272.63	93.68	758.87	156.85	2.55	635.53	74	2.93
1990	0806	Agriculture	Gasoline		708864.21	2.28	31.60	949.55	88.42	47524.17	73	1.28

1990	0807	Forestry	Diesel		145345.57	93.68	857.48	156.47	2.54	645.65	74	2.97
1990	0807	Forestry	Gasoline		341429.76	2.28	40.39	7206.91	60.42	18057.40	73	0.37
1990	0808	Industry	Diesel		10158405.86	93.68	933.58	178.23	2.90	655.80	74	2.94
1990	0808	Industry	Gasoline		175227.11	2.28	136.27	1610.77	120.61	14797.46	73	1.33
1990	0808	Industry	LPG		1184855.79	0.00	1328.11	146.09	7.69	104.85	65	3.50
1990	0809	Household and gardening	Gasoline		1883802.80	2.28	65.27	2420.87	96.45	32167.96	73	1.14
1990	80501.00	Air traffic, Copenhagen airport	Jet fuel	Dom. < 3000 ft	502153.07	22.99	283.87	20.73	2.20	129.70	72	4.58
1990	80501.00	Air traffic, Copenhagen airport	Aviation gasoline		8642.20	22.83	859.00	1242.60	21.90	6972.00	73	2.00
1990	80502.00	Air traffic, Copenhagen airport	Jet fuel	Int. < 3000 ft	2001203.83	22.99	324.87	34.25	3.64	157.15	72	3.79
1990	80502.00	Air traffic, Copenhagen airport	Aviation gasoline		5612.28	22.83	859.00	1242.60	21.90	6972.00	73	2.00
1990	80503.00	Air traffic, Copenhagen airport	Jet fuel	Dom. > 3000 ft	1305208.09	22.99	314.86	11.78	1.25	84.05	72	2.30
1990	80504.00	Air traffic, Copenhagen airport	Jet fuel	Int. > 3000 ft	20330315.02	22.99	290.20	10.08	1.07	37.65	72	2.30

Year	SNAP ID	Category	Fuel type	Mode	Fuel	SO2	NOx	NMVOC	CH4	CO	CO2	N2O
					[GJ]	[g/GJ]	[g/GJ]	[g/GJ]	[g/GJ]	[g/GJ]	[kg/GJ]	[g/GJ]
2004	70101	Passenger cars	Diesel	Highway driving	2367692.82	2.34	278.56	11.59	4.31	95.36	74	13.24
2004	70101	Passenger cars	Gasoline 2-stroke	Highway driving	560.94	2.28	288.90	2357.34	10.03	3490.86	73	2.01
2004	70101	Passenger cars	Gasoline conventional	Highway driving	2431463.24	2.28	1362.36	333.59	11.45	2637.78	73	2.20
2004	70101	Passenger cars	Gasoline catalyst	Highway driving	10334217.85	2.28	243.63	27.94	3.58	1613.44	73	16.92
2004	70101	Passenger cars	LPG	Highway driving	83.86	0.00	1151.70	187.09	10.06	3914.25	65	6.04
2004	70102	Passenger cars	Diesel	Rural driving	5033891.32	2.34	250.86	18.93	2.58	88.15	74	15.02
2004	70102	Passenger cars	Gasoline 2-stroke	Rural driving	1575.25	2.28	352.84	2476.82	13.84	2594.44	73	1.73
2004	70102	Passenger cars	Gasoline conventional	Rural driving	5327550.38	2.28	1163.16	452.60	14.16	3155.17	73	2.43
2004	70102	Passenger cars	Gasoline catalyst	Rural driving	22410272.74	2.28	175.60	29.93	4.14	541.79	73	8.58
2004	70102	Passenger cars	LPG	Rural driving	169.20	0.00	1248.46	305.18	16.91	1146.38	65	7.25
2004	70103	Passenger cars	Diesel	Urban driving	5771889.77	2.34	256.86	53.08	2.52	241.10	74	10.14
2004	70103	Passenger cars	Gasoline 2-stroke	Urban driving	2024.84	2.28	51.89	4470.04	43.97	7400.54	73	0.82
2004	70103	Passenger cars	Gasoline conventional	Urban driving	6225773.06	2.28	635.44	858.78	52.55	8038.06	73	1.61
2004	70103	Passenger cars	Gasoline catalyst	Urban driving	31280010.90	2.28	169.53	213.29	48.77	3546.92	73	15.33
2004	70103	Passenger cars	LPG	Urban driving	213.26	0.00	618.83	421.82	33.68	1298.79	65	4.44
2004	70201	Light-duty vehicles	Diesel	Highway driving	3535197.72	2.34	312.66	30.60	1.59	198.22	74	6.06
2004	70201	Light- duty vehicles	Gasoline conventional	Highway driving	122385.19	2.28	1369.26	170.29	10.11	2987.40	73	2.43
2004	70201	Light-duty vehicles	Gasoline catalyst	Highway driving	294121.96	2.28	140.96	16.71	2.51	666.52	73	12.03
2004	70202	Light-duty vehicles	Diesel	Rural driving	10770333.75	2.34	330.79	35.07	1.74	185.83	74	6.63
2004	70202	Light-duty vehicles	Gasoline conventional	Rural driving	432603.23	2.28	1188.86	262.59	15.25	2316.18	73	2.29
2004	70202	Light-duty vehicles	Gasoline catalyst	Rural driving	1038500.57	2.28	124.02	22.63	2.87	498.99	73	5.19

2004	70203	Light-duty vehicles	Diesel	Urban driving	10489915.52	2.34	364.26	56.95	2.27	216.85	74	4.81
2004	70203	Light-duty vehicles	Gasoline conventional	Urban driving	525645.81	2.28	626.11	685.91	59.59	7231.71	73	1.34
2004	70203	Light-duty vehicles	Gasoline catalyst	Urban driving	1258563.91	2.28	132.44	124.38	22.88	3250.80	73	10.07
2004	70301	Heavy-duty vehicles	Diesel	Highway driving	11307971.46	2.34	472.55	51.41	4.31	112.12	74	2.85
2004	70301	Heavy-duty vehicles	Gasoline	Highway driving	9556.80	2.28	1037.78	474.61	9.69	7610.35	73	0.83
2004	70302	Heavy-duty vehicles	Diesel	Rural driving	17202120.67	2.34	559.70	64.29	4.71	132.98	74	2.89
2004	70302	Heavy-duty vehicles	Gasoline	Rural driving	19444.56	2.28	1141.55	820.40	16.74	8371.39	73	0.91
2004	70303	Heavy-duty vehicles	Diesel	Urban driving	12286671.47	2.34	606.35	73.07	7.93	158.40	74	2.35
2004	70303	Heavy-duty vehicles	Gasoline	Urban driving	19858.28	2.28	456.62	696.09	14.21	7102.99	73	0.61
2004	704	Mopeds	Gasoline		211381.41	2.28	25.40	6338.24	158.08	10804.39	73	0.91
2004	70501	Motorcycles	Gasoline	Highway driving	119292.56	2.28	218.43	1170.15	119.98	17378.93	73	1.27
2004	70502	Motorcycles	Gasoline	Rural driving	277434.16	2.28	175.99	1404.95	143.85	16502.09	73	1.52
2004	70503	Motorcycles	Gasoline	Urban driving	330690.34	2.28	94.93	1877.22	144.82	14993.66	73	1.53

Year	SNAP ID	Category	Fuel type	Mode	Fuel	SO2	NOx	NMVOC	CH4	CO	CO2	N2O
					[GJ]	[g/GJ]	[g/GJ]	[g/GJ]	[g/GJ]	[g/GJ]	[kg/GJ]	[g/GJ]
2004	801	Military	Diesel		585796.00	2.34	429.41	51.37	3.88	160.78	74	5.45
2004	801	Military	Jet fuel	< 3000 ft	66524.00	22.99	250.57	24.94	2.65	229.89	72	2.30
2004	801	Military	Jet fuel	> 3000 ft	598713.00	22.99	250.57	24.94	2.65	229.89	72	2.30
2004	801	Military	Gasoline		3975.00	2.28	288.90	279.15	27.72	2761.31	73	11.32
2004	801	Military	Aviation gasoline		6095.00	22.99	859.00	1242.60	21.90	6972.00	73	2.00
2004	802	Railways	Diesel		2950035.40	2.34	1190.53	74.44	2.86	204.95	74	2.04
2004	803	Inland waterways	Diesel		902453.33	93.68	877.17	170.01	2.76	452.68	74	2.97
2004	803	Inland waterways	Gasoline		1001571.20	2.28	398.23	2524.24	54.65	15863.15	73	1.07
2004	80402	National sea traffic	Residual oil		1822827.30	1101.71	1393.60	56.90	1.76	180.90	78	4.90
2004	80402	National sea traffic	Diesel		3827868.83	93.68	1334.90	54.50	1.69	173.30	74	4.70
2004	80402	National sea traffic	Kerosene		1078.80	4.60	50.00	3.00	7.00	20.00	72	2.00
2004	80402	National sea traffic	LPG		230.00	0.00	1249.00	384.90	20.30	443.00	65	2.00
2004	80403	Fishing	Residual oil		84023.55	1101.71	1393.60	56.90	1.76	180.90	78	4.90
2004	80403	Fishing	Diesel		8428083.30	93.68	1334.90	54.50	1.69	173.30	74	4.70
2004	80403	Fishing	Kerosene		730.80	4.60	50.00	3.00	7.00	20.00	72	2.00
2004	80403	Fishing	Gasoline		0.00	2.28	64.34	10809.60	108.10	18485.10	73	0.52
2004	80403	Fishing	LPG		20332.00	0.00	1249.00	384.90	20.30	443.00	65	2.00
2004	80404	International sea traffic	Residual oil		20461868.55	1575.67	2127.10	56.90	1.76	180.90	78	4.90
2004	80404	International sea traffic	Diesel		20729767.13	468.38	2037.50	54.50	1.69	173.30	74	4.70

2004	80501	Air traffic, other airports	Jet fuel	Dom. < 3000 ft	184147.19	22.99	252.17	29.42	3.12	163.42	72	21.05
2004	80501	Air traffic, other airports	Aviation gasoline		75380.00	22.83	859.00	1242.60	21.90	6972.00	73	2.00
2004	80502	Air traffic, other airports	Jet fuel	Int. < 3000 ft	239381.32	22.99	299.33	14.63	1.55	162.38	72	8.47
2004	80502	Air traffic, other airports	Aviation gasoline		5565.00	22.83	859.00	1242.60	21.90	6972.00	73	2.00
2004	80503	Air traffic, other airports	Jet fuel	Dom. > 3000 ft	531959.09	22.99	280.06	21.04	2.23	133.41	72	2.30
2004	80504	Air traffic, other airports	Jet fuel	Int. > 3000 ft	2378028.80	22.99	242.26	5.87	0.62	50.37	72	2.30
2004	806	Agriculture	Diesel		########	23.42	878.84	100.12	1.63	475.69	74	3.12
2004	806	Agriculture	Gasoline		489193.78	2.28	86.41	1032.34	129.17	27766.67	73	1.54
2004	807	Forestry	Diesel		4625.38	23.42	822.93	65.33	1.06	362.42	74	3.20
2004	807	Forestry	Gasoline		56785.69	2.28	48.43	6386.40	52.96	15880.08	73	0.41
2004	808	Industry	Diesel		8581033.78	23.42	827.97	113.65	1.85	478.43	74	3.08
2004	808	Industry	Gasoline		134440.46	2.28	191.31	1458.32	101.67	12652.23	73	1.39
2004	808	Industry	LPG		1498954.83	0.00	1328.11	146.09	7.69	104.85	65	3.50
2004	809	Household and gardening	Gasoline		1116969.62	2.28	77.77	2141.22	71.19	27974.82	73	1.17
2004	80501	Air traffic, Copenhagen airport	Jet fuel	Dom. < 3000 ft	229614.67	22.99	255.88	39.13	4.16	202.97	72	11.22
2004	80501	Air traffic, Copenhagen airport	Aviation gasoline		611.00	22.83	859.00	1242.60	21.90	6972.00	73	2.00
2004	80502	Air traffic, Copenhagen airport	Jet fuel	Int. < 3000 ft	2587577.02	22.99	335.05	38.17	4.05	214.71	72	4.13
2004	80502	Air traffic, Copenhagen airport	Aviation gasoline		885.00	22.83	859.00	1242.60	21.90	6972.00	73	2.00
2004	80503	Air traffic, Copenhagen airport	Jet fuel	Dom. > 3000 ft	890213.23	22.99	286.55	18.99	2.02	69.59	72	2.30
2004	80504	Air traffic, Copenhagen airport	Jet fuel	Int. > 3000 ft	25170689.68	22.99	310.56	11.03	1.17	35.96	72	2.30

	Category	Mode		SO2 [tons]	NOx [tons]	NMVOC [tons]	CH4 [tons]	CO [tons]	CO2 [ktons]	N2O [tons]
1990	Passenger cars	Highway driving	70101	121	14676	4111	126	38170	877	36
1990	Passenger cars	Rural driving	70102	246	27453	11792	336	95013	1882	88
1990	Passenger cars	Urban driving	70103	302	17524	26630	1456	276338	2209	67
1990	Light duty vehicles	Highway driving	70201	275	1228	145	8	1959	240	17
1990	Light duty vehicles	Rural driving	70202	837	4006	614	33	5804	741	56
1990	Light duty vehicles	Urban driving	70203	802	5000	1465	103	13593	730	39
1990	Heavy duty vehicles	Highway driving	70301	824	7281	691	54	1641	652	26
1990	Heavy duty vehicles	Rural driving	70302	1331	13467	1476	98	3529	1053	44
1990	Heavy duty vehicles	Urban driving	70303	1027	11399	1387	139	3416	813	27
1990	Mopeds		704	1	7	2173	54	3711	20	0
1990	Motorcycles	Highway driving	70501	0	12	72	7	1006	4	0
1990	Motorcycles	Rural driving	70502	0	23	202	19	2226	10	0
1990	Motorcycles	Urban driving	70503	0	15	319	23	2422	12	0

1990	Evaporation	706	0	0	28438	0	0	0	0
1990	Military	801	48	480	56	5	427	119	4
1990	Railways	802	376	4913	321	12	895	297	8
1990	Inland waterways	803	51	649	1493	23	6433	71	2
1990	National sea traffic	80402	5483	8678	355	11	1127	484	30
1990	Fishing	80403	1360	13869	581	18	1813	771	49
1990	International sea traffic	80404	54300	84417	2259	70	7180	3087	194
1990	Air traffic, Dom. < 3000 ft.	80501	24	373	158	4	895	75	5
1990	Air traffic, Int. < 3000 ft.	80502	50	722	116	8	590	156	9
1990	Air traffic, Dom. > 3000 ft.	80503	54	750	28	3	203	168	5
1990	Air traffic, Int. > 3000 ft.	80504	504	6293	215	23	853	1580	50
1990	Agriculture	806	1547	12541	3260	105	44172	1272	49
1990	Forestry	807	14	138	2483	21	6259	36	1
1990	Industry	808	952	11081	2266	60	9379	842	34
1990	Household and gardening	809	4	123	4560	182	60598	138	2

	Category	Mode		SO2 [tons]	NOx [tons]	NMVOC [tons]	CH4 [tons]	CO [tons]	CO2 [ktons]	N2O [tons]
2004	Passenger cars	Highway driving	70101	34	5644	910	68	21463	1071	212
2004	Passenger cars	Rural driving	70102	73	9851	2537	162	24881	2329	285
2004	Passenger cars	Urban driving	70103	97	9813	10918	1790	149436	3095	554
2004	Light duty vehicles	Highway driving	70201	11	1459	147	8	1336	335	29
2004	Light duty vehicles	Rural driving	70202	33	4677	554	31	3731	1037	90
2004	Light duty vehicles	Urban driving	70203	32	4823	1151	86	10449	1027	73
2004	Heavy duty vehicles	Highway driving	70301	27	5382	589	49	1340	842	32
2004	Heavy duty vehicles	Rural driving	70302	41	9741	1131	82	2456	1287	50
2004	Heavy duty vehicles	Urban driving	70303	29	7572	924	99	2103	924	29
2004	Mopeds		704	1	6	1529	38	2607	18	0
2004	Motorcycles	Highway driving	70501	0	29	154	16	2292	10	0
2004	Motorcycles	Rural driving	70502	1	54	431	44	5057	22	0
2004	Motorcycles	Urban driving	70503	1	35	689	53	5500	27	1
2004	Evaporation		706	0	0	4814	0	0	0	0
2004	Military		801	46	1079	129	11	718	239	12
2004	Railways		802	7	3478	217	8	599	216	6
2004	Inland waterways		803	95	1040	1191	25	6865	104	3
2004	National sea traffic		80402	2164	6950	284	9	902	387	24
2004	Fishing		80403	632	8528	354	11	1112	473	30
2004	International sea traffic		80404	34821	69705	1865	58	5928	2545	161

2004	Air traffic, Dom. < 3000 ft.	80501	9	159	131	3	729	29	5
2004	Air traffic, Int. < 3000 ft.	80502	70	1015	120	12	696	219	14
2004	Air traffic, Dom. > 3000 ft.	80503	32	393	27	3	128	99	3
2004	Air traffic, Int. > 3000 ft.	80504	711	9424	327	35	1152	2228	71
2004	Agriculture	806	315	11837	1667	62	15042	1017	42
2004	Forestry	807	4	135	506	4	1291	17	1
2004	Industry	808	263	10744	1676	46	7600	912	39
2004	Household and gardening	809	9	317	8731	290	114073	298	5

Annex 3B-13: Fuel use and emissions in CRF format

Fuel

IPCC ID	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Industry-Other (1A2f)	11.7	11.7	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Civil Aviation (1A3a)	3.6	3.3	4	4	4	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2
Road (1A3b)	110.6	116.9	117	118	119	126	131	134	133	138	143	146	149	151	153	152	152	154	159	164
Railways (1A3c)	4.9	4.9	4	5	4	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3
Navigation (1A3d)	6.4	7.3	8	7	8	7	9	8	9	8	9	9	8	7	6	6	6	7	7	7
Residential (1A4b)	1.9	1.9	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	4	4
Ag./for./fish. (1A4c)	26.2	27.7	26	27	28	28	28	27	25	24	24	24	24	23	23	23	22	22	22	20
Military (1A5)	5.5	4.3	5	3	2	2	4	2	3	3	3	2	2	3	3	2	1	1	1	3
Navigation int. (1A3d)	17.3	20.1	29	37	38	40	36	38	56	63	66	63	58	58	55	56	47	39	41	33
Civil Aviation int. (1A3a)	19.3	20.9	22	24	25	24	23	24	23	25	26	27	28	30	32	33	33	29	30	34

pol_name	IPCC ID	Unit	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
SO2	Industry-Other (1A2f)	[tonnes]	2402	1441	1440	1438	956	952	955	957	957	959
SO2	Civil Aviation (1A3a)	[tonnes]	82	77	85	86	83	77	64	62	61	63
SO2	Road (1A3b)	[tonnes]	11620	7861	7846	7856	5486	5766	5902	3819	1562	1658
SO2	Railways (1A3c)	[tonnes]	1152	695	618	641	393	376	382	263	105	95
SO2	Navigation (1A3d)	[tonnes]	4178	5502	6122	4349	6133	5534	6698	3392	3664	3272
SO2	Residential (1A4b)	[tonnes]	4	4	4	4	4	4	4	4	5	5
SO2	Ag./for./fish. (1A4c)	[tonnes]	5047	3736	3545	3324	2844	2922	2689	2660	2436	2183
SO2	Military (1A5)	[tonnes]	408	260	193	72	70	48	206	82	76	80
SO2	Navigation int. (1A3d)	[tonnes]	20684	24627	39745	51685	52277	54300	46066	37478	65384	69311
SO2	Civil Aviation int. (1A3a)	[tonnes]	444	480	515	551	578	554	521	541	530	580
NOx	Industry-Other (1A2f)	[tonnes]	10903	10964	11011	11044	11065	11081	11282	11440	11558	11677
NOx	Civil Aviation (1A3a)	[tonnes]	1203	1132	1237	1252	1208	1123	920	902	900	940
NOx	Road (1A3b)	[tonnes]	89618	94432	94420	95431	96389	102091	103297	102403	99004	96332
NOx	Railways (1A3c)	[tonnes]	6025	6063	5391	5589	5145	4913	4995	5284	5485	4971
NOx	Navigation (1A3d)	[tonnes]	8153	9373	9972	8708	9731	9326	11117	10140	11079	10478
NOx	Residential (1A4b)	[tonnes]	114	117	119	122	122	123	134	143	152	161
NOx	Ag./for./fish. (1A4c)	[tonnes]	23067	25098	22736	24785	25885	26548	26979	26830	24161	23404
NOx	Military (1A5)	[tonnes]	2221	1884	1557	979	848	480	1698	915	1213	1200
NOx	Navigation int. (1A3d)	[tonnes]	36143	42057	61836	78416	80275	84417	75576	79058	117623	132160
NOx	Civil Aviation int. (1A3a)	[tonnes]	5663	6129	6569	7035	7313	7016	6586	6846	6702	7317
NMVOC	Industry-Other (1A2f)	[tonnes]	2422	2395	2368	2339	2304	2266	2231	2191	2147	2107
NMVOC	Civil Aviation (1A3a)	[tonnes]	216	213	190	198	193	186	168	164	161	191
NMVOC	Road (1A3b)	[tonnes]	77938	77903	77406	77098	75603	79517	80422	79811	75378	69511
NMVOC	Railways (1A3c)	[tonnes]	393	396	352	365	336	321	326	345	358	324
NMVOC	Navigation (1A3d)	[tonnes]	1763	1812	1847	1804	1855	1848	1931	1901	1953	1933
NMVOC	Residential (1A4b)	[tonnes]	4667	4637	4606	4574	4567	4560	4600	4609	4592	4606
NMVOC	Ag./for./fish. (1A4c)	[tonnes]	6500	6566	6358	6421	6385	6324	5945	5504	5049	4725
NMVOC	Military (1A5)	[tonnes]	608	481	185	477	311	56	197	109	143	137
NMVOC	Navigation int. (1A3d)	[tonnes]	967	1126	1655	2098	2148	2259	2022	2116	3149	3536
NMVOC	Civil Aviation int. (1A3a)	[tonnes]	261	288	313	342	361	331	309	316	309	308
CH4	Industry-Other (1A2f)	[tonnes]	63	63	62	61	61	60	58	57	56	54
CH4	Civil Aviation (1A3a)	[tonnes]	8	8	8	8	8	7	6	6	6	7
CH4	Road (1A3b)	[tonnes]	2341	2371	2398	2361	2322	2456	2739	2904	3076	3181
CH4	Railways (1A3c)	[tonnes]	15	15	14	14	13	12	13	13	14	12

CH4	Navigation (1A3d)	[tonnes]	32	34	35	33	35	34	37	36	37	36
CH4	Residential (1A4b)	[tonnes]	192	189	186	183	182	182	181	178	176	174
CH4	Ag./for./fish. (1A4c)	[tonnes]	160	159	151	150	148	144	137	129	119	112
CH4	Military (1A5)	[tonnes]	29	24	16	18	13	5	16	8	12	12
CH4	Navigation int. (1A3d)	[tonnes]	30	35	51	65	66	70	63	65	97	109
CH4	Civil Aviation int. (1A3a)	[tonnes]	25	27	30	32	33	31	29	30	29	31
CO	Industry-Other (1A2f)	[tonnes]	9863	9784	9702	9611	9502	9379	9294	9188	9070	8956
CO	Civil Aviation (1A3a)	[tonnes]	1256	1241	1118	1167	1140	1098	989	955	930	1098
CO	Road (1A3b)	[tonnes]	550715	530183	511392	465749	438153	448826	467522	462370	454463	418376
CO	Railways (1A3c)	[tonnes]	1098	1105	982	1018	937	895	910	963	999	906
CO	Navigation (1A3d)	[tonnes]	7319	7477	7577	7435	7590	7560	7815	7711	7859	7799
CO	Residential (1A4b)	[tonnes]	64155	63226	62266	61278	60942	60598	60675	60462	60379	60245
CO	Ag./for./fish. (1A4c)	[tonnes]	61580	60133	57669	56160	54237	52244	49256	46037	42898	39968
CO	Military (1A5)	[tonnes]	4153	3093	1325	3085	1927	427	1056	541	872	889
CO	Navigation int. (1A3d)	[tonnes]	3074	3578	5260	6670	6828	7180	6428	6725	10007	11241
CO	Civil Aviation int. (1A3a)	[tonnes]	1103	1207	1289	1416	1564	1442	1357	1399	1388	1342
CO2	Industry-Other (1A2f)	[ktonnes]	852	852	851	849	845	842	843	843	842	841
CO2	Civil Aviation (1A3a)	[ktonnes]	256	241	268	271	262	243	199	193	190	196
CO2	Road (1A3b)	[ktonnes]	8123	8588	8600	8658	8754	9241	9654	9825	9785	10135
CO2	Railways (1A3c)	[ktonnes]	364	366	326	338	311	297	302	319	331	300
CO2	Navigation (1A3d)	[ktonnes]	485	553	588	518	577	555	656	602	655	622
CO2	Residential (1A4b)	[ktonnes]	139	139	138	138	138	138	140	143	146	149
CO2	Ag./for./fish. (1A4c)	[ktonnes]	1936	2052	1897	2012	2057	2079	2075	2026	1861	1775
CO2	Military (1A5)	[ktonnes]	402	316	361	196	165	119	287	141	237	252
CO2	Navigation int. (1A3d)	[ktonnes]	1320	1537	2261	2869	2936	3087	2762	2887	4300	4829
CO2	Civil Aviation int. (1A3a)	[ktonnes]	1391	1503	1613	1725	1809	1736	1632	1693	1659	1818
N2O	Industry-Other (1A2f)	[tonnes]	34	34	34	34	34	34	34	35	35	35
N2O	Civil Aviation (1A3a)	[tonnes]	10	10	11	11	11	10	9	9	9	9
N2O	Road (1A3b)	[tonnes]	339	366	369	374	382	402	471	532	579	686
N2O	Railways (1A3c)	[tonnes]	10	10	9	9	9	8	8	9	9	8
N2O	Navigation (1A3d)	[tonnes]	28	33	35	30	34	32	39	35	39	36
N2O	Residential (1A4b)	[tonnes]	2	2	2	2	2	2	2	2	2	2
N2O	Ag./for./fish. (1A4c)	[tonnes]	89	96	87	93	97	98	99	98	87	84
N2O	Military (1A5)	[tonnes]	16	13	13	6	6	4	13	7	10	10
N2O	Navigation int. (1A3d)	[tonnes]	83	97	142	180	185	194	174	182	270	304
N2O	Civil Aviation int. (1A3a)	[tonnes]	47	50	54	58	61	59	56	58	57	63

pol_name	IPCC ID	Unit	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
SO2	Industry-Other (1A2f)	[tonnes]	968	244	246	249	251	253	256	258	261	263
SO2	Civil Aviation (1A3a)	[tonnes]	63	65	68	62	56	49	52	45	44	41
SO2	Road (1A3b)	[tonnes]	1679	1720	1743	1766	1087	351	351	355	369	378
SO2	Railways (1A3c)	[tonnes]	96	95	93	78	40	7	7	7	7	7
SO2	Navigation (1A3d)	[tonnes]	2780	2144	1905	1738	1780	1712	1452	2115	1927	2259
SO2	Residential (1A4b)	[tonnes]	5	5	5	5	5	5	6	7	8	9
SO2	Ag./for./fish. (1A4c)	[tonnes]	2189	1368	1447	1139	1115	1108	1066	1072	1088	951
SO2	Military (1A5)	[tonnes]	80	56	54	65	47	27	12	19	17	46
SO2	Navigation int. (1A3d)	[tonnes]	76281	71536	65585	59858	60339	65168	54366	39610	44114	34821
SO2	Civil Aviation int. (1A3a)	[tonnes]	596	629	642	689	731	750	761	658	684	781
NOx	Industry-Other (1A2f)	[tonnes]	11882	12080	12248	12425	12262	12096	11869	11617	11214	10744
NOx	Civil Aviation (1A3a)	[tonnes]	958	971	998	911	815	723	747	636	590	552
NOx	Road (1A3b)	[tonnes]	94690	91590	86967	82353	77984	72515	68785	64205	62574	59085
NOx	Railways (1A3c)	[tonnes]	5015	4977	4846	4089	3730	3727	3396	3396	3540	3478
NOx	Navigation (1A3d)	[tonnes]	11052	11456	10037	8225	7443	7518	7384	8902	8660	7990
NOx	Residential (1A4b)	[tonnes]	168	174	180	186	190	194	225	256	287	317
NOx	Ag./for./fish. (1A4c)	[tonnes]	23357	24170	24716	24407	24624	24482	24044	23730	22612	20501
NOx	Military (1A5)	[tonnes]	1586	888	1061	1221	956	497	580	416	447	1079
NOx	Navigation int. (1A3d)	[tonnes]	138528	131504	120575	120988	113827	117148	98722	81292	85761	69705
NOx	Civil Aviation int. (1A3a)	[tonnes]	7517	7904	8058	8662	9204	9446	9611	8738	9097	10439
NMVOC	Industry-Other (1A2f)	[tonnes]	2088	2095	2083	2074	1997	1926	1873	1815	1754	1676
NMVOC	Civil Aviation (1A3a)	[tonnes]	206	194	186	169	162	156	155	151	143	158
NMVOC	Road (1A3b)	[tonnes]	67664	63777	57320	51865	46118	39042	35617	32150	29871	26477
NMVOC	Railways (1A3c)	[tonnes]	327	325	316	267	276	253	248	243	223	217
NMVOC	Navigation (1A3d)	[tonnes]	1966	1992	1931	1843	1782	1745	1687	1683	1594	1474
NMVOC	Residential (1A4b)	[tonnes]	4699	4798	4894	4985	5099	5209	6083	6955	7837	8731
NMVOC	Ag./for./fish. (1A4c)	[tonnes]	4567	4309	4137	3854	3680	3474	3280	3063	2814	2528
NMVOC	Military (1A5)	[tonnes]	190	107	132	149	127	64	75	55	58	129
NMVOC	Navigation int. (1A3d)	[tonnes]	3707	3519	3226	3237	3045	3134	2641	2174	2294	1865
NMVOC	Civil Aviation int. (1A3a)	[tonnes]	343	360	365	386	395	407	406	391	399	448
CH4	Industry-Other (1A2f)	[tonnes]	53	53	53	53	51	50	49	48	47	46
CH4	Civil Aviation (1A3a)	[tonnes]	7	7	7	7	6	5	5	5	5	6
CH4	Road (1A3b)	[tonnes]	3493	3813	3644	3644	3400	3244	3167	2913	2832	2526
CH4	Railways (1A3c)	[tonnes]	13	12	12	10	11	10	10	9	9	8

CH4	Navigation (1A3d)	[tonnes]	37	38	36	34	33	33	33	35	34	34
CH4	Residential (1A4b)	[tonnes]	173	173	173	173	175	177	205	233	261	290
CH4	Ag./for./fish. (1A4c)	[tonnes]	108	104	99	94	92	90	88	85	82	78
CH4	Military (1A5)	[tonnes]	15	9	10	11	10	5	5	4	4	11
CH4	Navigation int. (1A3d)	[tonnes]	115	109	100	100	94	97	82	67	71	58
CH4	Civil Aviation int. (1A3a)	[tonnes]	35	37	38	40	41	42	42	41	42	47
CO	Industry-Other (1A2f)	[tonnes]	8910	8963	8939	8907	8647	8395	8227	8030	7842	7600
CO	Civil Aviation (1A3a)	[tonnes]	1180	1117	1085	973	932	895	888	860	832	857
CO	Road (1A3b)	[tonnes]	420514	419178	368994	353211	320362	299720	290617	268471	259570	232650
CO	Railways (1A3c)	[tonnes]	914	907	883	745	717	694	637	627	611	599
CO	Navigation (1A3d)	[tonnes]	7896	7971	7811	7602	7528	7567	7582	7812	7816	7767
CO	Residential (1A4b)	[tonnes]	60312	60886	61386	61815	62860	63852	76214	88416	101233	114073
CO	Ag./for./fish. (1A4c)	[tonnes]	37791	35139	32964	30305	28151	26013	24044	21943	19748	17445
CO	Military (1A5)	[tonnes]	919	632	620	702	714	405	320	316	309	718
CO	Navigation int. (1A3d)	[tonnes]	11783	11185	10256	10291	9681	9963	8396	6914	7294	5928
CO	Civil Aviation int. (1A3a)	[tonnes]	1421	1502	1564	1662	1743	1790	1796	1610	1670	1848
CO2	Industry-Other (1A2f)	[ktonnes]	848	853	860	867	873	879	888	897	907	912
CO2	Civil Aviation (1A3a)	[ktonnes]	199	205	212	194	174	154	161	140	137	128
CO2	Road (1A3b)	[ktonnes]	10483	10723	10936	11124	11270	11159	11163	11279	11722	12024
CO2	Railways (1A3c)	[ktonnes]	303	301	293	247	232	228	211	210	218	216
CO2	Navigation (1A3d)	[ktonnes]	655	678	600	501	458	463	456	541	527	490
CO2	Residential (1A4b)	[ktonnes]	152	155	159	162	166	169	201	233	265	298
CO2	Ag./for./fish. (1A4c)	[ktonnes]	1764	1752	1767	1715	1710	1684	1647	1645	1603	1507
CO2	Military (1A5)	[ktonnes]	252	176	171	204	182	111	97	89	92	239
CO2	Navigation int. (1A3d)	[ktonnes]	5061	4803	4403	4414	4155	4279	3605	2966	3130	2545
CO2	Civil Aviation int. (1A3a)	[ktonnes]	1867	1971	2010	2159	2290	2350	2385	2059	2142	2447
N2O	Industry-Other (1A2f)	[tonnes]	35	36	36	36	37	37	38	38	38	39
N2O	Civil Aviation (1A3a)	[tonnes]	10	11	11	9	9	8	8	8	8	8
N2O	Road (1A3b)	[tonnes]	782	868	977	1063	1134	1172	1191	1244	1298	1357
N2O	Railways (1A3c)	[tonnes]	8	8	8	7	6	6	6	6	6	6
N2O	Navigation (1A3d)	[tonnes]	38	40	35	29	26	26	26	31	30	28
N2O	Residential (1A4b)	[tonnes]	2	2	3	3	3	3	3	4	4	5
N2O	Ag./for./fish. (1A4c)	[tonnes]	83	84	85	83	83	83	81	81	79	73
N2O	Military (1A5)	[tonnes]	12	7	8	10	8	4	5	4	5	12
N2O	Navigation int. (1A3d)	[tonnes]	318	302	277	278	262	270	228	187	198	161
N2O	Civil Aviation int. (1A3a)	[tonnes]	64	69	70	75	80	82	82	72	75	85

Annex 3B-14: Uncertainty estimates

Uncertainty estimation, CO_2

	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emis-	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		Gg	Gg	%	%	%	%	%	%	%	%	%
Road transport	CO2	9241	12024	2	5	5.385	4.094	0.08880068	0.8898	0.4440	2.5168	2.5557
Military	CO2	119	239	2	5	5.385	0.081	0.00738001	0.0177	0.0369	0.0500	0.0622
Railways	CO2	297	216	2	5	5.385	0.074	-0.0096995	0.0160	-0.0485	0.0453	0.0663
Navigation (small boats)	CO2	71	104	42	5	42.297	0.277	0.00148273	0.0077	0.0074	0.4556	0.4557
Navigation (large vessels)	CO2	484	387	2	5	5.385	0.132	-0.0132818	0.0286	-0.0664	0.0809	0.1047
Fisheries	CO2	771	473	2	5	5.385	0.161	-0.0317425	0.0350	-0.1587	0.0990	0.1870
Agriculture	CO2	1272	1017	26	5	26.476	1.703	-0.0349005	0.0753	-0.1745	2.7679	2.7734
Forestry	CO2	36	17	32	5	32.388	0.036	-0.0017996	0.0013	-0.0090	0.0584	0.0591
Industry (mobile)	CO2	842	912	36	5	36.346	2.097	-0.0053628	0.0675	-0.0268	3.4376	3.4377
Residential	CO2	138	298	36	5	36.346	0.684	0.01011675	0.0220	0.0506	1.1215	1.1227
Civil aviation	CO2	243	128	10	5	11.180	0.091	-0.0115393	0.0095	-0.0577	0.1340	0.1459
		13.513	15815				24.669					27.5876

Total uncertainties	**Overall uncertainty in the year (%):**	**4.967**	**Trend uncertainty (%):**	**5.252**

Uncertainty estimation, CH_4

	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		Mg	Mg	%	%	%	%	%	%	%	%	%
Road transport	CH4	2456	2526	2	40	40.050	33.738	-0.0044744	0.8711	-0.1790	2.4640	2.4705
Military	CH4	5	11	2	100	100.020	0.358	0.00193484	0.0037	0.1935	0.0105	0.1938
Railways	CH4	12	8	2	100	100.020	0.279	-0.0015104	0.0029	-0.1510	0.0082	0.1513
Navigation (small boats)	CH4	23	25	42	100	108.462	0.899	0.000278	0.0086	0.0278	0.5092	0.5099
Navigation (large vessels)	CH4	11	9	2	100	100.020	0.293	-0.000888	0.0030	-0.0888	0.0086	0.0892
Fisheries	CH4	18	11	2	100	100.020	0.372	-0.0027485	0.0038	-0.2748	0.0109	0.2751
Agriculture	CH4	105	62	26	100	103.325	2.140	-0.0159305	0.0214	-1.5930	0.7875	1.7771
Forestry	CH4	21	4	32	100	104.995	0.150	-0.0060123	0.0015	-0.6012	0.0668	0.6049
Industry (mobile)	CH4	60	46	36	100	106.283	1.628	-0.0054357	0.0158	-0.5436	0.8067	0.9727
Residential	CH4	182	290	36	100	106.283	10.288	0.03528156	0.1001	3.5282	5.0961	6.1983
Civil aviation	CH4	7	6	10	100	100.499	0.205	-0.0004714	0.0021	-0.0471	0.0298	0.0558
		2900	2999				1252.620					49.3990
Total uncertainties				**Overall uncertainty in the year (%):**			**35.392**			**Trend uncertainty (%):**		**7.028**

Uncertainty estimation, N_2O

	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		Mg	Mg	%	%	%	%	%	%	%	%	%
Road transport	N2O	402	1357	2	50	50.040	44.465	0.53562412	2.2916	26.7812	6.4817	27.5544
Military	N2O	4	12	2	1000	1000.002	7.897	0.00242262	0.0204	2.4226	0.0576	2.4233
Railways	N2O	8	6	2	1000	1000.002	3.903	-0.0255565	0.0101	-25.5565	0.0285	25.5565
Navigation (small boats)	N2O	2	3	42	1000	1000.882	2.235	-0.002821	0.0058	-2.8210	0.3420	2.8416
Navigation (large vessels)	N2O	30	24	2	1000	1000.002	16.016	-0.0912164	0.0413	-91.2164	0.1168	91.2165
Fisheries	N2O	49	30	2	1000	1000.002	19.631	-0.1609416	0.0506	-160.9416	0.1432	160.9417
Agriculture	N2O	49	42	26	1000	1000.338	27.819	-0.1426504	0.0717	-142.6504	2.6371	142.6748
Forestry	N2O	1	1	32	1000	1000.512	0.354	-0.0015269	0.0009	-1.5269	0.0413	1.5275
Industry (mobile)	N2O	34	39	36	1000	1000.648	25.252	-0.0839872	0.0651	-83.9872	3.3135	84.0525
Residential	N2O	2	5	36	1000	1000.648	3.132	-0.0012478	0.0081	-1.2478	0.4110	1.3138
Civil aviation	N2O	10	8	10	1000	1000.050	5.206	-0.0313833	0.0134	-31.3833	0.1899	31.3838
		592	1527				4150.216					64058.9164
Total uncertainties				**Overall uncertainty in the year (%):**			**64.422**			**Trend uncertainty (%):**		**253.099**

Annual working hours, load factors and lifetimes for **agricultural tractors**

Tractor type	Annual working hours	Load factor	Lifetime (yrs)
Diesel	500 (0-7 years)	0.5	30
	500-100 (7-16 years)		
	100 (>16 years)		
Gasoline (certified)	100	0.4	37
Gasoline (non certified)	50	0.4	37

Annual working hours, load factors and lifetimes for **harvesters**

Annual working hours	Load factor	Lifetime (yrs)
250-100 (linear decrease 0-24 years)	0.8	25

Annual working hours, load factors and lifetime for **machine pool machinery**

Tractor type	Hours/yr	Load factor	Lifetime (yrs)
Tractors	750	0.5	7
Harvesters	100	0.8	11
Self-propelled vehicles	500	0.75	6

Operational data for **other machinery types in agriculture**

Machinery type	Fuel type	Load factor	Lifetime (yrs)	Hours	Size (kW)
ATV private	Gasoline	-	6	250	-
ATV professional	Gasoline	-	8	400	-
Bedding machines	Gasoline	0.3	10	50	3
Fodder trucks	Gasoline	0.4	10	200	8
Other (gasoline)	Gasoline	0.4	10	50	5
Scrapers	Gasoline	0.3	10	50	3
Self-propelled vehicles	Diesel	0.75	15	150	60
Sweepers	Gasoline	0.3	10	50	3

Annual working hours, load factors and lifetimes for **forestry machinery**

Machinery type	Hours	Load factors	Lifetime
Chippers	1200	0.5	6
Tractors (other)	100 (1990)	0.5	15
	400 (2004)		
Tractors (silvicultural)	800	0.5	6
Harvesters	1200	0.5	8
Forwarders	1200	0.5	8
Chain saws (forestry)	800	0.4	3

Annual working hours, load factors and lifetime for **fork lifts**

Hours/yr	Load factor	Lifetime (yrs)
1200 (>=50 kW and <=10 years old)	0.27	20
650 (>=50 kW and >10 years old)		
650 (<50 kW)		

Operational data for **construction machinery**

Machinery type	Load factor	Lifetime	Hours	Size
Track type dozers	0.5	10	1100	140
Track type loaders	0.5	10	1100	100 (1990) 150 (2004)
Wheel loaders (0-5 tons)	0.5	10	1200	20
Wheel loaders (> 5,1 tons)	0.5	10	1200	120
Wheel type excavators	0.6	10	1200	100
Track type excavators (0-5 tons)	0.6	10	1100	20
Track type excavators (>5,1 tons)	0.6	10	1100	120
Excavators/Loaders	0.45	10	700	50
Dump trucks	0.4	10	900 (1990) 1200 (2004)	60 (1990) 180 (2004)
Mini loaders	0.5	14	700	30
Telescopic loaders	0.5	14	1000	35

Stock and operational data for **other machinery types in industry**

Sector	Fuel type	Machinery type	Size (kW)	No	Load Factor	Hours
Construction machinery	Diesel	Tampers/Land rollers	30	2800	0.45	600
Construction machinery	Diesel	Generators (diesel)	45	5000	0.5	200
Construction machinery	Diesel	Kompressors (diesel)	45	5000	0.5	500
Construction machinery	Diesel	Pumps (diesel)	75	1000	0.5	5
Construction machinery	Diesel	Asphalt pavers	80	300	0.35	700
Construction machinery	Diesel	Motor graders	100	100	0.4	700
Construction machinery	Diesel	Refuse compressors	160	100	0.25	1300
Construction machinery	Gasoline	Generators (gasoline)	2.5	11000	0.4	80
Construction machinery	Gasoline	Pumps (gasoline)	4	10000	0.4	300
Construction machinery	Gasoline	Kompressors (gasoline)	4	500	0.35	15
Industry	Diesel	Refrigerating units (distribution)	8	3000	0.5	1250
Industry	Diesel	Refrigerating units (long distance)	15	3500	0.5	200
Industry	Diesel	Tractors (transport, industry)	50	3000	0.4	500
Airport GSE and other	Diesel	Airport GSE and other (light duty)	100	500	0.5	400
Airport GSE and other	Diesel	Airport GSE and other (medium duty)	125	350	0.5	300
Airport GSE and other	Diesel	Airport GSE and other (Heavy duty)	175	650	0.5	200
Building and construction	Diesel	Vibratory plates	6	3500	0.6	300
Building and construction	Diesel	Aereal lifts (diesel)	30	150	0.4	400
Building and construction	Diesel	Sweepers (diesel)	30	200	0.4	300
Building and construction	Diesel	High pressure cleaners (diesel)	30	50	0.8	500
Building and construction	Gasoline	Rammers	2.5	3000	0.4	80
Building and construction	Gasoline	Drills	3	100	0.4	10
Building and construction	Gasoline	Vibratory plates (gasoline)	4	2500	0.5	200
Building and construction	Gasoline	Cutters	4	800	0.5	50
Building and construction	Gasoline	Other (gasoline)	5	1000	0.5	40
Building and construction	Gasoline	High pressure cleaners (gasoline)	5	500	0.6	200
Building and construction	Gasoline	Sweepers (gasoline)	10	500	0.4	150
Building and construction	Gasoline	Slicers	10	100	0.7	150
Building and construction	Gasoline	Aereal lifts (gasoline)	20	50	0.4	400

Operational data for the most important types of **household and gardening machinery**

Machinery type	Engine	Size (kW)	Hours	Load factor	Lifetime (yrs)
Chain saws (private)	2-stroke	2	5	0.3	10
Chain saws (professional)	2-stroke	3	270	0.4	3
Cultivators (private-large)	4-stroke	3.7	5	0.6	5
Cultivators (private-small)	4-stroke	1	5	0.6	15
Cultivators (professional)	4-stroke	7	360	0.6	8
Hedge cutters (private)	2-stroke	0.9	10	0.5	10
Hedge cutters (professional)	2-stroke	2	300	0.5	4
Lawn movers (private)	4-stroke	2.5 (2000) 3.5 (2004)	25	0.4	8
Lawn movers (professional)	4-stroke	2.5 (2000) 3.5 (2004)	250	0.4	4
Riders (private)	4-stroke	11	50	0.5	12
Riders (professional)	4-stroke	13	330	0.5	5
Shrub clearers (private)	2-stroke	1	15	0.6	10
Shrub clearers (professional)	2-stroke	2	300	0.6	4
Trimmers (private)	2-stroke	0.9	20	0.5	10
Trimmers (professional)	2-stroke	0.9	200	0.5	4

Stock and operational data for **other machines in household and gardening**

Machinery type	Engine	No.	Size (kW)	Hours	Load factor	Lifetime (yrs)
Chippers	2-stroke	200	10	100	0.7	10
Garden shredders	2-stroke	500	3	20	0.7	10
Other (gasoline)	2-stroke	200	2	20	0.5	10
Suction machines	2-stroke	300	4	80	0.5	10
Wood cutters	4-stroke	100	4	15	0.5	10

Operational data for **recreational craft**

Fuel type	Vessel type	Engine type	Stroke	Hours	Lifetime	Load factor
Gasoline	Other boats (<20 ft)	Out board engine	2-stroke	30	10	0.5
Gasoline	Other boats (<20 ft)	Out board engine	4-stroke	30	10	0.5
Gasoline	Yawls and cabin boats	Out board engine	2-stroke	50	10	0.5
Gasoline	Yawls and cabin boats	Out board engine	4-stroke	50	10	0.5
Gasoline	Sailing boats (<26ft)	Out board engine	2-stroke	5	10	0.5
Gasoline	Sailing boats (<26ft)	Out board engine	4-stroke	5	10	0.5
Gasoline	Speed boats	In board engine	4-stroke	75	10	0.5
Gasoline	Speed boats	Out board engine	2-stroke	50	10	0.5
Gasoline	Speed boats	Out board engine	4-stroke	50	10	0.5
Gasoline	Water scooters	Built in	2-stroke	10	10	0.5
Gasoline	Water scooters	Built in	4-stroke	10	10	0.5
Diesel	Motor boats (27-34 ft)	In board engine		150	15	0.5
Diesel	Motor boats (>34 ft)	In board engine		100	15	0.5
Diesel	Motor boats (<27 ft)	In board engine		75	15	0.5
Diesel	Motor sailors	In board engine		75	15	0.5
Diesel	Sailing boats (<26ft)	In board engine		25	15	0.5

Annex 3C

Industrial Processes. CRF sector 2

No annexes for industry 2004

Agriculture

Background data for CRF, table 4.A
Enteric Fermentation

Table 1 Detailed information related to the feed intake 1990 - 2004

IPCC livestock category	Subcategory	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
		Average feed intake (MJ/head/day)														
Dairy cattle	Large breed and Jersey	278.2	278.4	278.6	278.8	295.3	295.6	295.8	295.9	297.9	297.9	297.9	304.2	310.5	317.8	323.5
Non-dairy cattle	Heifer. bull. calves. suckling cattle	96.1	96.3	96.8	97.3	96.6	96.6	96.8	97.2	97.0	98.4	98.4	99.8	99.7	99.3	95.5
Sheep	Covers mother sheep incl. lambs	43.6	43.6	43.6	43.6	43.6	43.6	43.6	43.6	43.6	43.6	43.6	43.6	43.6	43.6	43.6
Goats	Covers mother goats incl. kids	40.1	40.1	40.1	40.1	40.1	40.1	40.1	40.1	40.1	40.1	40.1	40.1	40.1	40.1	40.1
Horses		130.1	130.1	130.1	130.1	130.1	130.1	130.1	130.1	130.1	130.1	130.1	130.1	130.1	130.1	130.1
Swine	Sows. slaughter pigs. piglets	27.1	27.9	28.5	27.9	28.0	27.3	28.2	28.0	27.9	28.3	28.3	28.0	28.2	27.9	28.4
Poultry	Laying hens, broilers, ducks, turkeys, geese	NE	NE	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	NE	NE

Table 2 Cattle and swine subcategories 2004

IPCC livestock category	Subcategory	2004
		Feed intake (MJ/head/day)
Dairy Cattle	Average	**323.5**
	Large breed	330.6
	Jersey	274.7
Non-dairy cattle	Average	**95.5**
	Calves. bull < ½ year	63.8
	Calves. heifer <½ year	41.2
	Bull >½ year	109.4

	Heifer >½ year	99.8
	Suckling cattle	170.2
Swine	Average	**284**
	Sows	69.1
	Piglets and slaughter pigs	24.5

Background data for CRF - table 4.A
Enteric Fermentation – additional information

Table 3 Detailed information - the feeding situation for cattle

Feeding situation	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
						Feeding in stable (percentage)									
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	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	1.00	1.00
Bulls (> ½ year)	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	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	1.00	1.00
Heifer (> ½ year)	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	0.46	0.46
Cattle for suckling[a]	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	0.39	0.39

[a]In CRF table 4.A Additional information for the category "Non-Dairy Cattle" is cover data for the subcategory Heifer (> ½ year).

Table 4 Dairy Cattle - milk yield

Milk yield	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Kg milk/cow/day	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	21.67	22.22
Kg milk/cow/year	6231	6187	6288	6560	6533	6628	6872	7001	7118	7252	7308	7416	7525	7911	8000

Table 5 Detailed information for digestibility - Cattle

Digestibility of feed	In stable (pct.)	On grass (pct.)
Dairy cattle	71	78
Bull-calves	79	79
Bulls (> ½ year)	75	78
Heifer-calves	78	78

Heifer (> ½ year)	71	78
Cattle for suckling	67	77

Annex 3

Background data for CRF, table 4.B(a)
CH_4 Emissions from Manure Management

Table 6

IPCC livestock category	Acs content	Typical animal mass	VS daily excretion	Comments
	1990-2004	1990-2004	1990-2004	
		Average kg	Average VS kg DM/head/year	
Dairy cattle	8%	575.0	1600.0	Varies slightly due to changes in stable type - see table 8
Non-dairy cattle (heifer > ½ year)	8%	325.0	300.0	Varies slightly due to changes in stable type - see table 9
Sheep (mother)	8%	70.0	86.0	
Goats (mother)	8%	60.0	84.0	
Horses	8%	600.0	520.0	
Swine (slaughter pigs)	2,2%	76.0	22.0	Varies slightly due to changes in stable type - see table 10
Poultry (Broilers)	8%	2.0	0.3	

Table 7 Detailed information related to the VS daily excretion for dairy cattle 1990 and 2004

Livestock category	Stable type		Manure type	Methane convention factor - MCF	Distribution of stable type 2004	Vs daily excretion kg VS/ head/yr 2004	Distribution of stable type 1990	Vs daily excretion kg VS/prod. head/yr 1990
Dairy cattle	Tethered with liquid and solid manure		Solid manure	1	0.06	1317	0.35	1317
(large breed)		+	Liquid	10	0.06	225	0.35	225
	Tethered with slurry		Slurry	10	0.16	1473	0.44	1473
	Loose-housing with beds, slatted floor		Slurry	10	0.44	1473	0.13	1473
	Loose-housing with beds, slatted floor, scrapes		Slurry	10	0.06	1473	0.01	1473

	Loose-housing with beds, solid floor		Slurry	10	0.17	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					**1618**		**1539**

Table 8 VS daily excretion for heifer > ½ year 1990 and 2004

Livestock category	Stable type		Manure type	Methane convention factor - MCF	Distribution of stable type 2004	Vs daily excretion kg VS/prod. head/yr 2004	Distribution of stable type 1990	Vs daily excretion kg VS/prod. head/yr 1990
Heifer								
> ½ year*	Tethered with liquid and solid manure		Solid manure	1	0.07	216	0.19	255
		+	Liquid	10	0.07	29	0.19	35
	Tethered with slurry		Slurry	10	0.07	235	0.19	279
	Slatted floor-boxes		Slurry	10	0.30	191	0.40	227
	Loose-holding with beds, slatted floor		Slurry	10	0.21	235	0.04	279
	Deep litter (all)		Deep litter	1	0.00	446	0.03	528
	Deep litter, solid floor		Deep litter	1	0.26	394	0.09	467
	Deep litter, slatted floor		Deep litter	1	0.05	340	0.04	403
		+	Slurry	10	0.05	77	0.04	91
	Deep litter, slatted floor, scrapes		Deep litter	1	0.01	340	0.01	403
		+	Slurry	10	0.01	77	0.01	91
	Deep litter, solid floor, scrapes		Deep litter	1	0.03	340	0.01	403
		+	Slurry	10	0.03	77	0.01	91
	Average VS daily excretion					**299**		**310**

* is the largest subcategory

Table 9 VS daily excretion for swine 19990 and 2003

Livestock	Stable type	Manure type	Methane conven-	Distribution of	Vs daily excretion	Distribution of	Vs daily excretion

category			tion factor - MCF	stable type 2003	kg VS/prod. head/yr 2003	stable type 1990	kg VS/prod. head/yr 1990
Slaughter pigs	Full slatted floor	Slurry	10	0.55	22	0.51	22
	Partly slatted floor	Slurry	10	0.38	24	0.23	24
	Solid floor	Solid manure	1	0.03	16	0.22	16
		+ Liquid	10	0.03	5	0.22	5
	Deep litter	Deep litter	1	0.01	42	0.04	42
	Partly slatted floor and partly deep litter	Deep litter	1	0.05	20	0.00	20
		+ Slurry	10	0.05	11	0.00	11
	Average VS daily excretion				**23.2**		**22.8**

Table 10 Changes in stable type 1990 – 2004

Livestock categories	Stable type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
								pct								
Horses		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Cattle																
Bull, 0-6 mth.	Deep litter (boxes)	100	100	100	100	100	100	100	100	100	100	100	91	86	82	77
	Deep litter, solid floor	0	0	0	0	0	0	0	0	0	0	0	9	14	18	23
Bull, 6 mth.-440 kg (jersey = 328 kg)	Tethered with liquid and solid manure	20	19	17	16	15	14	13	12	11	11	10	9	8	8	7
	Tethered with slurry	20	19	17	16	15	14	13	12	11	11	10	9	8	8	87
	Slatted floor-boxes	41	40	40	39	38	37	37	36	35	34	33	32	31	30	28
	Deep litter (all)	3	3	2	2	2	1	1	0	0	0	0	0	0	0	0
	Deep litter, solid floor	10	12	14	16	18	20	22	24	27	29	33	37	41	45	48
	Deep litter, slatted floor	4	5	6	7	8	8	9	10	11	10	9	8	7	5	6
	Deep litter, slatted floor, scrapes	1	1	1	1	1	2	2	2	2	2	2	2	2	1	1
	Deep litter, solid floor, scrapes	1	2	2	2	2	3	3	3	3	3	3	3	3	3	3
Heifer, 0-6 mth.	Deep litter (boxes)	100	100	100	100	100	100	100	100	100	100	100	89	84	83	80
	Deep litter, solid floor	0	0	0	0	0	0	0	0	0	0	0	11	16	17	20
Heifer, 6 mth.-calving	Tethered with liquid and solid manure	19	18	17	16	15	13	12	11	10	10	9	8	7	7	5
	Tethered with slurry	19	18	17	16	15	13	12	11	10	10	9	8	7	7	5
	Slatted floor-boxes	40	39	38	37	36	35	34	33	33	32	32	31	30	30	29
	Loose-housing with beds, slatted floor	4	4	5	6	7	7	8	10	12	13	14	17	20	21	23
	Deep litter (all)	3	3	2	2	2	1	1	0	0	0	0	0	0	0	0

	Deep litter, solid floor	9	11	13	15	17	18	22	24	24	24	25	26	26	26	28
	Deep litter, slatted floor	4	4	5	6	7	7	7	7	6	6	6	5	5	5	5
	Deep litter, slatted floor, scrapes	1	1	1	1	1	1	1	1	2	2	2	2	2	1	2
	Deep litter, solid floor, scrapes	1	1	2	2	2	2	3	3	3	3	3	3	3	3	3
Dairy cows	Tethered with liquid and solid manure	35	35	34	33	32	31	30	30	30	30	18	15	12	8	6
	Tethered with slurry	44	43	43	43	43	42	42	36	30	30	28	25	23	18	16
	Loose-holding with beds, slatted floor	13	14	15	16	16	17	18	21	24	24	34	36	39	42	44
	Loose-holding with beds, slatted floor, scrapes	1	1	1	1	1	1	1	2	3	3	3	4	4	5	6
	Loose-holding with beds, solid floor	4	3	3	3	3	3	3	3	3	3	6	9	11	16	17
	Deep litter (all)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Deep litter, slatted floor	3	3	3	4	4	5	5	6	8	8	7	7	7	7	7
	Deep litter, slatted floor, scrapes	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
	Deep litter, solid floor, scrapes	1	1	1	1	1	1	1	2	2	2	3	3	3	3	3

Livestock categories	**Stable type**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
								pct								
Suckling cattle	Tethered with liquid and solid manure	10	10	10	10	10	10	10	10	10	10	9	8	7	4	5
	Deep litter (all)	73	69	66	62	59	55	52	48	45	45	45	44	43	44	43
	Deep litter, solid floor	17	21	24	28	31	35	38	42	45	45	46	48	50	52	52
Sheep and goats																
Sheep	Deep litter (all)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Goats	Deep litter (all)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Swine																
Sows	Full slatted floor	9	10	10	11	12	12	13	13	14	14	14	13	13	12	21
(incl. 22-25 pigs to 7.5 kg)	Partly slatted floor	56	57	57	57	57	57	57	57	57	57	56	55	54	53	51
	Solid floor	30	27	25	22	20	17	15	12	10	7	7	6	6	6	5
	Deep litter	5	5	5	6	6	7	7	8	9	9	10	10	10	10	11
	Deep litter + slatted floor	0	0	1	1	2	2	3	3	4	4	6	7	8	9	10
	Deep litter + solid floor	0	0	1	1	2	2	3	3	4	4	5	6	7	8	9
	Outdoor sows	0	0	1	1	1	2	2	2	3	3	3	3	2	2	2
Piglets, 7.5-30 kg	Fully slatted floor	54	57	60	57	54	51	49	46	43	40	38	36	35	33	31
	Partly slatted floor	20	20	20	24	27	31	34	38	41	45	47	49	50	52	54
	Solid floor	21	18	15	14	12	11	9	8	6	5	5	5	5	5	5
	Deep litter (to-clima stables)	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Deep litter + slatted floor	0	0	0	1	1	2	3	4	4	5	5	5	5	5	5

Slaugther pigs, 30-98.3 kg	Fully slatted floor	51	56	60	60	60	60	60	60	60	60	58	57	56	55	53
(75 kg slaugther weigt)	Partly slatted floor	23	21	20	21	23	24	25	26	28	29	31	33	34	35	38
	Solid floor	22	19	15	14	12	11	9	8	6	5	5	4	4	4	3
	Deep litter	4	4	5	4	4	3	3	2	2	1	1	1	1	1	1
	Partly slatted floor and partly deep litter	0	0	0	1	1	2	3	4	4	5	5	5	5	5	5
Poultry																
Outdoor hens (100 pcs.)		0	1	2	4	5	6	7	8	9	9	9	9	7	8	7
Ecological hens (100 pcs.)		0	1	2	4	5	6	7	10	12	14	15	15	15	16	16
Scrabe hens (100 pcs.)		11	11	12	12	13	13	13	15	17	18	18	17	19	18	20
Battery hens, manure house (100 pcs.)		54	52	49	47	44	41	39	36	32	29	26	26	23	23	20
Battery hens, manure tank (100 pcs.)		12	11	11	10	9	8	7	6	6	5	5	5	4	5	4
Battery hens, manure cellar (100 pcs.)		23	23	24	24	25	25	26	25	25	24	27	27	32	30	33
HPR-hens (egg for hatching) (100 pcs.)		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Pullet, consumption, net (100 pcs.)		17	16	15	14	13	12	11	10	8	7	8	7	6	7	5
Pullet, consumption, floor (100 pcs.)		57	58	60	61	62	63	64	65	66	67	69	67	69	68	69
Pullet, egg for hatching (100 pcs.)		26	26	26	26	26	26	26	26	26	26	23	25	25	25	26
Livestock categories	**Stable type**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
								pct								
Broilers, conv. 39 days) (1000 pcs.)		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Broilers, skrabe(81 days) (1000 pcs.)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Broilers, ecological (81 days) (1000 pcs.)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turkey, male (100 pcs.)		50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Turkey, female (100 pcs.)		50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Ducks (100 pcs.)		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Geese (100 pcs.)		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Fur farming																
Mink	Slurry system	18	20	20	22	23	25	26	28	29	30	42	50	55	60	65
	Solid manure and black liquid	82	80	80	78	77	75	74	73	71	70	58	50	45	40	35
Foxes	Slurry system	0	0	0	0	0	0	0	0	0	0	2	5	10	15	30
	Solid manure and black liquid	100	100	100	100	100	100	100	100	100	100	98	95	90	85	70

Livestock Category	**Stable type**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
						pct.										

Cattle																
	Tethered in stables	79	78	77	76	74	73	72	66	60	60	46	40	35	26	22
	Loose-housing with beds	57	57	58	58	59	59	60	57	54	54	62	61	62	60	60
	Deep litter	14	15	16	17	17	18	19	23	27	27	37	40	43	47	50
Swine																
	Fully slatted floor	51	56	60	60	60	60	60	60	60	60	58	57	56	55	53
	Partly slatted floor	23	21	20	21	23	24	25	26	28	29	31	33	34	35	38
	Solid floor	22	19	15	14	12	11	9	8	6	5	5	4	4	4	3
	Deep litter	4	4	5	4	4	3	3	2	2	1	1	1	1	1	1

Reference: The Danish Agricultural Advisory Centre

Table 11 Background data for estimation of N_2O emission from crop residue 2004

	Stubble	Husks	Top	Leafs	Frequency of ploughing	Nitrogen content in crop residue	
Crop type	kg N/ha	kg N/ha	kg N/ha	kg N/ha	No. of year before ploughing	kg N/ha/yr	M kg N/yr
Winter wheat	6.3	10.7	-	-	1	17.0	11.05
Spring wheat	6.3	7.4	-	-	1	13.7	0.22
Winter rye	6.3	10.7	-	-	1	17.0	0.53
Triticale	6.3	10.7	-	-	1	17.0	0.69
Winter barley	6.3	5.9	-	-	1	11.3	1.49
Spring barley	6.3	4.1	-	-	1	10.4	5.94
Oats	6.3	4.1	-	-	1	10.4	0.57
Winter rape	4.4	-	-	-	1	4.4	0.53
Spring rape	4.4	-	-	-	1	4.4	0.01
Potatoes (top), non-harvest	-	-	48.7	-	1	48.7	2.00
Beet (top), non-harvest	-	-	54.4[a]	-	1	54.4	3.03
Straw, non-harvest	-	-	-	-	1	7.6[a]	8.97
Pulse	11.3	-	-	-	1	11.3	0.30
Lucerne	32.3	-	-	-	3	10.8	0.04
Maize – for green fodder	6.3	-	-	-	1	6.3	0.81
Cereal – for green fodder	6.3	-	-	-	1	6.3	0.64

Pulses, fodder cabbage and other green fodder	6.3	-	-	-	1	6.3	0.00
Peas for canning	11.3	-	-	-	1	11.3	0.03
Vegetable	11.3	-	-	-	1	11.3	0.08
Grass- and clover fiel in rotation	32.3		-	10.0	2	26.2	5.14
Grass- and clover field out of rotation	38.8		-	20.0	-	20.0	3.45
Aftermath	6.3	-	-	-	1	6.3	0.96
Seeds of grass crops	6.3	10.7	-	-	2	13.9	1.15
Set-a-side	38.8	-	-	15.0	10	18.9	3.93
Total N from crop residue - 2003							51.55

[a] express the yield for 2003 - varies from year to year. Based on yield datta from Statistics Denmark and N-content from the feeding plan.
Reference: Djurhuus and Hansen 2003

A1. Emission from organic soils. Literature, data corrected to average Danish climate (Svend E. Olesen, Danish Institute of Agricultural Sciences).

Crop	Country	Peat type	Depth, m	Distance to water table, m	climate corr. factor	Emission, C ha^{-1} y^{-1}	Source
Permanent grass	Finland	Fen/moor	?	not drained		-0.6-0.9	Tolonen & Turonen (1996)
	Holland	Fen/moor	>1.0	0.3-0.4	0.7	0.5-1.0	Shothorst (1977)
	Holland	Fen/moor	>1.0	0.55-0.6	0.7	1.2-2.1	Shothorst (1977)
	Holland	Fen/moor	>1.0	0.7	0.7	2.4-2.8	Shothorst (1977)
	Germany	Fen/moor	0.5	0.3	0.6	1.7	Mundel (1976)
	Germany	Fen/moor	0.5	0.6	0.6	2.4	Mundel (1976)
	Germany	Fen/moor	0.5	0.9-1.2	0.6	2.5	Mundel (1976)
	Germany	Fen/moor	>1.0	0.3	0.6	1.8	Mundel (1976)
	Germany	Fen/moor	>1.0	0.6	0.6	3.3	Mundel (1976)
	Germany	Fen/moor	>1.0	0.9-1.2	0.6	3.9	Mundel (1976)
	Holland	Fen/moor	>1.0	0.3-0.5	0.7	2.0	Langeveld et al. (1997)
	Denmark	Raised bog	>1.0	drained	1.0	5.6	Pedersen (1978)
	Denmark	Raised bog	>1.0	drained	1.0	4.5	Pedersen (1978)
	Sweden	Fen/moor	>1.0?	drained	1.2	2.0	Staff (2001) e. Berglund (1989)
	Finland	Fen/moor	>1.0	0.2-1.2	2.0	3.6	Nykänen et al. (1995)
	Scotland	Hill blanket	>0.5	drained?	2.0	5.7	Chapman & Thurlow, 1996
	Scotland	Hill blanket	>0.5	drained?	2.0	4.4	Chapman & Thurlow, 1996
Grass in rotation	Finland	Fen/moor	0.2	drained	2.0	15.0	Maljanen et al, (2001)
	Finland	Fen/moor	>1.0	0.2-1.2	2.0	11.8	Nykänen et al. (1995)
	Finland	Fen/moor	?	drained	2.0	1.6	Lohila et al. (2004)
	Finland	Fen/moor	0.3	drained	2.0	6.6	Maljanen et al. 2004
	Finland	Fen/moor	0.7	drained	2.0	9.2	Maljanen et al. 2004
	Sweden	Fen/moor	>1.0?	drained	1.2	3.8	Staff (2001) e. Berglund (1989)
	Sweden	Fen/moor	>1.0?	drained	1.2	5.1-10.4	Kasismir et al.(1997) e. Berglund(1989)
Cereals	Finland	Fen/moor	>0.4	0.8-1.0	2.0	4.2	Lohila et al. (2004)
	Finland	Fen/moor	0.2	drained	2.0	8.0	Maljanen et al. (2001)
	Finland	Fen/moor	0.3	drained	2.0	16.6	Maljanen et al. 2004
	Finland	Fen/moor	0.7	drained	2.0	16.6	Maljanen et al. 2004
	Sweden	Fen/moor	>1.0?	drained	1.2	5.8	Staff (2001) e. Berglund (1989)
	Sweden	Fen/moor	>1.0?	drained	1.2	10.4-20.9	Kasismir et al.(1997) e. Berglund(1989)
Row crops	Sweden	Fen/moor	>1.0?	drained	1.2	9.3	Staff (2001) e. Berglund (1989)
	Sweden	Fen/moor	>1.0?	drained	1.2	20.9-31.0	Kasismir et al.(1997) e. Berglund(1989)

A2 Output of Excel model used for calculation of the amounts of CO_2 sequestered due to afforestation since 1990.

Table A2.1. Main output table giving areas and annual and cumulated uptake of CO_2.

CO2-sinks due to national afforestation programme

		Afforestation area, ha				Total CO2 uptake	
Planting year	**Years after establishment**	**Broadleaves**	**Conifers**	**Total**	**Cumulated area since 1990**	**Annual, Gg/yr**	**Cumulated, Gg**
1990	0	320	410	730	730	0	0
1991	1	527	466	993	1723	1	1
1992	2	721	534	1255	2978	3	4
1993	3	738	542	1280	4258	5	10
1994	4	912	579	1491	5749	8	17
1995	5	790	536	1326	7075	10	28
1996	6	833	543	1376	8451	16	44
1997	7	1614	646	2260	10711	24	68
1998	8	912	493	1405	12116	34	102
1999	9	3613	810	4423	16539	43	145
2000	10	2115	638	2753	19292	59	204
2001	11	1570	554	2124	21416	74	277
2002	12	1824	514	2338	23754	88	365
2003	13	1991	556	2547	26301	108	473

TableA2.2. 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, CO2/ha/yr	t Storage, t CO2/ha	Increment, CO2/ha/yr	t 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
2003	13	9	68	9	68	12	79	12	79	0

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

Table A2.3

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	2003
	Area	320	527	721	738	912	790	833	1614	912	3613	2115	1570	1824	1991
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	7732	0			
2001	11	2739	3383	4629	4738	5855	5072	1783	3454	1952	7732	4526	0		
2002	12	2739	4511	4629	4738	5855	5072	5348	3454	1952	7732	4526	3360	0	
2003	13	2739	4511	6172	4738	5855	5072	5348	10362	1952	7732	4526	3360	3903	0

Table A2.4

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	2003
	Area (ha)	410	466	534	542	579	536	543	646	493	810	638	554	514	556
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	1118	0			
2001	11	5092	3215	3685	3740	3995	3698	749	891	680	1118	880	0		
2002	12	5092	5788	3685	3740	3995	3698	3747	891	680	1118	880	765	0	
2003	13	5092	5788	6632	3740	3995	3698	3747	4457	680	1118	880	765	709	0

Annex 3E Waste

Solid Waste Disposal on Land

The starting year for the FOD model used is 1960, using historic data for waste amounts. ISAG registration of waste amounts does not go this far back, but, for the time series 1990-2003 to be reported here, this does not play a significant role with regard to time-series consistency.

In Table 3E.1, results from the calculations from the model for selected years 1970-1979 are presented to illustrate how the model performs. The first and second column from the left represent the time-series for potential emissions. Actual emissions are presented in the next column, as totals. In the “From year”columns, the contributions of emissions from all individual previous years from 1960 to the actual year’s emission (i.e. the Total) are presented. For example, the contribution from the waste deposited in 1970 to the actual emission total (potential emission in 1970 =39.2) was 2.63 in 1970. In 1971, the contribution from the waste deposited in 1970 was 2.45. In 1972, it was 2.29 and so on. Summing the 1970 column for the ten years in the period shown in the table, the result is 19.6. This corresponds with the half-life being 10 years, which means that half of the potential emission of 39.2 is then emitted after 10 years. The reason for using the historic time-series, 1970 to 1979, in this illustration is simply that this also illustrates the open empty triangle where no contributions are added.

Table 3E.1 Results from the FOD model 1970-1979

Year	Emissions [kt]																					
	Po ten tial	Actual																				
			From year																			
		Total	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1970	39,2	20,9	1,31	1,41	1,51	1,62	1,73	1,86	1,99	2,13	2,29	2,45	2,63									
1971	42,8	22,4	1,23	1,31	1,41	1,51	1,62	1,73	1,86	1,99	2,13	2,29	2,45	2,86								
1972	46,3	24,0	1,14	1,23	1,31	1,41	1,51	1,62	1,73	1,86	1,99	2,13	2,29	2,67	3,10							
1973	49,9	25,7	1,07	1,14	1,23	1,31	1,41	1,51	1,62	1,73	1,86	1,99	2,13	2,49	2,90	3,34						
1974	53,5	27,6	1,00	1,07	1,14	1,23	1,31	1,41	1,51	1,62	1,73	1,86	1,99	2,33	2,70	3,12	3,58					
1975	57,0	29,6	0,93	1,00	1,07	1,14	1,23	1,31	1,41	1,51	1,62	1,73	1,86	2,17	2,52	2,91	3,34	3,82				
1976	60,6	31,6	0,87	0,93	1,00	1,07	1,14	1,23	1,31	1,41	1,51	1,62	1,73	2,03	2,35	2,71	3,12	3,56	4,06			
1977	64,2	33,8	0,81	0,87	0,93	1,00	1,07	1,14	1,23	1,31	1,41	1,51	1,62	1,89	2,19	2,53	2,91	3,33	3,79	4,30		
1978	67,7	36,1	0,75	0,81	0,87	0,93	1,00	1,07	1,14	1,23	1,31	1,41	1,51	1,76	2,05	2,36	2,71	3,10	3,53	4,01	4,54	
1979	71,3	38,4	0,70	0,75	0,81	0,87	0,93	1,00	1,07	1,14	1,23	1,31	1,41	1,65	1,91	2,20	2,53	2,89	3,30	3,74	4,23	4,77
												total	19,6									

The result of summing this table horizontally in the “From year” rows is the total actual emission (the third coulumn) of that year.

Wastewater treatment plants (6B)

Background

Wastewater treated by wastewater treatment plants (WWTPs) comprises domestic and industrial wastewater as well as rainwater. 90% of Danish households are connected to a municipal sewer system. The WWTPs have been upgraded significantly since 1987 when the first Action Plan for the Aquatic Environment was launched by the Danish parliament. The plan included stricter emission standards for WWTPs with a capacity above 5000 PE for nutrients and organic matter and, thus, rendered technological upgrading of the majority of Danish WWTPs necessary.

In 2002, there were 1 267 Danish WWTPs larger than 30 person equivalents (PE), Table 3E.2.

One PE expresses how much one person pollutes, i.e. 1 PE being defined as 21.9 kg BOD/year. BOD is the Biological Oxygen Demand, which is a measure of total degradable organic matter in wastewater. The WWWTP capacity is calculated based on the amount of organic matter in the influent wastewater and converted to number of PEs irrespective of the origin of the wastewater, i.e. household or industry. Therefore, it is not possible to calculate the emission contribution from industry and household separately. The percentage contribution from industry is, however, known (cf. Table 3E.3).

Table 3E.2. Size distributions of the Danish WWTPs in the year 2002.

WWTP capacity	*Number of WWTPs*	*Load in % of total load on all WWTPs*
>30 PE	1267	100
>500 PE	658	99
>2 000 PE	441	98
>5 000 PE	274	93
>15 000 PE	130	83
>50 000 PE	63	68
>100 000 PE	30	48

In 1989, only 10% of wastewater treatment processing included reduction of N, P and BOD; in 1996, the number was 76%. Today, 85% of total wastewater is treated at so-called MBNDC-WWTPs (i.e. WWTPS including Mechanical, Biological, Nitrification, Denitrification and Chemical treatment processes), which is indicative of a high removal of N, P and DOC at the WWTPs.

Since 1987, the fraction of industrial influent wastewater load at municipal and private WWTPs has increased from zero to around 40 % from 1999 and forward. The proportion of wastewater discharged to city sewers from industrial sources, contributing to the influent wastewater load in the national WWTPs is given as a percentage based on PEs (1 PE = 60g BOD/day) in Table 3E.3.

Table 3E.3. The proportion of wastewater from industrial sources discharged to city sewers, i.e. industrial load of wastewater relative to total influent load at WWTPs*.

	1984-1993	*1993*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*
% industrial load	0-5	5	-	48	41	42	38	38	37	40

* based on information on influent loads in wastewater amounts and/or the amount of organic matter in the industry catchment area belonging to each WWTP.

Today, about one fifth of the largest WWTPs treat almost 90% of the total volume of sewage in Denmark. Typically, these plants have mechanical treatment and biological treatment, including removal of nitrogen and organic matter in activated sludge systems, a chemical precipitation step and finally settling of suspended particles in a clarifier tank. The chemical processes include lime stabilisation. Many WWTPs are, in addition to this, equipped with a filter or lagoon after the settling step. Overall stabilisation can be split into two processes, i.e. a biological and a chemical process. The biological processes include anaerobic stabilisation where the sludge is digested in a digesting tank and aerobic stabilisation by long-term aeration (DEPA, 2002). In addition to hygienisation, dewatering and stabilisation of the sludge, the sludge may be mineralised, composted, dried or combusted. A storage time of 3 to 6 months applies in relation to composting and sanitation. For plants with sludge mineralisation, the storage time is about 10 years.

At this point in time, data are available at national level. The wastewater treatment processes are divided into the following steps:

M = Mechanical
B = Biological
N = Nitrification (removal of nitrogen)
D = Denitrification (removal of ammonia)
C = Chemical

In general, the more steps the higher the cleaning level regarding nitrogen, phosphorous and dissolved organic matter (DOC). The technological development and increased level of cleaning wastewater is clearly observed by the percentage reduction in the effluent amount of nitrogen, phosphor and DOC of 81%, 93% and 96%, respectively, in 2003. The development in the effectiveness of reducing the nutrient content of the effluent wastewater is shown in Table 3E.4.

Table 3E.4. Per cent reduction in nutrient content of effluent wastewater.

Effluent % reduction	*1993*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*
BOD	93	87	92	79	94	94	95	96	96	96	95
N	64	56	68	66	74	74	77	79	77	81	80
P	76	80	85	91	90	90	91	92	91	93	96

Quality Check and verification - Methane

Country-specific Total degradable Organic Waste (TOW)

The total organic waste in kg BOD/year based on country-specific data is given in Table 3E.5. Activity data on influent TOW are needed for the unit of tonnes BOD /year, which is obtained by using the volume of total annual influent water multiplied by the measured BOD in the inlet wastewater given in the second row of Table 3E.5-(DEPA 1994, 1996, 1997, 1998, 1999, 2001, 2002, 2003 and 2004). Values for BOD were provided by DEPA (personal communication for 1993, 2002-2004).

Table 3E.5 Total degradable organic waste (TOW) calculated by use of country-specific data.

Year	1993	1999	2000	2001	2002	2003	2004
BOD (mg/L)	129.6*	160	175	203	189	262	
Influent water (million m^3 / year)	-	825	825	720	809	611	
TOW_{BOD} (tonnes BOD/year)	99750	132000	144375	146160	152497	159858	143091
TOW_{COD} (tonnes BOD/year)**		148500	138600	142560	159858	160571	163026
$TOW_{average}$***		140250	141488	144360	156178	160214	153059

*BOD for the year 1993 is given in 1000 tonnes, whereas the amount of influent water is not given (DEPA, 1994).
** Calculated from country-specific COD data by use of BOD = COD/2.5.
*** $TOW_{average}$=(TOW_{BOD}+ TOW_{COD})/2

The total organic waste in kg BOD/year based on the IPCC default method is given in Table 3E.6. The default region-specific TOW value is 18,250 kg/ BOD/1,000 persons/yr (IPCC GL, page 6.23, Table 6-5) for Europe. The total organic degradable waste is estimated by multiplying the default value by the population number. In addition, the default TOW data are increased by the percentage contribution from industry in order to investigate the comparability by including this correction factor for the “missing” industrial contribution to the influent load TOW.

Table 3E.6. Total degradable organic waste (TOW) calculated by use of the IPCC default BOD value for European countries.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Population-Estimates (1000)	5140	5153	5170	5188	5208	5228	5248	5268	5287	5305	5322	5338	5351.0	5384	5398
TOW (tons BOD/year), default BOD IPCC	93805	94042	94353	94681	95046	95411	95776	96141	96488	96816	97127	97419	97656	98249	98507
Contribution from industrial inlet BOD	2.5	2.5	2.5	5.0	15.5	23.9	32.3	40.7	48.0	41.0	42.0	38.0	38.0	37.0	40.5
TOW (tons BOD/year), default BOD IPCC corrected for industrial contribution	96150	96393	96711	99415	109778	118214	126712	135270	142802	136511	137920	134438	137044	139511	138388

By comparing the estimated TOW by use of country-specific data (cf. Table 3E.5) and TOW by use of default European data on the inlet BOD (cf. Table 3E.6), it can be observed that the default parameter method seems to underestimate TOW. By increasing the default TOW data according to the industrial contribution to the TOW, the degree of underestimation becomes less significant.

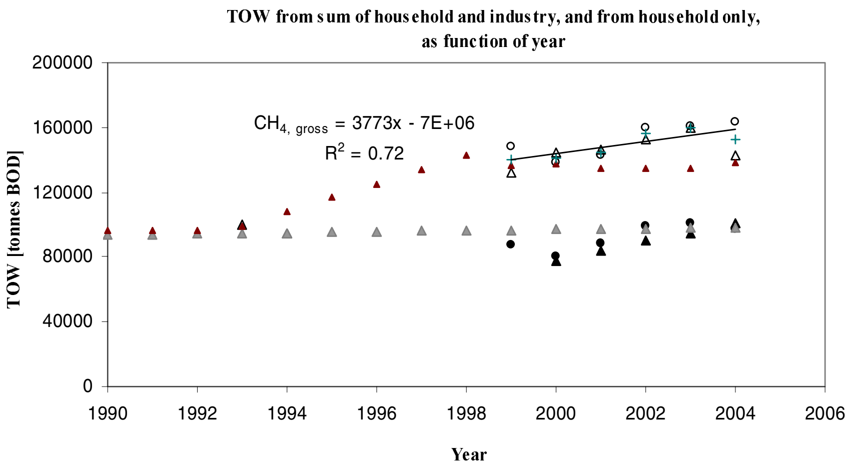

Figure 3E.1. Open triangles represent measured BOD data; open circles measured COD data; black triangles and circles, the measured BOD and COD data minus the reported industrial influents load, respectively. The grey triangles represent the TOW calculated based on the default IPCC method and the brown triangles represent the case where the industrial influent load has been added. The BOD and COD derived TOW data, representing household wastewater, only show that the BOD derived data has a steep slope which would make the influent load from household become negative in around 1995. The BOD derived TOW data point from 1993 fits the brown data point well. The default methodology adding the percentage corresponding to the industrial influent was used from 1990 to 1998, after which the average of the national statistics on measured BOD and COD reported TOW data was used (blue crosses).

Based on mean values and standard deviation of TOW from Table 3E.5 and the last row of

Table 3E.6, an estimate of the maximum uncertainty for TOW is 20 %.

EF used for calculating the Gross emission of Methane

The emission factor (EF) is found by multiplying the maximum methane-producing capacity (Bo) with the fraction of BOD that will ultimately degrade anaerobically, i.e. the methane conversion factor (MCF). The default value for Bo, given in the IPCC GPG (page 5.17), of 0.6 kg CH4/kg BOD is used.

The fraction of sludge (in dry weight (dw) or wet weight (ww)) treated anaerobically is used as an estimate of the "fraction of BOD that will ultimately degrade anaerobically". This fraction, shown in Table 3E.7, is set equal to the MCF. In so doing, it is assumed that all of the sludge treated anaerobically is treated 100 % anaerobically and no weighted MCF is calculated. The relative percentages of sludge treated anaerobically, aerobically and by additional different stabilisation methods are given in Table 3E.7.

Table 3E.7. Stabilisation of sludge by different methods in tonnes dry weight (dw) and wet weight (ww), respectively DEPA 1989, 1999, 2001and 2003 a.

		Biological		Chemical		EF (IPCC 1996) [kg CH_4 / kg BOD]*
Year**	Units	Anaerobic	Aerobic	Other	total	
1987	Sludge amount in tonnes dw	52401	24364	48760	125525	
1997		65368	66086	19705	151159	
1999		65268	70854	19499	155621	
2000		68047	69178	21677	158902	
2001		70992	68386	18638	158016	
2002		63500	58450	18071	140021	
1987	Sludge amount in % of total dw	41.7	19.4	38.9	100	0.25
1995		32	41	27	100	0.19
1996		32.7	41	26.3	100	0.20
1997		43.2	43.7	13.1	100	0.26
1999		41.9	45.5	12.5	100	0.25
2000		42.8	43.5	13.7	100	0.26
2001		45	43.3	11.7	100	0.27
2002		45	42	13	100	0.27
1997	Sludge amount in tonnes ww	363055	648686	149028	1160769	
1999		336654	829349	271949	1437952	
2000		459600	1110746	321427	1891773	
2001		494655	1217135	330229	2042019	
2002		262855	827703	279911	1370469	
1997	Sludge amount in % of total ww	31.3	55.9	12.8	100	0.19
1999		23.4	57.7	18.9	100	0.14
2000		24.3	58.7	17.0	100	0.15
2001		24.2	59.6	16.2	100	0.15
2002		19.2	60.4	20.4	100	0.12

*EF=Bo*MCF, where MCF equals the percentage of sludge treated anaerobically divided by 100 and Bo 0.6 kg CH4/kg BOD
**The report series "Private and municipal wastewater" including data from 2003 has not yet been released.

For comparison, both the emissions factors based on wet weight and dry weight are given in Table 3E.7 in the last column. The emission factor calculated from the dry weight fractions is fairly constant from year 1997 to 2002. It seems reasonable to assume a constant emission factor of 0.26 kg CH_4 / kg BOD based on the dry weight fraction of sludge treated anaerobically and an emission factor of 0.15 kg CH4 / kg BOD based on the wet weight fraction of sludge treated anaerobically. The emission factor based on wet weight is used for calculating the gross CH_4 emission since it seems the most appropriate one to use when combined with BOD data in the emission calculation procedure.

The uncertainty in the fraction of wastewater treated anaerobically is judged by the average and spread of the average of the data given above. The anaerobic fraction data based on wet and dry weight are included. The uncertainty is estimated to be 28%.

Recovered and combusted methane potentials

The calculated theoretical CH_4 not emitted is given in Table 3E.8 below.

Table 3E.8. Theoretical CH_4 amount not emitted to the atmosphere [Gg]

Year	Regression by interpolation				Country-specific data			
	CH_4 potential, external combustion	CH_4 potential, internal combustion	CH_4 potential internal combusted and reused for production of sandblasting products	CH_4 potential used for production of biogas	CH_4 potential , external combustion	CH_4 potential, internal combustion	CH_4 potential internal combusted and reused for production of sandblasting products	CH_4 potential used for production of biogas
1987	2.34	4.91	0.76	0.17	2.33	4.67	1.53	0.00*
1990	2.39	4.67	1.20	0.24				
1991	2.41	4.60	1.34	0.27				
1992	2.43	4.52	1.49	0.30				
1993	2.44	4.44	1.63	0.32				
1994	2.46	4.36	1.78	0.35				
1995	2.47	4.29	1.92	0.38				
1996	2.49	4.21	2.07	0.40				
1997	2.51	4.13	2.21	0.43	1.87	4.70	0.24	0.48
1998	2.52	4.05	2.36	0.45				
1999	2.54	3.98	2.50	0.48	1.97	4.60	2.83	0.62
2000	2.56	3.90	2.65	0.51	4.72	2.35	4.57	0.51
2001	2.57	3.82	2.79	0.53	2.91	4.73	3.58	0.33
2002	2.59	3.75	2.94	0.56	1.22	3.19	2.80	0.26
2003	2.61	3.67	3.08	0.58				
2004	2.07	3.59	3.23	0.61				

*The biogas production is assumed zero in 1987.

Due to a lack of data, linear regression was performed based on the above country-specific CH_4 potentials, not emitted, from 1990 to 2002. Based on the targets for final sludge disposal categories defined in the "Waste strategy 2004-2008" (The Danish Government, 2002), the internal and external combustion is expected to remain at a constant level from 2003 and forward; the target value for combustion based on the above calculation method corresponds to 6.20 Gg (cf. Thomsen & Lyck, 2005).

The variation in time trends is high as illustrated in Figure 3.E.E. Based on the percent distance between country-specific data to regression line, an estimate of the average uncertainty is around 30%. The maximal uncertainty estimated for internal combustion is around 25%, while the uncertainty for external combustion, combustion for production of sandblasting product and biogas is around 70%. The variations/uncertainties are originating from the activity data given in Table 4.16 in the main report. The methane potential internally combusted and reused for production of sandblasting products is, however, expected to increase due to a target corresponding to an increase in the reuse of sludge corresponding to 7.75 Gg (cf. Thomsen & Lyck, 2005).

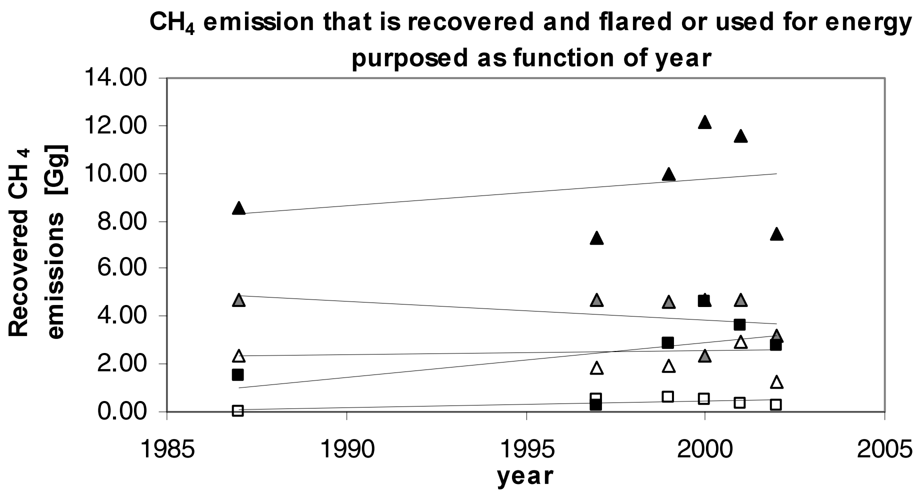

Figure 3.E.2. From top to bottom based on 1987 data points, the upper regression line represents the total methane potential not emitted. The grey triangles and decreasing regression line represent the trend in internal combusting. The open triangles and regression line of insignificant slope represents external combustion. The black squares and increasing regression line represent the methane potential internally combusted and reused for production of sandblasting products (corresponds to the category "Other" in Table 4.16 in the main document). Lastly, the open squares and regression line with no or slightly positive slope represent the methane potential used for biogas production.

Average emission data are based on regression estimates and country-specific data is reported where available. Regression estimates are used where no country-specific data are available (cf. Table 4.12 in the main report).

Quality Check and verification - Nitrous oxide

EF used for calculating the direct emission of N_2O

A German estimate of the emission factor for the direct emission of N_2O from wastewater treatment processes, not including industrial influents, is 7 g N_2O / person per year (Schøn et al, 1993). In an investigation for the Netherlands, the emission factor is suggested to be 3.2 g N_2O / person per year (Czepiel, Crill and Harries, 1995). As with the German estimated EF, this emission factor does not account for co-discharges of industrial nitrogen. To take into account the contribution from non-household nitrogen, Scheehle and Doorn (1997) suggest using the difference between residential (decentralised) WWTPs and the centralised loading averages of influent nitrogen. As the decentralised WWTPs are assumed to have no influent wastewater load from industry, and the centralised WWTPs receive most of the industrial wastewater, the difference in average influent loads may be used to derive an estimate of the fraction of industrial nitrogen in the influent load. The estimated fraction of influent nitrogen load for industry is used in combination with the Netherlands emission factor to arrive at an EF corrected for the nitrogen load industrial influent. In the United States, a correction factor of 1.25 was obtained, resulting in an emission factor of (1.25*3.2) 4 g N_2O / person per year (Scheehle and Doorn, 1997), including the influent load contribution from industrial nitrogen. An analoguous approach has been used for calculating the Danish direct emission of N_2O upon wastewater treatment.

Key data on nitrogen influent load distribution according to small, medium and large WWTPs are available from the Danish Water and Wastewater Association (Danva, 2001). The data are based on 20-25 WWTPs located in five large city areas in Denmark and are reported for the years 1998 to 2001. Based on these data an average factor of 3.52 was calculated as the average influent nitrogen for the large (centralised) WWTPs minus the average influent nitrogen load for the medium (decentralised) WWTPs divided by the average nitrogen load for the medium WWTPs.

Table 3E.9. Correction factors (CF) to adjust the emission factor (EF) to include influent loads of N to WWTPs from industry.

year	WWTP-large [tonne N / year]	WWTP-medium [tonne N/year]	CF	EF [N_2O /capita per year]
1987			1	3.2
1998	1081	233	3.64	11.7
1999	1042	220	3.74	12.0
2000	1016	222	3.58	11.5
2001	894	216	3.14	10.0

The use of this factor to correct the emission factor based on household wastewater only is based on the assumption that the emission factor is the same for household and industrial wastewater, respectively. The correction factor in 1987 is equal to 1, corresponding to zero contribution from industry. Emission factors are equal to CF * 3.2 g N_2O / person per year. The average resulting emission factor for direct emission of N_2O is (3.52*3.2) 11.3 g N_2O / person per year. However, the contribution to the Danish WWTPs from industry has changed from close to zero in 1984 to an average of 42 % since 1998. Therefore, the percentage industrial wastewater influent loads from 1987 (where it was zero) and the years 1998 to 2001, for which a corrected emission factor can be estimated, were used in a simple regression of % industrial wastewater influent load versus the corrected emission factors. Regression Equation 1 was used for estimating the emission factor for all years, 1990-2002.

Eq. 1: $EF_{N2O.WWTP.direct} = 0.1887 * I + 3.2816$

where I is the percentage industrial influent load.

Annex 3F

Solvents

National Atmospheric Inventory,
http://www.aeat.co.uk/netcen/airqual/naei/annreport/annrep99/app1_28.html

The emission inventory for Great Britain is prepared by the National Environmental Technology Centre, June 2000, and covers the following sectors:

Total emission
Energy Production
Comm+ Residn Combusn.
Industrial Combustion
Production Processes
Extr & Distrib of Fossil Fuels
Solvent Use
Road Transport
Other Transp & Mach
Waste Treatment & Disp
Nature (Forests)

For the following substances:

1 (1-methylethyl)cyclohexane
2 (1-methylpropyl)cyclohexane
3 (2-methyl-1-propyl)acetate
4 (2-methylbutyl)cyclohexane
5 (2-methylpropyl)cyclohexane
6 1-(2-butoxy-1-methyl-ethoxy)-2-propanol
7 1-(2-ethoxy-1-methyl-ethoxy)-2-propanol
8 1-(2-methoxy-1-methyl-ethoxy)2-propanol
9 1-(butoxyethoxy)-2-propanol
10 1,1,1-trichloroethane
11 1,1,1-trichlorotrifluoroethane
12 1,1,2,2-tetrachloroethane
13 1,1,2-trimethylcyclohexane
14 1,1,2-trimethylcyclopentane
15 1,1,3-trimethylcyclohexane
16 1,1,4,4-tetramethylcyclohexane
17 1,1-dichloroethane
18 1,1-dichloroethene
19 1,1-dichlorotetrafluoroethane
20 1,1-dimethylcyclohexane
21 1,1-dimethylcyclopentane
22 1,2,3,4-tetrahydronaphthalene
23 1,2,3,4-tetramethylbenzene
24 1,2,3,5-tetramethylbenzene
25 1,2,3,5-tetramethylcyclohexane
26 1,2,3-trichlorobenzene
27 1,2,3-trimethylbenzene
28 1,2,3-trimethylcyclohexane

29 1,2,3-trimethylcyclopentane
30 1,2,4,4-tetramethylcyclopentane
31 1,2,4,5-tetramethylbenzene
32 1,2,4-trichlorobenzene
33 1,2,4-trimethlycyclopentane
34 1,2,4-trimethylbenzene
35 1,2,4-trimethylcyclohexane
36 1,2,4-trimethylcyclopentane
37 1,2-diaminoethane
38 1,2-dibromoethane
39 1,2-dichlorobenzene
40 1,2-dichloroethane
41 1,2-dichloroethene
42 1,2-dichlorotetrafluoroethane
43 1,2-dimethyl-3-isopropylcyclopentane
44 1,2-dimethylcyclohexane
45 1,2-dimethylcyclopentane
46 1,2-ethanedioldiacetate
47 1,2-ethylmethylcyclopentane
48 1,2-propanediol
49 1,3,4,5,6-pentahydroxy-2-hexanone
50 1,3,5-trichlorobenzene
51 1,3,5-trimethylbenzene
52 1,3,5-trimethylcyclohexane
53 1,3-butadiene
54 1,3-dichlorobenzene
55 1,3-diethylbenzene
56 1,3-dimethyl-4-ethylbenzene
57 1,3-dimethyl-5-propylbenzene
58 1,3-dimethylcyclohexane
59 1,3-dimethylcyclopentane
60 1,3-dioxolane
61 1,3-ethylmethylcyclopentane
62 1,3-hexadiene
63 1,4-butyrolacetone
64 1,4-dichlorobenzene
65 1,4-diethylbenzene
66 1,4-dimethyl-2-isopropylbenzene
67 1,4-dimethylcyclohexane
68 1,4-dimethylpiperazine
69 1,4-dioxane
70 11-methyl-1-dodecanol
71 1-butanal
72 1-butanol
73 1-butene
74 1-butoxy-2-propanol
75 1-butyne
76 1-chloro-2,3-epoxypropane
77 1-chloro-4-nitrobenzene
78 1-chloropropane
79 1-decene
80 1-ethoxy-2-propanol
81 1-ethoxy-2-propyl acetate
82 1-ethyl-1,4-dimethylcyclohexane

83 1-ethyl-2,2,6-trimethylcyclohexane
84 1-ethyl-2,3-dimethylbenzene
85 1-ethyl-2,3-dimethylcyclohexane
86 1-ethyl-2-propylbenzene
87 1-ethyl-2-propylcyclohexane
88 1-ethyl-3,5-dimethylbenzene
89 1-ethyl-3-methylcyclohexane
90 1-ethyl-4-methylcyclohexane
91 1-ethylpropylbenzene
92 1-heptene
93 1-hexanal
94 1-hexene
95 1-hydrophenol
96 1-methoxy-2-ethanol
97 1-methoxy-2-propanol
98 1-methoxy-2-propyl acetate
99 1-methyl-1-phenylcyclopropane
100 1-methyl-1-propylcyclopentane
101 1-methyl-2-isopropylbenzene
102 1-methyl-2-propylbenzene
103 1-methyl-3-(isopropyl)benzene
104 1-methyl-3-isopropylcyclopentane
105 1-methyl-3-propylbenzene
106 1-methyl-4-isopropylbenzene
107 1-methyl-4-isopropylcyclohexane
108 1-methyl-4-tertbutylbenzene
109 1-methylbutylbenzene
110 1-methylindan
111 1-methylindene
112 1-nonene
113 1-octene
114 1-pentanal
115 1-pentanol
116 1-pentene
117 1-propanal
118 1-propanol
119 2-(2-aminoethylamino)ethanol
120 2-(2-butoxyethoxy)ethanol
121 2-(2-butoxyethoxy)ethyl acetate
122 2-(2-ethoxyethoxy)ethanol
123 2-(2-ethoxyethoxy)ethyl acetate
124 2-(2-hydroxy-ethoxy)ethanol
125 2-(2-hydroxy-propoxy)-1-propanol
126 2-(methoxyethoxy)ethanol
127 2,2,3,3-tetramethylhexane
128 2,2,4,6,6-pentamethylheptane
129 2,2,4-trimethyl-1,3-pentanediol
130 2,2,4-trimethylpentane
131 2,2,5-trimethylhexane
132 2,2-dimethylbutane
133 2,2-dimethylhexane
134 2,2-dimethylpentane
135 2,2-dimethylpropane
136 2,2′-iminodi(ethylamine)

137 2,2′-iminodiethanol
138 2,3,3,4-tetramethylpentane
139 2,3,3-trimethyl-1-butene
140 2,3,4-trimethylhexane
141 2,3,4-trimethylpentane
142 2,3,5-trimethylhexane
143 2,3-dimethylbutane
144 2,3-dimethylfuran
145 2,3-dimethylheptane
146 2,3-dimethylhexane
147 2,3-dimethylnonane
148 2,3-dimethyloctane
149 2,3-dimethylpentane
150 2,3-dimethylundecane
151 2,4,6-trichloro-1,3,5-triazine
152 2,4-difluoroaniline
153 2,4-dimethyl-1-(1-methylethyl)benzene
154 2,4-dimethylfuran
155 2,4-dimethylheptane
156 2,4-dimethylhexane
157 2,4-dimethylpentane
158 2,4-toluene diisocyanate
159 2,5-dimethyldecane
160 2,5-dimethylfuran
161 2,5-dimethylheptane
162 2,5-dimethylhexane
163 2,5-dimethyloctane
164 2,6-dimethyldecane
165 2,6-dimethylheptane
166 2,6-dimethyloctane
167 2,6-dimethylundecane
168 2,6-toluene diisocyanate
169 2,7-dimethyloctane
170 2-[2-(2-ethoxy-ethoxy)-ethoxy]ethanol
171 2-acetoxy-propyl acetate
172 2-aminoethanol
173 2-butanol
174 2-butanone
175 2-butanone oxime
176 2-butene
177 2-butoxyethanol
178 2-butoxyethyl acetate
179 2-chloroethanol
180 2-chloropropane
181 2-chlorotoluene
182 2-ethoxyethanol
183 2-ethoxyethyl acetate
184 2-ethoxypropanol
185 2-ethyl hexanol
186 2-ethyl-1,3-dimethylbenzene
187 2-ethyltoluene
188 2-hexoxyethanol
189 2-hydrophenol
190 2-isopropoxyethanol

191 2-methoxy-2-methylpropane
192 2-methoxyethanol
193 2-methoxyethyl acetate
194 2-methoxypropane
195 2-methyl benzaldehyde
196 2-methyl-1,3-dioxolane
197 2-methyl-1-butene
198 2-methyl-1-butylbenzene
199 2-methyl-1-pentene
200 2-methyl-1-propanol
201 2-methyl-2,4-pentanediol
202 2-methyl-2-butene
203 2-methyl-2-hexene
204 2-methyl-5-ethyloctane
205 2-methylbutanal
206 2-methylbutane
207 2-methyldecalin
208 2-methyldecane
209 2-methylfuran
210 2-methylheptane
211 2-methylhexane
212 2-methylnonane
213 2-methyloctane
214 2-methylpentane
215 2-methylpropanal
216 2-methylpropane
217 2-methylpropenal
218 2-methylpropene
219 2-methylpropyl acetate
220 2-methylpyridine
221 2-methylundecane
222 2-pentanone
223 2-pentene
224 2-phenoxy ethanol
225 2-phenylpropene
226 2-propanol
227 2-propen-1-ol
228 2-propyl acetate
229 3-(2-hydroxy-propoxy)-1-propanol
230 3,3,4-trimethylhexane
231 3,3,5-trimethylheptane
232 3,3-dimethylheptane
233 3,3-dimethyloctane
234 3,3-dimethylpentane
235 3,4-dimethylheptane
236 3,4-dimethylhexane
237 3,5-dimethyloctane
238 3,6-dimethyloctane
239 3,7-dimethylnonane
240 3A,4,7,7A-tetrahydro-4,7-methanoindene
241 3-chloro-4-fluoropicoline
242 3-chloropropene
243 3-chloropyridine
244 3-ethyl-2-methylheptane

245 3-ethyl-2-methylhexane
246 3-ethylheptane
247 3-ethylhexane
248 3-ethyloctane
249 3-ethylpentane
250 3-ethyltoluene
251 3-hydrophenol
252 3-methyl benzaldehyde
253 3-methyl-1-butene
254 3-methylbutanal
255 3-methylbutanol
256 3-methyldecane
257 3-methylfuran
258 3-methylheptane
259 3-methylhexane
260 3-methylnonane
261 3-methyloctane
262 3-methylpentane
263 3-methylundecane
264 3-pentanone
265 4,4-dimethylheptane
266 4,4′-methylenedianiline
267 4,5-dimethylnonane
268 4,6-dimethylindan
269 4,7-dimethylindan
270 4-4′-methylenediphenyl diisocyanate
271 4-bromophenyl acetate
272 4-chlorotoluene
273 4-ethyl morpholine
274 4-ethyl-1,2-dimethylbenzene
275 4-ethyloctane
276 4-ethyltoluene
277 4-methyl benzaldehyde
278 4-methyl-1,3-dioxol-2-one
279 4-methyl-1-pentene
280 4-methyl-2-pentanol
281 4-methyl-2-pentanone
282 4-methyl-4-hydroxy-2-pentanone
283 4-methyldecane
284 4-methylheptane
285 4-methylnonane
286 4-methyloctane
287 4-methylpentene
288 4-propylheptane
289 5-methyl-2-hexanone
290 5-methyldecane
291 5-methylnonane
292 5-methylundecane
293 6-ethyl-2-methyldecane
294 6-ethyl-2-methyloctane
295 6-methylundecane
296 8-methyl-1-nonanol
297 acenaphthene
298 acenaphthylene

299 acetaldehyde
300 acetic acid
301 acetic anhydride
302 acetone
303 acetonitrile
304 acetyl chloride
305 acetylene
306 acrolein
307 acrylamide
308 acrylic acid
309 acrylonitrile
310 aniline
311 anthanthrene
312 anthracene
313 atrazine
314 benzaldehyde
315 benzene
316 benzene-1,2,4-tricarboxylic acid 1,2-
317 benzo (a) anthracene
318 benzo (a) pyrene
319 benzo (b) fluoranthene
320 benzo (c) phenanthrene
321 benzo (e) pyrene
322 benzo (g,h,i) fluoranthene
323 benzo (g,h,i) perylene
324 benzo (k) fluoranthene
325 benzophenone
326 benzopyrenes
327 benzyl alcohol
328 benzyl chloride
329 biphenyl
330 bis(2-hydroxyethyl)ether
331 bis(chloromethyl)ether
332 bis(tributyltin) oxide
333 bromoethane
334 bromoethene
335 bromomethane
336 butane
337 butanethiols
338 butene
339 butoxyl
340 butyl acetate
341 butyl acrylate
342 butyl glycolate
343 butyl lactate
344 butylbenzene
345 butylcyclohexane
346 butyrolactone
347 C10 alkanes
348 C10 alkenes
349 C10 aromatic hydrocarbons
350 C10 cycloalkanes
351 C11 alkanes
352 C11 alkenes

353 C11 aromatic hydrocarbons
354 C11 cycloalkanes
355 C12 alkanes
356 C12 cycloalkanes
357 C13 alkanes
358 C13+ alkanes
359 C13+ aromatic hydrocarbons
360 C14 alkanes
361 C15 alkanes
362 C16 alkanes
363 C2-alkyl-anthracenes
364 C2-alkyl-benzanthracenes
365 C2-alkyl-benzophenanthrenes
366 C2-alkyl-chrysenes
367 C2-alkyl-phenanthrenes
368 C5 alkenes
369 C6 alkenes
370 C7 alkanes
371 C7 alkenes
372 C7 cycloalkanes
373 C8 alkanes
374 C8 alkenes
375 C8 cycloalkanes
376 C9 alkanes
377 C9 alkenes
378 C9 aromatic hydrocarbons
379 C9 cycloalkanes
380 camphor/fenchone
381 carbon disulphide
382 carbon tetrachloride
383 carbonyl sulphide
384 chlorobenzene
385 chlorobutane
386 chlorocyclohexane
387 chlorodifluoromethane
388 chloroethane
389 chloroethene
390 chloroethylene
391 chlorofluoromethane
392 chloromethane
393 chrysene
394 cis-1,3-dimethylcyclopentane
395 cis-2-butene
396 cis-2-hexene
397 cis-2-pentene
398 coronene
399 crotonaldehyde
400 cycloheptane
401 cyclohexanamine
402 cyclohexane
403 cyclohexanol
404 cyclohexanone
405 cyclopenta (c,d) pyrene
406 cyclopenta-anthracenes

407 cyclopentane
408 cyclopenta-phenanthrenes
409 cyclopentene
410 decalin
411 decane
412 diacetoneketogulonic acid
413 diazinon
414 dibenzanthracenes
415 dibenzo (a,h) anthracene
416 dibenzopyrenes
417 dichlorobutenes
418 dichlorodifluoromethane
419 dichlorofluoromethane
420 dichloromethane
421 dichlorvos
422 diethyl disulphide
423 diethyl ether
424 diethyl sulphate
425 diethylamine
426 diethylbenzene
427 difluoromethane
428 dihydroxyacetone
429 diisopropyl ether
430 diisopropylbenzene
431 dimethoxymethane
432 dimethyl disulphide
433 dimethyl esters
434 dimethyl ether
435 dimethyl sulphate
436 dimethyl sulphide
437 dimethylamine
438 dimethylbutene
439 dimethylcyclopentane
440 dimethylformamide
441 dimethylhexene
442 dimethylnonane
443 dimethylpentane
444 dipentene
445 dipropyl ether
446 dodecane
447 ethane
448 ethanethiol
449 ethanol
450 ethofumesate
451 ethyl acetate
452 ethyl acrylate
453 ethyl butanoate
454 ethyl chloroformate
455 ethyl hexanol
456 ethyl lactate
457 ethyl pentanoate
458 ethyl propionate
459 ethylamine
460 ethylbenzene

461 ethylcyclohexane
462 ethylcyclopentane
463 ethyldimethylbenzene
464 ethylene
465 ethylene glycol
466 ethylene oxide
467 ethylisopropylbenzene
468 fenitrothion
469 fluoranthene
470 fluorene
471 formaldehyde
472 formanilide
473 formic acid
474 fumaric acid
475 glycerol
476 glyoxal
477 heptadecane
478 heptane
479 hexachlorocyclohexane
480 hexachloroethane
481 hexadecane
482 hexafluoropropene
483 hexamethylcyclotrisiloxane
484 hexamethyldisilane
485 hexamethyldisiloxane
486 hexamethylenediamine
487 hexane
488 hexylcyclohexane
489 indan
490 indeno (1,2,3-c,d) pyrene
491 iodomethane
492 isobutylbenzene
493 isobutylcyclohexane
494 isopentylbenzene
495 isophorone
496 isoprene
497 isoprene + BVOC (1)
498 isopropylbenzene
499 isopropylcyclohexane
500 limonene
501 malathion
502 maleic anhydride
503 m-cresol
504 menthene
505 methacrylic acid
506 methanethiol
507 methanol
508 methyl acetate
509 methyl acrylate
510 methyl butanoate
511 methyl ethyl ether
512 methyl formate
513 methyl glyoxal
514 methyl methacrylate

515 methyl naphthalenes
516 methyl pentanoate
517 methyl styrene
518 methylamine
519 methyl-anthracenes
520 methyl-benzanthracenes
521 methyl-benzphenanthrenes
522 methylcyclodecane
523 methylcyclohexane
524 methylcyclopentane
525 methylethylbenzene
526 methyl-fluoranthenes
527 methylhexane
528 methylindane
529 methyl-phenanthrenes
530 methylpropene
531 methylpropylbenzene
532 methyltetralin
533 m-xylene
534 N-(hydroxymethyl) acrylamide
535 N,N-diethyl benzenamine
536 N,N-dimethyl benzenamine
537 naphthalene
538 naphthol
539 Nedocromil Sodium
540 nitrobenzene
541 nitromethane
542 nitropentane
543 nitropropane
544 N-methyl pyrrolidone
545 nonane
546 o-cresol
547 octahydroindan
548 octamethylcyclotetrasiloxane
549 octane
550 octylamine
551 o-xylene
552 palmitic acid
553 p-benzoquinone
554 p-cresol
555 pentadecane
556 pentafluoroethane
557 pentane
558 pentanethiols
559 pentylbenzene
560 pentylcyclohexane
561 permethrin
562 perylene
563 phenol
564 phenoxyacetic acid (phenoxy acid)
565 phenylacetic acid
566 phenylacetonitrile
567 phthalic anhydride
568 pine oil

569 polyethylene glycol
570 polyisobutene
571 polyvinyl chloride
572 potassium phenylacetate
573 propadiene
574 propane
575 propanetriol
576 propanoic acid
577 propionitrile
578 propyl acetate
579 propyl butanoate
580 propyl propionate
581 propylamine
582 propylbenzene
583 propylcyclohexane
584 propylcyclopentane
585 propylene
586 propylene oxide
587 propyne
588 p-xylene
589 pyrene
590 pyridine
591 salicylic acid
592 sec-butylbenzene
593 sec-butylcyclohexane
594 simazine
595 sodium 2-ethylhexanoate
596 sodium acetate
597 sodium phenylacetate
598 styrene
599 sulphanilamide
600 terpenes
601 tert-butylamine
602 tert-butylbenzene
603 tert-butylcyclohexane
604 tert-butylcyclopropane
605 tert-pentylbenzene
606 tetrachloroethene
607 tetradecane
608 tetrafluoroethene
609 tetrahydrofuran
611 tetramethylcyclohexane
612 toluene
613 toluene-2,3-diamine
614 toluene-2,4-diamine
615 toluene-2,4-diisocyanate
616 toluene-2,5-diamine
617 toluene-2,6-diamine
618 toluene-2,6-diisocyanate
619 toluene-3,4-diamine
620 toluene-3,5-diamine
621 trans-2-butene
622 trans-2-hexene
623 trans-2-pentene

624 trans-3-hexene
625 trialkyl phosphate
626 trichloroethene
627 trichlorofluoromethane
628 trichloromethane
629 tridecane
630 triethanolamine
631 triethylamine
632 trifluoroethene
633 trifluoromethane
634 trifluralin
635 trimethylamine
636 trimethylfluorosilane
637 tri-n-butyl phosphate
638 undecane
639 unspeciated alcohols
640 unspeciated aliphatic hydrocarbons
641 unspeciated alkanes
642 unspeciated alkenes
643 unspeciated amines
644 unspeciated aromatic hydrocarbons
645 unspeciated carboxylic acids
646 unspeciated cycloalkanes
647 unspeciated hydrocarbons
648 unspeciated ketones
649 urea
650 vinyl acetate
(1) BVOC- biogenic VOCs, such as alpha-pinene and other terpenes

Annex 4 CO_2 reference approach and comparison with sectoral approach, and relevant information on the national energy balance

Please refer to Annex 3

Annex 5 Assessment of completeness and (potential) sources and sinks of greenhouse gas emissions and removals excluded

The Danish greenhouse gas emission inventories for 1990-2004 include all sources identified by the Revised IPPC Guidelines except the following:

Agriculture: The methane conversion factor in relation to the enteric fermentation for poultry and fur farming is not estimated. There is no default value recommended in IPCC GPG (Table A-4). However, this emission is seen as non-significant compared with the total emission from enteric fermentation.

Annex 6.1 Additional information to be considered as part of the NIR submission (where relevant) or other useful reference information

Annual emission inventories 1990-2004 CRF Table 10 for the Kingdom of Denmark

In NIR reports up until NIR 2004, the full CRF tables have been included in the NIR report, itself, together with the CRF as spreadsheet files. In NIR 2005 and the present NIR, the trend tables 1990-2004 (CRF Table 10 sheet 1-5) are only included, as they appear in the CRF 2004 spreadsheet file, Tables 10.1-10.5. The full CRF tables 1990-2004 are submitted as spreadsheets separately, as well as the files in the new CRF reporter tools. Note that this tool defines the base year in the sense of the Climate Change Convention (not as in the Kyoto protocol), i.e. 1990.

The tables enclosed in this Annex, Tables A6.1.1-6.1.5 are for the Kingdom of Denmark, i.e. Denmark, the Faroe Islands and Greenland. Emissions for the Faroe Islands and Greenland are entered under the Category "7. Other".

Table A6.1.1

TABLE 10 EMISSIONS TRENDS (CO_2)

(Sheet 1 of 5)

Inventory 2004

Submission 2006 v1.1

Kingdom DENMARK

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Change from base to latest reported year
	(Gg)															%
1. Energy	**51.474,10**	**61.984,18**	**56.074,61**	**58.207,12**	**61.673,81**	**58.879,83**	**72.285,47**	**62.614,92**	**58.555,08**	**55.759,41**	**51.265,43**	**52.846,73**	**52.456,80**	**57.771,94**	**52.093,87**	**1,20**
A. Fuel Combustion (Sectoral Approach)	51.210,67	61.466,16	55.540,40	57.738,78	61.206,20	58.514,58	71.885,09	62.049,91	58.132,81	54.861,60	50.671,21	52.213,45	51.921,42	57.222,12	51.485,49	0,54
1. Energy Industries	26.173,20	35.113,22	30.082,25	31.627,29	35.351,77	31.934,16	44.320,89	35.084,13	31.380,85	28.231,12	25.114,52	26.399,74	26.552,92	31.401,90	25.387,80	-3,00
2. Manufacturing Industries and Construction	5.423,48	5.848,05	5.677,33	5.583,79	5.805,50	5.974,09	6.136,71	6.132,35	6.114,33	6.166,45	5.946,24	6.018,16	5.700,21	5.697,72	5.841,04	7,70
3. Transport	10.335,91	10.811,23	10.940,04	10.960,61	11.254,07	11.638,58	11.906,65	12.040,56	12.065,35	12.133,69	12.004,10	11.991,83	12.170,05	12.604,51	12.858,60	24,41
4. Other Sectors	9.159,06	9.406,97	8.700,00	9.329,97	8.542,85	8.715,85	9.344,92	8.622,04	8.368,25	8.147,98	7.495,82	7.706,84	7.409,47	7.426,01	7.159,03	-21,84
5. Other	119,01	286,69	140,79	237,13	252,01	251,89	175,92	170,83	204,03	182,35	110,53	96,87	88,78	91,98	239,02	100,83
B. Fugitive Emissions from Fuels	263,44	518,02	534,21	468,34	467,60	365,25	400,38	565,01	422,27	897,81	594,22	633,28	535,37	549,82	608,39	130,94
1. Solid Fuels	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
2. Oil and Natural Gas	263,44	518,02	534,21	468,34	467,60	365,25	400,38	565,01	422,27	897,81	594,22	633,28	535,37	549,82	608,39	130,94
2. Industrial Processes	**1.101,46**	**1.275,41**	**1.394,83**	**1.415,11**	**1.440,68**	**1.446,29**	**1.553,72**	**1.721,16**	**1.725,17**	**1.653,54**	**1.681,74**	**1.707,91**	**1.696,71**	**1.571,96**	**1.731,23**	**57,18**
A. Mineral Products	1.072,21	1.246,16	1.365,58	1.383,34	1.406,38	1.406,93	1.517,08	1.685,28	1.682,42	1.609,93	1.640,36	1.660,41	1.696,16	1.570,92	1.728,22	61,18
B. Chemical Industry	0,80	0,80	0,80	0,80	0,80	0,80	1,45	0,87	0,56	0,58	0,65	0,83	0,55	1,05	3,01	275,75
C. Metal Production	28,45	28,45	28,45	30,97	33,50	38,56	35,19	35,01	42,19	43,04	40,73	46,68	NA,NO	NA,NO	NA,NO	-100,00
D. Other Production	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	0,00
E. Production of Halocarbons and SF_6																
F. Consumption of Halocarbons and SF_6																
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0,00
3. Solvent and Other Product Use	136,90	134,78	132,67	130,55	128,44	123,29	127,28	127,12	119,36	115,69	119,58	112,57	106,33	107,24	113,48	-17,11
4. Agriculture																
A. Enteric Fermentation																
B. Manure Management																
C. Rice Cultivation																
D. Agricultural Soils																
E. Prescribed Burning of Savannas																
F. Field Burning of Agricultural Residues																
G. Other																
5. Land Use, Land-Use Change and Forestry[(2)]	**551,65**	**-1.686,92**	**-1.546,42**	**-1.154,01**	**-1.613,04**	**-1.664,37**	**-1.211,47**	**-1.172,45**	**-1.946,45**	**-1.221,26**	**1.642,01**	**-756,87**	**-1.965,11**	**-1.940,44**	**-2.279,64**	**-513,24**
A. Forest Land	-2.830,67	-3.007,91	-2.998,67	-3.209,98	-3.098,63	-2.987,71	-3.063,43	-3.155,13	-3.312,17	-3.306,31	-652,89	-3.538,63	-3.813,30	-3.532,21	-3.449,42	21,86
B. Cropland	3.287,46	1.228,37	1.361,40	1.969,70	1.401,95	1.232,81	1.767,59	1.909,09	1.297,12	2.015,75	2.227,06	2.712,45	1.779,21	1.525,81	1.108,51	-66,28
C. Grassland	92,91	90,68	88,92	84,33	81,69	88,59	82,46	71,68	66,84	68,24	71,10	74,29	75,94	75,97	73,77	-20,60
D. Wetlands	1,94	1,94	1,94	1,94	1,94	1,94	1,91	1,91	1,76	1,06	-3,26	-4,99	-6,97	-10,01	-12,50	-743,40
E. Settlements	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	0,00
F. Other Land	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	0,00
G. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0,00
6. Waste	**IE,NA,NE,NO**	**IE,NA,NE,NO**	**IE,NA,NE,NO**	**IE,NA,NE,NO**	**0,07**	**0,39**	**0,38**	**0,37**	**2,96**	**3,65**	**3,43**	**2,28**	**2,56**	**2,97**	**2,04**	**100,00**
A. Solid Waste Disposal on Land	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	0,00
B. Waste-water Handling																
C. Waste Incineration	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	0,00
D. Other	NO	NO	NO	NO	0,07	0,39	0,38	0,37	2,96	3,65	3,43	2,28	2,56	2,97	2,04	100,00
7. Other *(as specified in Summary 1.A)*	**1.333,00**	**1.291,00**	**1.244,00**	**1.080,00**	**1.038,00**	**1.064,00**	**1.142,00**	**1.134,00**	**1.166,00**	**1.230,00**	**1.358,00**	**1.408,00**	**1.368,00**	**1.425,00**	**1.454,41**	**9,11**
Greenland total	624,00	609,00	594,00	544,00	494,00	523,00	564,00	575,00	550,00	585,00	659,00	617,00	577,00	634,00	663,41	6,32
Faroe Islands total	709,00	682,00	650,00	536,00	544,00	541,00	578,00	559,00	616,00	645,00	699,00	791,00	791,00	791,00	791,00	11,57
Total CO2 emissions including net CO2 from LULUCF[(3)]	**54.597,11**	**62.998,44**	**57.299,69**	**59.678,77**	**62.667,95**	**59.849,42**	**73.897,38**	**64.425,11**	**59.622,12**	**57.541,04**	**56.070,17**	**55.320,61**	**53.665,28**	**58.938,68**	**53.115,39**	**-2,71**
Total CO2 emissions excluding net CO2 from LULUCF[(3)]	**54.045,46**	**64.685,37**	**58.846,11**	**60.832,78**	**64.280,99**	**61.513,79**	**75.108,84**	**65.597,57**	**61.568,57**	**58.762,30**	**54.428,17**	**56.077,49**	**55.630,39**	**60.879,11**	**55.395,03**	**2,50**
Memo Items:																
International Bunkers	**4.823,30**	**4.394,45**	**4.580,16**	**5.958,35**	**6.646,69**	**6.927,68**	**6.773,80**	**6.413,77**	**6.573,23**	**6.445,41**	**6.629,22**	**5.989,80**	**5.024,93**	**5.272,11**	**4.991,90**	**3,50**
Aviation	1.736,10	1.632,12	1.693,19	1.658,84	1.817,70	1.867,05	1.971,08	2.010,44	2.158,98	2.290,07	2.349,78	2.384,97	2.059,41	2.142,08	2.447,40	40,97
Marine	3.087,20	2.762,33	2.886,97	4.299,51	4.828,99	5.060,63	4.802,71	4.403,33	4.414,25	4.155,35	4.279,45	3.604,83	2.965,52	3.130,03	2.544,50	-17,58
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0,00
CO_2 Emissions from Biomass	4.640,89	5.032,95	5.321,34	5.574,45	5.533,46	5.868,80	6.295,78	6.542,43	6.491,97	6.857,21	7.090,04	7.696,30	8.199,10	9.113,55	9.646,95	107,87

Table A6.1.2

TABLE 10 EMISSIONS TRENDS (CH_4)
(Sheet 2 of 5)

Inventory 2004
Submission 2006 v1.1
Kingdom DENMARK

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Change from base to latest reported year
	(Gg)															%
Total CH_4 emissions	**271,90**	**274,96**	**275,13**	**281,57**	**281,64**	**287,81**	**291,75**	**286,22**	**287,35**	**281,52**	**280,96**	**287,94**	**285,96**	**285,07**	**275,90**	**1,47**
1. Energy	10,56	12,03	12,67	15,17	18,57	25,05	29,94	29,96	31,37	31,52	31,16	32,66	32,46	32,49	32,70	209,70
A. Fuel Combustion (Sectoral Approach)	8,67	9,75	10,50	12,78	16,02	22,11	27,12	26,84	28,25	27,95	27,35	28,85	28,52	28,47	27,86	221,25
1. Energy Industries	1,11	1,53	1,83	3,38	6,37	11,51	14,96	14,51	15,70	15,63	14,84	16,07	16,00	15,71	15,37	1.287,93
2. Manufacturing Industries and Construction	0,71	0,74	0,71	0,73	0,74	0,84	1,27	1,27	1,35	1,35	1,54	1,60	1,47	1,47	1,51	113,82
3. Transport	2,51	2,79	2,96	3,13	3,24	3,55	3,87	3,70	3,69	3,45	3,29	3,22	2,96	2,88	2,57	2,59
4. Other Sectors	4,35	4,67	4,99	5,52	5,67	6,20	7,01	7,36	7,49	7,51	7,67	7,96	8,08	8,41	8,40	93,34
5. Other	0,00	0,02	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,00	0,00	0,01	116,81
B. Fugitive Emissions from Fuels	1,89	2,28	2,17	2,39	2,55	2,94	2,83	3,12	3,12	3,56	3,81	3,82	3,94	4,02	4,84	156,56
1. Solid Fuels	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
2. Oil and Natural Gas	1,89	2,28	2,17	2,39	2,55	2,94	2,83	3,12	3,12	3,56	3,81	3,82	3,94	4,02	4,84	156,56
2. Industrial Processes	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**0,00**
A. Mineral Products	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	0,00
B. Chemical Industry	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
C. Metal Production	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
D. Other Production																
E. Production of Halocarbons and SF_6																
F. Consumption of Halocarbons and SF_6																
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0,00
3. Solvent and Other Product Use																
4. Agriculture	**190,98**	**191,56**	**190,74**	**193,77**	**191,33**	**192,21**	**190,60**	**186,00**	**187,72**	**181,11**	**181,73**	**186,71**	**183,88**	**181,96**	**178,10**	**-6,74**
A. Enteric Fermentation	155,19	154,08	150,75	151,37	149,91	150,89	148,63	143,39	143,30	137,33	136,28	139,07	135,41	133,38	129,07	-16,83
B. Manure Management	35,79	37,49	40,00	42,40	41,42	41,32	41,97	42,61	44,41	43,77	45,45	47,64	48,47	48,58	49,03	37,00
C. Rice Cultivation	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
D. Agricultural Soils	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	0,00
E. Prescribed Burning of Savannas	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0,00
F. Field Burning of Agricultural Residues	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0,00
5. Land Use, Land-Use Change and Forestry	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**0,00**
A. Forest Land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0,00
B. Cropland	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
C. Grassland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0,00
D. Wetlands	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0,00
E. Settlements	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	0,00
F. Other Land	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	0,00
G. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0,00
6. Waste	**69,51**	**70,49**	**70,83**	**71,76**	**70,83**	**69,65**	**70,30**	**69,33**	**67,36**	**67,98**	**67,12**	**67,59**	**68,65**	**69,65**	**63,73**	**-8,31**
A. Solid Waste Disposal on Land	63,53	64,65	65,06	65,69	63,59	61,22	60,68	57,51	55,33	56,70	56,77	56,57	53,87	55,39	51,13	-19,52
B. Waste-water Handling	5,98	5,84	5,78	6,07	7,24	8,43	9,62	11,81	12,03	11,28	10,34	11,02	14,78	14,26	12,61	110,73
C. Waste Incineration	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	0,00
D. Other	NO	NO	NO	NO	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	100,00
7. Other *(as specified in Summary 1.A)*	**0,85**	**0,89**	**0,88**	**0,88**	**0,91**	**0,91**	**0,90**	**0,94**	**0,91**	**0,92**	**0,96**	**0,97**	**0,97**	**0,97**	**1,37**	**60,23**
Greenland and Faroe Islands total	0,85	0,89	0,88	0,88	0,91	0,91	0,90	0,94	0,91	0,92	0,96	0,97	0,97	0,97	1,37	60,23
Memo Items:																
International Bunkers	0,10	0,09	0,10	0,13	0,14	0,15	0,15	0,14	0,14	0,14	0,14	0,12	0,11	0,11	0,10	3,29
Aviation	0,03	0,03	0,03	0,03	0,03	0,04	0,04	0,04	0,04	0,04	0,04	0,04	0,04	0,04	0,05	49,56
Marine	0,07	0,06	0,07	0,10	0,11	0,11	0,11	0,10	0,10	0,09	0,10	0,08	0,07	0,07	0,06	-17,35
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0,00
CO_2 Emissions from Biomass																

Table A6.1.3

TABLE 10 EMISSIONS TRENDS (N_2O)
(Sheet 3 of 5)

Inventory 2004
Submission 2006 v1.1
Kingdom DENMARK

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Change from base to latest reported year
	(Gg)															%
Total N_2O emissions	**34,25**	**33,64**	**32,28**	**31,58**	**31,05**	**30,77**	**29,67**	**29,44**	**29,24**	**28,31**	**27,66**	**26,87**	**25,73**	**25,58**	**24,61**	**-28,14**
1. Energy	**1,37**	**1,57**	**1,56**	**1,63**	**1,76**	**1,86**	**2,13**	**2,14**	**2,16**	**2,22**	**2,20**	**2,25**	**2,31**	**2,40**	**2,40**	**75,01**
A. Fuel Combustion (Sectoral Approach)	1,37	1,56	1,55	1,63	1,75	1,86	2,12	2,13	2,16	2,20	2,19	2,24	2,30	2,39	2,39	74,82
1. Energy Industries	0,38	0,47	0,43	0,45	0,49	0,50	0,65	0,57	0,53	0,52	0,48	0,51	0,52	0,55	0,50	29,83
2. Manufacturing Industries and Construction	0,18	0,19	0,18	0,18	0,18	0,18	0,19	0,19	0,19	0,19	0,19	0,19	0,18	0,18	0,19	7,31
3. Transport	0,45	0,53	0,59	0,64	0,74	0,84	0,93	1,03	1,11	1,17	1,21	1,23	1,29	1,34	1,40	208,62
4. Other Sectors	0,35	0,36	0,34	0,35	0,33	0,33	0,35	0,33	0,32	0,31	0,30	0,31	0,30	0,31	0,29	-16,34
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	0,00	0,01	192,79
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	0,01	0,01	130,08
1. Solid Fuels	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	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	0,01	0,01	130,08
2. Industrial Processes	**3,36**	**3,08**	**2,72**	**2,56**	**2,60**	**2,92**	**2,69**	**2,74**	**2,60**	**3,07**	**3,24**	**2,86**	**2,50**	**2,89**	**1,71**	**-49,11**
A. Mineral Products	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	0,00
B. Chemical Industry	3,36	3,08	2,72	2,56	2,60	2,92	2,69	2,74	2,60	3,07	3,24	2,86	2,50	2,89	1,71	-49,11
C. Metal Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0,00
D. Other Production																
E. Production of Halocarbons and SF_6																
F. Consumption of Halocarbons and SF_6																
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0,00
3. Solvent and Other Product Use	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0,00
4. Agriculture	**29,15**	**28,65**	**27,68**	**27,02**	**26,31**	**25,64**	**24,55**	**24,27**	**24,18**	**22,74**	**21,92**	**21,47**	**20,64**	**20,03**	**20,19**	**-30,73**
A. Enteric Fermentation																
B. Manure Management	2,21	2,20	2,21	2,21	2,14	2,07	2,08	2,07	2,10	2,03	1,94	1,95	1,89	1,80	1,81	-18,10
C. Rice Cultivation																
D. Agricultural Soils	26,94	26,45	25,47	24,81	24,17	23,57	22,47	22,20	22,08	20,71	19,98	19,52	18,75	18,23	18,38	-31,77
E. Prescribed Burning of Savannas	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0,00
F. Field Burning of Agricultural Residues	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0,00
5. Land Use, Land-Use Change and Forestry	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**-17,07**
A. Forest Land	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	0,00
B. Cropland	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
C. Grassland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0,00
D. Wetlands	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-17,07
E. Settlements	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	0,00
F. Other Land	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	0,00
G. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0,00
6. Waste	**0,28**	**0,27**	**0,24**	**0,29**	**0,30**	**0,27**	**0,22**	**0,21**	**0,21**	**0,20**	**0,21**	**0,18**	**0,19**	**0,16**	**0,17**	**-39,27**
A. Solid Waste Disposal on Land																
B. Waste-water Handling	0,28	0,27	0,24	0,29	0,30	0,27	0,22	0,21	0,21	0,20	0,21	0,18	0,19	0,16	0,17	-39,29
C. Waste Incineration	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	0,00
D. Other	NO	NO	NO	NO	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	100,00
7. Other *(as specified in Summary 1.A)*	**0,07**	**0,08**	**0,08**	**0,07**	**0,08**	**0,08**	**0,08**	**0,09**	**0,08**	**0,09**	**0,10**	**0,10**	**0,10**	**0,10**	**0,13**	**74,17**
Greenland and Faroe Islands total	0,07	0,08	0,08	0,07	0,08	0,08	0,08	0,09	0,08	0,09	0,10	0,10	0,10	0,10	0,13	74,17
Memo Items:																
International Bunkers	**0,25**	**0,23**	**0,24**	**0,33**	**0,37**	**0,38**	**0,37**	**0,35**	**0,35**	**0,34**	**0,35**	**0,31**	**0,26**	**0,27**	**0,25**	**-3,02**
Aviation	0,06	0,06	0,06	0,06	0,06	0,06	0,07	0,07	0,08	0,08	0,08	0,08	0,07	0,07	0,08	43,62
Marine	0,19	0,17	0,18	0,27	0,30	0,32	0,30	0,28	0,28	0,26	0,27	0,23	0,19	0,20	0,16	-17,20
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0,00
CO_2 Emissions from Biomass																

Table 6.1.4

TABLE 10 EMISSION TRENDS (HFCs, PFCs and SF_6)
(Sheet 4 of 5)

Inventory 2004
Submission 2006 v1.1
Kingdom DENMARK

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Change from base to latest reported year
	(Gg)															%
Emissions of HFCs[4] - (Gg CO_2 equivalent)	**NA,NE,NO**	**NA,NE,NO**	**3,4360**	**93,9338**	**134,5289**	**217,7281**	**329,3025**	**323,7532**	**411,1850**	**502,9828**	**604,6369**	**647,3172**	**672,0590**	**695,4772**	**754,3036**	**100,00**
HFC-23	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
HFC-32	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NO	NA,NO	0,0001	0,0008	0,0018	0,0027	0,0038	0,0057	0,0110	0,0084	0,0101	0,0120	100,00
HFC-41	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
HFC-43-10mee	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
HFC-125	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NO	0,0002	0,0026	0,0095	0,0158	0,0218	0,0317	0,0431	0,0488	0,0485	0,0549	0,0599	100,00
HFC-134	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
HFC-134a	NA,NE,NO	NA,NE,NO	0,0023	0,0690	0,0974	0,1501	0,2038	0,1724	0,2106	0,2274	0,2518	0,2687	0,2806	0,2683	0,2861	100,00
HFC-152a	NA,NE,NO	NA,NE,NO	0,0030	0,0300	0,0460	0,0434	0,0322	0,0152	0,0097	0,0382	0,0168	0,0134	0,0130	0,0020	0,0061	100,00
HFC-143	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
HFC-143a	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NO	0,0002	0,0024	0,0086	0,0137	0,0193	0,0291	0,0396	0,0401	0,0432	0,0490	0,0528	100,00
HFC-227ea	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
HFC-236fa	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
HFC-245ca	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
Unspecified mix of listed HFCs[5] - (Gg CO_2 equivalent)	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
Emissions of PFCs[4] - (Gg CO_2 equivalent)	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NO**	**0,0525**	**0,5023**	**1,6595**	**4,1186**	**9,0967**	**12,4815**	**17,8904**	**22,1272**	**22,1677**	**19,3410**	**15,9015**	**100,00**
CF_4	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
C_2F_6	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
C_3F_8	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NO	0,0000	0,0001	0,0002	0,0006	0,0013	0,0018	0,0026	0,0032	0,0032	0,0028	0,0023	100,00
C_4F_{10}	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
$c-C_4F_8$	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
C_5F_{12}	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
C_6F_{14}	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
Unspecified mix of listed PFCs[5] - (Gg CO_2 equivalent)	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
Emissions of SF6[4] - (Gg CO_2 equivalent)	**44,4540**	**63,5023**	**89,1542**	**101,1696**	**122,0601**	**107,3379**	**60,9584**	**73,0626**	**59,4212**	**65,3581**	**59,2258**	**30,4013**	**25,0096**	**31,3723**	**33,1454**	**-25,44**
SF_6	0,0019	0,0027	0,0037	0,0042	0,0051	0,0045	0,0026	0,0031	0,0025	0,0027	0,0025	0,0013	0,0010	0,0013	0,0014	-25,44

Table 6.1.5

TABLE 10 EMISSION TRENDS (SUMMARY)
(Sheet 5 of 5)

Inventory 2004
Submission 2006 v1.1
Kingdom DENMARK

GREENHOUSE GAS EMISSIONS	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Change from base to latest reported year
	CO_2 equivalent (Gg)															(%)
CO2 emissions including net CO_2 from LULUCF[(3)]	54.597,11	62.998,44	57.299,69	59.678,77	62.667,95	59.849,42	73.897,38	64.425,11	59.622,12	57.541,04	56.070,17	55.320,61	53.665,28	58.938,68	53.115,39	-2,71
CO2 emissions excluding net CO_2 from LULUCF[(3)]	54.045,46	64.685,37	58.846,11	60.832,78	64.280,99	61.513,79	75.108,84	65.597,57	61.568,57	58.762,30	54.428,17	56.077,49	55.630,39	60.879,11	55.395,03	2,50
CH_4	5.709,91	5.774,24	5.777,75	5.913,06	5.914,43	6.044,03	6.126,74	6.010,72	6.034,25	5.911,93	5.900,18	6.046,75	6.005,18	5.986,49	5.793,86	1,47
N_2O	10.616,03	10.428,84	10.005,28	9.790,82	9.624,18	9.539,26	9.198,61	9.127,63	9.063,58	8.776,92	8.575,16	8.328,46	7.975,41	7.929,03	7.628,15	-28,14
HFCs	NA,NE,NO	NA,NE,NO	3,44	93,93	134,53	217,73	329,30	323,75	411,19	502,98	604,64	647,32	672,06	695,48	754,30	100,00
PFCs	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NO	0,05	0,50	1,66	4,12	9,10	12,48	17,89	22,13	22,17	19,34	15,90	100,00
SF_6	44,45	63,50	89,15	101,17	122,06	107,34	60,96	73,06	59,42	65,36	59,23	30,40	25,01	31,37	33,15	-25,44
Total (including net CO_2 from LULUCF)[(3)]	**70.967,50**	**79.265,02**	**73.175,31**	**75.577,75**	**78.463,20**	**75.758,28**	**89.614,65**	**79.964,39**	**75.199,64**	**72.810,72**	**71.227,27**	**70.395,67**	**68.365,09**	**73.600,39**	**67.340,75**	**-5,11**
Total (excluding net CO_2 from LULUCF)[(3), (6)]	**70.415,85**	**80.951,94**	**74.721,73**	**76.731,76**	**80.076,24**	**77.422,65**	**90.826,12**	**81.136,84**	**77.146,09**	**74.031,98**	**69.585,26**	**71.152,54**	**70.330,21**	**75.540,83**	**69.620,39**	**-1,13**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Change from base to latest reported year
	CO2 equivalent (Gg)															(%)
1. Energy	52.121,25	62.722,31	56.823,81	59.032,23	62.609,65	59.983,88	73.574,45	63.906,80	59.884,12	57.108,91	52.601,14	54.231,34	53.853,28	59.197,37	53.525,10	2,69
2. Industrial Processes	2.188,81	2.293,74	2.331,01	2.405,13	2.503,83	2.675,71	2.779,96	2.970,32	3.011,38	3.184,56	3.366,99	3.293,06	3.190,01	3.212,82	3.059,95	39,80
3. Solvent and Other Product Use	136,90	134,78	132,67	130,55	128,44	123,29	127,28	127,12	119,36	115,69	119,58	112,57	106,33	107,24	113,48	-17,11
4. Agriculture	13.047,91	12.903,56	12.586,57	12.444,92	12.172,98	11.983,37	11.612,05	11.430,80	11.436,96	10.853,29	10.610,97	10.576,71	10.258,35	10.031,13	10.000,29	-23,36
5. Land Use, Land-Use Change and Forestry[(7)]	551,74	-1.686,83	-1.546,33	-1.153,92	-1.612,95	-1.664,28	-1.211,38	-1.172,36	-1.946,36	-1.221,18	1.642,08	-756,80	-1.965,04	-1.940,36	-2.279,57	-513,16
6. Waste	1.547,35	1.563,69	1.560,89	1.597,83	1.579,74	1.548,12	1.546,19	1.521,43	1.483,40	1.493,16	1.478,30	1.479,04	1.502,41	1.515,45	1.393,63	-9,93
7. Other	1.373,54	1.333,77	1.286,68	1.121,01	1.081,52	1.108,20	1.186,09	1.180,30	1.210,80	1.276,29	1.408,21	1.459,74	1.419,74	1.476,74	1.527,88	11,24
Total (including LULUCF)[(7)]	**70.967,50**	**79.265,02**	**73.175,31**	**75.577,75**	**78.463,20**	**75.758,28**	**89.614,65**	**79.964,39**	**75.199,64**	**72.810,72**	**71.227,27**	**70.395,67**	**68.365,09**	**73.600,39**	**67.340,75**	**-5,11**

Annex 6.2 Additional information to be considered as part of the NIR submission (where relevant) or other useful reference information – Greenland/Faroe islands

CO_2 emissions in Greenland and the Faroe Islands

In the Faroe Islands, a major project was carried out 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.

An update has recently been produced (Heilsufrøðiliga Starvsstovan, 2005). The results reported in the latter work are, however, incomplete as regards the emission sources included and, thus, the 2002 estimate is used also for 2003 and 2004.

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.

For Greenland, the inventory for 2004 has been expanded to include emissions from agriculture and consumption of F-gases and the pollutants CH_4, N_2O, HFCs, CO, NMVOC and NO_X. However, fossil fuels are still the most important source of greenhouse gases in this region. Figures for CO_2 emissions from 1990 to 2004 and for CH_4, N_2O and HFCs for 2004 are given in the table below. The inventory is based on information from KNI Pilersuisoq, Statoil, Nukissiorfiit Årsoversigt 2004, Grønlands Kommando (Greenland Command) and Konsulenttjenesten for Landbrug (Consultancy for Agriculture).

The time-series for Greenland for the pollutants CH_4, N_2O, HFCs, CO, NMVOC and NO_X will be completed for 1990-2003.

Table 1 Estimation of greenhouse gas emissions in Greenland and the Faroe Islands 1990-2004.

	Greenland				Faroe Islands		
	Gg CO_2	Mg CH_4	Mg N_2O	HFCs Gg CO_2-eq.	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	544[1]				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
2003	634				791	973	101
2004	663	394	26	5,3	791	973	101

1. The CO_2 emission for 1993 is intrapolated.

References

Heilsufrøðiliga Starvsstovan 2005: Útlát av veðurlagsgassi í Føroyum – Uppgerð dagført fram til 2003. Heilsufrøðiliga Starvsstovan: 20 pp. Available at: http://www.hfs.fo/tíðindaskriv/tidindi.asp.

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 Table 6.1 and 6.2 of the IPCC good practice guidance

IPCC Source category	Gas	Base year emission	Year t emission	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty i trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data							
		Gg CO2 eq	Gg CO2 eq	%	%	%	%	%	%	%	%	%
Stationary Combustion, Coal	CO2	24077	17337	1	5	5,099	1,301	-0,092	0,251	-0,461	0,355	0,582
Stationary Combustion, BKB	CO2	11	0	3	5	5,831	0,000	0,000	0,000	-0,001	0,000	0,001
Stationary Combustion, Coke	CO2	138	123	3	5	5,831	0,011	0,000	0,002	-0,001	0,008	0,008
Stationary Combustion, Petroleum coke	CO2	410	817	3	5	5,831	0,070	0,006	0,012	0,030	0,050	0,058
Stationary Combustion, Plastic waste	CO2	349	676	5	5	7,071	0,070	0,005	0,010	0,024	0,069	0,073
Stationary Combustion, Residual oil	CO2	2505	1832	2	2	2,828	0,076	-0,009	0,027	-0,018	0,075	0,077
Stationary Combustion, Gas oil	CO2	4564	2712	4	5	6,403	0,255	-0,026	0,039	-0,129	0,222	0,257
Stationary Combustion, Kerosene	CO2	366	15	4	5	6,403	0,001	-0,005	0,000	-0,025	0,001	0,025
Stationary Combustion, Orimulsion	CO2	0	1	1	2	2,236	0,000	0,000	0,000	0,000	0,000	0,000
Stationary Combustion, Natural gas	CO2	4330	11143	3	1	3,162	0,518	0,100	0,161	0,100	0,685	0,692
Stationary Combustion, LPG	CO2	164	108	4	5	6,403	0,010	-0,001	0,002	-0,004	0,009	0,010
Stationary Combustion, Refinery gas	CO2	806	904	3	5	5,831	0,078	0,002	0,013	0,008	0,056	0,056
Stationary combustion plants, gas engines	CH4	6	386	2,2	40	40,060	0,228	0,006	0,006	0,220	0,017	0,221
Stationary combustion plants, other	CH4	115	136	2,2	100	100,024	0,200	0,000	0,002	0,033	0,006	0,034
Stationary combustion plants	N2O	240	268	2,2	1000	1000,002	3,939	0,000	0,004	0,449	0,012	0,449
Transport, Road transport	CO2	9241	12024	2	5	5,385	0,953	0,042	0,174	0,211	0,493	0,536
Transport, Military	CO2	119	239	2	5	5,385	0,019	0,002	0,003	0,009	0,010	0,013
Transport, Railways	CO2	297	216	2	5	5,385	0,017	-0,001	0,003	-0,006	0,009	0,010
Transport, Navigation (small boats)	CO2	71	104	42	5	42,297	0,065	0,000	0,002	0,002	0,089	0,089
Transport, Navigation (large vessels)	CO2	484	387	2	5	5,385	0,031	-0,001	0,006	-0,007	0,016	0,017
Transport, Fisheries	CO2	771	473	2	5	5,385	0,037	-0,004	0,007	-0,021	0,019	0,028
Transport, Agriculture	CO2	1272	1017	26	5	26,476	0,396	-0,003	0,015	-0,017	0,542	0,542
Transport, Forestry	CO2	36	17	32	5	32,388	0,008	0,000	0,000	-0,001	0,011	0,012
Transport, Industry (mobile)	CO2	842	912	36	5	36,346	0,488	0,001	0,013	0,006	0,673	0,673
Transport, Residential	CO2	138	298	36	5	36,346	0,159	0,002	0,004	0,012	0,220	0,220
Transport, Civil aviation	CO2	243	128	10	5	11,180	0,021	-0,002	0,002	-0,008	0,026	0,027
Transport, Road transport	CH4	52	53	2	40	40,050	0,031	0,000	0,001	0,001	0,002	0,003
Transport, Military	CH4	0	0	2	100	100,020	0,000	0,000	0,000	0,000	0,000	0,000
Transport, Railways	CH4	0	0	2	100	100,020	0,000	0,000	0,000	0,000	0,000	0,000
Transport, Navigation (small boats)	CH4	0	1	42	100	108,462	0,001	0,000	0,000	0,000	0,000	0,000
Transport, Navigation (large vessels)	CH4	0	0	2	100	100,020	0,000	0,000	0,000	0,000	0,000	0,000
Transport, Fisheries	CH4	0	0	2	100	100,020	0,000	0,000	0,000	0,000	0,000	0,000
Transport, Agriculture	CH4	2	1	26	100	103,325	0,002	0,000	0,000	-0,001	0,001	0,001
Transport, Forestry	CH4	0	0	32	100	104,995	0,000	0,000	0,000	0,000	0,000	0,001

Transport, Industry (mobile)	CH4	1	1	36	100	106,283	0,002	0,000	0,000	0,000	0,001	0,001
Transport, Residential	CH4	4	6	36	100	106,283	0,010	0,000	0,000	0,003	0,004	0,006
Transport, Civil aviation	CH4	0	0	10	100	100,499	0,000	0,000	0,000	0,000	0,000	0,000
Transport, Road transport	N2O	125	421	2	50	50,040	0,310	0,004	0,006	0,216	0,017	0,216
Transport, Military	N2O	1	4	2	1000	1000,002	0,055	0,000	0,000	0,036	0,000	0,036
Transport, Railways	N2O	3	2	2	1000	1000,002	0,027	0,000	0,000	-0,009	0,000	0,009
Transport, Navigation (small boats)	N2O	1	1	42	1000	1000,882	0,016	0,000	0,000	0,007	0,001	0,007
Transport, Navigation (large vessels)	N2O	9	8	2	1000	1000,002	0,112	0,000	0,000	-0,025	0,000	0,025
Transport, Fisheries	N2O	15	9	2	1000	1000,002	0,137	0,000	0,000	-0,080	0,000	0,080
Transport, Agriculture	N2O	15	13	26	1000	1000,338	0,194	0,000	0,000	-0,027	0,007	0,028
Transport, Forestry	N2O	0	0	32	1000	1000,512	0,002	0,000	0,000	0,000	0,000	0,000
Transport, Industry (mobile)	N2O	11	12	36	1000	1000,648	0,176	0,000	0,000	0,022	0,009	0,023
Transport, Residential	N2O	1	1	36	1000	1000,648	0,022	0,000	0,000	0,012	0,001	0,012
Transport, Civil aviation	N2O	3	2	10	1000	1000,050	0,036	0,000	0,000	-0,010	0,001	0,010
Energy, fugitive emissions, oil and natural gas	CO2	263	608	15	5	15,811	0,142	0,005	0,009	0,025	0,187	0,189
Energy, fugitive emissions, oil and natural gas	CH4	40	102	15	50	52,202	0,078	0,001	0,001	0,045	0,031	0,055
Energy, fugitive emissions, oil and natural gas	N2O	1	3	15	50	52,202	0,003	0,000	0,000	0,001	0,001	0,002
6 A. Solid Waste Disposal on Land	CH4	1334	1074	10	63	63,591	1,004	-0,003	0,016	-0,219	0,220	0,310
6 B. Wastewater Handling	CH4	126	265	20	35	40,311	0,157	0,002	0,004	0,072	0,109	0,130
6 B. Wastewater Handling	N2O	88	53	10	30	31,623	0,025	0,000	0,001	-0,014	0,011	0,018
2A1 Cement production	CO2	882	1539	1	2	2,236	0,051	0,010	0,022	0,019	0,032	0,037
2A2 Lime production	CO2	152	110	5	5	7,071	0,011	-0,001	0,002	-0,003	0,011	0,012
2A3 Limestone and dolomite use	CO2	18	64	5	5	7,071	0,007	0,001	0,001	0,003	0,007	0,007
2A5 Asphalt roofing	CO2	0	0	5	25	25,495	0,000	0,000	0,000	0,000	0,000	0,000
2A6 Road paving with asphalt	CO2	2	2	5	25	25,495	0,001	0,000	0,000	0,000	0,000	0,000
2A7 Glass and Glass wool	CO2	17	13	5	2	5,385	0,001	0,000	0,000	0,000	0,001	0,001
2B5 Catalysts/Fertilizers, Pesticides and Sulphuric acid	CO2	1	3	5	5	7,071	0,000	0,000	0,000	0,000	0,000	0,000
2C1 Iron and steel production	CO2	28	0	5	5	7,071	0,000	0,000	0,000	-0,002	0,000	0,002
2B2 Nitric acid production	N2O	1043	531	2	25	25,080	0,196	-0,007	0,008	-0,180	0,022	0,181
2F Consumption of HFC	HFC	218	749	10	50	50,990	0,562	0,008	0,011	0,387	0,153	0,417
2F Consumption of PFC	PFC	1	16	10	50	50,990	0,012	0,000	0,000	0,011	0,003	0,012
2F Consumption of SF6	SF6	105	33	10	50	50,990	0,025	-0,001	0,000	-0,051	0,007	0,051
4A Enteric Fermentation	CH4	3110	2711	10	8	12,806	0,511	-0,005	0,039	-0,041	0,556	0,557
4B Manure Management	CH4	743	1030	10	100	100,499	1,522	0,004	0,015	0,432	0,211	0,480
4B Manure Management	N2O	685	560	10	100	100,499	0,827	-0,002	0,008	-0,167	0,115	0,202
4D Agricultural Soils	N2O	8308	5699	7,6	19,5	20,929	1,755	-0,036	0,083	-0,701	0,888	1,131
Total		69004	67976				**26,953**					**4,529**
Total uncertainties					**Overall uncertainty i the year (%):**		**5,192**			**Trend uncertainty (%):**	**2,128**	

Annex 8 Other annexes – (Any other relevant information)

Please see Chapter 1.6 for information

Annex 9 Annual emission inventories 1990-2004 CRF Table 10 for Denmark

Up until NIR 2004, NERI included the full CRF tables in the NIR report itself as well as the CRF submitted as spreadsheet files. In NIR 2005 and the present year's NIR (2006), only the trend tables 1990-2004 (CRF Table 10 sheet 1-5) have been included, as they appear in the CRF 2004 spreadsheet file, Tables 10.1-10.5. The full CRF tables 1990-2004 are submitted as spreadsheets separately, as well as the files in the new CRF reporter tool. Notice that this tool defines the base year regarding emissions in the sense of the Climate Change Convention (not as in the Kyoto protocol) which is the emissions in 1990.

Table A9.1

TABLE 10 EMISSIONS TRENDS (CO_2)
(Sheet 1 of 5)

Inventory 2004
Submission 2006 v1.1
DENMARK

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Change from base to latest reported year
								(Gg)								%
1. Energy	**51.474,10**	**61.984,18**	**56.074,61**	**58.207,12**	**61.673,81**	**58.879,83**	**72.285,47**	**62.614,92**	**58.555,08**	**55.759,41**	**51.265,43**	**52.846,73**	**52.456,80**	**57.771,94**	**52.093,87**	**1,20**
A. Fuel Combustion (Sectoral Approach)	51.210,67	61.466,16	55.540,40	57.738,78	61.206,20	58.514,58	71.885,09	62.049,91	58.132,81	54.861,60	50.671,21	52.213,45	51.921,42	57.222,12	51.485,49	0,54
1. Energy Industries	26.173,20	35.113,22	30.082,25	31.627,29	35.351,77	31.934,16	44.320,89	35.084,13	31.380,85	28.231,12	25.114,52	26.399,74	26.552,92	31.401,90	25.387,80	-3,00
2. Manufacturing Industries and Construction	5.423,48	5.848,05	5.677,33	5.583,79	5.805,50	5.974,09	6.136,71	6.132,35	6.114,33	6.166,45	5.946,24	6.018,16	5.700,21	5.697,72	5.841,04	7,70
3. Transport	10.335,91	10.811,23	10.940,04	10.960,61	11.254,07	11.638,58	11.906,65	12.040,56	12.065,35	12.133,69	12.004,10	11.991,83	12.170,05	12.604,51	12.858,60	24,41
4. Other Sectors	9.159,06	9.406,97	8.700,00	9.329,97	8.542,85	8.715,85	9.344,92	8.622,04	8.368,25	8.147,98	7.495,82	7.706,84	7.409,47	7.426,01	7.159,03	-21,84
5. Other	119,01	286,69	140,79	237,13	252,01	251,89	175,92	170,83	204,03	182,35	110,53	96,87	88,78	91,98	239,02	100,83
B. Fugitive Emissions from Fuels	263,44	518,02	534,21	468,34	467,60	365,25	400,38	565,01	422,27	897,81	594,22	633,28	535,37	549,82	608,39	130,94
1. Solid Fuels	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
2. Oil and Natural Gas	263,44	518,02	534,21	468,34	467,60	365,25	400,38	565,01	422,27	897,81	594,22	633,28	535,37	549,82	608,39	130,94
2. Industrial Processes	**1.101,46**	**1.275,41**	**1.394,83**	**1.415,11**	**1.440,68**	**1.446,29**	**1.553,72**	**1.721,16**	**1.725,17**	**1.653,54**	**1.681,74**	**1.707,91**	**1.696,71**	**1.571,96**	**1.731,23**	**57,18**
A. Mineral Products	1.072,21	1.246,16	1.365,58	1.383,34	1.406,38	1.406,93	1.517,08	1.685,28	1.682,42	1.609,93	1.640,36	1.660,41	1.696,16	1.570,92	1.728,22	61,18
B. Chemical Industry	0,80	0,80	0,80	0,80	0,80	0,80	1,45	0,87	0,56	0,58	0,65	0,83	0,55	1,05	3,01	275,75
C. Metal Production	28,45	28,45	28,45	30,97	33,50	38,56	35,19	35,01	42,19	43,04	40,73	46,68	NA,NO	NA,NO	NA,NO	-100,00
D. Other Production	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	0,00
E. Production of Halocarbons and SF_6																
F. Consumption of Halocarbons and SF_6																
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0,00
3. Solvent and Other Product Use	136,90	134,78	132,67	130,55	128,44	123,29	127,28	127,12	119,36	115,69	119,58	112,57	106,33	107,24	113,48	-17,11
4. Agriculture																
A. Enteric Fermentation																
B. Manure Management																
C. Rice Cultivation																
D. Agricultural Soils																
E. Prescribed Burning of Savannas																
F. Field Burning of Agricultural Residues																
G. Other																
5. Land Use, Land-Use Change and Forestry (2)	**551,65**	**-1.686,92**	**-1.546,42**	**-1.154,01**	**-1.613,04**	**-1.664,37**	**-1.211,47**	**-1.172,45**	**-1.946,45**	**-1.221,26**	**1.642,01**	**-756,87**	**-1.965,11**	**-1.940,44**	**-2.279,64**	**-513,24**
A. Forest Land	-2.830,67	-3.007,91	-2.998,67	-3.209,98	-3.098,63	-2.987,71	-3.063,43	-3.155,13	-3.312,17	-3.306,31	-652,89	-3.538,63	-3.813,30	-3.532,21	-3.449,42	21,86
B. Cropland	3.287,46	1.228,37	1.361,40	1.969,70	1.401,95	1.232,81	1.767,59	1.909,09	1.297,12	2.015,75	2.227,06	2.712,45	1.779,21	1.525,81	1.108,51	-66,28
C. Grassland	92,91	90,68	88,92	84,33	81,69	88,59	82,46	71,68	66,84	68,24	71,10	74,29	75,94	75,97	73,77	-20,60
D. Wetlands	1,94	1,94	1,94	1,94	1,94	1,94	1,91	1,91	1,76	1,06	-3,26	-4,99	-6,97	-10,01	-12,50	-743,40
E. Settlements	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	0,00
F. Other Land	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	0,00
G. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0,00
6. Waste	**IE,NA,NE,NO**	**IE,NA,NE,NO**	**IE,NA,NE,NO**	**IE,NA,NE,NO**	**0,07**	**0,39**	**0,38**	**0,37**	**2,96**	**3,65**	**3,43**	**2,28**	**2,56**	**2,97**	**2,04**	**100,00**
A. Solid Waste Disposal on Land	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	0,00
B. Waste-water Handling																
C. Waste Incineration	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	0,00
D. Other	NA,NO	NA,NO	NA,NO	NA,NO	0,07	0,39	0,38	0,37	2,96	3,65	3,43	2,28	2,56	2,97	2,04	100,00
7. Other *(as specified in Summary 1.A)*	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**0,00**
Total CO2 emissions including net CO2 from LULUCF (3)	**53.264,11**	**61.707,44**	**56.055,69**	**58.598,77**	**61.629,95**	**58.785,42**	**72.755,38**	**63.291,11**	**58.456,12**	**56.311,04**	**54.712,17**	**53.912,61**	**52.297,28**	**57.513,68**	**51.660,97**	**-3,01**
Total CO2 emissions excluding net CO2 from LULUCF (3)	**52.712,46**	**63.394,37**	**57.602,11**	**59.752,78**	**63.242,99**	**60.449,79**	**73.966,84**	**64.463,57**	**60.402,57**	**57.532,30**	**53.070,17**	**54.669,49**	**54.262,39**	**59.454,11**	**53.940,61**	**2,33**
Memo Items:																
International Bunkers	**4.823,30**	**4.394,45**	**4.580,16**	**5.958,35**	**6.646,69**	**6.927,68**	**6.773,80**	**6.413,77**	**6.573,23**	**6.445,41**	**6.629,22**	**5.989,80**	**5.024,93**	**5.272,11**	**4.991,90**	**3,50**
Aviation	1.736,10	1.632,12	1.693,19	1.658,84	1.817,70	1.867,05	1.971,08	2.010,44	2.158,98	2.290,07	2.349,78	2.384,97	2.059,41	2.142,08	2.447,40	40,97
Marine	3.087,20	2.762,33	2.886,97	4.299,51	4.828,99	5.060,63	4.802,71	4.403,33	4.414,25	4.155,35	4.279,45	3.604,83	2.965,52	3.130,03	2.544,50	-17,58
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0,00
CO_2 Emissions from Biomass	4.640,89	5.032,95	5.321,34	5.574,45	5.533,46	5.868,80	6.295,78	6.542,43	6.491,97	6.857,21	7.090,04	7.696,30	8.199,10	9.113,55	9.646,95	107,87

Table A9.2

TABLE 10 EMISSIONS TRENDS (CH_4)
(Sheet 2 of 5)

Inventory 2004
Submission 2006 v1.1
DENMARK

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Change from base to latest reported year
	(Gg)															%
Total CH_4 emissions	**271,05**	**274,08**	**274,25**	**280,70**	**280,73**	**286,90**	**290,85**	**285,29**	**286,44**	**280,60**	**280,00**	**286,97**	**284,99**	**284,10**	**274,53**	**1,29**
1. Energy	10,56	12,03	12,67	15,17	18,57	25,05	29,94	29,96	31,37	31,52	31,16	32,66	32,46	32,49	32,70	209,70
A. Fuel Combustion (Sectoral Approach)	8,67	9,75	10,50	12,78	16,02	22,11	27,12	26,84	28,25	27,95	27,35	28,85	28,52	28,47	27,86	221,25
1. Energy Industries	1,11	1,53	1,83	3,38	6,37	11,51	14,96	14,51	15,70	15,63	14,84	16,07	16,00	15,71	15,37	1.287,93
2. Manufacturing Industries and Construction	0,71	0,74	0,71	0,73	0,74	0,84	1,27	1,27	1,35	1,35	1,54	1,60	1,47	1,47	1,51	113,82
3. Transport	2,51	2,79	2,96	3,13	3,24	3,55	3,87	3,70	3,69	3,45	3,29	3,22	2,96	2,88	2,57	2,59
4. Other Sectors	4,35	4,67	4,99	5,52	5,67	6,20	7,01	7,36	7,49	7,51	7,67	7,96	8,08	8,41	8,40	93,34
5. Other	0,00	0,02	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,00	0,00	0,01	116,81
B. Fugitive Emissions from Fuels	1,89	2,28	2,17	2,39	2,55	2,94	2,83	3,12	3,12	3,56	3,81	3,82	3,94	4,02	4,84	156,56
1. Solid Fuels	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
2. Oil and Natural Gas	1,89	2,28	2,17	2,39	2,55	2,94	2,83	3,12	3,12	3,56	3,81	3,82	3,94	4,02	4,84	156,56
2. Industrial Processes	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**IE,NA,NO**	**0,00**
A. Mineral Products	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	0,00
B. Chemical Industry	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
C. Metal Production	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
D. Other Production																
E. Production of Halocarbons and SF_6																
F. Consumption of Halocarbons and SF_6																
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0,00
3. Solvent and Other Product Use																
4. Agriculture	**190,98**	**191,56**	**190,74**	**193,77**	**191,33**	**192,21**	**190,60**	**186,00**	**187,72**	**181,11**	**181,73**	**186,71**	**183,88**	**181,96**	**178,10**	**-6,74**
A. Enteric Fermentation	155,19	154,08	150,75	151,37	149,91	150,89	148,63	143,39	143,30	137,33	136,28	139,07	135,41	133,38	129,07	-16,83
B. Manure Management	35,79	37,49	40,00	42,40	41,42	41,32	41,97	42,61	44,41	43,77	45,45	47,64	48,47	48,58	49,03	37,00
C. Rice Cultivation	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
D. Agricultural Soils	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	0,00
E. Prescribed Burning of Savannas	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0,00
F. Field Burning of Agricultural Residues	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0,00
5. Land Use, Land-Use Change and Forestry	**NE,NO**	**NE,NO**	**NE,NO**	**NE,NO**	**NE,NO**	**NE,NO**	**NE,NO**	**NE,NO**	**NE,NO**	**NE,NO**	**NE,NO**	**NE,NO**	**NE,NO**	**NE,NO**	**NE,NO**	**0,00**
A. Forest Land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0,00
B. Cropland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0,00
C. Grassland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0,00
D. Wetlands	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0,00
E. Settlements	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	0,00
F. Other Land	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	0,00
G. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0,00
6. Waste	**69,51**	**70,49**	**70,83**	**71,76**	**70,83**	**69,65**	**70,30**	**69,33**	**67,36**	**67,98**	**67,12**	**67,59**	**68,65**	**69,65**	**63,73**	**-8,31**
A. Solid Waste Disposal on Land	63,53	64,65	65,06	65,69	63,59	61,22	60,68	57,51	55,33	56,70	56,77	56,57	53,87	55,39	51,13	-19,52
B. Waste-water Handling	5,98	5,84	5,78	6,07	7,24	8,43	9,62	11,81	12,03	11,28	10,34	11,02	14,78	14,26	12,61	110,73
C. Waste Incineration	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	0,00
D. Other	NA,NO	NA,NO	NA,NO	NA,NO	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	100,00
7. Other ***(as specified in Summary 1.A)***	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**0,00**
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0,00
Memo Items:																
International Bunkers	0,10	0,09	0,10	0,13	0,14	0,15	0,15	0,14	0,14	0,14	0,14	0,12	0,11	0,11	0,10	3,29
Aviation	0,03	0,03	0,03	0,03	0,03	0,04	0,04	0,04	0,04	0,04	0,04	0,04	0,04	0,04	0,05	49,56
Marine	0,07	0,06	0,07	0,10	0,11	0,11	0,11	0,10	0,10	0,09	0,10	0,08	0,07	0,07	0,06	-17,35
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0,00
CO_2 Emissions from Biomass																

Table A9.3

TABLE 10 EMISSIONS TRENDS (N_2O)
(Sheet 3 of 5)

Inventory 2004
Submission 2006 v1.1
DENMARK

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Change from base to latest reported year
	(Gg)															%
Total N_2O emissions	**34,17**	**33,56**	**32,20**	**31,51**	**30,97**	**30,69**	**29,59**	**29,36**	**29,15**	**28,23**	**27,56**	**26,76**	**25,63**	**25,48**	**24,48**	**-28,36**
1. Energy	**1,37**	**1,57**	**1,56**	**1,63**	**1,76**	**1,86**	**2,13**	**2,14**	**2,16**	**2,22**	**2,20**	**2,25**	**2,31**	**2,40**	**2,40**	**75,01**
A. Fuel Combustion (Sectoral Approach)	1,37	1,56	1,55	1,63	1,75	1,86	2,12	2,13	2,16	2,20	2,19	2,24	2,30	2,39	2,39	74,82
1. Energy Industries	0,38	0,47	0,43	0,45	0,49	0,50	0,65	0,57	0,53	0,52	0,48	0,51	0,52	0,55	0,50	29,83
2. Manufacturing Industries and Construction	0,18	0,19	0,18	0,18	0,18	0,18	0,19	0,19	0,19	0,19	0,19	0,19	0,18	0,18	0,19	7,31
3. Transport	0,45	0,53	0,59	0,64	0,74	0,84	0,93	1,03	1,11	1,17	1,21	1,23	1,29	1,34	1,40	208,62
4. Other Sectors	0,35	0,36	0,34	0,35	0,33	0,33	0,35	0,33	0,32	0,31	0,30	0,31	0,30	0,31	0,29	-16,34
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	0,00	0,01	192,79
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	0,01	0,01	130,08
1. Solid Fuels	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	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	0,01	0,01	130,08
2. Industrial Processes	**3,36**	**3,08**	**2,72**	**2,56**	**2,60**	**2,92**	**2,69**	**2,74**	**2,60**	**3,07**	**3,24**	**2,86**	**2,50**	**2,89**	**1,71**	**-49,11**
A. Mineral Products	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	IE,NA	0,00
B. Chemical Industry	3,36	3,08	2,72	2,56	2,60	2,92	2,69	2,74	2,60	3,07	3,24	2,86	2,50	2,89	1,71	-49,11
C. Metal Production	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0,00
D. Other Production																
E. Production of Halocarbons and SF_6																
F. Consumption of Halocarbons and SF_6																
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0,00
3. Solvent and Other Product Use	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0,00
4. Agriculture	**29,15**	**28,65**	**27,68**	**27,02**	**26,31**	**25,64**	**24,55**	**24,27**	**24,18**	**22,74**	**21,92**	**21,47**	**20,64**	**20,03**	**20,19**	**-30,73**
A. Enteric Fermentation																
B. Manure Management	2,21	2,20	2,21	2,21	2,14	2,07	2,08	2,07	2,10	2,03	1,94	1,95	1,89	1,80	1,81	-18,10
C. Rice Cultivation																
D. Agricultural Soils	26,94	26,45	25,47	24,81	24,17	23,57	22,47	22,20	22,08	20,71	19,98	19,52	18,75	18,23	18,38	-31,77
E. Prescribed Burning of Savannas	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0,00
F. Field Burning of Agricultural Residues	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
G. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0,00
5. Land Use, Land-Use Change and Forestry	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**-17,07**
A. Forest Land	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	IE,NE,NO	0,00
B. Cropland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0,00
C. Grassland	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0,00
D. Wetlands	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-17,07
E. Settlements	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	0,00
F. Other Land	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	0,00
G. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0,00
6. Waste	**0,28**	**0,27**	**0,24**	**0,29**	**0,30**	**0,27**	**0,22**	**0,21**	**0,21**	**0,20**	**0,21**	**0,18**	**0,19**	**0,16**	**0,17**	**-39,27**
A. Solid Waste Disposal on Land																
B. Waste-water Handling	0,28	0,27	0,24	0,29	0,30	0,27	0,22	0,21	0,21	0,20	0,21	0,18	0,19	0,16	0,17	-39,29
C. Waste Incineration	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	0,00
D. Other	NA,NO	NA,NO	NA,NO	NA,NO	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	100,00
7. Other ***(as specified in Summary 1.A)***	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**0,00**
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0,00
Memo Items:																
International Bunkers	**0,25**	**0,23**	**0,24**	**0,33**	**0,37**	**0,38**	**0,37**	**0,35**	**0,35**	**0,34**	**0,35**	**0,31**	**0,26**	**0,27**	**0,25**	**-3,02**
Aviation	0,06	0,06	0,06	0,06	0,06	0,06	0,07	0,07	0,08	0,08	0,08	0,08	0,07	0,07	0,08	43,62
Marine	0,19	0,17	0,18	0,27	0,30	0,32	0,30	0,28	0,28	0,26	0,27	0,23	0,19	0,20	0,16	-17,20
Multilateral Operations	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0,00
CO_2 Emissions from Biomass																

Table 9.4

TABLE 10 EMISSION TRENDS (HFCs, PFCs and SF_6)
(Sheet 4 of 5)

Inventory 2004
Submission 2006 v1.1
DENMARK

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Change from base to latest reported year
	(Gg)															
Emissions of HFCs(4) - (Gg CO2 equivalent)	**NA,NE,NO**	**NA,NE,NO**	**3,4360**	**93,9338**	**134,5289**	**217,7281**	**329,3025**	**323,7532**	**411,1850**	**502,9828**	**604,6369**	**647,3172**	**672,0590**	**695,4772**	**748,9576**	**100,00**
HFC-23	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
HFC-32	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NO	NA,NO	0,00011	0,00084	0,00177	0,00272	0,00377	0,00575	0,01105	0,00844	0,01009	0,01198	100,00
HFC-41	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
HFC-43-10mee	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
HFC-125	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NO	0,00023	0,00258	0,00946	0,01578	0,02182	0,03173	0,04306	0,04877	0,04851	0,05490	0,05988	100,00
HFC-134	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
HFC-134a	NA,NE,NO	NA,NE,NO	0,00232	0,06903	0,09740	0,15009	0,20378	0,17239	0,21062	0,22744	0,25179	0,26874	0,28059	0,26826	0,28611	100,00
HFC-152a	NA,NE,NO	NA,NE,NO	0,00300	0,03000	0,04600	0,04340	0,03216	0,01521	0,00966	0,03820	0,01675	0,01341	0,01305	0,00204	0,00614	100,00
HFC-143	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
HFC-143a	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NO	0,00022	0,00243	0,00865	0,01373	0,01925	0,02912	0,03965	0,04009	0,04320	0,04900	0,05281	100,00
HFC-227ea	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
HFC-236fa	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
HFC-245ca	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
Unspecified mix of listed HFCs(5) - (Gg CO2 equivalent)	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
Emissions of PFCs(4) - (Gg CO2 equivalent)	**NA,NE,NO**	**NA,NE,NO**	**NA,NE,NO**	**NA,NO**	**0,0525**	**0,5023**	**1,6595**	**4,1186**	**9,0967**	**12,4815**	**17,8904**	**22,1272**	**22,1677**	**19,3410**	**15,9015**	**100,00**
CF_4	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
C_2F_6	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
C_3F_8	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NO	0,00001	0,00007	0,00024	0,00059	0,00130	0,00178	0,00256	0,00316	0,00317	0,00276	0,00227	100,00
C_4F_{10}	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
$c\text{-}C_4F_8$	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
C_5F_{12}	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
C_6F_{14}	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
Unspecified mix of listed PFCs(5) - (Gg CO2 equivalent)	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0,00
Emissions of SF6(4) - (Gg CO2 equivalent)	**44,45**	**63,50**	**89,15**	**101,17**	**122,06**	**107,34**	**60,96**	**73,06**	**59,42**	**65,36**	**59,23**	**30,40**	**25,01**	**31,37**	**33,15**	**-25,44**
SF_6	0,00	0,00	0,00	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-25,44

Table 9.5

TABLE 10 EMISSION TRENDS (SUMMARY)
(Sheet 5 of 5)

Inventory 2004
Submission 2006 v1.1
DENMARK

GREENHOUSE GAS EMISSIONS	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Change from base to latest reported year
	CO2 equivalent (Gg)															(%)
CO2 emissions including net CO2 from LULUCF(3)	53.264,11	61.707,44	56.055,69	58.598,77	61.629,95	58.785,42	72.755,38	63.291,11	58.456,12	56.311,04	54.712,17	53.912,61	52.297,28	57.513,68	51.660,97	-3,01
CO2 emissions excluding net CO2 from LULUCF(3)	52.712,46	63.394,37	57.602,11	59.752,78	63.242,99	60.449,79	73.966,84	64.463,57	60.402,57	57.532,30	53.070,17	54.669,49	54.262,39	59.454,11	53.940,61	2,33
CH_4	5.692,00	5.755,65	5.759,25	5.894,68	5.895,40	6.024,94	6.107,76	5.991,08	6.015,18	5.892,61	5.880,04	6.026,32	5.984,74	5.966,06	5.765,16	1,29
N_2O	10.593,40	10.404,66	9.981,10	9.768,19	9.599,69	9.514,15	9.173,50	9.100,97	9.037,85	8.749,95	8.545,09	8.297,15	7.944,10	7.897,72	7.588,74	-28,36
HFCs	NA,NE,NO	NA,NE,NO	3,44	93,93	134,53	217,73	329,30	323,75	411,19	502,98	604,64	647,32	672,06	695,48	748,96	100,00
PFCs	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NO	0,05	0,50	1,66	4,12	9,10	12,48	17,89	22,13	22,17	19,34	15,90	100,00
SF_6	44,45	63,50	89,15	101,17	122,06	107,34	60,96	73,06	59,42	65,36	59,23	30,40	25,01	31,37	33,15	-25,44
Total (including net CO2 from LULUCF)(3)	**69.593,96**	**77.931,25**	**71.888,63**	**74.456,75**	**77.381,69**	**74.650,08**	**88.428,56**	**78.784,10**	**73.988,85**	**71.534,43**	**69.819,06**	**68.935,92**	**66.945,35**	**72.123,65**	**65.812,88**	**-5,43**
Total (excluding net CO2 from LULUCF)(3), (6)	**69.042,31**	**79.618,18**	**73.435,05**	**75.610,76**	**78.994,73**	**76.314,45**	**89.640,02**	**79.956,55**	**75.935,30**	**72.755,69**	**68.177,05**	**69.692,80**	**68.910,46**	**74.064,09**	**68.092,52**	**-1,38**

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year (1990)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Change from 1990(1) to latest reported year
	CO2 equivalent (Gg)															(%)
1. Energy	52.121,25	62.722,31	56.823,81	59.032,23	62.609,65	59.983,88	73.574,45	63.906,80	59.884,12	57.108,91	52.601,14	54.231,34	53.853,28	59.197,37	53.525,10	2,69
2. Industrial Processes	2.188,81	2.293,74	2.331,01	2.405,13	2.503,83	2.675,71	2.779,96	2.970,32	3.011,38	3.184,56	3.366,99	3.293,06	3.190,01	3.212,82	3.059,95	39,80
3. Solvent and Other Product Use	136,90	134,78	132,67	130,55	128,44	123,29	127,28	127,12	119,36	115,69	119,58	112,57	106,33	107,24	113,48	-17,11
4. Agriculture	13.047,91	12.903,56	12.586,57	12.444,92	12.172,98	11.983,37	11.612,05	11.430,80	11.436,96	10.853,29	10.610,97	10.576,71	10.258,35	10.031,13	10.000,29	-23,36
5. Land Use, Land-Use Change and Forestry(7)	551,74	-1.686,83	-1.546,33	-1.153,92	-1.612,95	-1.664,28	-1.211,38	-1.172,36	-1.946,36	-1.221,18	1.642,08	-756,80	-1.965,04	-1.940,36	-2.279,57	-513,16
6. Waste	1.547,35	1.563,69	1.560,89	1.597,83	1.579,74	1.548,12	1.546,19	1.521,43	1.483,40	1.493,16	1.478,30	1.479,04	1.502,41	1.515,45	1.393,63	-9,93
7. Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0,00
Total (including LULUCF)(7)	**69.593,96**	**77.931,25**	**71.888,63**	**74.456,75**	**77.381,69**	**74.650,08**	**88.428,56**	**78.784,10**	**73.988,85**	**71.534,43**	**69.819,06**	**68.935,92**	**66.945,35**	**72.123,65**	**65.812,88**	**-5,43**

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589 Denmark's National Inventory Report 2006

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 2006. The report contains information on Denmark's inventories for all years' from 1990 to 2004 for CO_2, CH_4, N_2O, HFCs, PFCs and SF_6, CO, NMVOC, SO_2.

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