



National Environmental Research Institute
Ministry of the Environment · Denmark

Emission Inventories

Denmark's National Inventory Report 2005

Submitted under the United Nations Framework
Convention on Climate Change. 1990-2003

Research Notes from NERI No. 211

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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 2005. The report contains information on Denmark's inventories for all years' from 1990 to 2003 for CO ₂ , CH ₄ , N ₂ O, 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) due by 15 April 2005 to the United Nations Framework Convention on Climate Change (UNFCCC). The report contains information on Denmark's inventories for all years from 1990 to 2003. The structure of the report is in accordance with the UNFCCC Guidelines on reporting and review and the report includes detailed information on the inventories for all years from the base year to the year of the current annual inventory submission, in order to ensure the transparency of the inventory.

The annual emission inventory for Denmark from 1990 to 2003 is reported in the Common Reporting Format (CRF). The CRF-spreadsheets contain data on emissions, activity data and implied emission factors for each year. Emission trends are given for each greenhouse gas and for the total greenhouse gas emissions in CO₂-equivalents.

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

The NIR and the CRF tables are available to the public on the National Environmental Research Institute's homepage:

http://www.dmu.dk/1_Viden/2_Miljoe-tilstand/3_luft/4_adai/default_en.asp

Responsible institute

The National Environmental Research Institute (NERI) under the Danish Ministry of Environment is responsible for the annual preparation and submission to the UNFCCC (and the EU) of the National Inventory Report and the GHG inventories in the Common Reporting Format in accordance with the UNFCCC Guidelines. NERI is also the designated entity with the overall responsibility for the national inventory under the Kyoto Protocol. The work concerning the annual greenhouse emission inventory is carried out in co-operation with other Danish ministries, research institutes, organisations and companies.

Greenhouse gases

The greenhouse gases reported under the Climate Convention are:

- Carbon dioxide (CO₂)
- Methane (CH₄)
- Nitrous Oxide (N₂O)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulphur hexafluoride (SF₆)

The global warming potential values of various gases have been defined as the warming effect of a given weight of a specific substance relative to CO₂. The purpose of this is to be able to compare and integrate the effects of individual substances on the global climate. The typical lifetimes are

100, 10 and 300 years for CO₂, CH₄ and N₂O, respectively, and the time perspective clearly plays a decisive role. The lifetime chosen is typically 100 years. Then the effect of the various greenhouse gases can be converted into the equivalent quantity of CO₂, i.e. the quantity of CO₂ giving the same effect in absorbing solar radiation. According to the IPCC, the most recent global warming potential values for a 100-year time horizon are:

- CO₂: 1
- Methane (CH₄): 21
- Nitrous oxide (N₂O): 310

Based on weight and a 100-year period, methane is thus 21 times more powerful a greenhouse gas than CO₂, and N₂O 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 global warming potential values used in this reporting are those prescribed by UNFCCC.

ES.2. Summary of national emission and removal related trends

Greenhouse Gas Emissions

The greenhouse gas emissions are estimated according to the IPCC guidelines and are aggregated in seven main sectors. The greenhouse gases include CO₂, CH₄, N₂O, HFCs, PFCs and SF₆. Figure ES.1 shows the estimated total greenhouse gas emissions in CO₂ equivalents from 1990 to 2003. The emissions are not corrected for electricity trade or temperature variations. CO₂ is the most important greenhouse gas followed by N₂O and CH₄ in relative importance. The contribution to national totals from HFCs, PFCs and SF₆ is about 1%. Stationary combustion plants, transport and agriculture are the largest sources. The net CO₂ removals by forestry and soil (Land Use Change and Forestry (LUCF)) are about 2% of the total emissions in CO₂ equivalents in 2003. The national total greenhouse gas emissions in CO₂ equivalents without LUCF have increased by 6,8% from 1990 to 2003 and by 4,8% with LUCF.

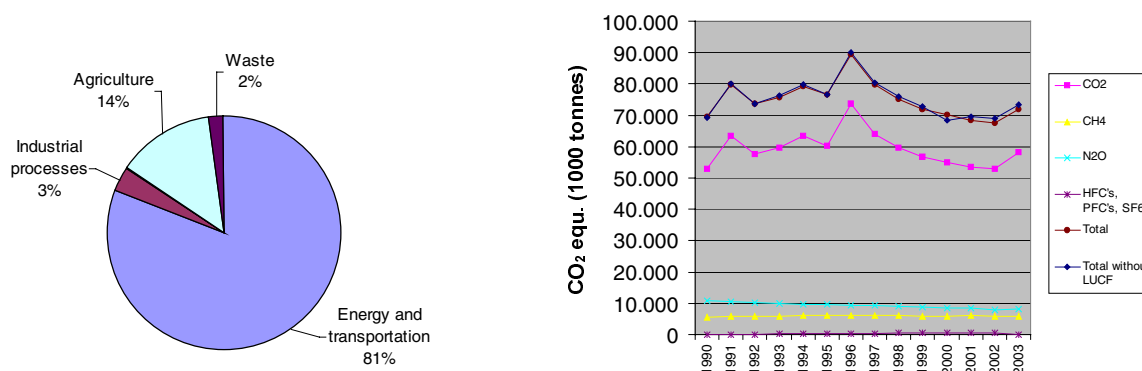


Figure ES.1 Greenhouse gas emissions in CO₂ equivalents distributed on main sectors for 2003. Left: Time-series for 1990 to 2003.

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

Energy

The largest source to the emission of CO₂ is the energy sector, which includes combustion of fossil fuels like oil, coal and natural gas. Public power and district heating plants contribute with more than half of the emissions. About 22% come from the transport sector. The CO₂ emission increased by about 9% from 2002 to 2003. The reason for this increase was mainly due to increasing export of

electricity. Also lower outdoor temperature in 2003 compared with 2002 contributed to the increase. A relatively large fluctuation in the emission time-series 1990 to 2003 is due to cross-country electricity trade. Thus 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 CH₄ is due to increasing use of gas engines in the decentralised cogeneration plants. The CO₂ emission from the transport sector has increased by 22% since 1990 mainly due to increasing road traffic.

Agriculture

The agricultural sector contributes with 14% of the total greenhouse gas emission in CO₂- equivalents and is one of the most important sectors regarding the emissions of N₂O and CH₄. In 2003 the contributions to the total emissions of N₂O and CH₄ were 78% and 62 % respectively. The main reason for a drop of the N₂O emission of about 31% from 1990 to 2003 is because of demands according to legislation to an improved utilisation of nitrogen in manure. This results in less nitrogen excreted per unit produced and a considerably reduction in the use of fertilisers. From 1990 the emissions of CH₄ from enteric fermentation have decreased because of decreasing numbers of cattle. However, the emission from manure management has increased due to change in stable systems towards an increase in slurry based stable systems. Altogether the emission of CH₄ for the agriculture sector has decreased by 4% from 1990 to 2003.

Industrial processes

The emissions from industrial processes – that is emissions from processes other than fuel combustion - amount to 3% of the total national emissions in CO₂- equivalents. The main sources are cement production, nitric acid production, refrigeration, foam blowing and calcination of limestone. The CO₂ emission from cement production – which is the largest source contributing with 2,6% of the national totals – increased with 55% from 1990 to 2003. The second largest source is N₂O from the production of nitric acid. The N₂O emission from this production decreased with 14% from 1990 to 2003.

The emissions of HFCs, PFCs and SF₆ have since 1995 and until 2003 increased by 129% mainly due to increasing emissions of HFCs. The use of HFCs, and especially HFC-134a have increased several fold so HFCs has become a very dominating F-gas contributing to the F-gas total from 66% in 1995 to 93% in 2003. HFC-134a is mainly used as a refrigerant. However, the use of HFC-134a is stagnant or falling. This is due to Danish law, which in 2007 forbids new HFC based refrigerant stationary systems. Counter to this trend is the increasing use of air conditioning systems, among these mobile systems.

Waste

Waste disposal is the third largest source to CH₄ emissions. The emission has decreased by 14% from 1990 to 2003 where the contribution was 20% of the total CH₄ emission. The decrease is due to increasing use of waste for power and heat production. Since all incinerated waste is used for power and heat production, the emissions are included in the 1A1a IPCC category. For the first time the CH₄ emissions from waste-water handling are included in the inventory. The emission from this sector amounts to about 4% of the total CH₄ emissions.

ES.4. Other information

ES.4.1 Quality assurance and quality control

A draft 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). The ISO 9000 standards are also used as an important input for the plan. The plan is under development and adjustments may still take place.

In the preparation of Denmark's annual emission inventory several quality control (QC) procedures are carried out already 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 frame 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 describe 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. So far the reviews have been completed for the stationary combustion plants sector and the transport sector. In order to verify the Danish emission inventories a project where emission levels and emission factors are compared with other countries have been started.

ES.4.2. Completeness

The Danish greenhouse gas emission inventory due 15 April 2005 includes all sources identified by the Revised IPPC Guidelines except the following:

- Industrial processes: CO₂ emission from use of lime and limestone for flue gas cleaning, sugar production and production of expanded clay will be included in the next submission. These sources are expected to contribute with about 0,2% of the total GHG emissions in 2003.
- 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. However, this emission is seen as non-significant compared to the total emission from enteric fermentation.

ES.4.3. Recalculations and improvements

Considerable improvements of 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:

- Disaggregation of the emissions for *Manufacturing Industries* has now been carried out according to splits given the CRF tables.
- For the *Waste Sector* methodologies for estimation of CH₄ and N₂O emissions from *Wastewater Handling* have been worked out and implemented.
- Emissions from *offshore activities* have been updated using the methodology described in the Emission Inventory Guidebook 3rd edition. The sources include emissions from extraction of oil and gas, on-shore oil tanks, on-shore and offshore loading of ships.
- The *quantitative uncertainty* estimate has been extended to cover more sources so it now includes 99,7% of the total Danish GHG emissions.

- The GHG emission inventories for *Faroe Island and Greenland* have been included in a separate version of the CRFs for Denmark, Faroe Island and Greenland for 1990-2003 submitted in an annex to this NIR.
- For *Solvent and Other Product Use* a new methodology has been worked out and implemented.
- For the *Agricultural Sector* all of the comments of the review team have been carefully considered and actions have been taken.
- The category *CO₂ Emissions and Removals from Soils* has been considered and emission estimates are included in the CRFs and described in this NIR.
- As a part of the quality assurance work reviews have been performed for the stationary combustion plant sector and the transport sector, and reviews are going on for the agriculture sector and the wastewater sector. National experts not involved in the emission inventory work have performed the reviews.
- For the *LULUCF Sector* in this submission the structure of the NIR has been improved and now follows the UNFCCC reporting guidelines.
- The description in this NIR of the methodology for estimation of CH₄ from *Solid Waste Disposal on Land* has been improved and default methodology has been used for comparison and as part of the QA-procedure.

For the **National Total CO₂ 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 -0.50 and +0.86. 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 CO₂ Equivalent Emissions with Land-Use Change and Forestry** the general impact of the **recalculations** is rather small, although the impact is bigger than without LULUCF due to recalculations in the LULUCF Sector. The differences are positive for all years. The differences vary between 2.75% and 5.41%. 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 2005. Rapporten indeholder oplysninger om Danmarks opgørelser for fra 1990 til 2003. 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 2003 er rapporteret i det format (CRF) som IPCC angiver. CRF-tabellerne indeholder oplysninger om emissioner, aktivitetsdata og emissionsfaktorer for hvert år, emissionsudvikling for de enkelte drivhusgasser samt den totale drivhusgasemission i CO₂ ækvivalenter.

Følgende emner er beskrevet i rapporten: Udviklingen i drivhusgasemissionerne, de forskellige IPCC-kategorier, usikkerheder, rekalkulationer, planlagte forbedringer og procedure for kvalitets-sikring og – kontrol.

Rapporten og tabellerne med emissionsopgørelserne er tilgængelige på DMU's hjemmeside om emissionsopgørelser:

http://www.dmu.dk/1_Viden/2_Miljoe-tilstand/3_luft/4_adaei/default_en.asp

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 retningslinier for rapportering diskuteres og vedtages og i EU's monitoringsmekanisme 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 (CO₂)
- Metan (CH₄)
- Lattergas (N₂O)
- Hydrofluorcarboner (HFC'er)
- Perfluorcarboner (PFC'er)
- Svovlhexafluorid (SF₆)

Det globale opvarmningspotentiale, på engelsk Global Warming Potential (GWP), udtrykker virkningen af en vægtenhed af et givet stof relativt til carbondioxid. Med karakteristiske levetider af størrelsesordenen 100, 10 og 300 år, for henholdsvis kuldioxid, metan og lattergas, er det klart at tidshorisonten spiller en afgørende rolle. 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 strålingspåvirkning. De seneste GWP-værdier for en 100-årig tidshorisont er ifølge IPCC:

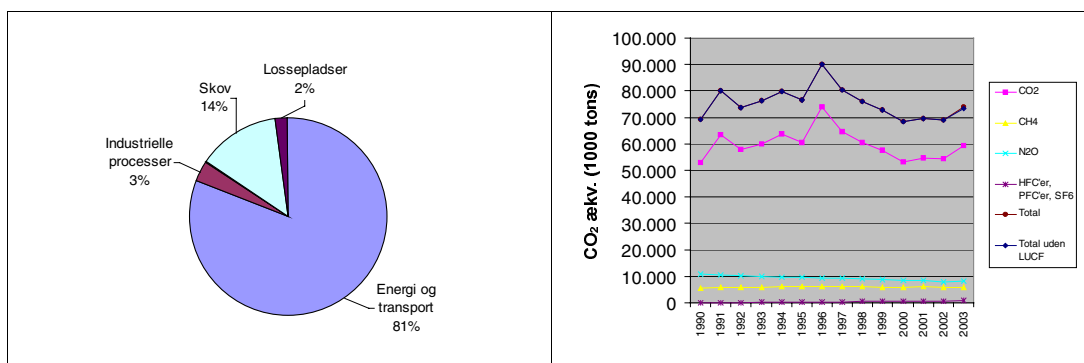
- Kuldioxid, CO_2 : 1
- Metan, CH_4 : 21
- Lattergas, N_2O : 310

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's¹ 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 2003. 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. 2 % af de totale emissioner i CO_2 -ækvivalenter i 2003. De nationale totale drivhusgasemissioner i CO_2 -ækvivalenter er steget med 6,8% fra 1990 til 2003 hvis netto-bidraget fra skovenes og jordenes udledninger og optag af CO_2 ikke indregnes og med 4,8% hvis de indregnes.



Figur S.1: Danske drivhusgasemissioner fordelt på kilder/sectorer, 1990 – 2003

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 22% stammer fra transportsektoren. CO_2 -emissionen steg med omkring 9% fra 2002 til 2003 grundet stigende eksport af elektricitet og lavere udendørstemperatu-

re i 2003 sammenlignet med 2002. 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 eksport, 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 CO₂-emissioner er steget med ca. 22% siden 1990 hovedsagelig på grund af voksende vejtrafik.

Landbrug

Landbrugssektoren bidrager med 14% af de totale drivhusgasser i CO₂-ækvivalenter og er den vigtigste kilde hvad angår emissioner af N₂O og CH₄. I 2003 var bidragene til de totale emissioner af N₂O og CH₄ henholdsvis 78% og 62%. Fra 1990 ses et fald på 31% i N₂O-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 2003 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 CH₄ emissionerne fra landbrugssektoren faldet med 4% fra 1990 til 2003.

Industrielle processer

Emissionerne fra industrielle processer – hvilket vil sige andre processer end forbrændingsprocesser – udgør 3% af de totale danske drivhusgasemissioner. De vigtigste kilder er cementproduktion, salpetersyreproduktion, kølesystemer, opskumning af plast og kalcinering af kalksten. CO₂-emissionen fra cementproduktion – som er den største kilde – bidrager med 2,6% af de totale emissioner i 2003 og stigningen fra 1990 til 2003 var 55%. Den anden største kilde er lattergas fra produktion af salpetersyre. Lattergasemissionen faldt med 14% fra 1990 til 2003.

Emissionerne af HFC'er, PFC'er og SF₆ er siden 1995 og indtil 2003 steget med 129% 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 66% i 1995 og til 93% i 2003. 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 airconditionssystemer, hvoraf nogle er mobile.

Affald

Lossepladser er den tredjestørste kilde til CH₄ emissioner. Emissionen er faldet med 14% fra 1990 til 2003 hvor andelen var 20% af de totale CH₄ emissioner. Faldet skyldes stigende anvendelse af affald til produktion af elektricitet og varme. Da alt affaldsforbrænding bruges til produktion af elektricitet og varme, er emissionerne inkluderet i IPCC-kategorien 1A1a, der omfatter kraft- og fjernvarmeværker. Emissionerne fra spildevandsanlæg er medtaget for første gang i de danske emissionsopgørelser. Emissionerne fra denne sektor udgør omkring 4% af de totale CH₄-emissioner.

S.4. Andre informationer

S.4.1 Kvalitetssikring og -kontrol

Rapporten indeholder en foreløbig plan for implementering af kvalitetssikring og -kontrol af emissionsopgørelserne. Kvalitetsplanen bygger på IPCC's retningslinier og ISO 9000 standarderne. Planen er under udvikling, og der vil derfor kunne ske ændringer i planen.

Som beskrevet i rapportens kapitel 3-8 anvendes allerede procedure, der sikre opgørelsernes kvalitet. Kvalitetsplanen vil forbedre disse procedure, 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. Kompletthed

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

Industrielle processer: CO₂-udledningerne fra anvendelse af kalk og kalksten til røggasrensning, produktion af ekspanderet ler og produktion af sukker. Disse kilder forventes at bidrage med ca. 0,2% af de totale drivhusgasemissioner.

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 foretaget 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:

- Emissionerne fra industrielle forbrændingsanlæg er diaggregerede i henhold til opdelingen i CRF-tabellerne.
- For spildevandsanlæg er der udviklet metoder til beregning af CH₄ og N₂O emissionerne, og resultaterne er implementeret i opgørelserne.
- Emissionerne fra olie- og gasindvinding er blevet opdaterede i henhold til de metoder, der er beskrevet i europæiske EMEP/EIONET guidebogen. Kilderne inkluderer emissioner fra ekstraktion af olie og gas, olietanke på land og lastning af olietankskibe til søs og på land.
- De kvantitative usikkerhedsberegninger er udvidet til at omfatte flere kilder og dækker nu 99,7% af de totale danske drivhusgasemissioner.
- Drivhusgasopgørelserne for Grønland og Færøerne er nu medtaget i en separat CRF-tabel for Danmark, Grønland og Færøerne for 1990 til 2003 og er vedlagt i et appendiks til rapporten.

- En ny metode til beregning af NMVOC-emissionerne fra brug af opløsningsmidler, er udviklet og implementeret.
- CO₂-emissioner og optag fra jorde er blevet beregnet og inkluderet i opgørelserne.
- Som en del af arbejdet med kvalitetssikring af opgørelserne er uafhængige nationale evalueringer blevet gennemført for stationære forbrændingsanlæg og transportsektoren. Evalueringer er igangsat for affaldssektoren og landbrugssektoren.
- Strukturen af rapportens kapitel om arealanvendelse og skovbrug er blevet forbedret og følger nu IPCC's retningslinier.
- Beskrivelsen af metoden til beregning af CH₄ emissioner fra lossepladser er blevet forbedret. Som en del af arbejdet med kvalitetssikring er resultaterne sammenlignet med resultater fra anvendelse af IPCC-standardmetode.

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 -0,5 og +0,86.

Ændringer i de danske totale drivhusgasemissioner er større når emissioner og optag fra jorde 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 +2,75% og +5,41%.

1 Introduction

1.1 Background information on greenhouse gas inventories and climate change

Annual report

This report is Denmark's National Inventory Report (NIR) due by 15 April 2005 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 2003. The structure of the report is in accordance with the UNFCCC Guidelines on reporting and review (UNFCCC, 2002). The report includes detailed and complete information on the inventories for all years from the base year to the year of the current annual inventory submission, in order to ensure the transparency of the inventory.

The annual emission inventory for Denmark from 1990 to 2003 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 CO₂ equivalents. The complete sets of CRF-files are available on the NERI homepage (www.dmu.dk). Annex 9 contains the CRF tables 10.1 to 10.5.

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

According to the instrument of ratification the Danish government has ratified the UNFCCC on behalf of Denmark, Greenland and the Faroe Islands. Annex 6.1 contains total emissions for Denmark, Greenland and the Faroe Islands for 1990 to 2003. In Annex 6.2 information on the Greenland and the Faroe Islands inventories are given. Apart from Annexes 6.1 and 6.2 the information in this report only relates to Denmark.

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

Greenhouse gases

The greenhouse gases reported under the Climate Convention are:

- Carbon dioxide (CO₂)
- Methane (CH₄)
- Nitrous Oxide (N₂O)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulphur hexafluoride (SF₆)

The main greenhouse gas responsible for the anthropogenic influence on the heat balance is CO₂. The atmospheric concentration of CO₂ has increased from 280 to 370 ppm (about 30%) since the pre-industrial era in the nineteenth century. The main cause is the use of fossil fuels, but changing land use, including forest clearance, has also been a significant factor. The concentrations of the

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

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

Based on weight and a 100-year period, methane is thus 21 times more powerful a greenhouse gas than CO_2 , and N_2O is 310 times more powerful. Some of the other greenhouse 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 enough countries, including Denmark, for it to enter into force on 21 March 1994. One of the provisions was to stabilise the greenhouse gas emissions from the industrialised nations by the end of 2000. At the first conference under the UN Climate Convention in March 1995 it was decided that the stabilisation goal was inadequate. At the third conference in December 1997 in Kyoto in Japan, a legally binding agreement was reached committing the industrialised countries to reduce the six greenhouse gases by 5.2% up to 2008-2012 compared to the 1990 level. However, for the F-gases the nations can freely choose between 1990 and 1995 as the base year. On May 16, 2002, the Danish parliament voted for the Danish ratification of the Kyoto Protocol. Denmark is, thus, under a legal commitment to meet the requirements of the Kyoto Protocol, when it comes into force. The European Union must reduce emissions of greenhouse gases by 8%. However, within the EU, Member States have made a political agreement – the Burden Sharing Agreement – on the contributions by each state to the overall EU reduction level of 8%.

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

In accordance with the Kyoto-Protocol Denmark's base year emissions include the emissions of CO_2 , CH_4 and N_2O in 1990 in CO_2 -equivalents and the emissions of HFCs, PFCs and SF_6 in 1995 in CO_2 -equivalents. Furthermore, the removals by sinks are included in the net emissions. Removals by sinks only include sequestration due to afforestation since 1990. When reporting to the Climate Convention the net CO_2 removals by forests existing in 1990 are included in the calculation also.

The role of the European Union

The European Union (EU) is a Party to the UNFCCC and the Kyoto Protocol. Therefore EU has to submit similar data sets and reports for the collective 15 EU Member States. The EU imposes some additional guidelines to EU Member States through the EU Greenhouse Gas Monitoring Mechanism to guarantee that 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 CO₂ 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 providing of data was on a voluntary basis but more formal agreements are now being worked out.

1.3 Brief description of the process of inventory preparation. Data collection and processing and 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 placed at NERI. The databases are in Access format and handled with software developed by the European Environmental Agency and NERI. As input to the databases various sub-models are used to estimate and aggregate the background data in order to fit the format and level in the central databases. The methodologies and data sources used for the different sectors are described in Chapter 1.4 and Chapters 3 to 9. As 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 backed up is archived safely. A further documentation and archiving system is the official journal for NERI for which there exist obligations for NERI as a governmental institute. In this journal system correspondence, in-going and out-going, is registered, which in this case involves registration of submissions and communication on inventories with the UNFCCC-Secretariat, with the European Commission, with 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 to UNFCCC and EU (the CRF format (Common Reporting Format)) and to United Nations Economic Commission for Europe/Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (UNECE/EMEP) (the NFR format (Nomenclature For Reporting)). For data handling the software tool is CollectER (Pulles et al., 1999a), for the CRF reporting the software tool is ReportER (Pulles et al., 1999b) and CRF correction templates have been developed by NERI. Data files and program files used in the inventory preparation process is listed in Table 1.1.

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

Level	Name	Application	Path	Type	Input sources	Remarks
5	NFR-tables (UNECE/EMEP)	External report	I:\ROSPROJ\LUFT_EMI\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\CcollectER\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	

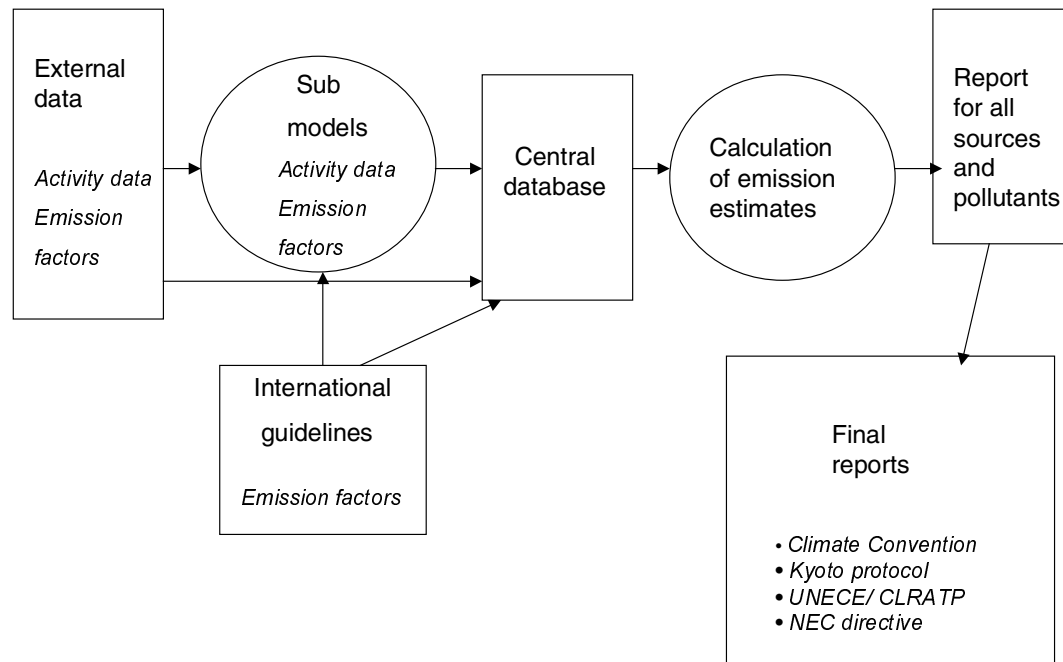


Figure 1.1. Schematic diagram of the process of inventory preparation.

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 as timely, consistent, transparent, accurate and comparable as possible, the inventory programme has developed calculation methodologies for most sub-sectors 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 mainly based on official statistics. The most consistent emission factors have been used, either as national values or default factors proposed by the CORINAIR methodology. The documentation on the CORINAIR methodology can be obtained from the "Joint EMEP/CORINAIR Atmospheric Emission Inventory Guidebook, Second edition (Richardson, S. (Ed), 1999). The documentation on the COPERT III is given in Ntziachristos et al. (2000).

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

1.4.1 Stationary Combustion Plants

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

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

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

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

Some of the large plants like e.g. power plants and municipal waste incineration plants are registered individually as large point sources and emission data from the actual plants are used. This enables use of plant specific emission factors that refers to emission measurements stated in annual environmental reports etc. At present the emission factors for CO₂, CH₄ and N₂O are, however, not plant specific whereas emission factors of SO₂ and NO_x often are.

The CO₂ 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, CO₂ emission from fuel combustion is aggregated using the reference approach. In 2003 the CO₂ emission inventory based on the reference approach and the national approach, respectively, differs 0,04%.

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

The specific methodologies regarding Fugitive Emissions from Fuels

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

Storage and handling of coal:

Coal mining is not occurring in Denmark, but power plants use a considerable amount of coal. CH₄ emission from storage and handling of coal is included in the Danish inventory. The CH₄ emission inventory is based on Tier 1 in the 'IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual'. The CH₄ emission occurring in Denmark is assumed to be half the post-mining emission.

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 extraction of oil and gas, on-shore oil tanks, on-shore and offshore loading of ships. The emission factors are based on the figures given in the Guidebook except for the on-shore oil tanks where national values are used.

Oil Refineries – Petroleum products processing:

The VOC emissions from petroleum refinery processes cover non-combustion emissions from feed stock handling/storage, petroleum products processing, product storage/handling and flaring. SO₂ is also emitted from the non-combustion processes and includes emissions from products processing and sulphur recovery plants. The emission calculations are based on information from the Danish refineries and the energy statistic.

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

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

Natural gas transmission and distribution:

Inventories of CH₄ 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 1999-2003 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).

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

For air traffic the 2001, 2002 and 2003 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 includes the findings from a Danish city-pair emission inventory in 1998.

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

The most thorough recalculations have changed the estimates for aviation, navigation and fisheries. As regards aviation a revised domestic/international jet fuel use split has been made, due to the inclusion of several turboprop representative aircraft types. The recalculations influence the CH₄ emission factors, and the emission estimates of CO₂, CH₄ and N₂O for the sector 1A3a. For navigation and fisheries the 2002 diesel fuel use has been updated, thus influencing the CO₂, CH₄ and N₂O estimates for the sectors 1A3d and 1A4c.

For transport the CO₂ emissions are determined with the lowest uncertainty, while the levels of the CH₄ and N₂O estimates are significantly more uncertain. The overall uncertainties in 2003 for CO₂, CH₄ and N₂O are around 5, 35 and 56 %, while the 1990-2003 emission trend uncertainties for the same three components are 5, 6 and 193 %, respectively.

Please refer to Chapter 3 and Annex 3B for further information about emission 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 companies according to obligations in Danish law. These accounts are subject to audit. The emission factor is produced as a result of weighting of emission factors resulting from the production of low alkali cement, rapid cement, basis cement, and white cement.

Mineral Products: Lime and bricks. CRF Table 2(I).A-G Sectoral Background Data for Industrial processes. A.2.

The reference for the activity data for production of lime, hydrated lime and bricks are the production statistics from the manufacturing industries published by Statistics Denmark. The productions of lime and yellow bricks imply CO₂ emissions. For the calculation of these emissions and the emission factors used please refer to Annex 3.C.

Mineral products: Glass and glass wool. CRF Table 2(I).A-G Sectoral Background Data for Industrial processes. A.7.

The reference for activity data for 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 CO₂ emission.

Chemical Industry. Nitric Acid production: CRF Table 2(I).A-G Sectoral Background Data for Industrial processes. B.2.

There is one producer. The data so far in the inventory relies on information from the producer. The producer only reports NO_x emissions associated with the production. The producer reports these emissions as measured emissions. Information on N₂O emission has been obtained by contact to the producer.

Chemical Industry. Catalysts/fertilisers: CRF Table 2(I).A-G Sectoral Background Data for Industrial processes. B.5 Others.

There is one producer. The data in the inventory relies on information published by the producer in environmental reports.

Metal production. Steelwork: CRF Table 2(I).A-G Sectoral Background Data for Industrial processes. C.1.

There is one producer. The activity data as well as data on consumption of raw materials (coke) has been published by the producer in environmental reports. Emission factors are based on stoichiometric relations between raw materials and CO₂ emission.

F-gases (HFCs, PFCs and SF₆): CRF Sectoral Report for Industrial Processes Table 2(I) and 2(II) and Sectoral Background Data for Industrial Processes Tables 2(II).F

The inventory on the F-gases: HFCs, PFCs and SF₆ is based on work carried out by the Danish Consultant Company "Planmiljø". Their yearly report (Danish Environmental Protection Agency, 2005) is available in Danish, and will be available in English as documentation of inventory data up to year 2003. The methodology is implemented for the whole time-series 1990-2003, but only since 1995 (1993) full information on activities exist.

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

1.4.4 Solvents

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

A new approach for calculating the emissions of Non-Methane Volatile Organic Carbon (NMVOC) from industrial and household use in Denmark is introduced. It focuses on single chemicals rather than activities. This will lead to a clearer picture of the influence from each specific chemical, which will enable a more detailed differentiation on products and the influence of product use on emissions. The procedure is to quantify the use of the chemicals and estimate the fraction of the chemicals that is emitted as a consequence of use.

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 pr. year (from 1995 to 2003)

is calculated. It is found that 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 in 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 NMVOC to emissions from industrial sectors and households; Tidal (annual) trend in NMVOC emissions, expressed as total NMVOC and single chemical, and specified in industrial sectors and households

Please refer to Chapter 5 for further information about 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 Guideline (IPCC, 1996) and the Good Practice Guidance (IPCC, 2000). Activity data for livestock is on a one-year average basis from Agriculture Statistics published in Statistics Denmark (2004). Data concerning the land use and crop yield is also from the Agricultural Statistic. Data concerning the feed consumption and nitrogen excretion is based on information from the Danish Institute of Agricultural Science. The CH₄ 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 classes. The emission from enteric fermentation for poultry and fur farming is not estimated. There is no default value recommended in IPCC (Table A-4 in Good Practice Guidance). The emission from manure management for fur farming is not estimated. It is not possible to report this emission source in CRF table 4s1.

Emission of N₂O 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 N₂O emission the IPCC standard value is used for all emission sources. The emission of CO₂ 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 (Mikkelsen et al., 2005). The emission from the agricultural sector is mainly related to the livestock production. DIEMA is working on a detailed level and includes about 30 livestock categories, and each category is subdivided according to stable type and manure type. The emission is calculated from each category and the emission is aggregated in accordance to the livestock category given in the CRF.

To ensure the data quality, both data used as activity data and background data used to estimate the emission factor are collected and discussed in corporation with specialists and researchers at different institutes and research sections. Thus the emission inventory will be evaluated continuously according to the latest knowledge. Furthermore, time-series of both emission factors and

emissions in relation to the CRF categories are prepared. Considerable variations in time-series are explained.

The uncertainties for assessment of emissions from Enteric Fermentation, Manure Management and Agricultural Soil have been estimated based on a Tier1 approach. The most significant uncertainties are related to the N₂O emission.

A more detail 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 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 are similar during the period 2000-2003. The data for annually harvested amounts of wood 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 2005 submission. The only minor data change concerns the area of broadleaved forest, which has been revised from 164 kha to 166 kha. The formerly used area was slightly too low due to various rounding off errors. This did not affect the previously reported C stock changes as the correct area (without rounding off errors) was used in calculations.

For cropland converted to forest land (afforestation), the reported change in C stocks 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 (subsidized private afforestation, municipal afforestation, and afforestation by state forest districts). Afforestation by private land owners without subsidies were based on total afforested area recorded by the Forestry Census 2000 for the period 1990-99 subtracted 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 2005 submission.

The annual C stock change for forest land remaining forest land in 2003 is slightly lower compared to that of 2002 as the harvested amount of wood was slightly higher in 2003 than in 2002. 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 increasing total area of afforested stands.

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, 2005

(see the reference list at Chapter 8 for the link to the report). CH₄ emissions from Solid Waste Disposal Sites are calculated with a model suited 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 CH₄ and N₂O at wastewater treatment plants (WWTPs) have been worked out and implemented.

The methodology for CH₄ is developed following the IPCC Guidelines and the IPCC Good Practice Guidance. The data available for the amounts of wastewater is registered by the 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 between those domestic/municipal and industrial contributions. 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 into sludge and 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 CH₄ not emitted, the recovered or combusted methane have been calculated based on yearly reported national final sludge disposal data from the DEPA. No emissions originating from on-site industrial treatment processes have been included.

For the methodology for N₂O 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 contribution by indirect emission originates from the effluents wastewater 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 Danish population number, $F_{connected}$ is the fraction of the Danish population connected to the municipal sewer system (90%) and $EF_{N_2O,WWTP,direct}$ is the emission factors, which has been adjusted by a correction factor accounting for an increasing influent of nitrogen containing wastewater from the industry from 1990 to 1998 after which the industrial contribution has reached a constant level. The methodology for calculation of the indirect N₂O 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 N₂O 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 are 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.

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

1.5 Brief description of key source categories

A key source analysis for year 2003 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 and 2004. The source categorisation used results in a total of 67 sources, of which 18 are identified as key sources due to both level and trend key source analysis. The energy sector contributes to those 18 key sources with 6 key sources of which CO₂ from coal is the most contributing category with 30.5% of the national total. The category CO₂ emissions from mobile combustion, road transportation is the second most contributing with 16.0% and CO₂ from natural gas is the third largest contributor with 15.1%. In the agriculture sector, there are 5 trend and level key sources, of which three are among the seventh most contributing sources to national total. These three sources are direct N₂O emissions from agriculture soils, indirect N₂O emissions from nitrogen used in agriculture and CH₄ from enteric fermentation, contributing 3.9, 3.7 and 3.7%, respectively, to the national total in 2003. The 4th agricultural key source is CH₄ from manure management contributing 1.3% and the 5th N₂O from manure management contributing 0.8%. Finally, the industrial sector contributes with three level and trend key sources, which is CO₂ from the cement production (contributes 1.9%), N₂O from the nitric acid production (1.2%) and emissions from substitutes for ODS, F-gases (1.0%). The waste sector includes one key source, which is CH₄ from solid waste disposal on land, contributing 1.6% to 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 draft plan for implementing a Quality Control (QC) and Quality Assurance (QA) for greenhouse gas emission inventories performed by the Danish National Environmental Research Institute. The plan is under development and thus not a finite status and adjustments will still take place. The plan is in accordance with the guidelines provided by the UNFCCC and the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC). 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 carried out already 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 lined out by ISO 9000 standards including Good Practice Guidance:

- Quality management (QM) Co-ordinate 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 work as shown in Figure 1.2.

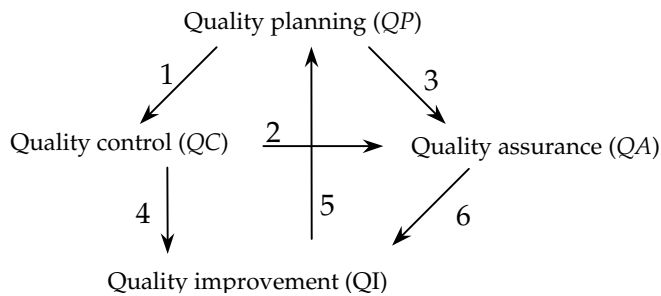


Figure 1.2. Inter-relation between the activities with regard to quality. The arrows are explained in the text below this figure.

1: The *QP* sets up the objectives and derive measurable properties valid for the *QC*. In case of multiple objectives the *QP* will typically need to perform some kind of priority among the single objectives. This is especially a challenge when high priority with regard to one objective will induce lower priority for others.

2: The *QC* will investigate the measurable properties and based of this conclude how well the objectives are fulfilled. Some of these properties will be communicated to the reviewing authorities in order to make them able to secure that the inventory meets the quality objectives.

3: The *QP* has to identify measurable indicators for the fulfilment of the quality objectives. They form the basis for the *QA* and have 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 of improvements of the inventory to meet the quality objective.

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

6: The evaluation done by external authorities is important input when improvements in quality are going to be 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. 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”

1.6.4 Definition of Critical Control Points (CCP)

A Critical Control Points (*CCP*) is 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 Good Practise* are to improve elements of transparency, consistency, comparability, completeness and confidence. In the UNFCCC guideline the element “confidence” is replaced by “accuracy” and in this plan “accuracy” is used.

These objectives are used as CCP’s including the comments above. The following explanation is given by UNFCCC guidelines 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 the 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 all subsequent years and if consistent data sets 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).

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 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* 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 CCPs above. The correctness of the inventory is formulated as an independent objective. This is done 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 Praxis Guideline is actually checks for miscalculations and thus a support of an objective of correctness.

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 degree 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*. E.g. new knowledge may suggest improvements in calculation methods for better *completeness* but the same improvements may partly violate the *consistency* and *comparability* with regard to former years inventories and the reporting from other nations. The application of *CCPs* It is therefore a multi-criteria problem of optimisation to apply the set of *CCPs* in the activity for good quality.

1.6.5 Definition of Point of Measurements (*PM*)

The *CCP's* has 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 *Point for Measuring (PM)* is identified as building blocks for a solid *QC*. The Table 8.1 in Good Praxis Guidance is a listing of such *PM's*. However, this listing is only a first tier approach and a more complete listing is needed in order to secure support for all the *CCP's*. The *PMs* will be routinely checked in the *QC* reporting and when external review takes place the reviewers will be asked to assess the fulfilment of the *PMs* using a check listing system.

1.6.6 Process oriented *QC*

The strategy is based on a process-oriented principle (ISO 9000 series) and first step is thus to set up a system for the process of the inventory work. The product specification for the inventory is a data set of emission figures and the process is thus identical 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 needs to be easy to find the original data background for any calculation and to trace the sequence of calculations from the raw data to the final emission result. Computer programming for automated calculations and checking will enhance the accuracy and minimise the number of miscalculations and flaw 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 is necessary for securing accuracy, but they can be difficult to make, do to an important degree of uncertainty related to the uncertainty estimates itself. It is therefore important to include the uncertainty calculation procedures into the data structure so much as possible. The *QC/QA* needs to be supported as much as possible by the data structure otherwise the procedures can easily become troublesome and subject for frustration.

The data structure is shown in Figure 1.3, however, the structure is still a matter of discussion with the inventory sector experts. The direction of the arrows shows the logical direction of data compilation and handling. The type of *QA/QC* activities are indicated on the right side and the direction of the arrows in case of *QA/QC* activities shows the information flow. Here assessment results from upper stream *QA/QC* can go down stream in the data flow from a data set and may change/control the data handling or the way the data set are organised at a lower level.

The boxes in Figure 1.3 represent data sets and assessment of such. The ellipses represent data processing and transformation using more or less complicated models and assessment of them. The external data are not under direct control by the data processing and transformation methodologies in contrast to higher level data sets.

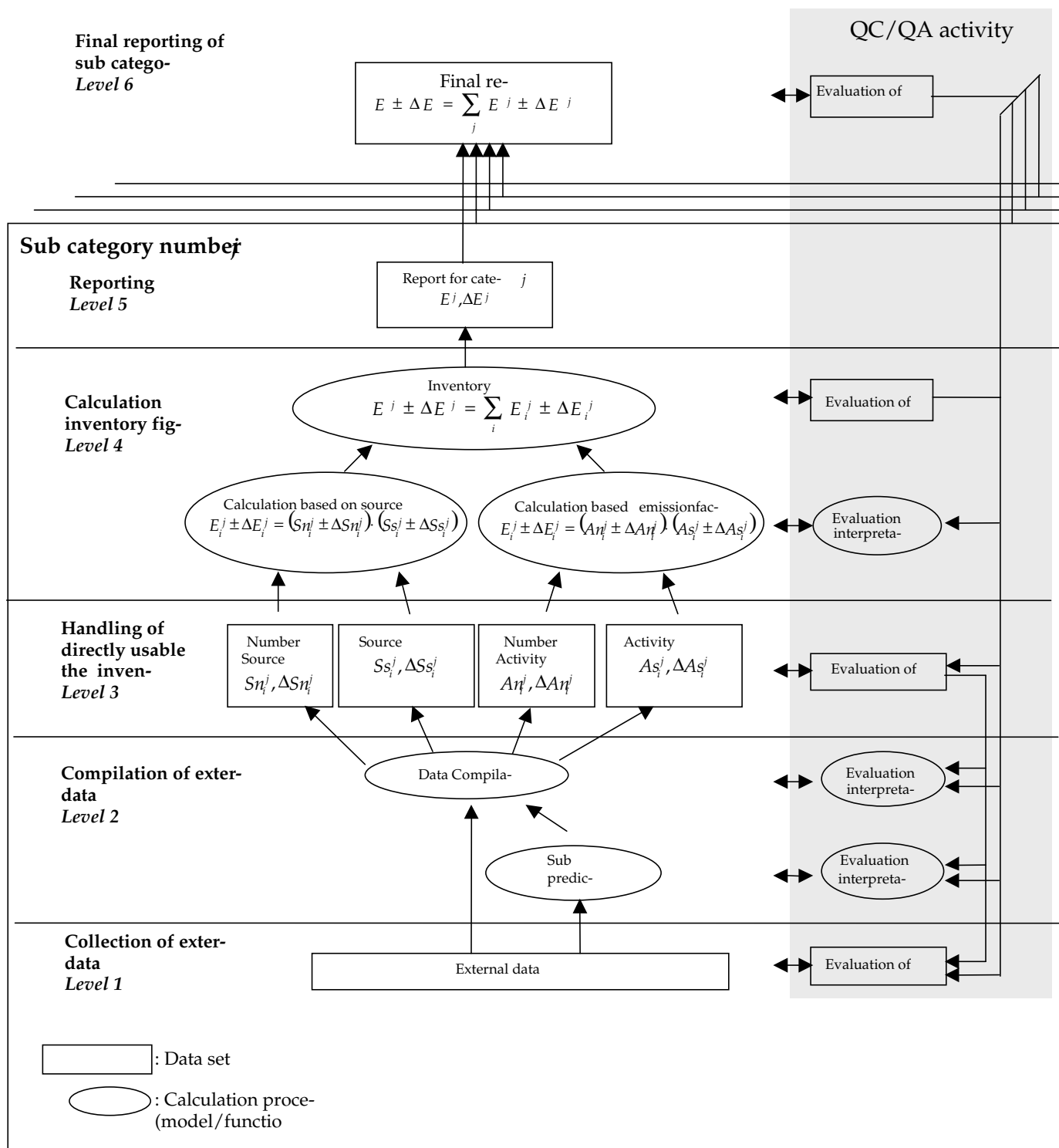


Figure 1.3. The general data structure and the relationship to the QA/QC activities. The term evaluation in this context covers all aspects in the QA/QC and thus also external review.

Key levels are defined in the data structure as:

Level 1, Collection of external data

Collection of external data sources from different sectors and statistical surveys typically reported on a yearly basis. Level 1 data consist of raw data, having identical format as the data received and gathered from external sources. Level 1 data acts as a base set, on which all subsequent calculations are based. If alterations in calculation procedures are made they are based on the same data set.

When new data are introduced they can be implemented in accordance with the QA/QC structure of the inventory

Level 2, 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 while others need to be interpreted using more or less complicated models. The interpretation of activity data is to be seen in connection to availability of emission factors. These models are compiled and processed as an integrated part of the inventory work.

Level 3, Handling of data directly usable for the inventory

Level 3 represents data that have been prepared and compiled in a form that is directly applicable for calculation of emissions. The compiled data is structured in a database for internal use as a link between more or less raw data and data that is ready for reporting.

The data is compiled in a way that elucidates the different approaches in emission assessment:

(1) Some parts of the inventory especially larger point sources is based directly on emission sources as:

(a) Sn_i^j as the number of source units having the uncertainty ΔSn_i^j

(b) Ss_i^j as the strength (release rate) for a single source unit having the uncertainty ΔSs_i^j

(2) Other inventory data is based on activities and emission factors as:

(a) An_i^j as the number of activity units having the uncertainty ΔAn_i^j .

(b) As_i^j as the strength (release rate) of every activity unit having the uncertainty ΔAs_i^j .

Level 4, Calculation of inventory figures

The emission for a sub category j (E^j) is calculated including the uncertainty (ΔE^j) from all sectors and activities. The summation of all contributions from sub sources makes the inventory at level 4 as

$$E^j \pm \Delta E^j = \sum E_i^j \pm \Delta E_i^j$$

where E^j is the total emission for a specific greenhouse gas and a specific sub category, ΔE^j is the total related uncertainty. The emission is calculated for each type of release using either a source or activity based approach as described as described at level 3 and by the following two equations:

Based directly on known emission sources :

$$E_i^j \pm \Delta E_i^j = (Sn_i^j \pm \Delta Sn_i^j) \cdot (Ss_i^j \pm \Delta Ss_i^j)$$

Based on activity estimates:

$$E_i^j \pm \Delta E_i^j = (An_i^j \pm \Delta An_i^j) \cdot (As_i^j \pm \Delta As_i^j)$$

Level 5, Reporting of every single subcategory

The emission calculations including uncertainty estimates are reported at level 5 for the specific sub category.

Level 6, Final reporting of all subcategories

The complete emission inventory is reported to the international community at this level by summing up the results from every sub category.

1.6.7 Quality Control

The QC has to be based on clear measurable factors, otherwise the *QP* will end up being just a loose declaration of intent. In Annex 8 a series of *Point for Measuring (PM)* is identified as building blocks for a solid QC. This part of the development for QC is still under discussion and may thus be adjusted during 2005.

1.6.8 Structure of reporting

The final inventory report sums up the emission from a series of sub categories of human activity such as larger point sources, agriculture, etc. Each sub category needs to have an individual reporting in order to include all necessary details adding up in complete inventory reports. The structure of reporting is shown in Figure 1.4 and will be explained in the following paragraphs.

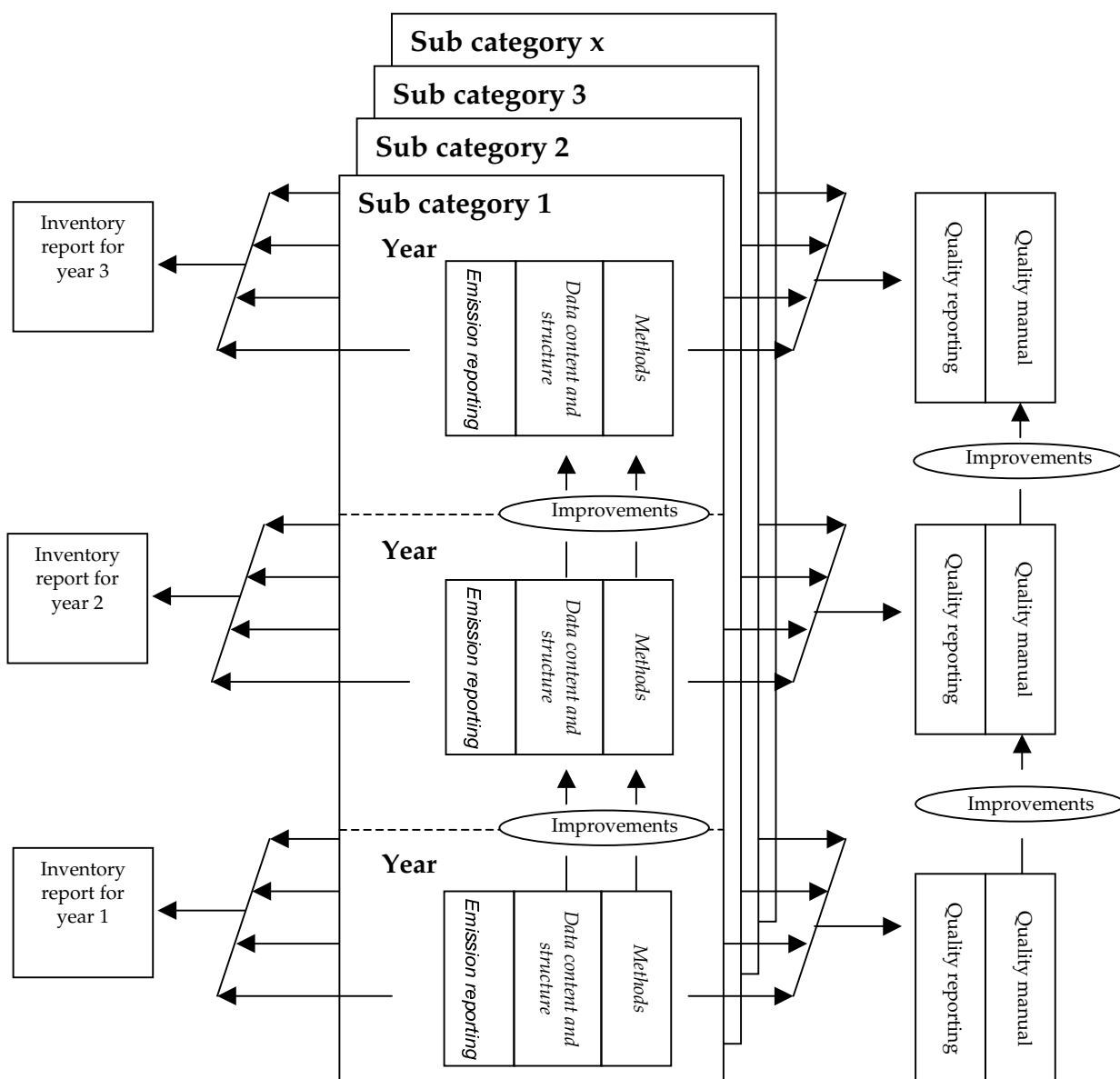


Figure 1.4. The general structure of reporting.

Four types of reporting activities are undertaken: (1) National state of year Inventories Reporting (NIR), (2) Data content and Structure (DCS), (3) Methodological Description (MD), (4) Quality Reporting (QAR) and (5) Quality Manual (QM). The reporting of NIR and QAR are presenting specific data sets and has thus to be done every year, while the other reporting DCS, MD and QM is process oriented and thus linked to changes in methods and procedures, which are not necessary change from one year to an other.

It may be meaningful to combine NIR and QR in one single result-oriented report every year. While the other reporting types have to be done in separate reports in order to optimise transparency.

The PM's has to be addressed in the type of reporting as shown in Table 1.2.

Table 1.2. The reporting place for evaluation of PM's.

Reporting type	PM's to be addressed
National state of year inventories	1.6, 1.7, 2.6, 4.5, 5.1, 5.2, 6.1
Data content and structure	1.1, 1.2, 1.3, 1.8, 1.9, 1.10, 2.8, 3.1, 3.2, 3.4, 3.5, 4.2, 4.7, 5.5
Methodological description	1.4, 1.5, 2.1, 2.2, 2.4, 2.5, 2.7, 2.8, 4.1, 4.3, 4.4, 4.6, 5.4, 6.2, 6.4
Quality assurance	Summary for all PM's and explicitly 1.7, 3.3
Quality manual	Listing and argument for the defined PMs'

1.6.9 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 data sets and more capacity, as well as to countries with less data and manpower available. The tiered approach helps focussing on areas of the inventories that are relatively weak instead of investing effort on irrelevant subjects. Furthermore the IPCC Guidelines recommends using higher Tier methods for key sources in particular. So the key source identification is crucial for the planning of quality work. However, there exist several topics for making priority sources listing as (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. Every of this listings is needed for different aspects of the quality work. In 2005 these listing will be used to secure implementation of the full quality scheme on the most relevant sources. Verification in relation to other countries (*PM 5.4*) is undertaken for priority sources during the first part of year 2005.

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 this 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 99.7% of the total Danish greenhouse gas emission (CO₂ eq., without CO₂ from LUCF).

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

The estimated uncertainties for total GHG and for CO₂, CH₄, N₂O and F-gases are shown in Table 1.3. The base year for F-gases is 1995, for all other sources the base year is 1990. The total Danish GHG emission is estimated with an uncertainty of $\pm 6.8\%$ and the trend of GHG emission since 1990 has been estimated to be $+6.5\%^2 \pm 2.1\%$ -age points. The GHG uncertainty estimates do not take into account the uncertainty of the GWP factors.

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

The uncertainty on N₂O from stationary combustion plants, N₂O emission from agricultural soils and CH₄ emission from manure management is the predominant source of uncertainty for the Danish GHG inventory.

The uncertainty of the GHG emission from combustion (sector 1A) is 8% and the trend uncertainty is +12.6% ±1.9%-age points.

Table 1.3 Uncertainty

1)	Uncertainty [%]	Trend [%]	Uncertainty in trend [%-age points]
CO ₂	2.5	+12.5	±1.9
CH ₄	20	+3.3	±9.3
N ₂ O	57	-25	±14
F-gases	48	+129	±54
GHG	6.8	+6.5	±2.1

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

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	22609	1	5
Stationary Combustion, BKB	CO2	11	0	3	5
Stationary Combustion, Coke	CO2	138	108	3	5
Stationary Combustion, Petroleum coke	CO2	410	779	3	5
Stationary Combustion, Plastic waste	CO2	349	649	5	5
Stationary Combustion, Residual oil	CO2	2505	2120	2	2
Stationary Combustion, Gas oil	CO2	4564	2918	4	5
Stationary Combustion, Kerosene	CO2	366	24	4	5
Stationary Combustion, Orimulsion	CO2	0	154	1	2
Stationary Combustion, Natural gas	CO2	4330	11152	3	1
Stationary Combustion, LPG	CO2	164	74	4	5
Stationary Combustion, Refinery gas	CO2	806	942	3	5
Stationary combustion plants, gas engines	CH4	6	391	2,2	40
Stationary combustion plants, other	CH4	115	130	2,2	100
Stationary combustion plants	N2O	398	440	2,2	1000
Transport, Road transport	CO2	9351	11864	2	5
Transport, Military	CO2	119	92	2	5
Transport, Railways	CO2	297	218	2	5
Transport, Navigation (small boats)	CO2	67	140	56	5
Transport, Navigation (large vessels)	CO2	484	426	2	5
Transport, Fisheries	CO2	771	632	2	5
Transport, Agriculture	CO2	1318	1219	26	5
Transport, Forestry	CO2	5	4	26	5
Transport, Industry (mobile)	CO2	778	742	40	5
Transport, Residential	CO2	87	82	51	5
Transport, Civil aviation	CO2	243	138	10	5
Transport, Road transport	CH4	55	62	2	40
Transport, Military	CH4	0	0	2	100
Transport, Railways	CH4	0	0	2	100
Transport, Navigation (small boats)	CH4	1	2	56	100
Transport, Navigation (large vessels)	CH4	0	0	2	100
Transport, Fisheries	CH4	0	0	2	100
Transport, Agriculture	CH4	2	2	26	100
Transport, Forestry	CH4	0	0	26	100
Transport, Industry (mobile)	CH4	3	3	40	100
Transport, Residential	CH4	3	3	51	100
Transport, Civil aviation	CH4	0	0	10	100
Transport, Road transport	N2O	131	416	2	50
Transport, Military	N2O	1	1	2	1000
Transport, Railways	N2O	3	2	2	1000
Transport, Navigation (small boats)	N2O	1	1	56	1000
Transport, Navigation (large vessels)	N2O	9	8	2	1000
Transport, Fisheries	N2O	15	12	2	1000
Transport, Agriculture	N2O	17	16	26	1000
Transport, Forestry	N2O	0	0	26	1000
Transport, Industry (mobile)	N2O	10	10	40	1000
Transport, Residential	N2O	1	1	51	1000
Transport, Civil aviation	N2O	3	3	10	1000
Energy, fugitive emissions, oil and natural gas	CO2	263	550	15	5
Energy, fugitive emissions, solid fuels	CH4	72	93	2	200
Energy, fugitive emissions, oil and natural gas	CH4	38	84	15	50
Energy, fugitive emissions, oil and natural gas	N2O	1	3	15	50
6 A. Solid Waste Disposal on Land	CH4	1334	1153	10	40,8
6 B. Wastewater Handling	CH4	200	244	20	35
6 B. Wastewater Handling	N2O	88	61	10	30
2A1 Cement production	CO2	882	1370	1	2
2A2 Lime production	CO2	138	102	5	5
2A7 Glass and Glass wool	CO2	17	13	5	2
2B5 Catalysts/Fertilizers, Pesticides and Sulphuric acid	CO2	2	3	5	5
2C1 Iron and steel production	CO2	28	0	5	5
2B2 Nitric acid production	N2O	1043	895	2	25
2F Consumption of HFC	HFC	218	695	10	50
2F Consumption of PFC	PFC	1	19	10	50
2F Consumption of SF6	SF6	107	31	10	50
4A Enteric Fermentation	CH4	3110	2734	10	8
4B Manure Management	CH4	743	972	10	100
4B Manure Management	N2O	685	560	10	100
4D Agricultural Soils	N2O	8308	5632	7,6	19,6

1.8 General assessment of the completeness

The Danish greenhouse gas emission inventory due 15 April 2005 includes all sources identified by the Revised IPPC Guidelines except the following:

- Industrial processes: CO₂ emission from use of lime and limestone for flue gas cleaning, sugar production etc., and production of expanded clay will be included in the next submission. These sources are expected to contribute with about 0.2% of the total GHG emissions in 2003.
- 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 (Table A-4 in GPG). However, this emission is seen as non-significant compared to 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 in seven main sectors. The greenhouse gases include CO₂, CH₄, N₂O, HFCs, PFCs and SF₆. Figure 2.1 shows the estimated total greenhouse gas emissions in CO₂ equivalents from 1990 to 2003. The emissions are not corrected for electricity trade or temperature variations. CO₂ is the most important greenhouse gas followed by N₂O and CH₄ in relative importance. The contribution to national totals from HFCs, PFCs and SF₆ is about 1%. Stationary combustion plants, transport and agriculture are the largest sources. The net CO₂ removals by forestry and soil (Land Use Change and Forestry (LUCF)) are about 2% of the total emissions in CO₂ equivalents in 2003. The national total greenhouse gas emissions in CO₂ equivalents without LUCF have increased by 6.8% from 1990 to 2003 and by 4.8% with LUCF.

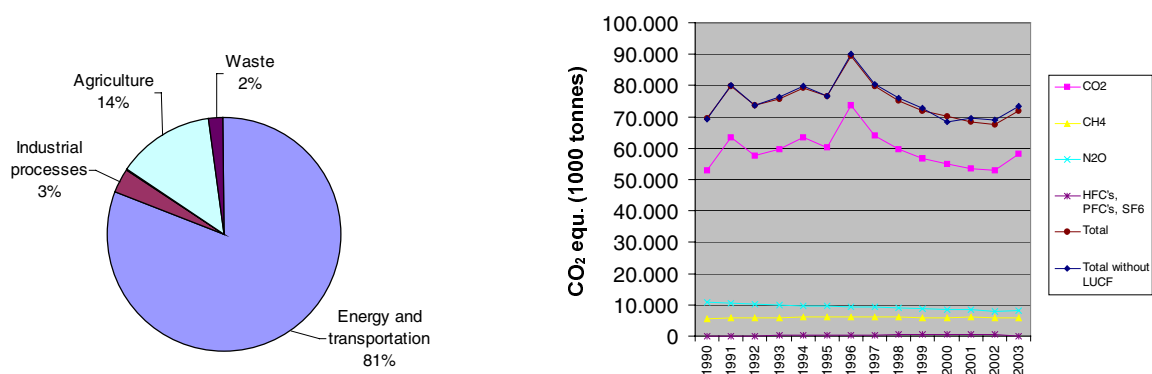


Figure 2.1. Greenhouse gas emissions in CO₂ equivalents distributed on main sectors for 2003. Left: Time-series for 1990 to 2003.

2.2 Description and interpretation of emission trends by gas

Carbon dioxide

The largest source to the emission of CO₂ 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 more than half of the emissions. About 22% come from the transport sector. The CO₂ emission increased by about 9% from 2002 to 2003. The reason for this increase was mainly due to increasing export of electricity. Also lower outdoor temperature in 2003 compared with 2002 contributed to the increase. If the CO₂ emission is adjusted for climatic variations and electricity trade with other countries the CO₂ emission from combustion of fossil fuels has decreased by 14.9% since 1990. The decrease in CO₂ emissions is observed despite an almost constant gross energy consumption and an increase in the gross national product of 30%. 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 CO₂ emission comes from oil combustion. In 2003 the actual CO₂ emission was 12% higher than the emission in 1990.

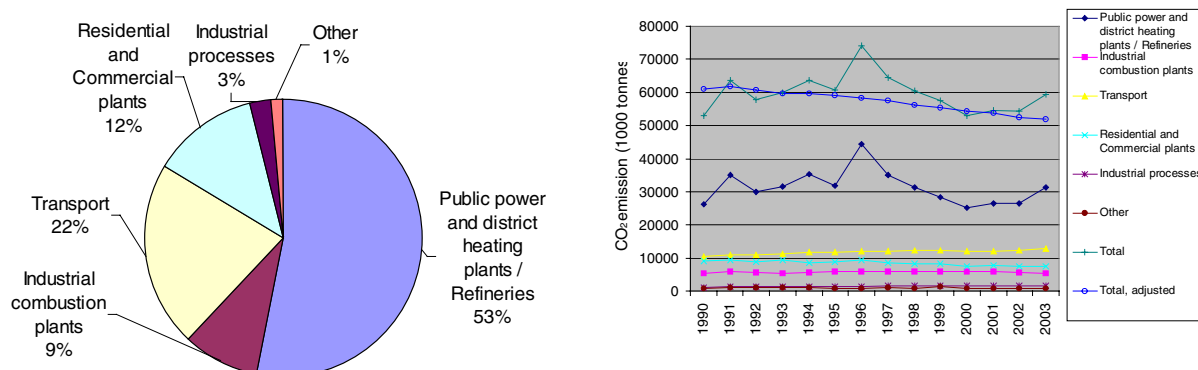


Figure 2.2. CO₂ emissions. Distribution on main sectors (2003) and time-series for 1990 to 2003.

Nitrous oxide

Agriculture is the most important N₂O emission source (Figure 2.3). N₂O 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 N₂O through bacterial processes. However, the nitrogen converted in these processes originates mainly from the agricultural use of manure and fertilisers. The main reason for the drop in the emissions of about 25% from 1990 to 2003 is due to demands according to legislation to an improved utilisation of nitrogen in manure. The legislation has resulted in less nitrogen excreted per unit produced and a considerably reduction in the use of fertilisers. The basis for N₂O emission is then reduced. About 12% come from combustion of fossil fuels and transport accounts for about 5%. The N₂O emission from transport has increased during the nineties because of an increasing use of catalyst cars. Emissions of N₂O from Nitric Acid production amount to about 10% of the total N₂O emission.

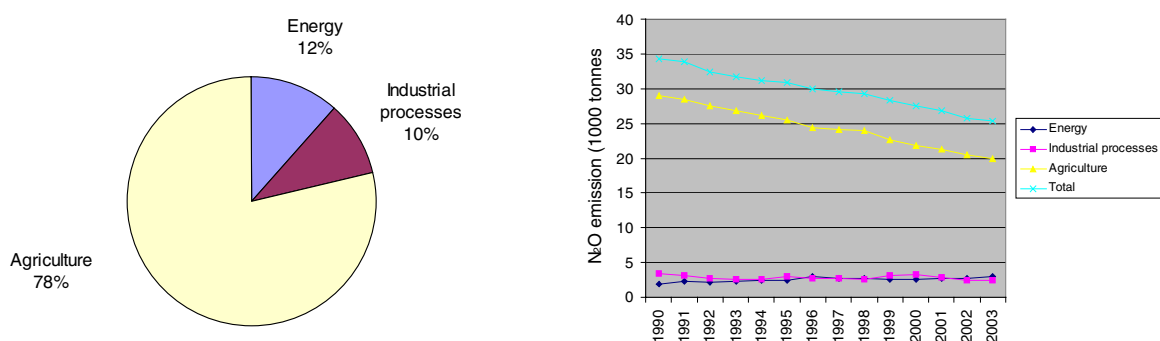


Figure 2.3. N₂O emissions. Distribution on the main sectors (2003) and time-series for 1990 to 2003.

Methane

The largest sources to anthropogenic CH₄ 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 CH₄ emissions from public power and district heating plants are due to an increasing use of gas engines in the decentralised cogeneration plants sector. About 3% of the natural gas in the gas engines are not combusted. From 1990 the emission of CH₄ from enteric fermentation has decreased because of decreasing numbers of cattle. However, the emission from manure management has increased due

to 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 about 4% from 1990 to 2003. The emission of CH_4 from waste disposal is decreasing slightly due to increasing waste incineration.

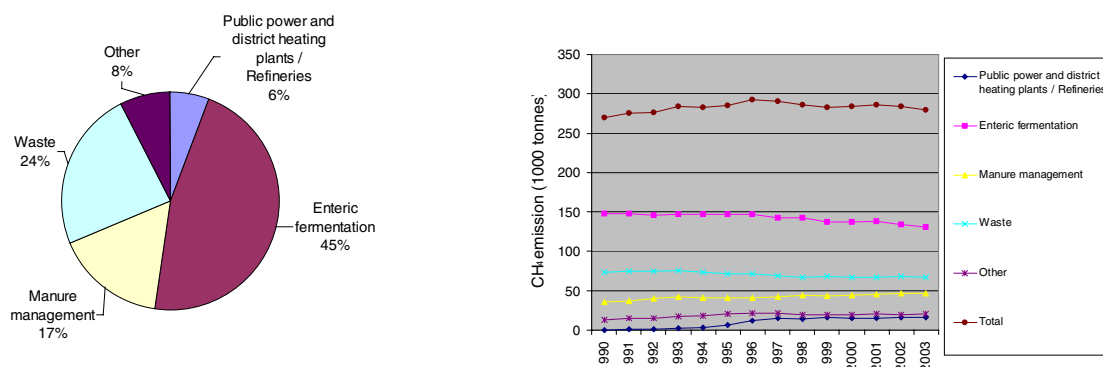


Figure 2.4. CH_4 emissions. Distribution on the main sectors (2003) and time-series for 1990 to 2003.

HFCs, PFCs and SF_6

This part of the Danish inventory only comprises data for all substances back to 1995. From 1995 to 2000 there has been a continuous and substantial increase in the contribution from the sum of F-gases, calculated as the sum of emissions in CO_2 -equivalents (Figure 2.5). The increase is occurring simultaneously with an increase in the emissions of HFCs. For the time-series 2000-2003 the increase has been much lower than for the years 1995 to 2000. The reasons for this trend are several. SF_6 contributed considerably in the first part of the trend, in 1993 by 52%. Environmental awareness and facing regulation of this gas in Danish law has decreased its industrial use and its contribution in 2003 is about 4%. The use of HFCs, and especially HFC-134a as a main contributor to the HFCs, has increased several folds. So HFCs has become a very dominating F-gas from 48% in 1993 to 93% in 2003. HFC-134a is mainly used as a refrigerant. However, the tendency is that the use of HFC-134a as a refrigerant, as well as the use of other HFCs as refrigerants are stagnant or falling. This is due to Danish law, which in 2007 forbids new HFC based refrigerant stationary systems. Counter to this trend is the increasing use of air conditioning in mobile systems.

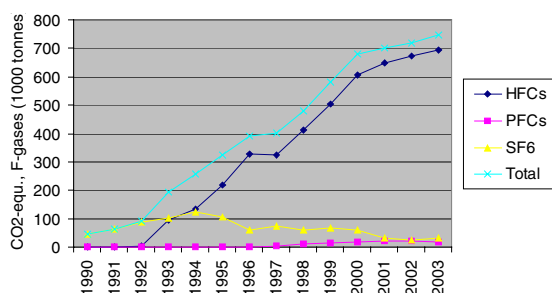


Figure 2.5. F-gas emissions. Time-series for 1990 to 2003.

2.3 Description and interpretation of emission trends by source

Energy

The emission of CO_2 from public power and district heating plants has increased by 20% from 1990 to 2003. The relatively large fluctuation in the emission is due to cross-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 in-

creasing use of gas engines in the decentralised cogeneration plants. The CO₂ emission from the transport sector has increased by 22% since 1990 mainly due to increasing road traffic.

Agriculture

The agricultural sector contributes by 14% of the total greenhouse gas emission in CO₂- equivalents and is one of the most important sectors regarding the emissions of N₂O and CH₄ and in 2003 the contributions to the total emissions were 78% and 62 %, respectively. The N₂O emission has decreased by 31% and the CH₄ emissions by 4% from 1990 to 2003.

Industrial processes

The emissions from industrial process – i.e. emissions from processes other than fuel combustion amount to 3% of the total emissions in CO₂ equivalents. The main sources are cement production, nitric acid production, refrigeration, foam blowing and calcination of limestone. The CO₂ emission from cement production – which is the largest source contributing with 2.6% of the national totals – increased by 55% from 1990 to 2003. The second largest source is N₂O from production of nitric acid. The N₂O emission from this production decreased by 14% from 1990 to 2003.

Waste

Waste disposal is the third largest source to CH₄ emission. The emission has decreased by 14% from 1990 to 2003 where the contribution was 20% of the total CH₄ emission. The decrease is due to an 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. For the first time the CH₄ emissions from wastewater handling are included in the inventory. The emission from this sector amounts to about 4% of the total CH₄ emissions.

Forest

The annual C stock change for forest land remaining forest land in 2003 is slightly lower compared to that of 2002 as the harvested amount of wood was slightly higher in 2003 than in 2002. 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 increasing total area of afforested stands.

Soil

Inclusion of emission estimates from land use and land use change (excluding forestry) in the inventory results in an increased emission in the base year (1990) of 3000 Gg CO₂-eqv. This is mainly due to the inclusion of organic soils, which are responsible for 2400 Gg CO₂ eqv. In 2003 the net emission is estimated to 2400 Gg CO₂-eqv. or a 20% reduction. This is mainly due to a reduction in liming (300 Gg CO₂-eqv.), a reduced cropland area with organic soils (150 Gg CO₂-eqv.) and establishment of shelterbelts on cropland (150 Gg CO₂-eqv.). Reestablishment of wetlands on cropland is responsible for the increase in carbon stock in wetlands and for part of the reduction in cropland and grassland. The trend between 1990 and 2003 is assumed to satisfactorily describe the Danish emission from the mentioned sources, however the emission estimates from mineral soils still need to be incorporated.

2.4 Description and interpretation of emission trends for indirect greenhouse gases and SO₂

NO_x

The three largest sources to emissions of NO_x are combustion in energy industries (mainly public power and district heating plants), road transport and other mobile sources. The transport sector is the sector contributing the most to the emission of NO_x and in 2003 37% of the Danish emissions of NO_x stem from road transport, national navigation, railways and civil aviation. Also emissions

from national fishing and off-road vehicles contribute significantly to the NO_x emission. For non-industrial combustion plants the main sources are combustion of gas oil, natural gas and wood in residential plants. The emissions from public power plants and district heating plants have decreased by 47% from 1985 to 2003. In the same period the total emission has decreased by 32%. The reduction is due to increasing use of catalyst cars and installation of low-NO_x-burners and denitrifying units on power and district heating plants.

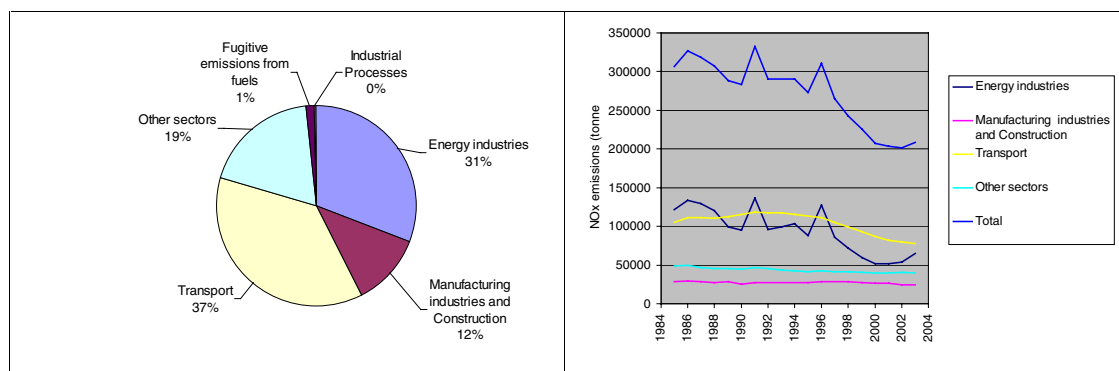


Figure 2.6. NO_x emissions. Distribution on the main sectors (2003) and time-series for 1990 to 2003.

CO

Even though catalyst cars were introduced in 1990, road transport still has the dominant share of the total CO emission. Also other mobile sources and non-industrial combustion plants contribute significantly to the total emission of this pollutant. The drop in the emissions seen in 1990 was a consequence of a law forbidding burning of agricultural waste on fields. The emission decreased by 23% from 1990 to 2003 mainly because of decreasing emissions from road transportation.

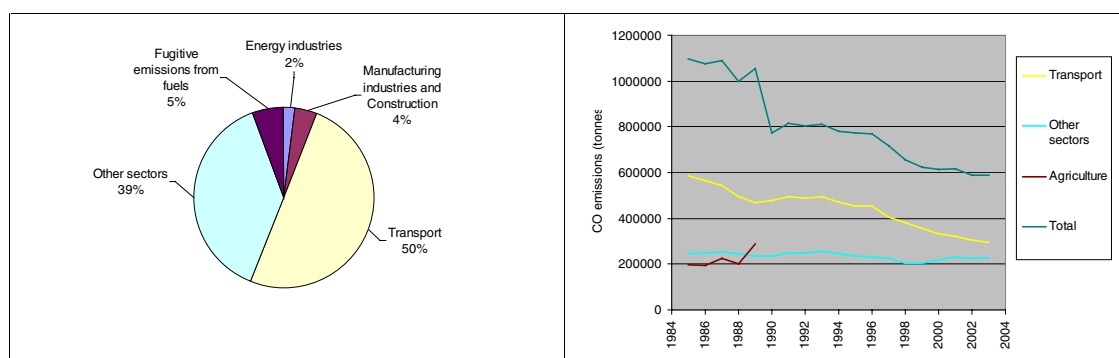


Figure 2.7. CO emissions. Distribution on the main sectors (2003) and time-series for 1990 to 2003.

NMVOC

The emissions of NMVOC originate from many different sources and can be divided into two main groups: Incomplete combustion and evaporation. The main sources to NMVOC emissions from incomplete combustion processes are road vehicles and other mobile sources such as national navigation vessels and off-road machinery. Road transportation vehicles are still the main contributors even though the emissions have declined since the introduction of catalyst cars in 1990. The evaporative emissions mainly originate from the use of solvents. The emissions from energy industries have increased during the nineties because of increasing use of stationary gas engines, which have much higher emissions of NMVOC than conventional boilers. The total anthropogenic emissions have decreased by 39% from 1985 to 2003 mainly due to an increasing use of catalyst cars and reduced emissions from use of solvents.

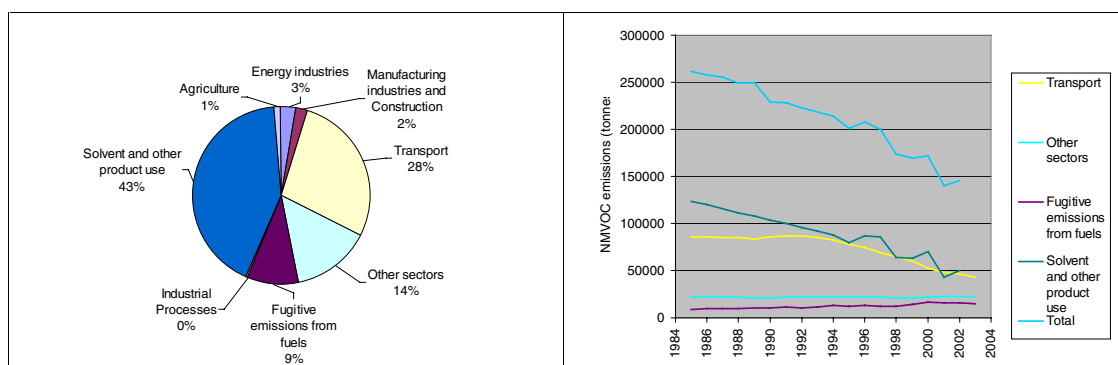


Figure 2.8. NMVOC emissions. Distribution on the main sectors (2003) and time-series for 1990 to 2003.

SO₂

The main part of the SO₂ emissions originates from combustion of fossil fuels, i.e. mainly coal and oil, on public power and district heating plants. From 1980 to 2003 the total emission has decreased by 93%. The large reduction is mainly due to installation of desulphurization plants and use of fuels with lower content of sulphur in public power and district heating plants. Despite the large reduction of the SO₂ emissions these plants make up 56% of the total emission. From 2002 to 2003 the emissions have increased by 23% due to a large export of electricity to the other Nordic countries. 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 SO₂ emission. This is due to the use of residual oil with high content of sulphur.

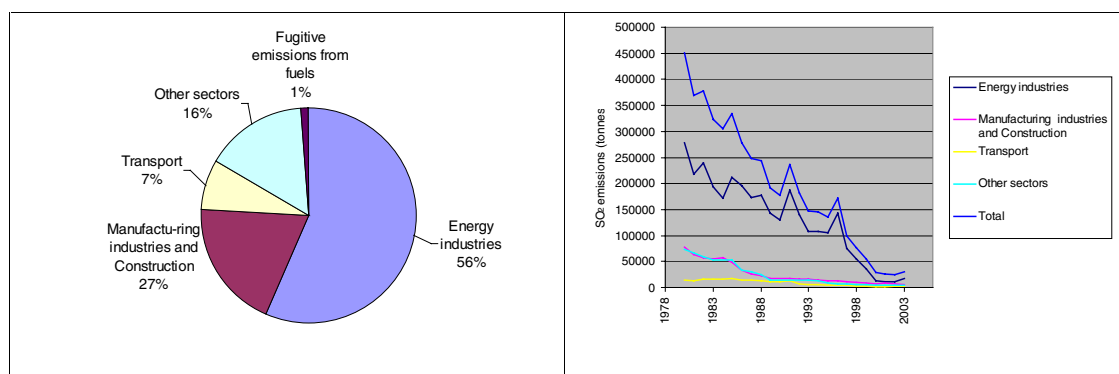


Figure 2.9. SO₂ emissions. Distribution on the main sectors (2003) and time-series for 1990 to 2003.

3 Energy (CRF sector 1)

3.1 Overview of the sector

The energy sector have been reported in four main chapters:

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

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

3.4 Additional information about fuel combustion (CRF sector 1A)

3.5 Fugitive emissions (CRF sector 1B)

Though industrial combustion is part of the 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 CO₂ 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
	(Gg)													
1. Energy	51.502	62.015	56.107	58.411	62.026	58.992	72.324	62.650	58.595	55.792	51.290	52.879	52.535	57.635
A. Fuel Combustion (Sectoral Approach)	51.239	61.497	55.573	57.943	61.558	58.627	71.923	62.085	58.173	54.895	50.696	52.246	52.000	57.085
1. Energy Industries	26.173	35.113	30.082	31.627	35.352	31.934	44.321	35.084	31.381	28.231	25.114	26.400	26.553	31.402
2. Manufacturing Industries and Construction	5.376	5.800	5.502	5.438	5.697	5.890	6.012	6.019	5.970	6.020	5.786	5.804	5.559	5.404
3. Transport	10.441	10.917	11.046	11.237	11.685	11.823	12.028	12.159	12.191	12.253	12.118	12.142	12.319	12.785
4. Other Sectors	9.129	9.380	8.801	9.403	8.573	8.728	9.386	8.652	8.427	8.208	7.567	7.803	7.481	7.402
5. Other	119	287	141	237	252	252	176	171	204	182	111	97	89	92
B. Fugitive Emissions from Fuels	263	518	534	468	468	365	400	565	422	898	594	633	535	550
1. Solid Fuels	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

Table 3.3 CH₄ 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
	(Gg)													
1. Energy	14,15	16,15	16,71	20,20	24,43	31,52	36,42	36,65	34,83	35,06	34,38	36,07	35,52	36,71
A. Fuel Combustion (Sectoral Approach)	8,88	9,96	10,70	13,08	16,39	22,34	27,30	27,04	28,29	28,17	27,58	29,00	28,68	28,30
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
2. Manufacturing Industries and Construction	0,78	0,82	0,79	0,81	0,83	0,93	1,35	1,36	1,44	1,45	1,64	1,69	1,65	1,62
3. Transport	2,69	2,97	3,11	3,38	3,55	3,71	3,98	3,82	3,66	3,58	3,44	3,40	3,15	3,10
4. Other Sectors	4,29	4,62	4,95	5,49	5,64	6,18	6,99	7,34	7,48	7,50	7,65	7,84	7,87	7,87
5. Other	0,01	0,02	0,01	0,01	0,01	0,02	0,01	0,01	0,01	0,01	0,01	0,01	0,00	0,00
B. Fugitive Emissions from Fuels	5,27	6,19	6,02	7,12	8,04	9,18	9,13	9,61	6,54	6,89	6,80	7,06	6,85	8,41
1. Solid Fuels	3,45	3,97	3,91	4,79	5,61	6,30	6,36	6,53	3,47	3,37	3,04	3,28	2,97	4,43
2. Oil and Natural Gas	1,83	2,22	2,11	2,33	2,43	2,88	2,76	3,08	3,07	3,51	3,76	3,78	3,88	3,98

Table 3.4 N₂O 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
	(Gg)													
1. Energy	1,90	2,29	2,17	2,29	2,48	2,46	2,93	2,74	2,65	2,63	2,55	2,65	2,71	2,94
A. Fuel Combustion (Sectoral Approach)	1,90	2,28	2,16	2,28	2,48	2,45	2,93	2,73	2,64	2,62	2,54	2,64	2,70	2,93
1. Energy Industries	0,89	1,17	1,01	1,06	1,17	1,05	1,44	1,14	1,01	0,92	0,82	0,87	0,89	1,06
2. Manufacturing Industries and Construction	0,18	0,19	0,18	0,18	0,18	0,18	0,18	0,18	0,18	0,19	0,18	0,18	0,19	0,18
3. Transport	0,47	0,55	0,61	0,67	0,79	0,87	0,94	1,05	1,12	1,18	1,23	1,27	1,32	1,38
4. Other Sectors	0,36	0,37	0,35	0,36	0,34	0,34	0,35	0,34	0,32	0,32	0,30	0,31	0,31	0,31
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
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
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
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

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

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

3.2.1 Source category description

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

3.2.1.1 Emission source categories

In the Danish emission database all activity rates and emissions are defined in SNAP sector categories (Selected Nomenclature for Air Pollution) 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 emission from transport subsectors. The emission source 1A2 includes emissions from some off-road machinery in the industry. The emis-

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

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 2003 the total fuel consumption for stationary combustion plants was 622 PJ of which 537 PJ was fossil fuels.

Fuel consumption distributed on the stationary combustion subsectors is shown in Figure 3.1 and Figure 3.2. The majority - 64% - of all fuels is combusted in the sector, *Public electricity and heat production*. Other sectors with high fuel consumption are *Residential* and *Industry*.

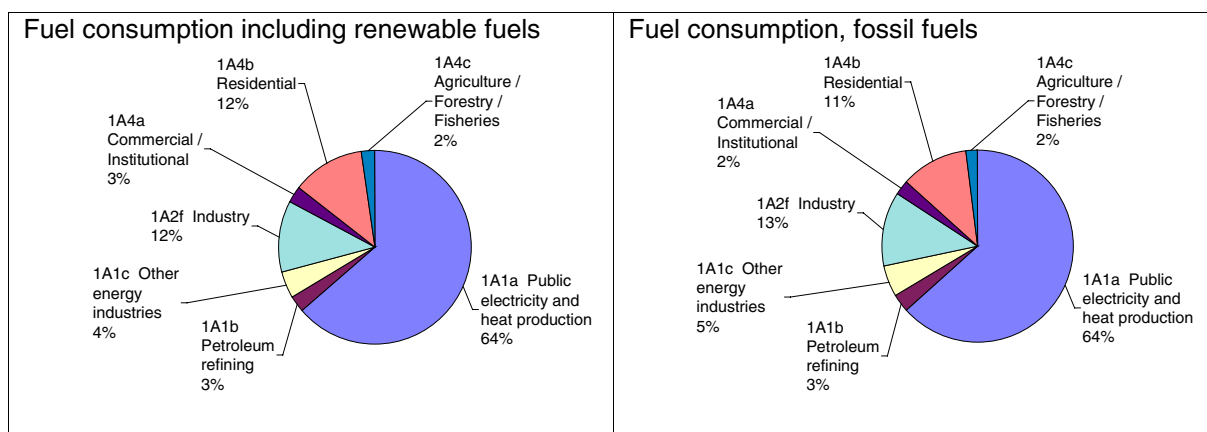


Figure 3.1 Fuel consumption rate of stationary combustion, 2003 (based on DEA 2004a)

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.

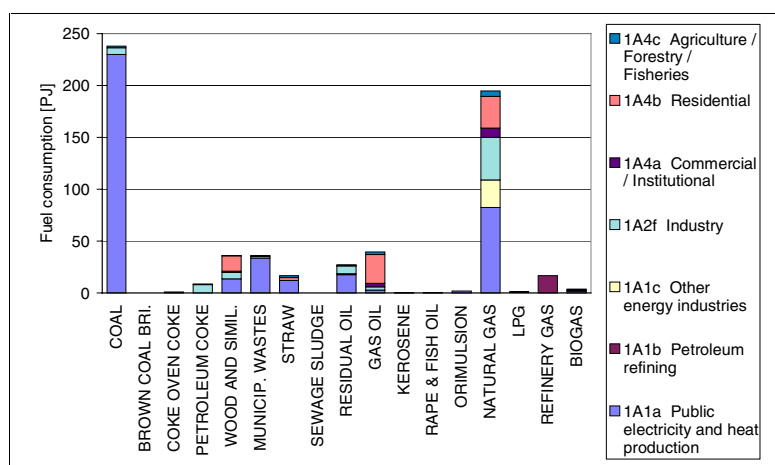


Figure 3.2 Fuel consumption of stationary combustion plants 2003 (based on DEA 2004a)

Fuel consumption time-series for stationary combustion plants are presented in Figure 3.3. The total fuel consumption increased by 25% from 1990 to 2003, while the fossil fuel consumption only increased by 18%. The consumption of natural gas and renewable fuels has increased since 1990 whereas the coal consumption has decreased.

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

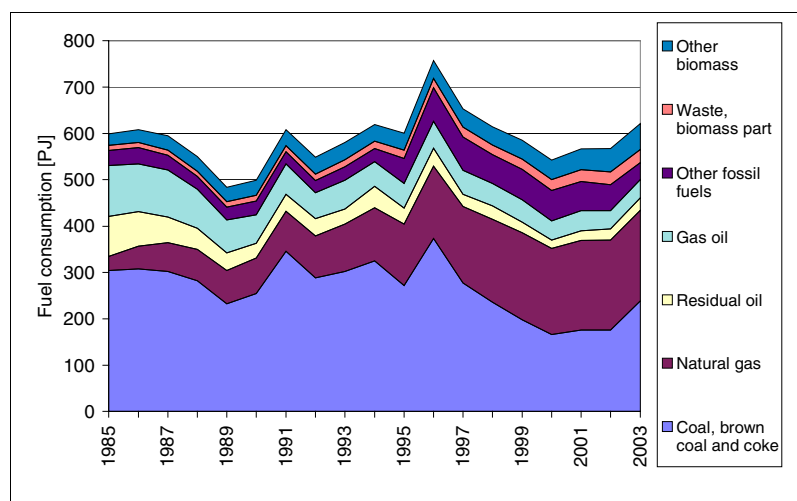


Figure 3.3 Fuel consumption time-series, stationary combustion (based on DEA 2004a)

3.2.1.3 Emissions

The GHG emissions from stationary combustion are listed in Table 3.5. The emission from stationary combustion accounts for 57% of the total Danish GHG emission.

The CO₂ emission from stationary combustion plants accounts for 70% of the total Danish CO₂ emission (not including land-use change and forestry). CH₄ accounts for 9% of the total Danish CH₄ emission and N₂O for only 5% of the total Danish N₂O emission.

Table 3.5 Greenhouse gas emission for the year 2003 ¹⁾.

	CO ₂	CH ₄	N ₂ O
	Gg CO ₂ equivalent		
1A1 Fuel consumption, Energy industries	31402	330	328
1A2 Fuel consumption, Manufacturing Industries and Construction ¹⁾	4662	31	46
1A4 Fuel consumption, Other sectors ¹⁾	5465	160	67
Total emission from stationary combustion plants	41529	521	440
Total Danish emission (gross)	59329	5873	8060
	%		
Emission share for stationary combustion	70	9	5

1) Only stationary combustion sources of the sector is included

CO₂ is the most important GHG pollutant and accounts for 97,7% of the GHG emission (CO₂ eqv.).

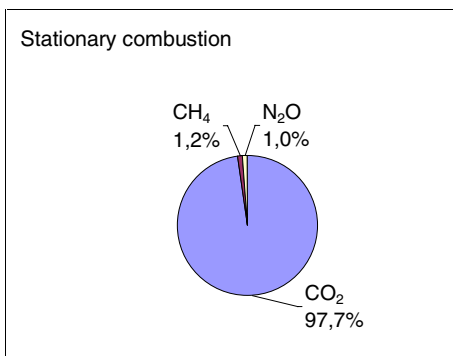


Figure 3.4 GHG emission (CO₂ equivalent) from stationary combustion plants

Figure 3.5 depicts the time-series of GHG emission (CO₂ eqv.) from stationary combustion and it can be seen that the GHG emission development follows the CO₂ emission development very closely. Both the CO₂ and the total GHG emission is higher in 2003 than in 1990, CO₂ by 10% and GHG by 11%. However, fluctuations in the GHG emission level are large.

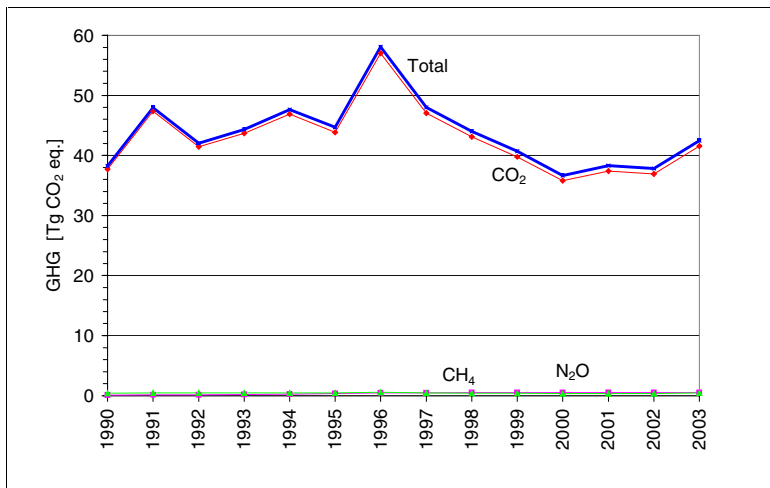


Figure 3.5 GHG emission time-series for stationary combustion

The fluctuations in the time-series are mainly 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 2003 the net electricity export was 30760 TJ which is much higher than in 2002. The high electricity export in 2003 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 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 20% since 1990, and the CO₂ emission by 21%.

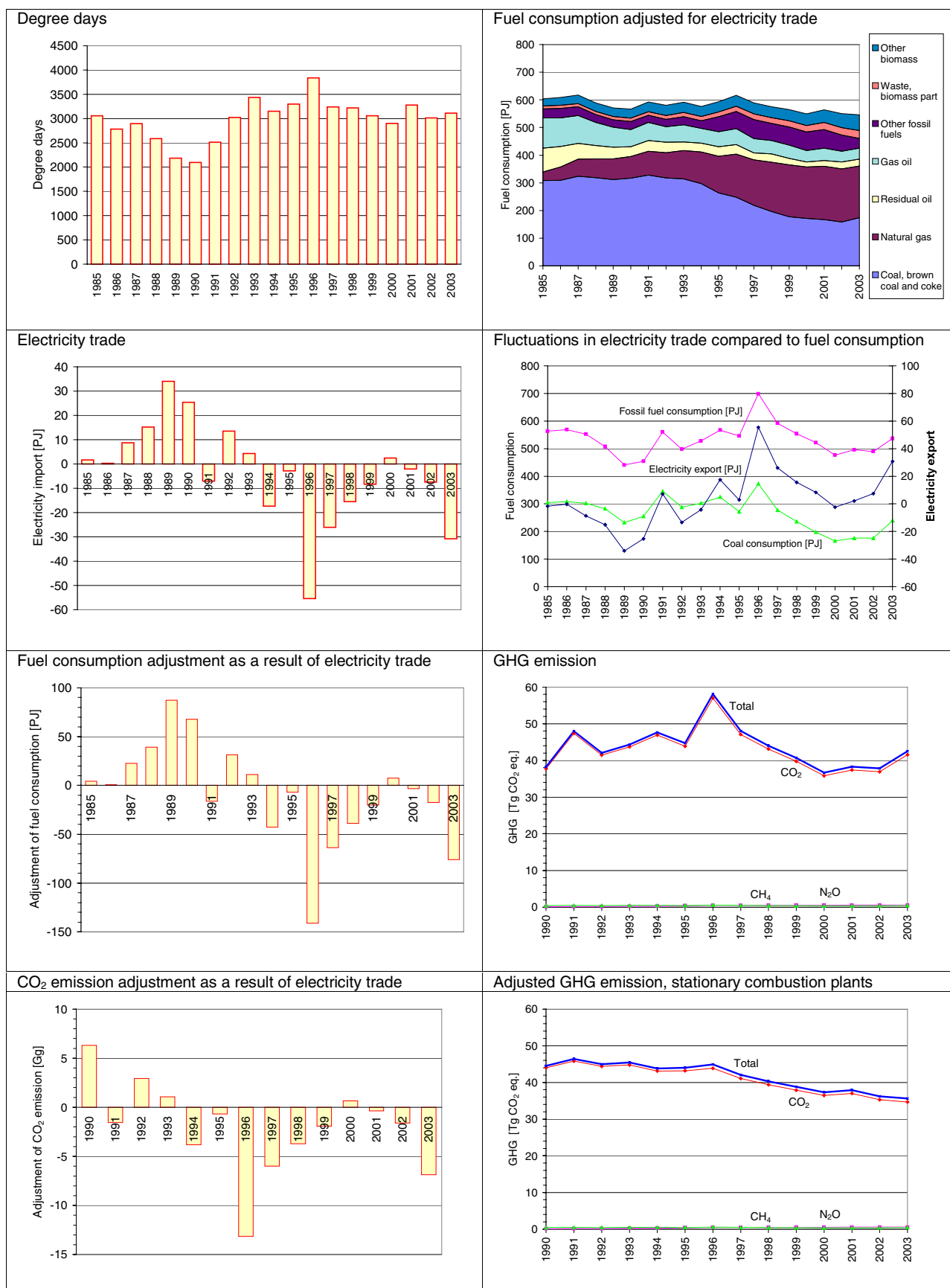


Figure 3.6 GHG emission time-series for stationary combustion and adjustment for electricity import/export and temperature variations (DEA 2004b)

3.2.1.3.1 CO₂

The CO₂ emission from stationary combustion plants is one of the most important GHG emission sources. Thus the CO₂ emission from stationary combustion plants accounts for 70% of the total Danish CO₂ emission. Table 3.6 lists the CO₂ emission inventory for stationary combustion plants for 2003. Figure 3.7 reveals that *Electricity and heat production* accounts for 70% of the CO₂ emission from stationary combustion. This share is somewhat higher than the fossil fuel consumption share for this sector, which is 64% (Figure 3.1). Other large CO₂ 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 CO₂ emission from stationary combustion plants 2003¹⁾

CO ₂	2003	
1A1a Public electricity and heat production	28869	Gg
1A1b Petroleum refining	1013	Gg
1A1c Other energy industries	1520	Gg
1A2 Industry	4662	Gg
1A4a Commercial / Institutional	854	Gg
1A4b Residential	3890	Gg
1A4c Agriculture / Forestry / Fisheries	721	Gg
Total	41529	Gg

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

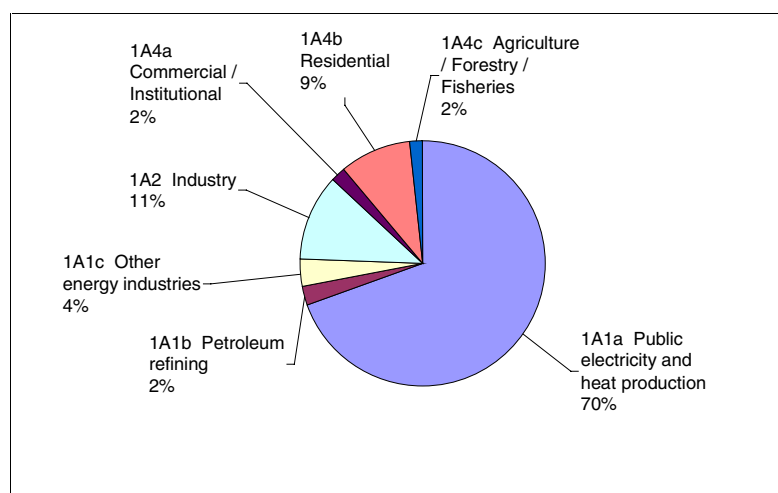


Figure 3.7 CO₂ emission sources, stationary combustion plants, 2003

The sector *Electricity and heat production* consists of the SNAP source sectors: *Public power* and *District heating*. The CO₂ emissions from each of these subsectors are listed in Table 3.7. The most important subsector is power plant boilers >50MW.

Table 3.7 CO₂ emission from subsectors to 1A1a Electricity and heat production.

SNAP source	SNAP name	2003
0101	Public power	0 Gg
010101	Combustion plants $\geq$ 300MW (boilers)	23365 Gg
010102	Combustion plants $\geq$ 50MW and $<$ 300 MW (boilers)	939 Gg
010103	Combustion plants $<$ 50 MW (boilers)	177 Gg
010104	Gas turbines	2515 Gg
010105	Stationary engines	1561 Gg
0102	District heating plants	- Gg
010201	Combustion plants $\geq$ 300MW (boilers)	- Gg
010202	Combustion plants $\geq$ 50MW and $<$ 300 MW (boilers)	41 Gg
010203	Combustion plants $<$ 50 MW (boilers)	260 Gg
010204	Gas turbines	- Gg
010205	Stationary engines	10 Gg

CO₂ emission from combustion of biomass fuels is not included in the total CO₂ emission data, because biomass fuels are considered CO₂ neutral. The CO₂ emission from biomass combustion is reported as a memo item in the Climate Convention reporting. In 2003 the CO₂ emission from biomass combustion was 9108 Gg.

Time-series for CO₂ emission are provided in Figure 3.8. Despite an increase in fuel consumption of 25% since 1990, CO₂ emission from stationary combustion has increased by only 10% due to of the change in fuel type used.

The fluctuations of CO₂ emission are discussed in Chapter 3.2.1.3.

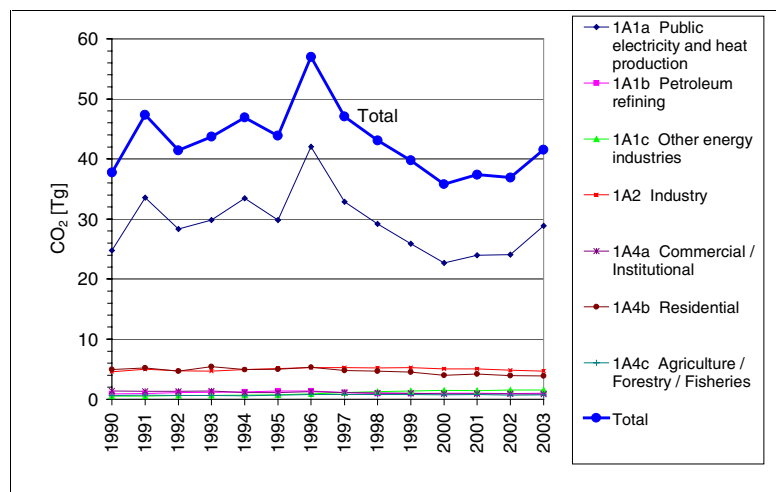


Figure 3.8 CO₂ emission time-series for stationary combustion plants

3.2.1.3.2 CH₄

CH₄ emission from stationary combustion plants accounts for 9% of the total Danish CH₄ emission. Table 3.8 lists the CH₄ emission inventory for stationary combustion plants in 2003. Figure 3.9 reveals that *Electricity and heat production* accounts for 64% of the CH₄ emission from stationary combustion, this being closely aligned with the fuel consumption share.

Table 3.8 CH₄ emission from stationary combustion plants 2003 ¹⁾

CH ₄	2003	
1A1a Public electricity and heat production	15647	Mg
1A1b Petroleum refining	2	Mg
1A1c Other energy industries	58	Mg
1A2 Industry	1485	Mg
1A4a Commercial / Institutional	961	Mg
1A4b Residential	4562	Mg
1A4c Agriculture / Forestry / Fisheries	2094	Mg
Total	24809	Mg

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

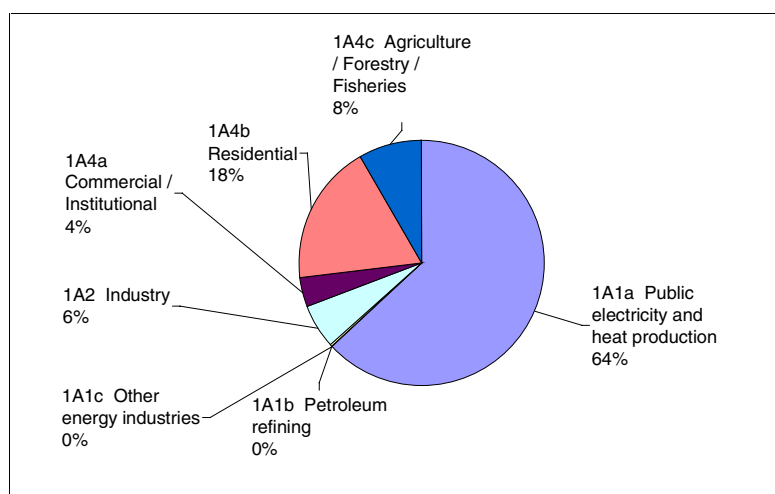


Figure 3.9 CH₄ emission sources, stationary combustion plants, 2003

The CH₄ 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 75% of the CH₄ 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.

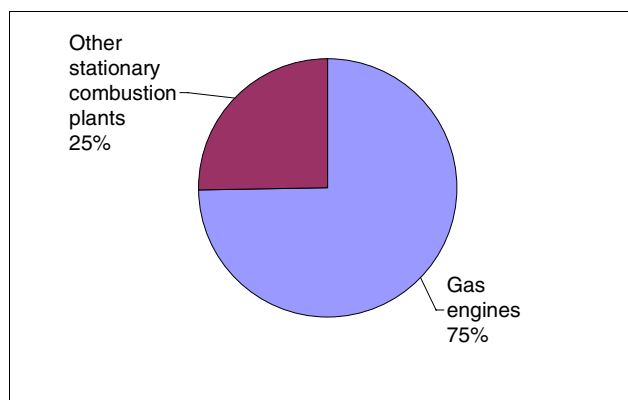


Figure 3.10 Gas engine CH₄ emission share, 2003.

The CH₄ 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 CRF sector 1A1, 1A2 and 1A4. Figure 3.12 provides time-series for the fuel consumption rate in gas engines and the corresponding increase of CH₄ emission.

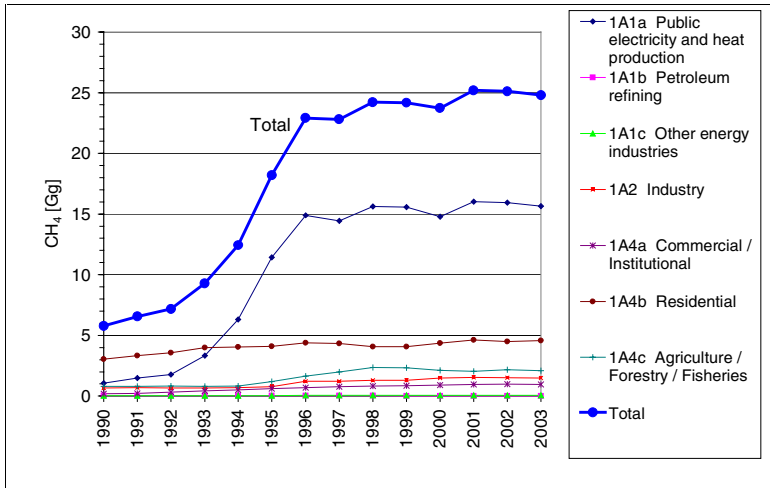


Figure 3.11 CH₄ emission time-series for stationary combustion plants

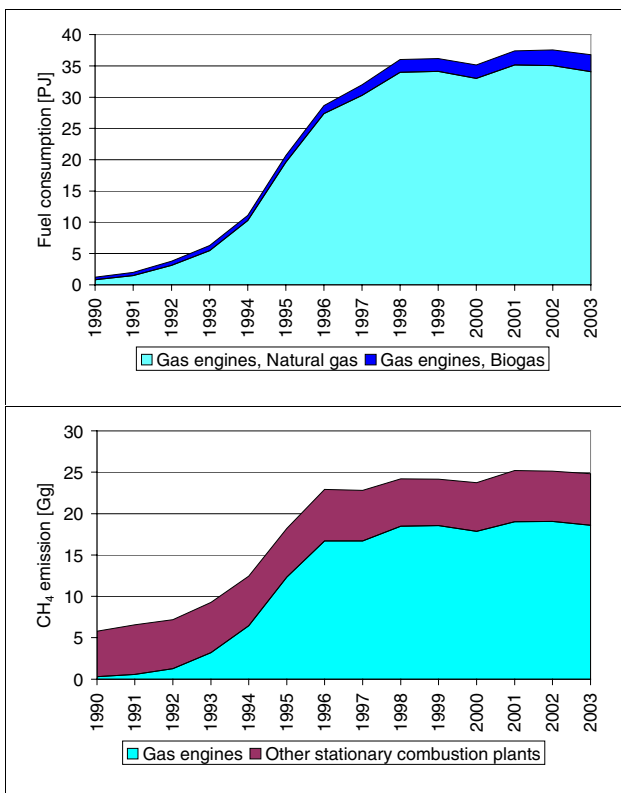


Figure 3.12 Fuel consumption and CH₄ emission from gas engines, time-series.

3.2.1.3.3 N₂O

The N₂O emission from stationary combustion plants accounts for 5% of the total Danish N₂O emission. Table 3.9 lists the N₂O emission inventory for stationary combustion plants in the year

2003. Figure 3.13 reveals that *Electricity and heat production* accounts for 68% of the N₂O emission from stationary combustion. This is only a little higher than the fuel consumption share.

Table 3.9 N₂O emission from stationary combustion plants 2003 ¹⁾

N ₂ O	2003	
1A1a Public electricity and heat production	963	Mg
1A1b Petroleum refining	36	Mg
1A1c Other energy industries	58	Mg
1A2 Industry	149	Mg
1A4a Commercial / Institutional	27	Mg
1A4b Residential	161	Mg
1A4c Agriculture / Forestry / Fisheries	27	Mg
Total	1420	Mg

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

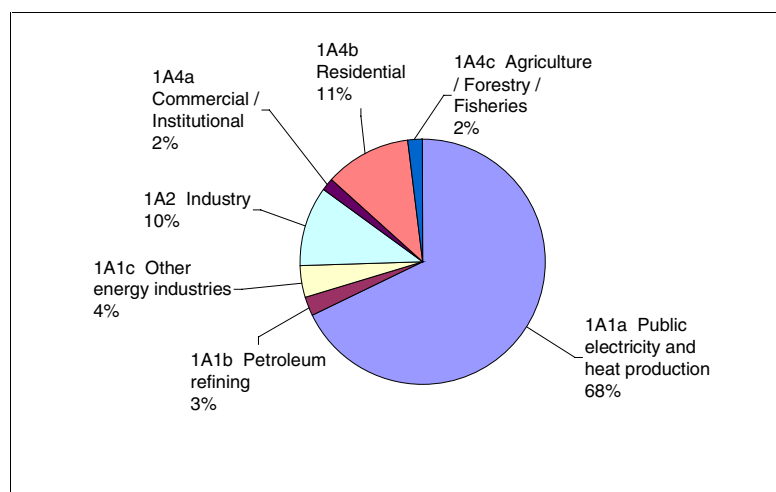


Figure 3.13 N₂O emission sources, stationary combustion plants, 2003

Figure 3.14 shows the time-series for the N₂O emission. The N₂O emission from stationary combustion increased by 11% from 1990 to 2003, but again fluctuations in emission level due to electricity import/export are considerable.

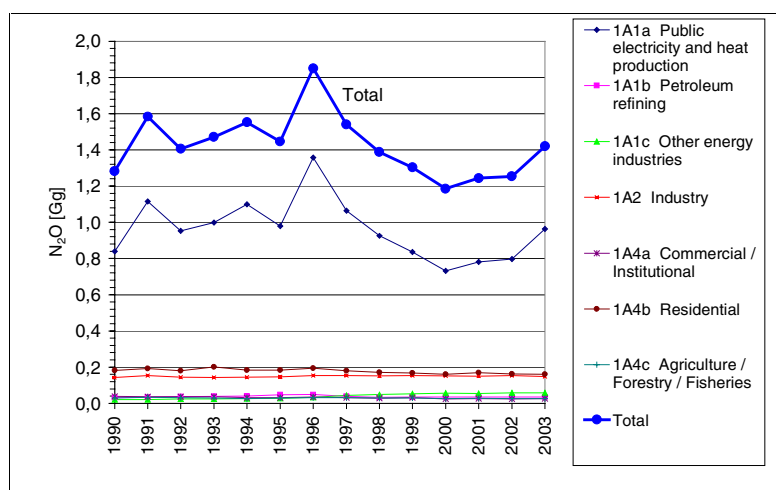


Figure 3.14 N₂O emission time-series for stationary combustion plants

3.2.1.3.4 SO₂, NO_x, NMVOC and CO

The emissions of SO₂, NO_x, NMVOC and CO from Danish stationary combustion plants 2003 are presented in Table 3.10. Further details are shown in Annex 3A. SO₂ from stationary combustion plants accounts for 89% of the total Danish emission. NO_x, CO and NMVOC account for 43%, 31% and 12%, respectively, of the total Danish emissions.

Table 3.10 SO₂, NO_x, NMVOC and CO emission from stationary combustion plants 2003

Pollutant	NO _x Gg	CO Gg	NMVOC Gg	SO ₂ Gg
1A1 Fuel consumption, Energy industries	64,5	12,6	4,3	17,5
1A2 Fuel consumption, Manufacturing Industries and Construction (Stationary combustion)	13,4	12,3	0,7	5,9
1A4 Fuel consumption, Other sectors (Stationary combustion)	7,7	158,8	13,5	3,6
Total emission from stationary combustion plants	85,6	183,7	18,5	26,9
Total Danish emission	198,7	591,0	158,0	30,1
%				
Emission share for stationary combustion	43	31	12	89

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 (CORe INventory on AIR emissions) system, which is a European program for air emission inventories. CORINAIR includes methodology structure and software for inventories. The methodology is described in the EMEP/Corinair Emission Inventory Guidebook 3rd edition, prepared by the UNECE/EMEP Task Force on Emissions Inventories and Projections (EMEP/Corinair 2004). Emission data are stored in an Access database, from which data are transferred to the reporting formats.

The emission 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 2003 70 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 fuel consumption of stationary combustion plants registered as large point sources is 414 PJ (2003). This corresponds to 67% of the overall fuel consumption for stationary combustion.

Further details about the large point sources are shown in Annex 3A. The number of large point sources registered in the databases increased from 1990 to 2003.

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.

SO₂ 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 SO₂ and NO_x from power plants >25MW_e prepared for the Danish Energy Authority due to Danish legislative requirement
- 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 data sets. 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 (CO₂, CH₄ and N₂O) 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 2004a). 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 enclosed 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 2004c).

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.

CO₂

The CO₂ emission factors applied for 2003 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 1990-2003.

In reporting to the Climate Convention, the CO₂ 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 CO₂ 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 CO₂ 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 CO₂. Thus, the full consumption of municipal waste is included in the fuel category, *Biomass*, and the full amount of non-CO₂ emissions from municipal waste combustion is also included in the *Biomass*-category.

The CO₂ 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 CO₂ emission from power plants in 2003 and 2004 (Lov nr. 376 1999) is based on standard CO₂ emission factors for each fuel. Thus, so far power plant operators have not been encouraged to estimate CO₂ 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 of improved emission factors for na-

tional emission inventories in future. The plants will report CO₂ emissions for 2005 according to this legislation.

Table 3.11 CO₂ emission factors 2003

Fuel	Emission factor		Unit	Reference type	IPCC fuel Category
	Biomass	Fossil fuel			
Coal			95 kg/GJ	Country specific	Solid
Brown coal briquettes			94,6 kg/GJ	IPCC reference manual	Solid
Coke oven coke			108 kg/GJ	IPCC reference manual	Solid
Petroleum coke			92 kg/GJ	Country specific	Liquid
Wood	102		kg/GJ	Corinair	Biomass
Municipal waste	94,5		17,6 kg/GJ	Country specific	Biomass / Other fuels
Straw	102		kg/GJ	Country specific	Biomass
Residual oil			78 kg/GJ	Corinair	Liquid
Gas oil			74 kg/GJ	Corinair	Liquid
Kerosene			72 kg/GJ	Corinair	Liquid
Fish & rape oil	74		kg/GJ	Country specific	Biomass
Orimulsion			80 kg/GJ	Country specific	Liquid
Natural gas			57,19 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

CH₄

The CH₄ emission factors applied for 2003 are presented in Table 3.12. In general, the same emission factors have been applied for 1990-2003. 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 CH₄ emission than other stationary combustion plants. The relatively high emission factor for gas engines is well documented, based on a very high number of emission measurements on Danish plants. The factor is further discussed in Annex 3A. Due to the considerable consumption of natural gas and biogas in gas engines the IEF (implied emission factor) in CRF sector 1A1, 1A2 and 1A4, fuel categories *Gaseous fuels* and *Biomass* is relatively high. The considerable change in IEF is a result of the increasing consumption of natural gas and biogas in gas engines as discussed in Chapter 3.2.1.2.

Table 3.12 CH₄ emission factors 1990-2003

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	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

N₂O

The N₂O emission factors applied for the 2003 inventory are listed in Table 3.13. The same emission factors have been applied for 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 on Danish plants (Nielsen & Illerup 2003). Other emission factors refer to the EMEP/Corinair Guidebook (EMEP/Corinair 2004).

Table 3.13 N₂O emission factors 1990-2003

Fuel	ipcc_id	SNAP_id	Emission factor [g/GJ]	Reference
COAL	all	all	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

SO₂, NO_x, NMVOC and CO

Emission factors for SO₂, 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 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 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.

SO₂ 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.

The industrial fuel consumption is considered in 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.

3.2.3 Uncertainties and time-series consistency

Time-series for fuel consumption and emission are shown and discussed in Chapter 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 $\pm 11\%$ and the increase in the GHG emission since 1990 has been estimated to be $11,1\% \pm 1,7\%$ -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:

- CO₂ emission from each of the applied fuel categories
- CH₄ emission from gas engines
- CH₄ emission from all other stationary combustion plants
- N₂O emission from all stationary combustion plants

The separate uncertainty estimation for gas engine CH₄ emission and CH₄ emission from other plants does not follow the recommendations in the IPCC Good Practice Guidance. Disaggregation is applied, because in Denmark the CH₄ emission from gas engines is much larger than the emission from other stationary combustion plants, and the CH₄ 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 ₂ O	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 val-

ues 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	NM VOC	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 $\pm 11\%$ and the uncertainty for the trend in GHG emission is $\pm 1.7\%$ -age points. The main sources of uncertainty for GHG emission are N₂O emission (all plants) and CO₂ emission from coal combustion. The main source of uncertainty in the trend in GHG emission is CO₂ emission from the combustion of coal and natural gas.

The total emission uncertainty is 7% for SO₂, 16% for NO_x, 38% for NM VOC and 43% for CO.

Table 3.16 Danish uncertainty estimates, 2003

Pollutant	Uncertainty Total emission	Trend 1990-2003	Uncertainty Trend
	[%]	[%]	[%-age points]
GHG	10,8	+11,1	$\pm 1,7$
CO ₂	2,9	+10,1	$\pm 1,7$
CH ₄	39	+330	± 320
N ₂ O	1000	+10,7	$\pm 3,4$
SO ₂	7	-82,9	$\pm 0,5$
NO _x	16	-26	± 2
NM VOC	38	46	± 15
CO	43	6,4	$\pm 4,1$

3.2.4 QA/QC and verification

The elaboration of a formal QA/QC plan started in 2004. A first draft QA/QC plan (in Danish) for stationary combustion has been developed and this draft version is now applied as one of two sector specific QA/QC cases. Adaptation to the general QA/QC plan will be performed in 2005.

The draft QA/QC plan for stationary combustion includes:

- Documentation concerning external data sources, including contacts, contracts with data supplier, archiving and suggested QC.
- Compilation of the data for the emission database, including current QC and suggested QC
- Data input to the emission database, including information on whether the data transfer is manual or not, current QC during and after data input, suggested QC.
- Emission inventory, including current and suggested QC of the emission inventory (consistency and completeness)

- Data transfer from the emission database to the reporting formats, including current and planned QC and archiving.
- A suggestion for the future archiving structure
- A time schedule for the QC plan
- QA
- Verification

The QC is not implemented yet. This year the QC procedures applied are the same as those applied last year. The QC includes:

- Checking of time-series in the IPCC and SNAP source categories. Considerable changes are controlled and explained.
- Comparison with the inventory of the previous year. Any major changes are verified.
- Total emission, when aggregated to IPCC reporting tables, is compared with totals based on SNAP source categories (control of data transfer).
- A manual log table in the emission databases is applied to collect information about recalculations.
- The IPCC reference approach validates the fuel consumption rates and CO₂ emissions of fuel combustion. Fuel consumption rates and CO₂ emissions differ by less than 1,5% (1990-2003). The reference approach is further discussed below.
- 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 factor 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 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 dk-Teknik³ both run accredited laboratories for emission measurements.

The first national external review of the inventories for stationary combustion was performed in 2004 by Jan Erik Johnsson, Technology University of Denmark. The review was performed after the reporting in 2004 and thus the improvements of emission factors suggested by Jan Erik Johnsson have been included the inventory presented in this report.

3.2.5 Recalculations

Improvements and recalculations since the 2004 emission inventory include:

- Update of fuel rates according to the latest energy statistics. The update includes the years 1980-2002.

³ Now FORCE

- Disaggregation of fuel consumption and emissions to industrial subsectors. In addition to fuel consumption the following pollutants have been disaggregated: CO₂, CH₄, N₂O, SO₂, NO_x, NMVOC and CO. The disaggregation itself does not change the reported totals.
- A contract between NERI and DEA specifying the content of the data supply for the emission inventory and deadlines have been signed. This contract also specifies that NERI will have access to the plant specific CO₂ data that will be collected by DEA from 2006.
- Brown coal and coke oven coke is not included in the fuel category *Coal* as in the former inventories.
- Improved emission factors for fish & rape oil have been estimated
- As a result of the first national external review some emission factors have been improved. These changes do not change the estimated total emissions considerably.

Furthermore, a few minor errors for large point sources have been corrected. These corrections do not affect greenhouse gases.

3.2.6 Planned improvements

Some planned improvements of the emission inventories are discussed below.

1) Improved documentation for CO₂ emission factors

The CO₂ 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 CO₂ emission based on plant specific CO₂ emission factors (2006).

2) Improved documentation for other emission factors

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. Implementation will start in 2005.

4) Uncertainty estimates

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

5) Other improvements

- The criteria for including a plant as a point source should be defined and the list of plants updated annually.
- White spirit will be dislocated to the fuel category *Other oil* in the IPCC reference approach.

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 emission 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 Table 3.17 (mobile sources only).

Table 3.17 SNAP – NFR 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 2003 in CRF sectors

CRF ID	Fuel use (PJ)
Military (1A5)	1
Railways (1A3c)	3
Navigation (1A3d)	8
Agriculture/forestry/fisheries (1A4c)	25
Civil Aviation (1A3a)	2
Industry-other (1A2f)	10
Residential (1A4b)	1
Road (1A3b)	161
Total	212

Table 3.18 shows the fuel use for domestic transport based on DEA statistics for 2003 in CRF sectors. The fuel use figures in time-series 1990-2003 are given in Annex 3.B.10 (CRF format) and are shown for 1990 and 2003 in Annex 3.B.9 (CollectER format). Road transport has a major share of the fuel consumption for domestic transport. In 2003 this sector's fuel use share is 76%, while the fuel use shares for agriculture/forestry/fisheries and Industry-Other are 12 and 5%, respectively. For the remaining sectors the total fuel use share is 7%.

From 1985 to 2003 the diesel and gasoline fuel uses have increased with 27 and 29%, respectively, and in 2003 the fuel use shares for diesel and gasoline were 57 and 40%, respectively (Figures 3.15 and 3.16. Other fuels only have a 3% share of the domestic transport total, divided on 1% for each of the fuel types: jet fuel, LPG and residual oil. 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 a considerable fuel use in most of the domestic transport categories, whereas a more limited use of residual oil and jet fuel, respectively, is taking place in the fisheries/navigation sectors and by aviation (civil and military flights).

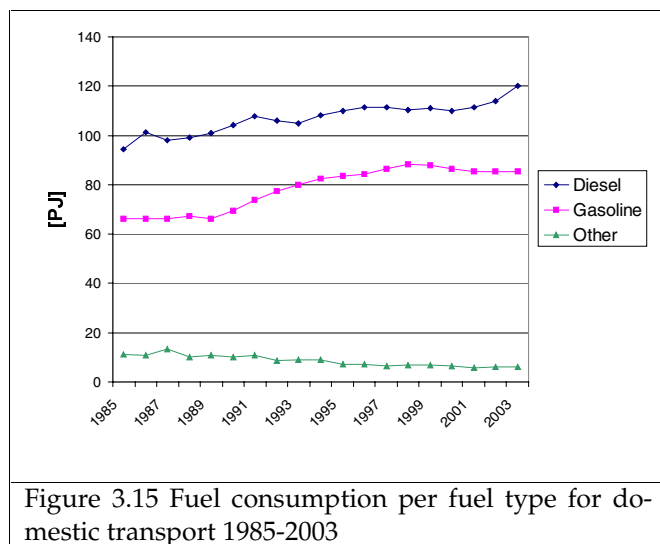


Figure 3.15 Fuel consumption per fuel type for domestic transport 1985-2003

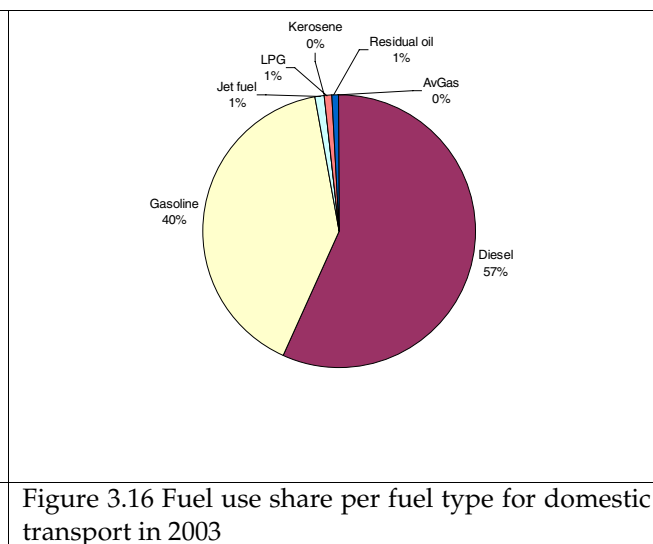
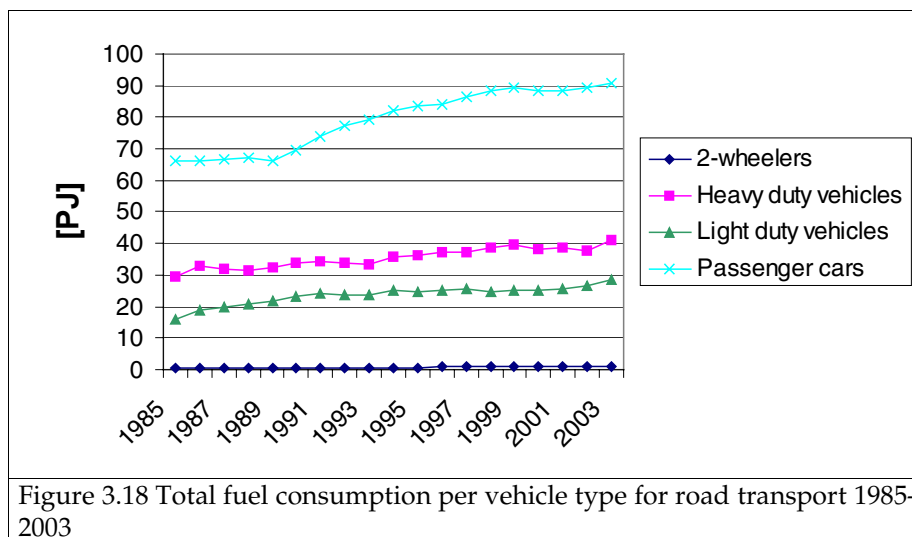
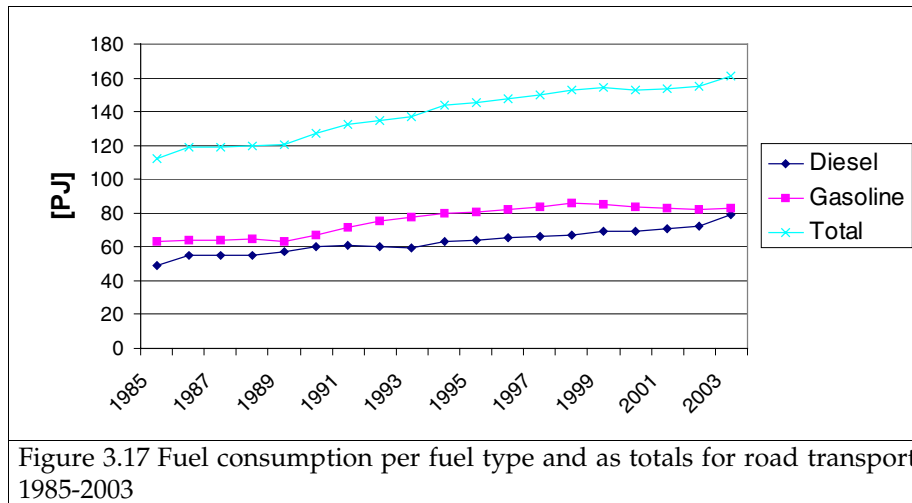


Figure 3.16 Fuel use share per fuel type for domestic transport in 2003

Road transport

As shown in Figure 3.17 the energy use for road transport has increased until 2000, where a small fuel use decline is noted. From 2001 onwards the fuel use increases, especially for the latest year, 2003. The fuel use development is due to a slight decrease in the use of gasoline fuels from 1999-

2002 combined with a steady growth in the diesel fuel use. Within sub-sectors passenger cars is the most fuel consuming vehicle category followed by heavy-duty vehicles, light duty vehicles and 2-wheelers in decreasing order (Figure 3.18).



As shown in Figure 3.19 the fuel use development for gasoline passenger cars dominates the total gasoline fuel use trend. The recent years development in diesel fuel use (Figure 3.20) is characterised by an increasing fuel use for diesel passenger cars and light duty vehicles, whereas the fuel use for trucks and buses (heavy-duty vehicles) has fluctuated since 1999. However, for the latter vehicle types the sudden fuel use increase in 2003 is very significant.

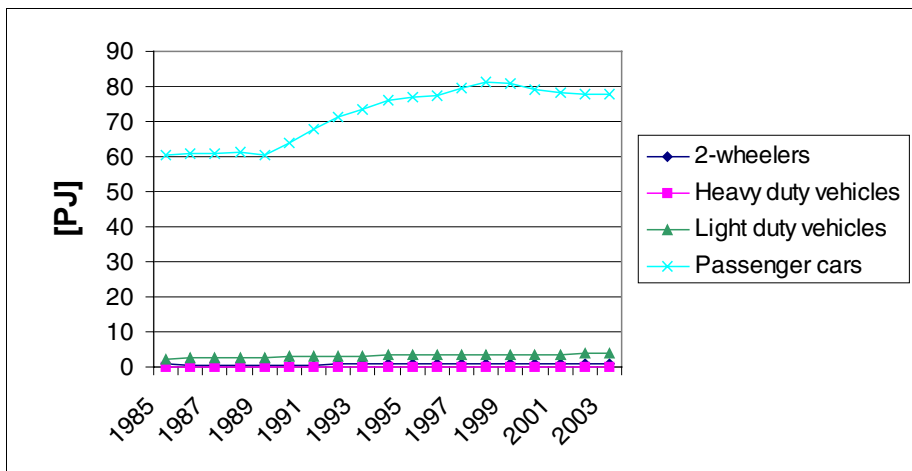


Figure 3.19 Gasoline fuel consumption per vehicle type for road transport 1985-2003

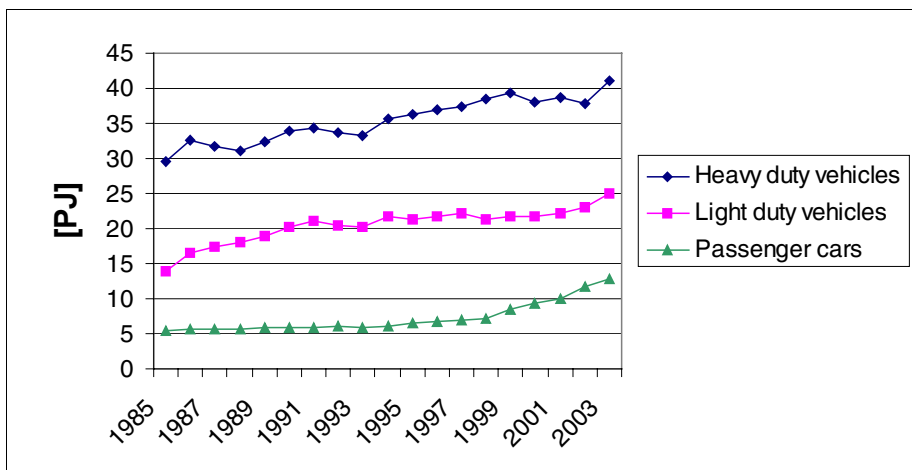


Figure 3.20 Diesel fuel consumption per vehicle type for road transport 1985-2003

In 2003 the fuel use shares for gasoline passenger cars, heavy-duty vehicles, diesel light duty vehicles, diesel passenger cars and gasoline light duty vehicles were 49, 25, 15, 8 and 2%, respectively (Figure 3.21).

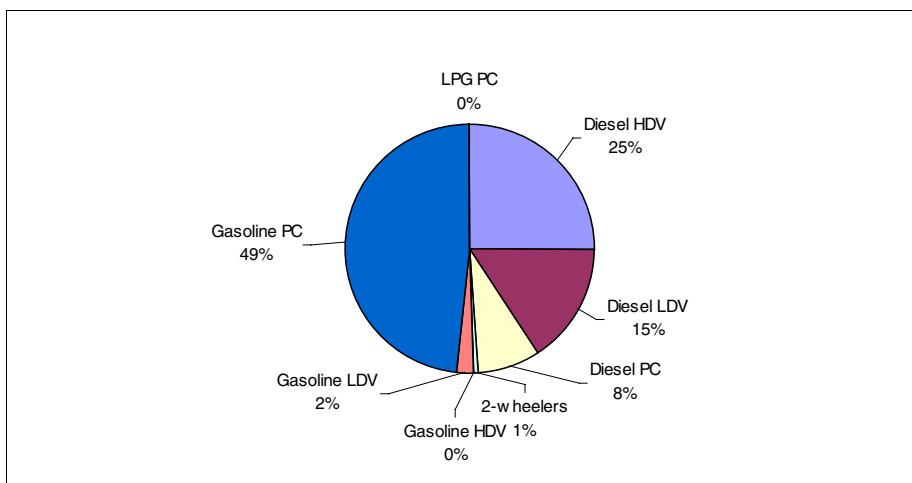


Figure 3.21 Fuel use share (PJ) per vehicle type for road transport in 2003

Other mobile sources

As explained in paragraph 3.3.2.2 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.

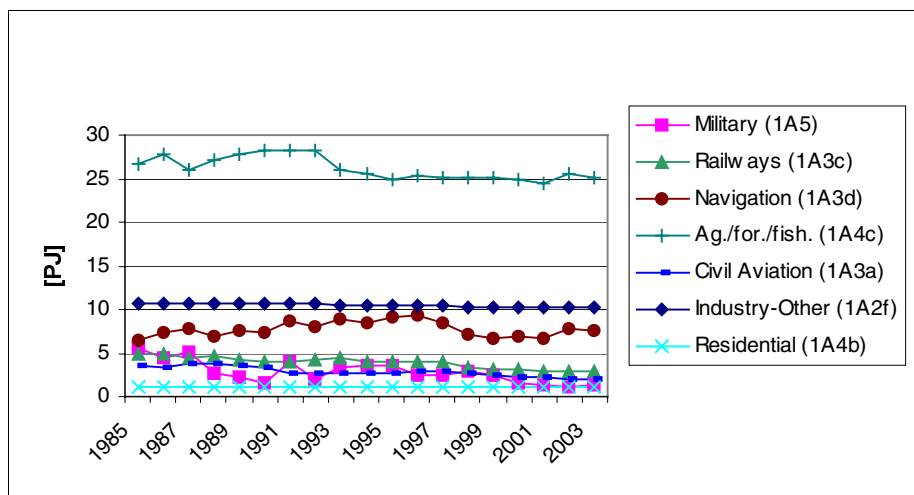


Figure 3.22 Total fuel use in CRF sectors for other mobile sources 1985-2003

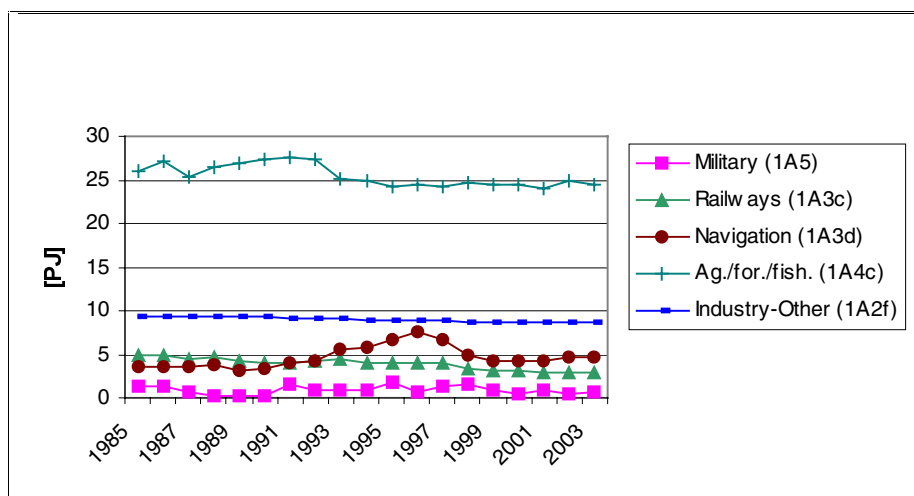
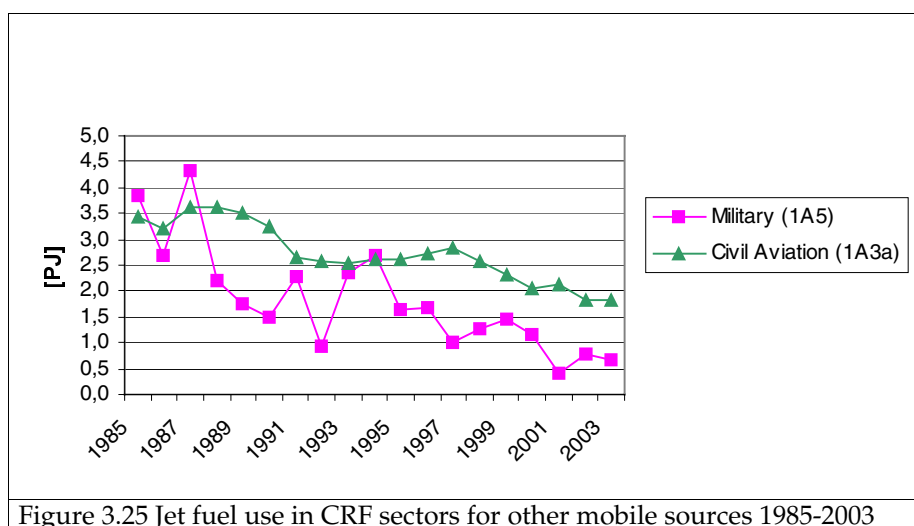
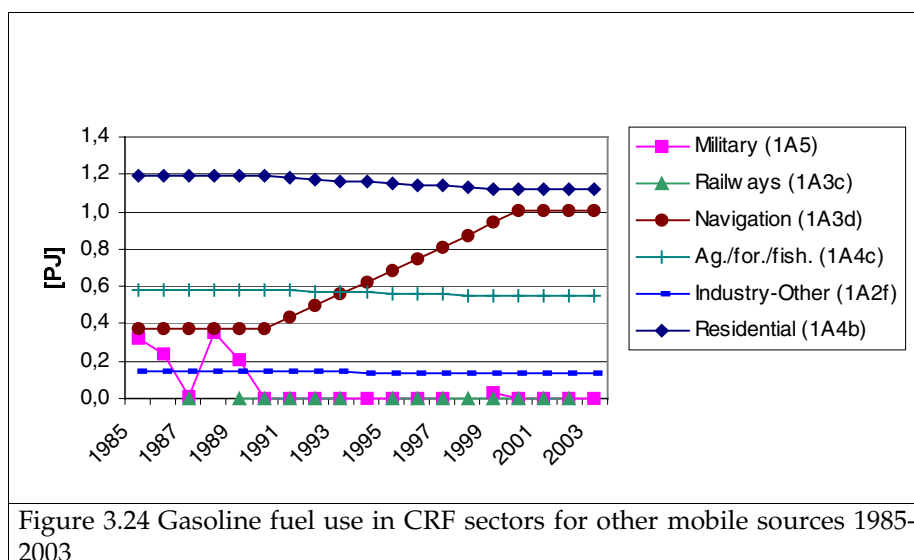


Figure 3.23 Diesel fuel use in CRF sectors for other mobile sources 1985-2003



Except for small boats and pleasure crafts (inland waterways) the fuel use has made a slight decrease from 1990 to 2000 in the above mentioned sectors. Classified according to CRF the most important sectors are Agriculture/forestry/fisheries (1A4c), Industry-other (mobile machinery part of 1A2f) and Navigation (1A3d), as seen in Figure 3.22. Minor fuel consuming sectors are Civil Aviation (1A3a), Railways (1A3c), Other (military mobile fuel use: 1A5) and Residential (1A4b). The 1985-2003 time-series are shown per fuel type in Figures 3.23-3.25 for diesel, gasoline and jet fuel, respectively.

In the Agriculture/forestry/fisheries sector the diesel fuel use by agricultural machines accounts for two thirds of the total fuel use. The fuel use decrease is the result of fluctuations in the diesel fuel use for fishery and the steady fuel use decrease for agricultural machines between 1990 and 2000.

The Navigation sector comprises national sea transport (fuel use between two Danish ports) and small boats and pleasure crafts. For the latter categories the fuel use has increased significantly from 1990 to 2000 due to more gasoline and diesel fuelled private boats. For national sea transport the diesel fuel use has shown some fluctuations in the same time period and the amount of fuel used is actually lower in 2003 than in 1990. The most important explanation for this fuel use de-

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

The considerable year by year variations in military jet fuel use is due to planning and budget-wise reasons and the passing demand for flying activities. Consequently, for some years a certain degree 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 emissions for this transport sector. The fuel used (and associated emissions) to produce electricity are 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.

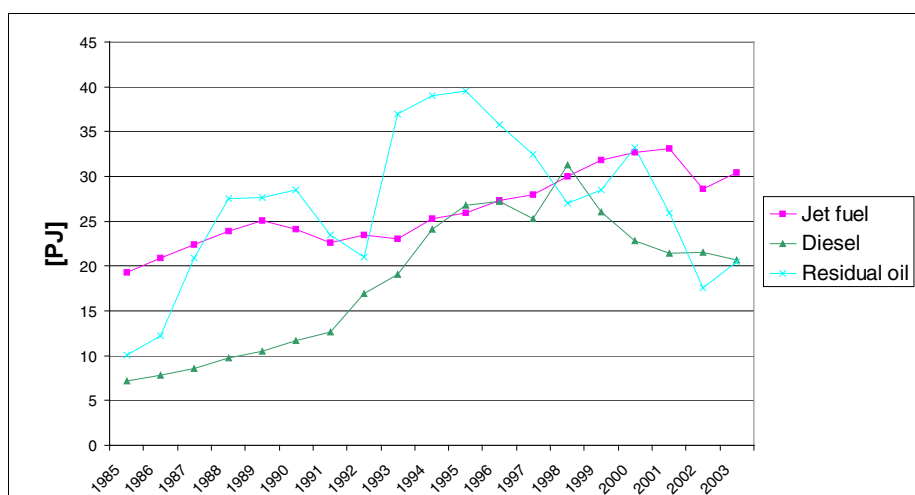


Figure 3.26 Bunker fuel use 1985-2003

3.3.1.2 Emissions of CO₂, CH₄ and N₂O

In Table 3.19 the CO₂, CH₄ and N₂O emissions for road transport and other mobile sources are shown for 2003 in CRF sectors. The emission figures in time-series 1985-2003 are given in Annex 3:B.10 (CRF format) and are shown for 1990 and 2003 in Annex 3.B.9 (CollectER format).

From 1985 to 2003 the road transport emissions of CO₂, CH₄ and N₂O have increased by 44, 19 and 294%, respectively, whereas the 1990-2003 emission increases are 27, 13 and 217%, respectively (from Figures 3.27-3.29). From 1985 and 1990 to 2003 the other mobile CO₂ emissions have decreased by 15 and 11%, respectively (from Figures 3.31-3.33).

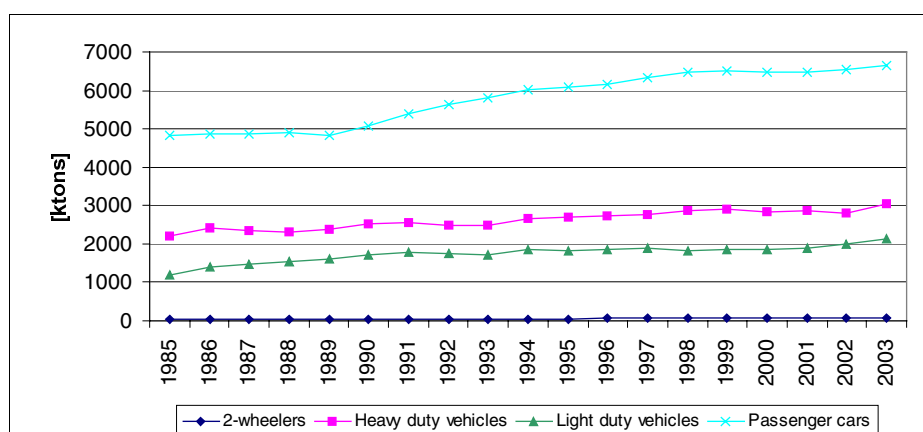
Table 3.19 Emissions of CO₂, CH₄ and N₂O in 2003 for road transport and other mobile sources

CRF Sector	CH ₄ [tons]	N ₂ O [tons]	CO ₂ [ktons]
Military (1A5)	5	5	92
Railways (1A3c)	9	6	218
Navigation (1A3d)	122	30	565
Ag./for./fish. (1A4c)	121	91	1855
Civil Aviation (1A3a)	5	8	138
Industry-Other (1A2f)	148	32	742
Residential (1A4b)	130	2	82
Total other mobile	538	173	3693
Road (1A3b)	2964	1339	11864
Total mobile	3502	1513	15556

Road transport

The CO₂ emissions are directly fuel use dependent and in this way the emission development 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 2003 the respective emission shares were 56, 25, 18 and 1%, respectively (Figure 3.30).

The majority of the CH₄ 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 the ones 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 traffic. The newer technology stages have lower CH₄ emission factors than conventional gasoline vehicles have. The 2003 emission shares for CH₄ was 83, 8, 5 and 4% for passenger cars, heavy-duty vehicles, 2-wheelers and light duty vehicles, respectively (Figure 3.30).

Figure 3.27 CO₂ emissions (ktons) per vehicle type for road transport 1985-2003

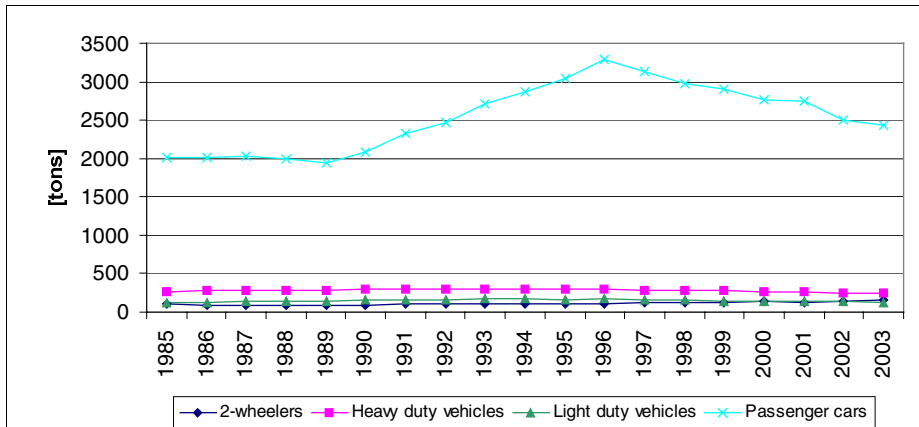


Figure 3.28 CH₄ emissions (tons) per vehicle type for road transport 1985-2003

An undesirable environmental side effect of the introduction of catalyst cars is the increase in the emissions of N₂O from 1990 onwards (Figure 3.29). However, the total road transport N₂O and CH₄ emission contributions are still small compared to the emissions from the agricultural sector. In 2003 the emission shares for passenger cars, light and heavy-duty vehicles were 80, 12, 8%, respectively, of the total road transport N₂O (Figure 3.30).

Referring to the second IPCC assessment report (IPCC, 1995) 1 g CH₄ and 1 g N₂O has the greenhouse effect of 21 and 310 g CO₂, respectively. In spite of the relatively large CH₄ and N₂O global warming potentials, the largest contribution to the total CO₂ emission equivalents for road transport comes from CO₂, and the CO₂ emission equivalent shares per vehicle category are almost the same as for CO₂.

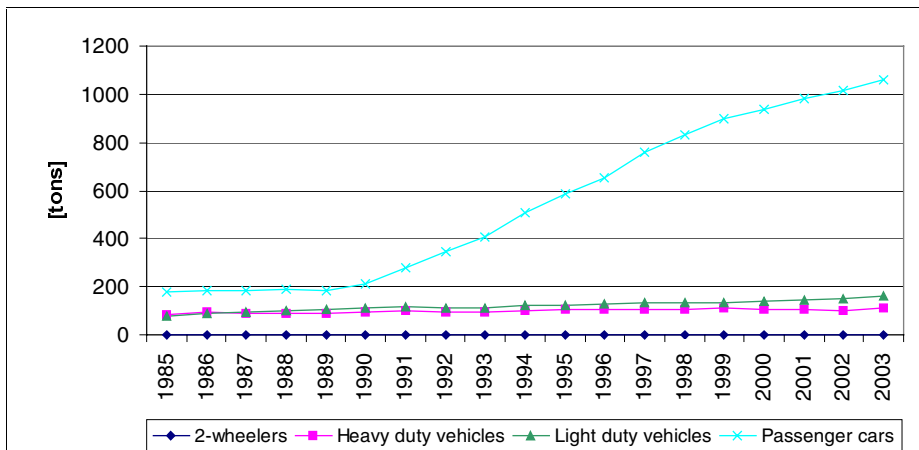
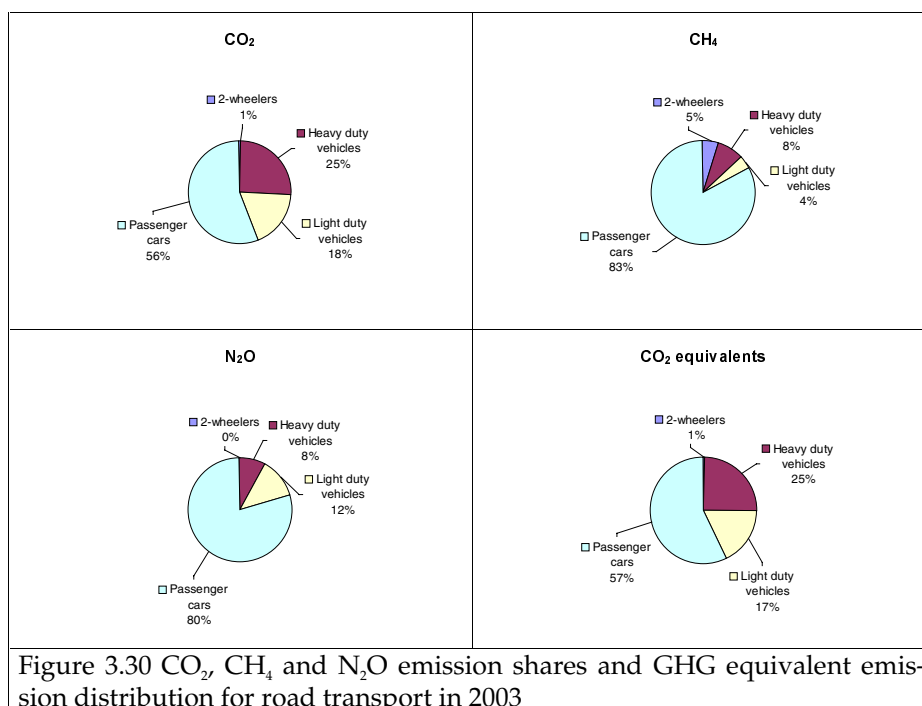


Figure 3.29 N₂O emissions (tons) per vehicle type for road transport 1985-2003



Other mobile sources

For other mobile sources the biggest CO₂ emissions come from Agriculture/forestry/fisheries (1A4c), Industry-other (1A2f), Navigation (1A3d), with shares of 51, 20 and 15%, respectively, in 2003 (Figure 20). The 1985-2003 emission trend is directly related to the fuel use development in the same time period (Figure 17). Minor CO₂ emission contributors are sectors such as Railways (1A3c), Civil Aviation (1A3a), Military (1A5) and Residential (1A4b). In 2003 the CO₂ emission shares from these sectors were 6, 4, 2 and 2%, respectively (Figure 3.34).

For CH₄ the most important sectors are Industry (1A2f), Residential (1A4b), Navigation (1A3d) and Agriculture/forestry/fisheries (1A4c) with almost equal shares of 27, 24, 23 and 22%, respectively, in 2003 (Figure 3.34). The remaining emissions come from the minor sources Railways (1A3c), Civil Aviation (1A3a) and Military (1A5).

The reasons for the high CH₄ emissions in the two most emitting sectors are the use of LPG trucks in industry and the relatively large amount of gasoline used in the residential sector. Also the appearance of more gasoline fuelled private boats in navigation has caused a significant increase in the emissions from this sector from 1990 to 2000 (Figure 3.32).

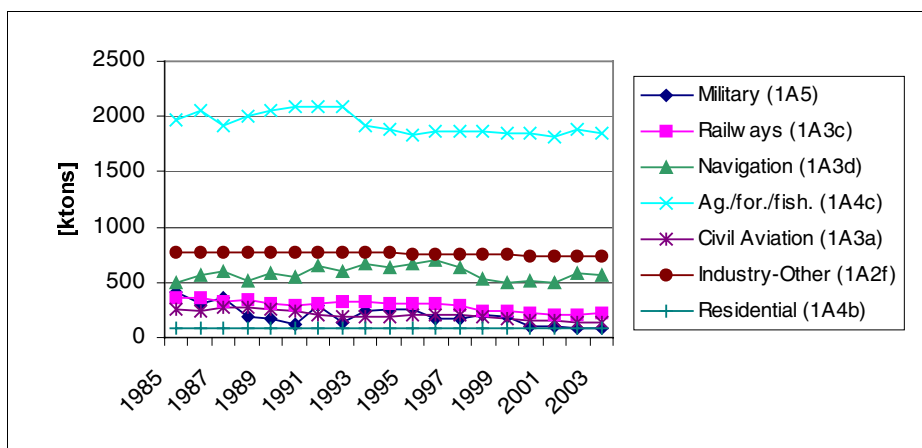


Figure 3.31 CO₂ emissions (ktons) in CRF sectors for other mobile sources 1985-2003

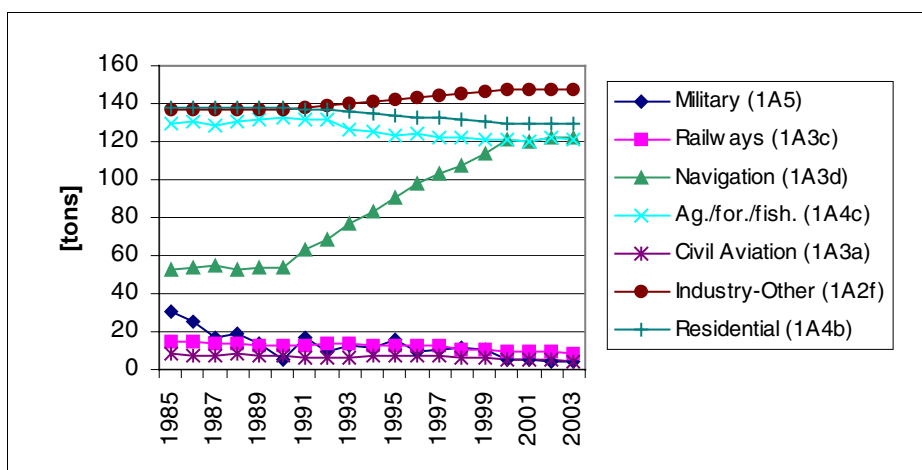
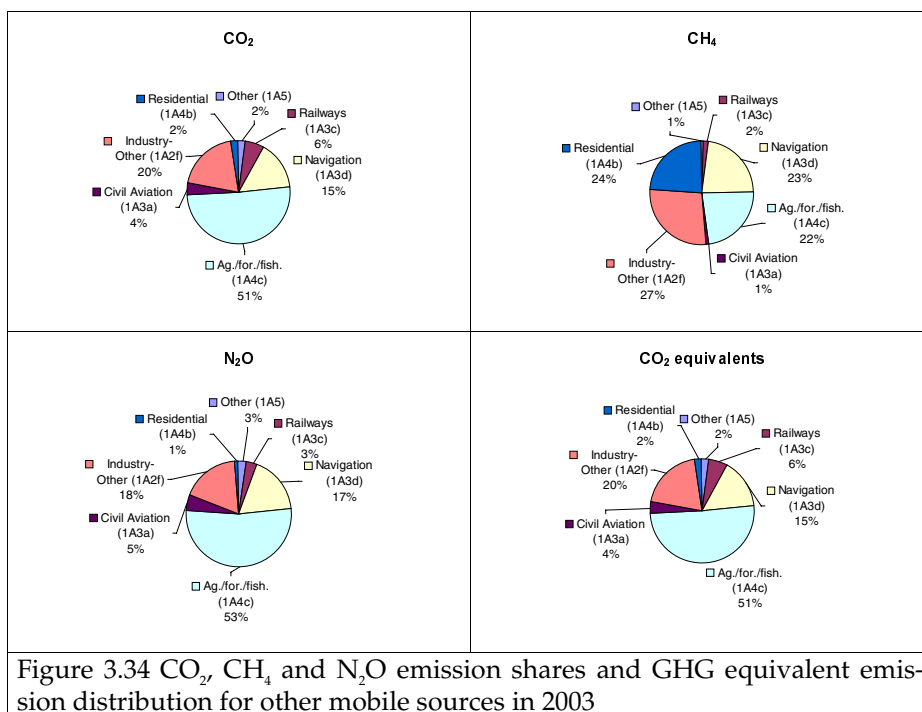
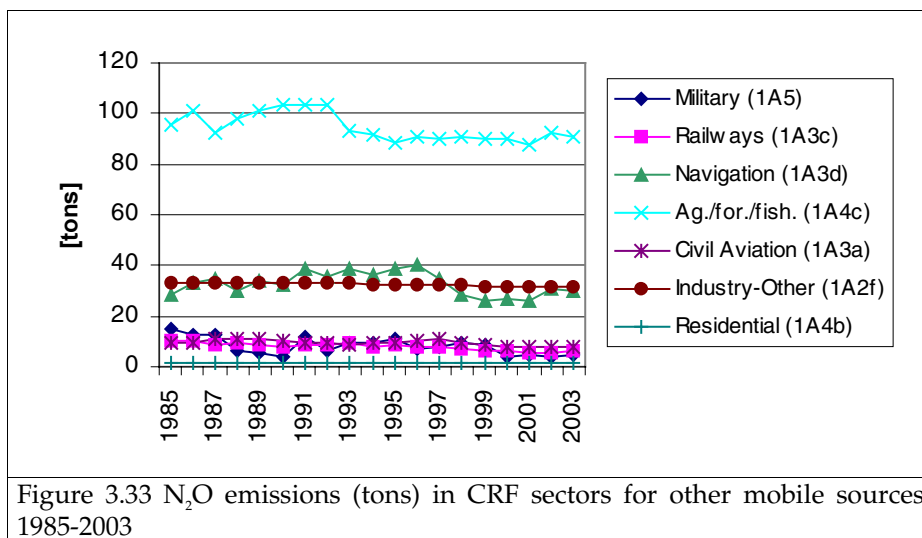


Figure 3.32 CH₄ emissions (tons) in CRF sectors for other mobile sources 1985-2003

For N₂O the emission trend in sub-sectors is the same as for fuel use and CO₂ emissions (Figure 3.33).

As for road transport, CO₂ alone contributes with far the most of the CO₂ emission equivalents in the case of other mobile sources and the sectoral CO₂ emission equivalent shares are almost the same as for CO₂ (Figure 3.34).



3.3.1.3 Emissions of SO₂, NO_x, NMVOC and CO

In Table 4 the SO₂, NO_x, NMVOC and CO emissions for road transport and other mobile sources are shown for 2003 in CRF sectors. The emission figures in time-series 1985-2003 are given in Annex 3.B.10 (CRF format) and are shown for 1990 and 2003 in Annex 3.B.9 (CollectER format).

From 1985 to 2003 the road transport emissions of NMVOC, CO and NO_x emissions have decreased by 61, 52, 28%, respectively (Figures 21-24). The highest CO, NO_x and NMVOC emissions occur in 1991, after which the emissions drop by 43, 36 and 61%, respectively, until 2003.

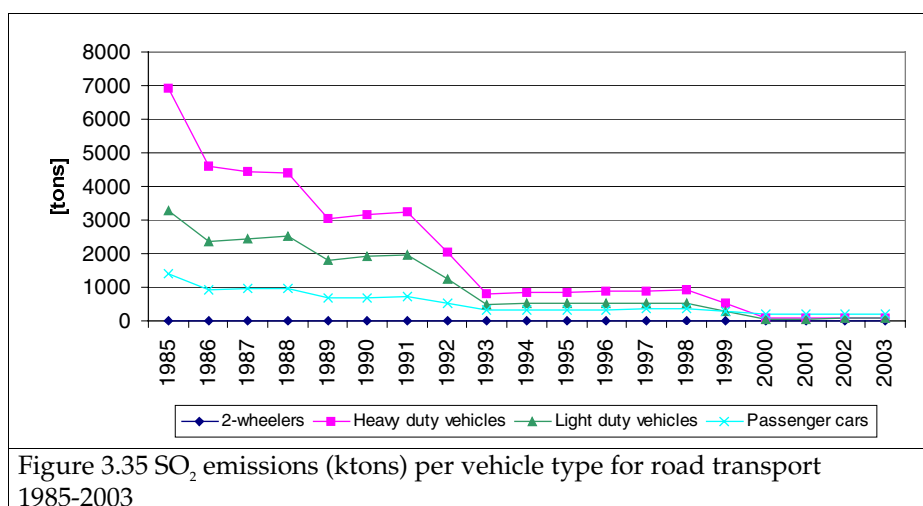
For other mobile sources the emissions of NO_x has decreased by 15% from 1985 to 2003 and for SO₂ the emission drop is as much as 75% (77% since 1980). In the same period the emissions of NMVOC and CO has increased by 28 and 2%, respectively (Figures 3.40-3.43).

Table 3.20 Emissions of SO₂, NO_x, NMVOC and CO in 2003 for road transport and other mobile sources

CRF ID	SO ₂ [tons]	NO _x [tons]	NMVOC [tons]	CO [tons]
Military (1A5)	4	449	58	310
Railways (1A3c)	7	3540	223	611
Navigation (1A3d)	1859	8842	11383	20045
Agriculture/for./fish. (1A4c)	1234	31028	4931	22259
Civil Aviation (1A3a)	5	585	123	718
Industry-Other (1A2f)	201	10646	3006	10778
Residential (1A4b)	3	239	4162	47601
Total other mobile	3312	55328	23887	102321
Road (1A3b)	373	64892	31861	274460
Total mobile	3685	120220	55748	376782

Road transport

The step-wise lowering of the sulphur content in diesel fuel has brought along a substantial decrease in the road transport emissions of SO₂ (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 2003 shares for SO₂ emissions and fuel use for passenger cars, heavy-duty vehicles, light-duty vehicles and 2-wheelers are the same in each case; 55, 26, 18 and 1%, respectively (Figure 3.39).


Figure 3.35 SO₂ emissions (ktons) per vehicle type for road transport 1985-2003

Historically the emission totals of NO_x and especially NMVOC and CO have been very dominated by the contributions coming from private cars, as shown in the Figures 3.36-3.38. However, the emissions from this vehicle type have shown a steady decreasing tendency since the introduction of catalyst private 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. For 2003, however, the significant increase in the diesel fuel use causes the NO_x emissions to increase for light and heavy-duty vehicles.

In 2003 the emission shares for passenger cars, heavy-duty vehicles, light-duty vehicles and 2-wheelers were 46, 38, 16 and 0%, respectively, for NO_x, 74, 9, 7 and 10%, respectively, for NMVOC and 87, 2, 6 and 5%, respectively, for CO (Figure 3.39).

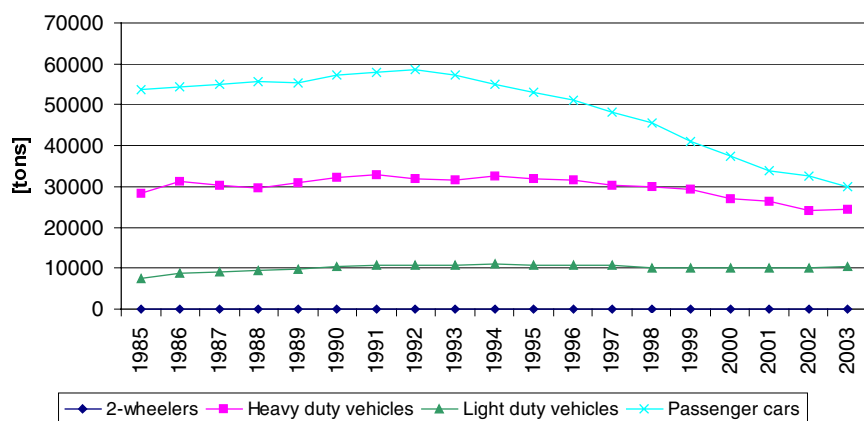


Figure 3.36 NO_x emissions (tons) per vehicle type for road transport 1985-2003

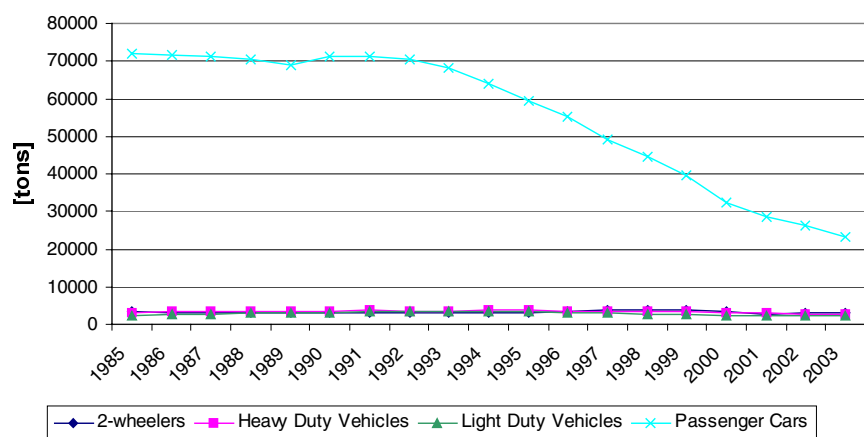


Figure 3.37 NMVOC emissions (tons) per vehicle type for road transport 1985-2003

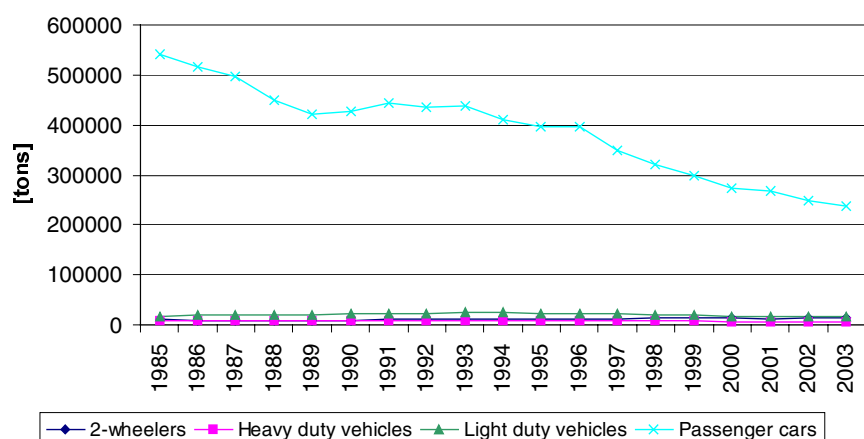
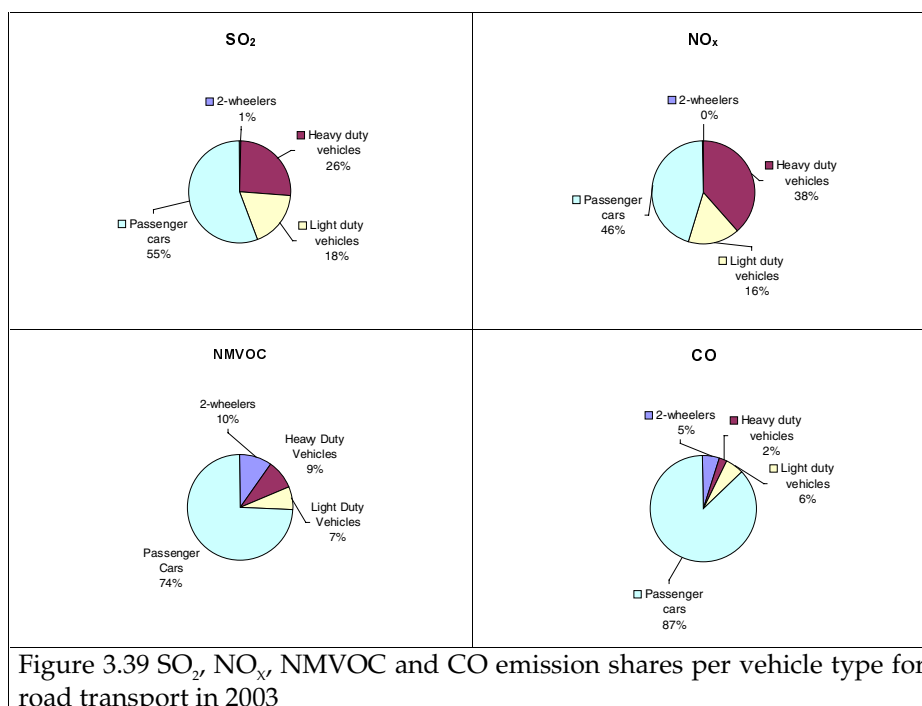
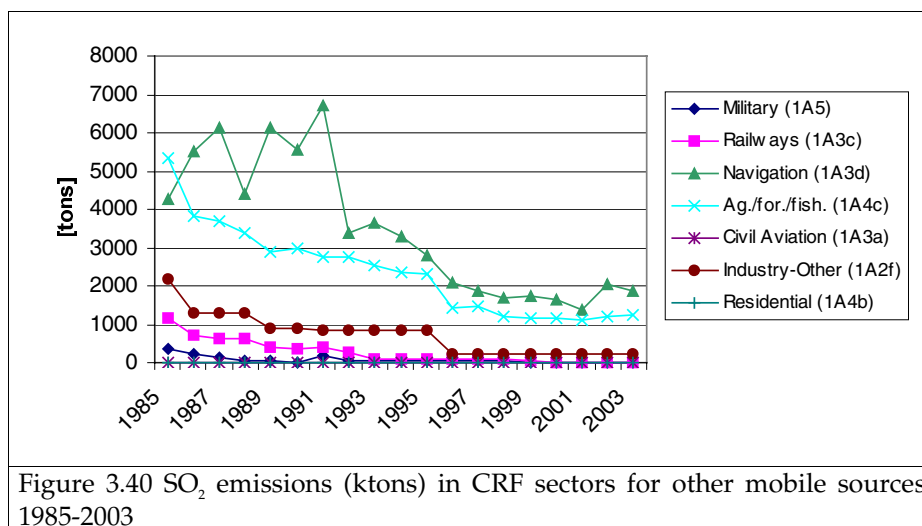


Figure 3.38 CO emissions (tons) per vehicle type for road transport 1985-2003



Other mobile sources

The SO₂ emissions decrease significantly from 1985 to 1996, as shown in Figure 3.40. The lowering is due to the reduction of the sulphur content for marine diesel fuel in Navigation (1A3d) and diesel fuel used by, among others, Railways (1A3c) and non-road machinery in Agriculture/forestry/fisheries (1A4c) and Industry (1A2f).

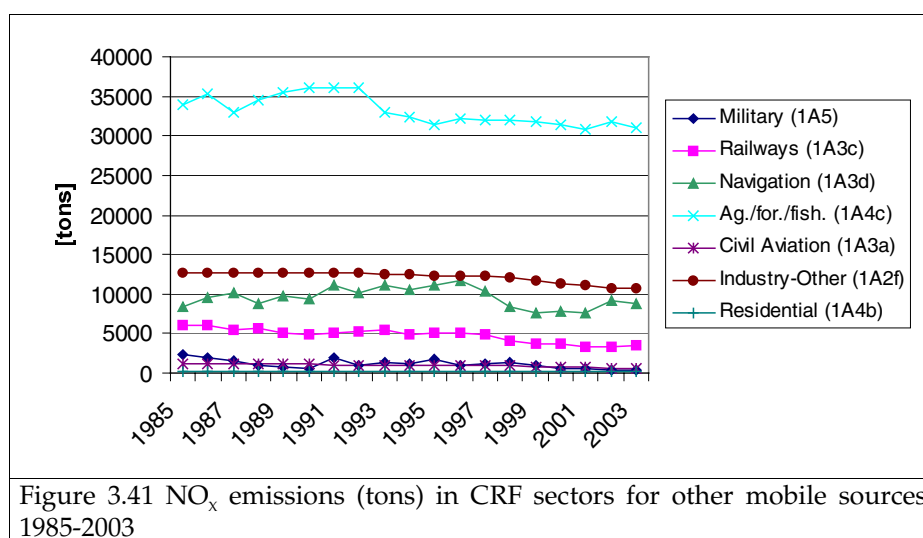


In general the emissions of NO_x, NMVOC and CO from diesel fuelled working equipment and machinery in agriculture, forestry and industry have decreased slightly since the end of the 1990s due to the implementation of a two-stage EU emission directive.

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 2003 emission shares are 57, 19, 16 and 6%, respectively (Figure 3.44). Minor emissions come from Civil Aviation (1A3a), Military (1A5) and Residential (1A4b).

The NO_x emission trend for Agriculture/forestry/fisheries is determined by fuel use (and hence emissions) fluctuations for fishery and the constant emission decrease for diesel fuelled agricultural machines. The latter emission decline is the product of decreasing fuel use between 1990 and 2000 and an improved emission performance for new machinery since the late 1990's.

The emission explanation for agricultural NO_x also applies for industry NO_x emissions. 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 service connections in connection with the opening of the Great Belt Bridge in 1997. For railways the gradual shift towards electrification explains the lowering trend in diesel fuel use and NO_x emissions for this transport sector.



The 1985-2003 time-series of NMVOC and CO emissions are shown in the Figures 3.42 and 3.43 for other mobile sources. The 2003 sectoral emission shares are shown in Figure 3.44. For NMVOC the most important sectors are Navigation (1A3d), Agriculture/forestry/fisheries (1A4c), Residential (1A4b) and Industry (1A2f) with 2003 emission shares of 47, 21, 17 and 13%, respectively. The same four sectors also contribute with most of the CO emissions. However, in this case the largest emission source is Residential (1A4b), followed by Agriculture/forestry/fisheries (1A4c), Navigation (1A3d) and Industry (1A2f), with 2003 emission shares of 46, 21, 20 and 11%, respectively. Minor NMVOC and CO emissions come from Railways (1A3c), Civil Aviation (1A3a) and Military (1A5).

The reason for high NMVOC and relatively large CO emissions in navigation is the appearance of more gasoline fuelled private boats in navigation, whereas the high CO and relatively large NMVOC emissions from the residential sector solely come from gasoline fuelled working machinery (characterised by high emission factors).

In agriculture/forestry/fisheries the large amount of diesel used by agricultural tractors causes most of the NMVOC, whereas the use of diesel and LPG (and to a smaller extent gasoline) causes the NMVOC emissions from industry. The majority of the CO emissions from the same two sectors is emitted by gasoline engines.

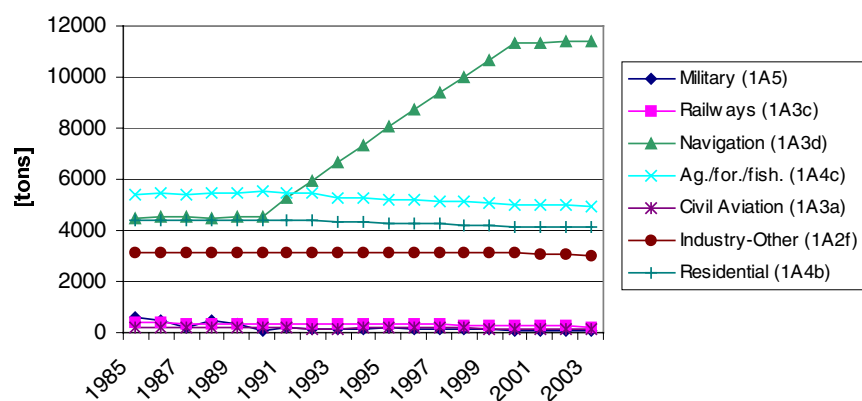


Figure 3.42 NMVOC emissions (tons) in CRF sectors for other mobile sources 1985-2003

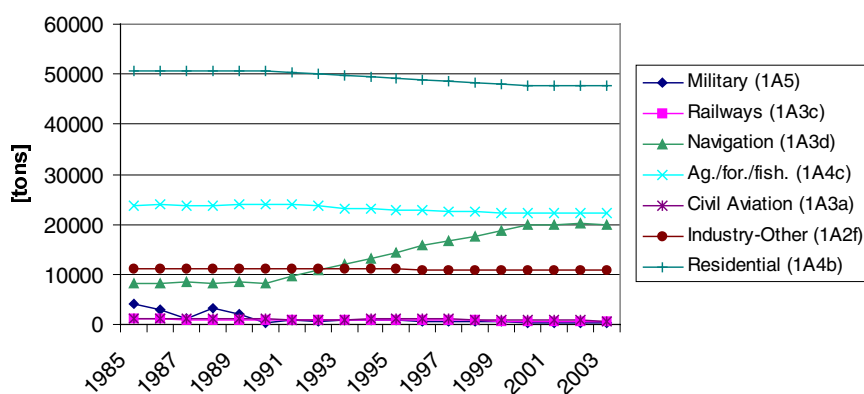


Figure 3.43 CO emissions (tons) in CRF sectors for other mobile sources 1985-2003

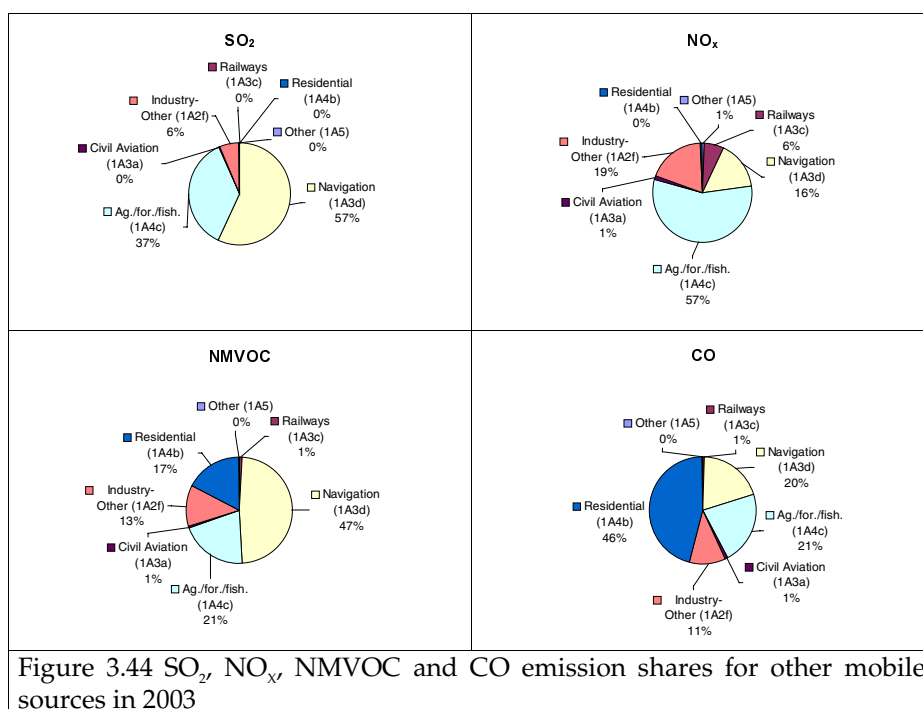


Figure 3.44 SO_2 , NO_x , NMVOC and CO emission shares for other mobile sources in 2003

Bunkers

The most important emissions from bunker fuel use (fuel use for international transport) are SO₂, NO_x and CO₂ (and TSP: not shown). However, compared to 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 2003, split into sea transport and civil aviation. All emission figures in time-series 1985-2003 are given in Annex 3.B.10 (CRF format). In Annex 3.B.9 the emissions are also given in CollectER format for the years 1990 and 2003.

Table 3.21 Emissions in 2003 for international transport and national totals

CRF sector	SO ₂ [tons]	NO _x [tons]	NMVOC [tons]	CH ₄ [tons]	CO [tons]	CO ₂ [ktons]	N ₂ O [tons]
Navigation int. (1A3d)	44114	85761	2294	71	7294	3130	198
Civil Aviation int. (1A3a)	70	9288	405	42	1684	2188	76
International total	44183	95049	2699	113	8978	5318	274

The differences in emissions between navigation and civil aviation are much larger than differences in fuel use (and derived CO₂ 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 (SO₂, NO_x and CO₂) due to shifting 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 (2001 onwards) statistics.

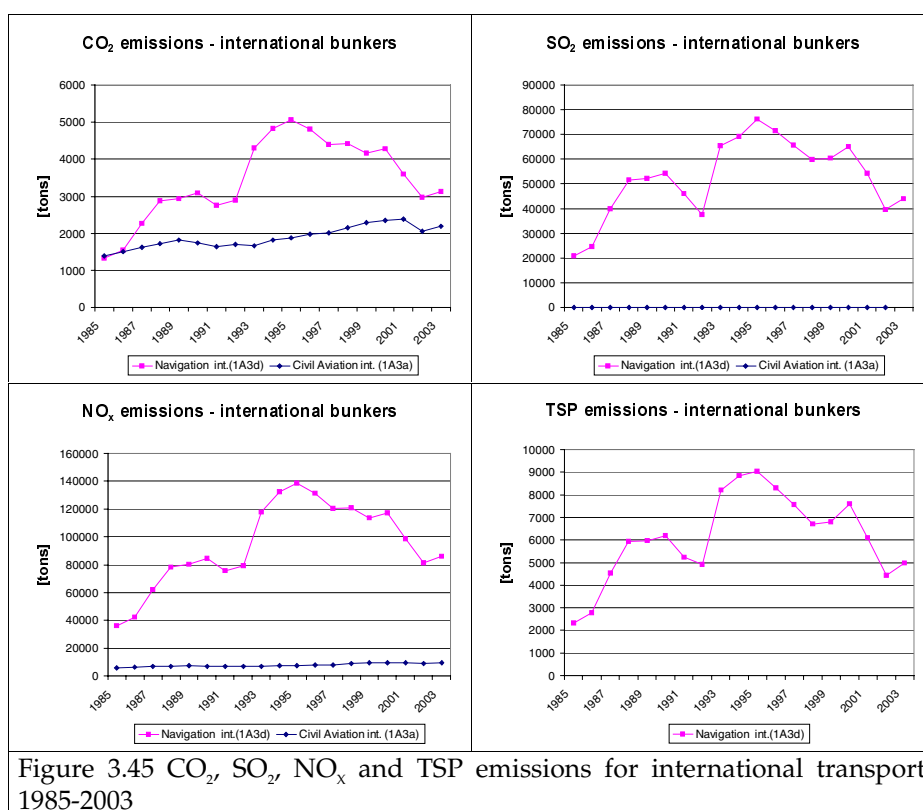


Figure 3.45 CO₂, SO₂, NO_x and TSP emissions for international transport 1985-2003

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 the European COPERT III model (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 traffic 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]			Mileage split [%]		
			Urban	Rural	Highway	Urban	Rural	Highway
PC	Gasoline	< 1.4 l.	40	70	100	35	46	19
PC	Gasoline	1.4 – 2 l.	40	70	100	35	46	19
PC	Gasoline	> 2 l.	40	70	100	35	46	19
PC	Diesel	< 2 l.	40	70	100	35	46	19
PC	Diesel	> 2 l.	40	70	100	35	46	19
PC	LPG		40	70	100	35	46	19
PC	2-stroke		40	70	100	35	46	19
LDV	Gasoline		40	65	80	35	50	15
LDV	Diesel		40	65	80	35	50	15
Trucks	Gasoline		35	60	80	32	47	21
Trucks	Diesel	3.5 – 7.5 tonnes	35	60	80	32	47	21
Trucks	Diesel	7.5 – 16 tonnes	35	60	80	32	47	21
Trucks	Diesel	16 – 32 tonnes	35	60	80	19	45	36
Trucks	Diesel	> 32 tonnes	35	60	80	19	45	36
Urban buses	Diesel		30	50	70	51	41	8
Coaches	Diesel		35	60	80	32	47	21
Mopeds	Gasoline		30	30	-	81	19	0
Motorcycles	Gasoline	2 stroke	40	70	100	47	39	14
Motorcycles	Gasoline	< 250 cc.	40	70	100	47	39	14
Motorcycles	Gasoline	250 – 750 cc.	40	70	100	47	39	14
Motorcycles	Gasoline	> 750 cc.	40	70	100	47	39	14

Information of the vehicle stock and annual mileage is obtained from the Danish Road Directorate (Ekman, 2004). 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.

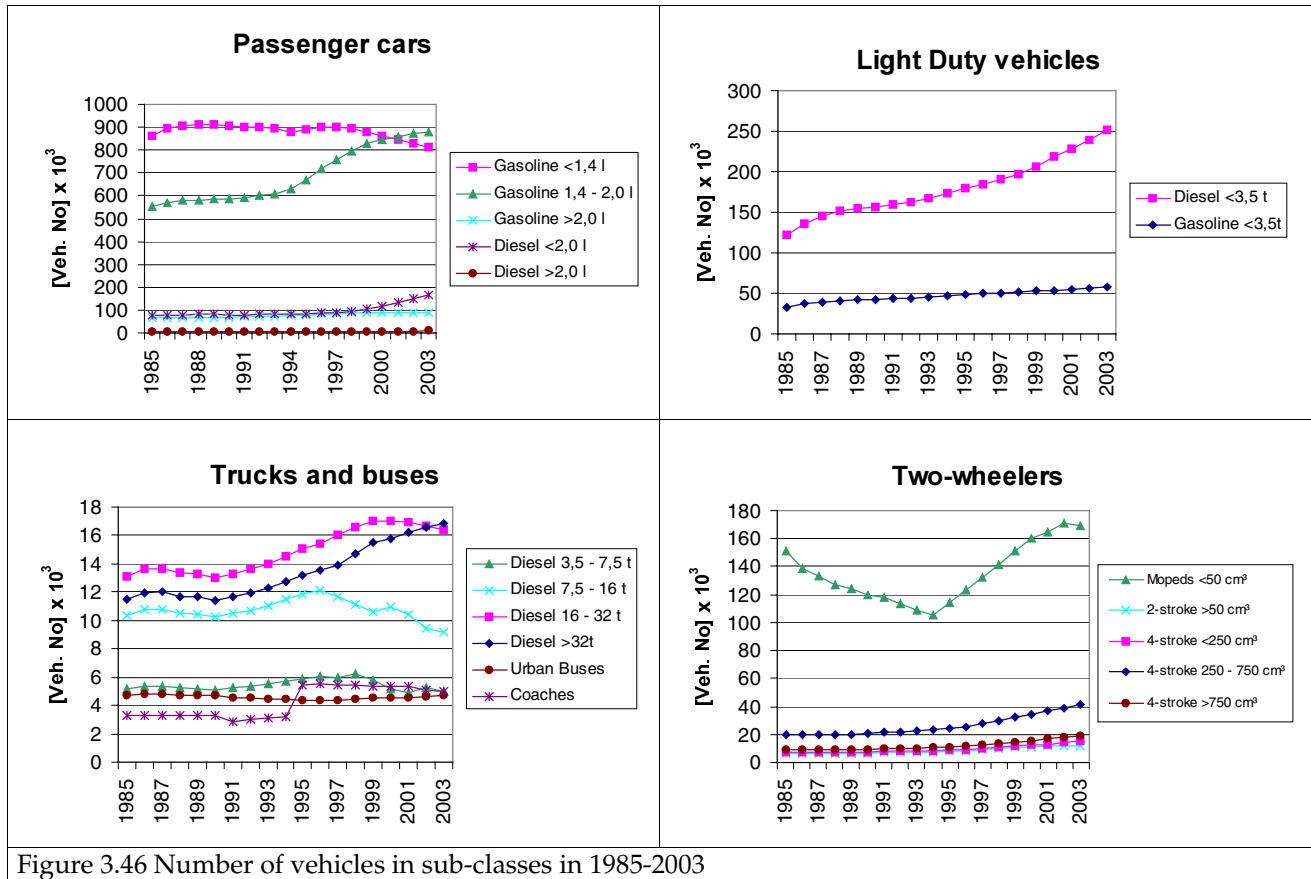


Figure 3.46 Number of vehicles in sub-classes in 1985-2003

The vehicle numbers per sub-class are shown in Figure 3.46. 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. In the later years there has been a decrease in the number of cars with engine sizes larger than 2 litres, and at the same time the number of diesel passenger cars has increased.

There has been a considerable growth in the number of diesel light duty vehicles from 1985 to 2003. The two largest truck sizes have also increased in numbers during the 1990's. From 2000 onwards this growth has continued for trucks larger than 32 tons, whereas the number of trucks with gross vehicle weights between 16 and 32 tons has decreased slightly.

The number of urban buses has been very constant from 1985 to 2003. 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 1985-2002 period. The increase is however most visible from the mid-1990's and onwards.

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

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

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

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

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

Vehicle numbers and weighted annual mileages per layer are shown in Annex 3.B.1 and 3.B.2 for 1985-2003. 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.

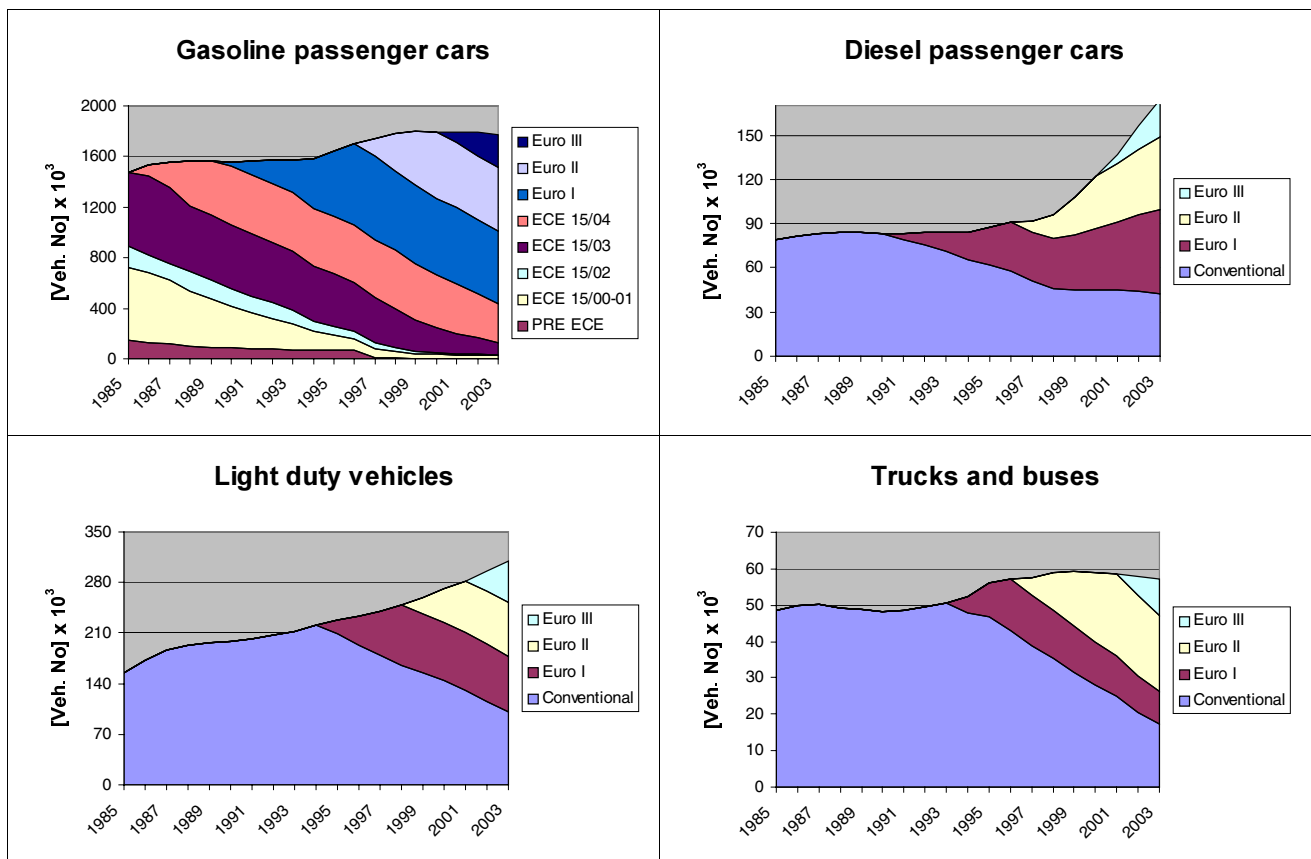


Figure 3.47 Layer distribution of vehicle numbers per vehicle type in 1985-2003

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

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 aver-

age 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":

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

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

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

In the case of trip speeds below 19 km/h the deterioration factor, DF, equals UDF, whereas for trip speeds exceeding 63 km/h DF=EUDF. For trip speeds between 19 and 63 km/h the deterioration factor, DF, is found as an interpolation between UDF and EUDF. Secondly the deterioration factors, one for each of the three road types, are aggregated into layers by taking into account the vehicle numbers and annual mileages per first registration year:

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

Where DF is the deterioration factor.

Emissions and fuel 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 numbers and their 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, 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 an amount of cold start emission and is assumed to take place under urban driving conditions. The number of trips is distributed evenly in 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 and 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 time periods for future EURO standards. Correspondingly the β -factor for gasoline vehicles is step-wise reduced for EURO II vehicles onwards.

For catalyst vehicles the cold extra emissions are found from:

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

Where β_{red} = the β reduction factor.

Evaporative emissions from gasoline vehicles

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

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

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

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

In the model hot and warm soak emissions for carburettor vehicles also 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 is the hot and warm soak emission factors, respectively. Since all catalyst vehicles are assumed to be carbon canister controlled no soak emissions are estimated for this vehicle type. Average maximum and minimum temperatures per month are used in combination with diurnal emission factors to estimate the diurnal emissions from uncontrolled vehicles $E^d(U)$:

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

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

Fuel use balance

The calculated fuel use in COPERT III must equal the statistical fuel sale totals from the Danish Energy Authority (DEA, 2004) according to the UNFCCC and UNECE emissions reporting format. The standard approach to achieve a fuel balance in annual emission inventories is to multiply the annual mileage with a fuel balance factor derived as the ratio between simulated and statistical fuel figures for gasoline and diesel, respectively. This method is also used in the present model.

Table 3.23 COPERT III:DEA statistics fuel use ratios and mileage adjustment factors for the Danish 2003 road transport emission inventories.

Description	2003
COPERT III:DEA Gasoline (sales)	0.93
COPERT III:DEA Diesel (sales)	0.64
COPERT III:DEA Gasoline (cons.)	1.07
COPERT III:DEA Diesel (cons.)	1.76
Gasoline mileage factor (sales)	1.05
Diesel mileage factor (sales)	0.71
Gasoline mileage factor (cons.)	0.95
Diesel mileage factor (cons.)	1.54

In Table 3.23 the COPERT III:DEA gasoline and diesel fuel use ratios are shown for fuel sales and fuel consumption in 2003. The figures for 1985-2002 are shown in Annex 3.B.7. The latter figures are related to the traffic on Danish roads. As previously mentioned the 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 made 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 3.23 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 numbers. The fuel difference for diesel is, however, still significant. The reasons for this inaccuracy are a combination of the 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 it is intended 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 in a COPERT model input format. In addition, a new version of the COPERT model – COPERT IV - will be available in 2005. The scientific basis for the new model version is the work on emission models and measurements performed in the EU 5th framework programme.

The final fuel use and emission factors are shown in Annex 3.B.5 for 1990-2003. The total fuel use and emissions are shown in Annex 3.B.6 per vehicle category and as grand totals for 1990-2003 (and CRF format in Annex 10). In Annex 3.B.9 fuel use and emission factors as well as total emissions are given in CollectER format for 1990 and 2003.

In Table 3.24 the aggregated emission factors for CO₂, CH₄ and N₂O are shown per fuel type for the Danish road transport.

Table 3.24 Fuel specific emission factors for CO₂, CH₄ and N₂O for road transport in Denmark

SNAP ID	Category	Fuel type	Mode	Emission factors ⁴		
				CH ₄ [g/GJ]	CO ₂ [kg/GJ]	N ₂ O [g/GJ]
70101	Passenger cars	Diesel	Highway driving	4.36	74	0.49
70101	Passenger cars	Gasoline 2-stroke	Highway driving	10.03	73	0.80
70101	Passenger cars	Gasoline conventional	Highway driving	11.46	73	0.88
70101	Passenger cars	Gasoline catalyst	Highway driving	4.12	73	49.11
70101	Passenger cars	LPG	Highway driving	10.06	65	0.00
70102	Passenger cars	Diesel	Rural driving	2.61	74	0.56
70102	Passenger cars	Gasoline 2-stroke	Rural driving	13.84	73	0.69
70102	Passenger cars	Gasoline conventional	Rural driving	14.17	73	0.97
70102	Passenger cars	Gasoline catalyst	Rural driving	4.59	73	54.83
70102	Passenger cars	LPG	Rural driving	16.91	65	0.00
70103	Passenger cars	Diesel	Urban driving	2.73	74	0.37
70103	Passenger cars	Gasoline 2-stroke	Urban driving	30.71	73	0.41
70103	Passenger cars	Gasoline conventional	Urban driving	54.58	73	0.63
70103	Passenger cars	Gasoline catalyst	Urban driving	58.01	73	20.92
70103	Passenger cars	LPG	Urban driving	35.11	65	0.00
70201	Light duty vehicles	Diesel	Highway driving	1.64	74	0.35
70201	Light duty vehicles	Gasoline conventional	Highway driving	10.11	73	0.81
70201	Light duty vehicles	Gasoline catalyst	Highway driving	2.72	73	34.36
70202	Light duty vehicles	Diesel	Rural driving	1.79	74	0.39
70202	Light duty vehicles	Gasoline conventional	Rural driving	15.25	73	0.76
70202	Light duty vehicles	Gasoline catalyst	Rural driving	3.11	73	32.44
70203	Light duty vehicles	Diesel	Urban driving	2.56	74	0.28
70203	Light duty vehicles	Gasoline conventional	Urban driving	61.78	73	0.44
70203	Light duty vehicles	Gasoline catalyst	Urban driving	26.13	73	13.11
70301	Heavy duty vehicles	Diesel	Highway driving	4.59	74	0.27
70301	Heavy duty vehicles	Gasoline	Highway driving	9.69	73	0.28
70302	Heavy duty vehicles	Diesel	Rural driving	5.01	74	0.26
70302	Heavy duty vehicles	Gasoline	Rural driving	16.74	73	0.30
70303	Heavy duty vehicles	Diesel	Urban driving	8.46	74	0.23
70303	Heavy duty vehicles	Gasoline	Urban driving	14.21	73	0.20
704	Mopeds	Gasoline		210.99	73	1.04
70501	Motorcycles	Gasoline	Highway driving	123.67	73	1.28
70502	Motorcycles	Gasoline	Rural driving	148.13	73	1.53
70503	Motorcycles	Gasoline	Urban driving	149.77	73	1.55

⁴ References. CO₂: Country specific; CH₄ and N₂O: COPERT III

3.3.2.2 Methodologies and references for other mobile sources

The other mobile sources are divided into several sub-sectors; sea transport, fishery, air traffic, railways, military and the working machinery and materiel in the industry, forestry, agriculture and household and gardening sectors. The emission calculations are made using the 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.

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 records are given per flight by CAA-DK as data for aircraft type and origin and destination airports. Prior to 2001 detailed LTO/aircraft type statistics were provided by Copenhagen Airport (for this airport only), while CAA-DK gave information of total take off numbers for other Danish airports. Fuel statistics for jet fuel use and aviation gasoline were obtained from the Danish energy statistics (DEA, 2004).

Prior to emission calculations the aircraft types are grouped into a smaller number of representative aircrafts for which fuel use and emission data exist in the EMEP/CORINAIR databank. In this procedure the actual aircraft types are classified according to their overall aircraft type (jets, turbo props, helicopters and piston engine). 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 documentation of the emission calculations for aviation will be given in the sector report for 2003.

Non-road working machinery and equipment

In Denmark non-road working machinery and equipment are used in agriculture, forestry, industry, household/gardening and inland waterways (small boats and pleasure crafts). The number of different types of machines, their load factors, engine sizes and annual working hours are taken from a national 1990 survey reported by the Danish Technological Institute (1992 and 1993). All activity data can be seen in Annex 3.B.8.

The amount of fuel sold for non-road machinery and small boats/pleasure crafts cannot be derived explicitly from national fuel sale statistics and hence it is necessary to make a bottom-up estimate of the fuel used. In this way the fuel use for diesel, gasoline and LPG is calculated for 1990 using the 1990 activity data and EMEP/CORINAIR fuel use factors. The latter factors are shown in Annex 3.B.6. Equation 13 explains the calculation procedure:

$$F = N \cdot HRS \cdot HP \cdot LF \cdot FC \quad (13)$$

Where F = fuel use, N = number of engines, HRS = annual working hours, HP = average rated engine size in kW, LF = load factor and FC = fuel use factor in g/kWh.

The total fuel use per fuel type is calculated as the sum of fuel use for all engines.

The results from a national 2000 survey funded by the Danish EPA are used to make a fuel use estimate per fuel type for non-road machinery in this year (Bak et al., 2003). The assumptions have been set in agreement with experts from the Danish Energy Authority and the Technological Institute of Denmark, see Winther (2003). For the years prior to 1990 and after 2000, respectively, the fuel use estimates for 1990 and 2000 are used. By interpolation the two latter figures are also used to make estimates for the years in between.

Table 3.25 Fuel use estimates for non-road in 1990 and 2000

	1990 (TJ)	2000 (TJ)
Diesel, non-road	26575	24580
Gasoline, non-road	1911	1797
LPG, non-road	1251	1499
Inland waterways, diesel	371	1002
Inland waterways, gasoline	545	902

In order to ensure that the same total fuel amount is behind the Danish emission inventories and the reported fuel sale figures by DEA, some decisions have to be made as regards fuel allocation on sub-sectoral levels (Winther, 2003).

For diesel and LPG, the non-road fuel use 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 small fuel amount 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 small boats and pleasure crafts the calculated fuel use totals are subsequently subtracted from the DEA fishery (diesel) and road transport (gasoline) sectors.

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.9 for the years 1990 and 2003 in CollectER format.

Emission factors

For military ground material aggregated emission factors for gasoline and diesel are derived from the road traffic emission simulations made with the COPERT model. For railways specific Danish measurements from the Danish State Railways (DSB) (Næraa, 2004) are used. The emission factors for the remaining sectors come from the EMEP/CORINAIR guidebook, see CORINAIR (2003). For all sectors emission factors are given in CollectER format in Annex 3.B.9 for the years 1990 and 2003.

Table 3.26 shows the emission factors CO₂, CH₄ and N₂O. These factors estimate the emissions from other mobile sources in Denmark.

Table 3.26 Fuel specific emission factors for CO₂, CH₄ and N₂O for other mobile sources in Denmark

SNAP ID	CRF ID	Category	Fuel type	Mode	Emission factors ⁵		
					CH ₄ [g/GJ]	CO ₂ [kg/GJ]	N ₂ O [g/GJ]
801	1A5	Military	Diesel		4.23	74	0.31
801	1A5	Military	Jet fuel	< 3000 ft	2.65	72	0.00
801	1A5	Military	Jet fuel	> 3000 ft	2.65	72	0.00
801	1A5	Military	Gasoline		31.72	73	29.99
801	1A5	Military	Aviation gasoline		21.90	73	1.60
802	1A3c	Railways	Diesel		2.90	74	0.20
803	1A3d	Inland waterways	Diesel		4.35	74	0.17
803	1A3d	Inland waterways	Gasoline		108.10	73	0.10
80402	1A3d	National sea traffic	Residual oil		1.76	78	-
80402	1A3d	National sea traffic	Diesel		1.69	74	0.00
80402	1A3d	National sea traffic	Kerosene		7.00	72	2.00
80402	1A3d	National sea traffic	LPG		20.30	65	0.00
80403	1A4c	Fishing	Residual oil		1.76	78	-
80403	1A4c	Fishing	Diesel		1.69	74	0.00
80403	1A4c	Fishing	Kerosene		7.00	72	-
80403	1A4c	Fishing	Gasoline		108.10	73	0.10
80403	1A4c	Fishing	LPG		20.30	65	0.00
80404	Memo item	International sea traffic	Residual oil		1.76	78	-
80404	Memo item	International sea traffic	Diesel		1.69	74	-
80501	1A3a	Air traffic, other airports	Jet fuel	Dom. < 3000 ft	1.92	72	-
80501	1A3a	Air traffic, other airports	Aviation gasoline		21.90	73	1.60
80502	Memo item	Air traffic, other airports	Jet fuel	Int. < 3000 ft	1.60	72	-
80502	Memo item	Air traffic, other airports	Aviation gasoline		21.90	73	1.60
80503	1A3a	Air traffic, other airports	Jet fuel	Dom. > 3000 ft	1.38	72	-
80504	Memo item	Air traffic, other airports	Jet fuel	Int. > 3000 ft	0.66	72	-
806	1A4c	Agriculture	Diesel		4.43	74	0.18
806	1A4c	Agriculture	Gasoline		51.10	73	0.12
807	1A4c	Forestry	Diesel		4.37	74	0.17
807	1A4c	Forestry	Gasoline		180.95	73	0.10
808	1A2f	Industry	Diesel		4.48	74	0.18
808	1A2f	Industry	Gasoline		119.76	73	0.11
808	1A2f	Industry	LPG		62.11	65	0.19
809	1A4b	Household and gardening	Gasoline		116.17	73	0.11
80501	1A3a	Air traffic, Copenhagen airport	Jet fuel	Dom. < 3000 ft	2.57	72	
80501	1A3a	Air traffic, Copenhagen airport	Aviation gasoline		21.90	73	1.60
80502	Memo item	Air traffic, Copenhagen airport	Jet fuel	Int. < 3000 ft	3.89	72	0.00
80502	Memo item	Air traffic, Copenhagen airport	Aviation gasoline		21.90	73	1.60
80503	1A3a	Air traffic, Copenhagen airport	Jet fuel	Dom. > 3000 ft	1.52	72	0.00
80504	Memo item	Air traffic, Copenhagen airport	Jet fuel	Int. > 3000 ft	1.20	72	0.00

Calculation method

Air traffic

For aviation the estimates are made separately for landing and take offs (LTOs < 3000 ft) and cruise (> 3000 ft). From 2001 the estimates are made on a city-pair level by combining activity data and emission factors and subsequently group the emission results into domestic and international totals. The overall fuel precision in the model is around 0.8 derived as the fuel ratio between model

⁵ References. CO₂: Country specific; CH₄ and N₂O: EMEP/CORINAIR

estimates and statistical sales. The fuel difference is accounted for by adjusting the cruise fuel use and emissions in the model according to the domestic and international cruise fuel shares.

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

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 equipment

The emissions from non-road working machinery and equipment are calculated by combining information from the number of different machine types and their respective load factors, engine sizes, annual working hours and emission factors. For gasoline and LPG no emission directives have currently come into force and the emission calculations are carried out using equation 14:

$$E = N \cdot HRS \cdot HP \cdot LF \cdot EF \quad (14)$$

Where E = emissions, N = number of engines, HRS = annual working hours, HP = average rated engine size in kW, LF = load factor and EF = emission factor in g/kWh.

For diesel the simulations take into account the implementation of a two-stage emission legislation directive for NO_x, VOC, CO and TSP depending on engine size. Stage I and II of the directive becomes effective for new machinery in use in 1999-2001 and 1999-2003 respectively.

In a specific year the weighted emission factors for each equipment type rely on the fractions of conventional Stage I and Stage II engine technologies in use. Due to lack of data it is assumed that all engines in a specific group have the same lifetime period.

If for a certain inventory year the lifetime period predicates the existence of conventional, Stage I and Stage II engine technologies in the machinery stock, new sales of Stage II technology in a $X_{\text{Stage II}}$ year period forms the newest part of the stock. Before that, in a period of $X_{\text{Stage I}}$ years, new sales of Stage I technology took place, and the remaining conventional types was sold in a X_{Conv} year period. The sum of the three periods gives the lifetime period, and the aggregated emission factor then becomes:

$$EF = \frac{(X_{\text{Conv}} \cdot EF_{\text{Conv}} + X_{\text{Stage I}} \cdot EF_{\text{Stage I}} + X_{\text{Stage II}} \cdot EF_{\text{Stage II}})}{LT} \quad (15)$$

Where EF = emission factor in g/kWh, X = number of years with new sales of one technology and LT = lifetime.

In specific cases where inventory years are before Stage I or Stage II implementation years, no contributions from the latter technologies goes into equation 15. The emissions are calculated by inserting (15) into (14).

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:

$$E = FC \cdot EF \quad (16)$$

Where E = emission, FC = fuel consumption, EF = emission factor.

The calculated emissions for other mobile sources are shown in CollectER format in Annex 3.B.9 for the years 1990 and 2003, and as time-series 1985-2003 in Annex 3.B.10 (CRF format).

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 sensible since in the real world almost no fuel is bunkered in Greenland/Faroe Islands by other flights 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 classifications made, subsequently.

Conclusively the domestic/international fuel split (and associated emissions) for navigation is not determined with the same 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 navigation 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) the latter source provides uncertainty factors for activity data that are used in the Danish situation. For other sectors the factors reflect specific national knowledge (Bak et al. 2003). 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.11 for all emission components.

Table 3.27 Uncertainties for activity data, emission factors and total emissions in 2003 and as a trend

Category	Activity data %	CO ₂ %	CH ₄ %	N ₂ O %
Road transport	2	5	40	50
Military	2	5	100	1000
Railways	2	5	100	1000
Navigation (small boats)	56	5	100	1000
Navigation (large vessels)	2	5	100	1000
Fisheries	2	5	100	1000
Agriculture	26	5	100	1000
Forestry	26	5	100	1000
Industry (mobile)	40	5	100	1000
Residential	51	5	100	1000
Civil aviation	10	5	100	1000
Overall uncertainty in 2003		5	35	68
Trend uncertainty		5	6	223

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

The time-series of emissions for 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.

For 1990 and 2000 background activity data (stock and operation) exists, but for the years in between 1990 and 2000 and for the years beyond 2000 data is presently missing. For consistency purposes for the years prior to 1990 and after 2000, the fuel use estimates for 1990 and 2000 are used. By interpolation the two latter figures are also used to make fuel use estimates for the years in between.

The strengthening of emission standards for diesel machinery is taken into account by using specific lifetime periods and emission directive implementation years. From this the share of different emission levels per machinery type can be found in a given year.

3.3.4 Quality assurance/quality control (QA/QC)

For road transport and air traffic the detailed methodology and fuel balance approach are used independently to provide a quality control of the emission estimations. Firstly, the bottom up approach (detailed methodology) is used as described in Sections 3.1 and 3.2. Secondly, the estimates are modified according to a fuel balance using the statistical sale figures respectively for road transportation and civil aviation fuel in Denmark (fuel balance approach), as described in the same sections. The usage of the fuel balance approach ensures that all fuel for road transport and civil aviation is accounted for in the estimations.

For non-road machinery and working equipment the detailed methodology determines the amount of fuel used. The subsequent adjustment of fuel totals to be used in the estimates for other sectors (see Section 3.2.1) ensures that no double counting of emissions is made.

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

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

A sector report for road transport and other mobile sources is published each year. Prior to it's publication the draft report is reviewed by two external experts. The expert recommendations are used to improve the work on inventories and documentation. Some important recommendations to the 2002 sector report were to include tables with emission factors and total emissions in the main report part, and to explain the level of fuel differences for road transport and civil aviation according to fuel balance. These recommendations have subsequently been incorporated in the 2002 sector report (Winther, 2004) and the present NIR report.

The recommendations of the reviewers are also to include some text in the sector report for each transport mode explaining the existing emission legislation and the associated emission test procedures. In addition more documentation of background data and trends should be given in cases where Tier2 estimates are made. These recommendations will be considered in the next sector and NIR reports.

Formal agreements of data deliverance have been made between NERI as an inventory agency and relevant institutions to ensure the provision of consistent, accurate and timely background data used in the national inventory. The institutions are the Danish State Railways (DSB) (emission factors for diesel locomotives), CAA-DK (flight data) and DEA (energy statistics). At the moment a formal agreement is being negotiated with the Danish Ministry of Transport (road transport fleet and mileage data).

Presently the level of QA/QC of the Danish emission inventories for transport is incomplete in comparison to the prescriptions given in the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC). It will, however, continuously be aspired to improve the QA/QC according to the IPCC Good Practice Guidelines (IPCC, 2000), and work will be initiated to improve next year's inventory in this part.

3.3.5 Recalculations

The following recalculations and improvements of the emission inventories have been made since the emission reporting in 2003:

Road transport

For the years 2000-2002 the division of the moped fleet into EURO categories has been changed due to better information from the Danish Motorcycle Association. In addition the fuel consumption factors for EURO I and II mopeds have been corrected for the same years.

Also for 2000-2002 the general gasoline RVP value has been changed to 60 for the month of September, according to information from the Danish EPA.

For 1990-2001 the POP emission factors have been updated in order to correct errors in the inventories for these years.

Railways

An update of the NO_x, NMVOC, CH₄, CO and PM emission factors for diesel are made for 2002. Previously 2001 factors were used for the year 2002 to compensate for missing data.

Agriculture/Forestry/Fisheries

An internal redistribution of gasoline fuel consumption is made. Small amounts of gasoline that appeared in the sub-sector fisheries (in some inventory years) are now accounted for in the road transport sector.

Civil Aviation

Several new turboprops are included in the list of representative aircraft for civil aviation based on new information in the EMEP/CORINAIR guidebook. This change has an impact on the fuel use split between domestic and international aviation and the emission factors used.

Navigation

For 2002 the diesel fuel use for navigation has been updated according to the official Danish energy statistics from DEA.

Uncertainties

The uncertainty factors for activity data have been changed to reflect specific national knowledge (Bak et al. 2003) 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). In addition the activity data uncertainty factor for civil aviation is changed to 10% according to own judgement.

3.3.6 Planned improvements

It will continuously be aspired to fulfil the requirements from UNECE and UNFCCC of good practice in inventory making for transport. A study has been made for transport going through the different issues of choices relating to methods (methods used, emission factors, activity data, completeness, time-series consistency, uncertainty assessment) reporting and documentation, and inventory quality assurance/quality control. This work and the overall priorities of NERI taking into account emission source importance (from the Danish 2003 key source analysis), background data available and time resources, lay down the following list of improvements to be made in the future.

Non-road machinery

According to the Danish 2003 key source analysis agricultural and industrial working machines are key sources of emissions. Thus an update of the vehicle stock and operational data for non-road machines in agriculture, forestry, industry and household and gardening will be made. The considered time-series will cover the period from 1990 to the latest historical year. In addition a review will be made of the emission factors used.

Fisheries

Since fishing vessels are a key source of emissions, the calculation method for fisheries will be upgraded to Tier2 based on detailed data for vessel numbers.

Emission factors

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

Documentation

For all modes of transport the existing emission legislation will be documented, and emission test procedures will be explained whenever possible. It is also planned to explain background data and trends more thoroughly in cases where Tier2 estimates are made.

QA/QC

Future improvements regarding this issue are dealt with in Section 3.3.4.

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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 CO₂ emission inventories (the national approach), the CO₂ 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 2004b). A fuel correspondence list is enclosed in Annex 3.A. In this inventory white spirit is included in the fuel category *Naphtha*, but in the next inventory it will be reported in the fuel category *Other oil* as recommended by the IPCC review team. 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, the 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 CO₂ 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.

Three fuels are used for non-energy purposes: lube oil, bitumen and white spirit. The total consumption for non-energy purposes is relatively low – 10.8 PJ in 2003.

In 2003 the fuel consumption rates in the two approaches differ by 0.28% and the CO₂ emission differs by 0.04%. In the period 1990-2003 fuel consumption differs by less than 1.5%, and the CO₂ emission by less than 1.4%. The differences are below 1% for all years except 1998.

A comparison of the national approach and the reference approach is illustrated in Figure 3.48.

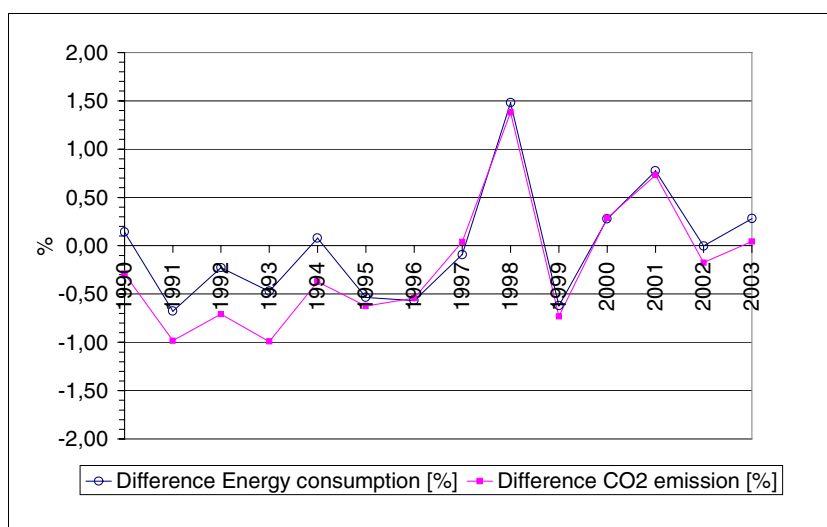


Figure 3.48 Comparison of reference approach and national approach

3.5 Fugitive emissions (CRF sector 1B)

3.5.1 Source category description

3.5.1.1 Fugitive emission from solid fuels, CRF sector 1B1c

Coal mining is not occurring in Denmark, but power plants use a considerable amount of coal. CH₄ emission from storage and handling of coal is included in the Danish inventory.

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 2003 the length of transmission pipelines excluding offshore pipeline is 830 km. The length of distribution pipelines was 18120 km in 2002 (cast iron 0 km, steel 2185 km, plastics 15935 km), and the transmission data has not been updated this year. Two natural gas storages are in operation in Denmark. In 2003 the gas input was 384 Mm³ and the withdrawal was 433 Mm³. Emission from gas storage is included in transmission.

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

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

3.5.2 Methodological issues

3.5.2.1 Fugitive emission from solid fuels, CRF sector 1B1c

The CH₄ emission inventory is based on the Tier 1 of the IPCC Reference Manual (IPCC 1996). The CH₄ emission occurring in Denmark is assumed to be half the post-mining emission.

Coal import refers to the official Danish energy statistics (DEA 2004b). In inventories for 1990-1999 country of origin of the imported coal and the underground fraction in each country is taken into account. The emission factor from 1999 has been applied for the 2000-2003 inventories.

Coal import and emission factors are shown in Table 3.28.

Table 3.28 Coal import and CH₄ emission factor, coal storage and handling

Year	Coal import [Mg coal import]	Emission factor 1) [g/Mg coal import]
1990	10255000	336
1991	12810000	310
1992	11942000	327
1993	10467000	458
1994	11772000	477
1995	13009000	485
1996	13134000	485
1997	13474000	485
1998	8071000	430
1999	7117000	474
2000	6415000	474
2001	6924000	474
2002	6262000	474
2003	9360791	474

1) ½ of total post mining emission factor

3.5.2.2 Fugitive emissions from oil (1B2a)

Offshore activities

Emissions from offshore activities include emissions from extraction of oil and gas, on-shore oil tanks, on-shore 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 emissions of CH₄ and NMVOC for extraction of oil and gas can be calculated as:

$$\begin{aligned} E_{extraction, NMVOC} &= E_{fugitive, NMVOC} + E_{flaring, NMVOC} \\ &= 0.25(40.2 \cdot N_p + 1.1 \cdot 10^{-2} P_{gas} + 8.5 \cdot 10^{-6} \cdot P_{oil}) + F_p \cdot EMF_{flaring, NMVOC} \end{aligned} \quad (3.5.3)$$

$$E_{\text{extraction,CH}_4} = E_{\text{fugitive,CH}_4} + E_{\text{flaring,CH}_4} \quad (3.5.4)$$

$$= 0.75(40.2 \cdot N_p + 1.1 \cdot 10^{-2} P_{\text{gas}} + 8.5 \cdot 10^{-6} \cdot P_{\text{oil}}) + F_p \cdot EMF_{\text{flaring,CH}_4}$$

In Denmark venting of gas is assumed to be negligible because controlled venting is sent through 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.

$$E_{\text{ships}} = EMF_{\text{ships}} \cdot L_{\text{oil}} \quad (3.5.5)$$

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.

$$E_{\text{tanks}} = EMF_{\text{tanks}} \cdot T_{\text{oil}} \quad (3.5.6)$$

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 3.29 and is based on information from the Danish Energy Authority (Danish Energy Authority, 2004a and 2004b) or from the green accounts from the Danish gas transmission company DONG (DONG, 2004).

Table 3.29. Activity data for 2003

Activity	Symbols	Year	
		2003	Ref.
Number of platforms	N_p	48	Danish Energy Agency (2004a)
Produced gas (10^6Nm^3)	P_{gas}	10213	Danish Energy Agency (2004a)
Produced oil(10^3m^3)	$P_{\text{oil,vol}}$	21327	Danish Energy Agency (2004a)
Produced oil (10^3ton)	P_{oil}	18341	Danish Energy Agency (2004a)
Oil loaded (10^3m^3)	$L_{\text{oil off-shore}}$	3308	Danish Energy Agency (2004a)
Oil loaded (10^3ton)	$L_{\text{oil off-shore}}$	2845	Danish Energy Agency (2004a)
Oil loaded (10^3m^3)	$L_{\text{oil on-shore}}$	13362	DONG (2004)
Oil loaded (10^3ton)	$L_{\text{oil on-shore}}$	11491	DONG (2004)

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 2003 (DONG, 2004) and the emission factor is calculated on the basis of the amount of oil transported in pipeline.

Table 3.30. 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 ³ m ³	DONG, 2004

From the activity data in Table 3.29 and the emission factors in Table 3.30 the emissions for NMVOC and CH₄ are calculated in Table 3.31.

Table 3.31. CH₄ emissions for 2003 (tonnes):

	CH ₄	NMVOC
Extraction (fugitive)	1524	508
Oil tanks	2000	4407
Off-shore loading of ships	142	2845
On-shore loading of ships	23	2298
Total	3689	10058

Oil Refineries

Petroleum products processing: In the production process at the refineries a part of the volatile hydrocarbons (VOC) is emitted to the atmosphere. It is assumed that CH₄ accounts for 1% and NMVOC for 99% of the emissions. The VOC emissions from the petroleum refinery processes cover non-combustion emissions from feed stock handling/storage, petroleum products processing, product storage/handling and flaring. SO₂ is also emitted from the non-combustion processes and includes emissions from products processing and sulphur recovery plants. The emission calculations are based on information from the Danish refineries and the energy statistic.

Table 3.32 Oil Refineries. Processed crude oil, emissions and emission factors

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Crude oil (1000 Mg)	7263	7798	8232	8356	8910	9802	10522	7910	7906	8106	8406	8284	8045	8350
CH ₄ emission (Mg)	37	39	42	43	57	48	62	45	45	45	50	44	43	37
CH ₄ emission factor (g/Mg)	5	5	5	5	6	5	6	6	6	6	6	5	5	4
NMVOC emission (Mg)	3667	3937	4203	4219	5855	4546	5875	4547	4558	4558	4983	4338	4302	3708
NMVOC emission factor (g/Mg)	505	505	511	505	657	464	558	575	577	562	593	524	535	444

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

Inventories of CH₄ 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) (Karl 2003, Karl 2004). The inventories estimated by the Danish gas sector are based on the work carried out by Marcogas and the International Gas Union (IGU). Data for gas distribution have not been updated this year, and instead the 2002 data are applied for 2003.

In the 1990-1999 inventories fugitive CH₄ emissions from storage facilities and the gas treatment plant are included in the emission factor for transmission. In the 2000-2003 emission inventories transmission, gas storage and gas treatment are registered separately and added.

Gas transmission data are shown in Table 3.33. Emissions from gas storage facilities and venting in the gas treatment plant are shown in Table 3.34. Gas distribution data are shown in Table 3.23.

Table 3.33 CH₄ emission from natural gas transmission

TRANSMISSION		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Transmission rate Mm ³	1)	2739	3496	3616	3992	4321	4689	5705	6956	6641	6795	7079	7289	7287	7275
CH ₄ emission Mg	2)		310	93	186	151	536	183	235	156	191	86	157	78	88
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

1) In 1990-1997 transmission rates refer to Danish energy statistics, in 1998 transmission rate refer to the annual environmental report of DONG, in 1999-2003 emissions refer to DONG/Danish Gas Technology Centre (Karl 2003, Karl 2004)

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 2000-2003 the CH₄ emission refers to DONG/Danish Gas Technology Centre (Karl 2003, Karl 2004)

3) IEF=Emission/transmission_rate. In 1990 the IEF is assumed to be the same as in 1991

Table 3.34 Additional fugitive CH₄ emissions from natural gas storage facilities and venting in gas treatment plant

	2000	2001	2002	2003
Gas treatment plant	7,55 Mg	0 Mg	67 Mg	68 Mg
Gas storage facilities	76,48 Mg	72,68 Mg		

Table 3.35 CH₄ emission from natural gas distribution

DISTRIBUTION		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003 ⁴⁾
Distribution rate Mm ³	1)	1574	1814	1921	2185	2362	2758	3254	3276	3403	3297	3181	3675	3420	3420
CH ₄ emission Mg	2)										43	49	56	38,9	38,9
CH ₄ IEF kg/Mm ³	3)	14,56	14,56	14,56	14,56	14,56	14,56	14,56	14,56	14,56	13,04	15,40	15,24	11,37	11,37

1) In 1999-2002 distribution rates refer to DONG / Danish Gas Technology Centre / Danish gas distribution companies (Karl 2003), In 1990-98 distribution rates are estimated from the Danish energy statistics. Distribution rates are assumed to equal total Danish consumption rate minus the consumption rates of sectors that receive the gas at high pressure. The following consumers are assumed to receive high pressure gas: Town gas production companies, production platforms and power plants

2) Danish Gas Technology Centre / DONG/ Danish gas distribution companies (Karl 2003)

3) In the years 1999-2002 IEF=CH₄ emission / distribution rate. In 1990-1998 an average IEF of 1999-2001 is assumed.

4) Data have not been updated since last year. Assumed to be the same in 2003 as in 2002.

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

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

The fuel consumption rates are shown in Table 3.36. Flaring rates in gas treatment and gas storage plants are not available until 1995.

The emission factors for off shore flaring are shown in Table 3.37. The CO₂ emission factor follows the same time-series as natural gas combusted in stationary combustion plants. All other emission factors are constant in 1990-2003.

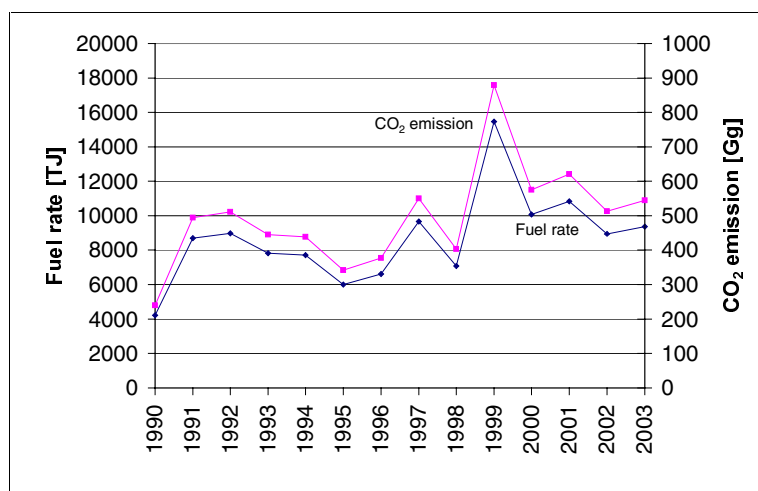
The time-series for CO₂ emission from gas flaring fluctuates due to fluctuation of offshore flaring rates as shown in Figure 3.49.

Table 3.36 Natural gas flaring rate (DEA 2004b)

Year	Flaring, off shore [TJ]	Gas treatment and gas storage [TJ]
1990	4218	-
1991	8692	-
1992	8977	-
1993	7819	-
1994	7709	-
1995	5964	43
1996	6595	30
1997	9629	35
1998	7053	29
1999	15509	32
2000	10023	29
2001	10806	36
2002	8901	44
2003	9333	33

Table 3.37 Emission factors for offshore flaring of natural gas

Pollutant	Emission factor
CO ₂	57,19 kg/GJ
CH ₄	5 g/GJ
N ₂ O	1 g/GJ
SO ₂	0,3 g/GJ
NO _x	300 g/GJ
NMVOC	3 g/GJ
CO	25 g/GJ

Figure 3.49 time-series for gas flaring and CO₂ emission in sector 1B2c ii Flaring, gas

3.5.3 Uncertainties and time-series consistency

Estimation of uncertainty is based on the Tier 1 methodology in IPCC Good Practice Guidance. Results of the uncertainty estimates are shown in Table 3.38.

Table 3.38 Uncertainty, CRF sector 1B Fugitive emissions

Pollutant	Uncertainty of emission inventory [%]	Uncertainty of emission trend [%]
CO ₂	16	44
CH ₄	108	44
N ₂ O	52	44
GHG	29	40

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

Uncertainty of activity rates for oil and gas activities is 15% referring to GPG. The uncertainty of emissions factors for CO₂ is the uncertainty of emissions factors for flaring. This emission factor uncertainty is 5% (GPG). Uncertainties of CH₄ and N₂O emission factors are both assumed to be 50%.

Table 3.39 Uncertainty of activity rates and emission factors

	Uncertainty Activity rate	Uncertainty Emission factor
CO ₂	15	5
CH ₄ , solid fuel	2	200
CH ₄ , oil and gas	15	50
N ₂ O	15	50

3.5.4 QA/QC and verification

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

3.5.5 Recalculations

3.5.5.1 Fugitive emission from solid fuels, CRF sector 1B1c

No recalculation has been carried out since last year.

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

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 identified sources is presented in Table 4.1 with an indication of the contribution to the industrial part of the emission of greenhouse gases in 2003. The emissions are extracted from the CRF tables and presented rounded.

Table 4.1 Overview of industrial greenhouse gas sources (2003).

Process	Code	Substance	Emission ton CO ₂ -eq.		Comment
Cement	2A		1.369.907	43,78%	Key-source (1,9% of the total emission of greenhouse gases)
Nitric acid	2B	N ₂ O	894.660	28,59%	Key-source (1,2% of the total emission of greenhouse gases)
Refrigeration	2F	HFCs+PFCs	574.728	18,37%	Key-source (when including the other HFC and PFC sources 1,0% of the total emission of greenhouse gases)
Foam blowing	2F	HFCs	128.721	4,11%	
Lime (quicklime)	2A		75.130	2,40%	
Bricks and tiles	2A		27.016	0,86%	
Other	2F	PFCs	23.498	0,75%	
Container glass	2A		12.109	0,39%	
Electrical equipment	2F	SF ₆	9.624	0,31%	
Aerosols / Metered dose inhalers	2F	HFCs	9.620	0,31%	
Catalysts / fertilisers	2B		2.670	0,09%	
Glass wool	2A		1.353	0,04%	
Steelwork	2C			0,00%	
Iron foundries	2C			0,00%	
Total - included in inventory			3.129.035		
Other lime consuming processes ¹	2A		144.184 ²		Not included in the present inventory - preparation of inventory for these sectors are in progress
Total - overall			3.273.219		

1. E.g. flue gas cleaning, refineries, mineral wool, expanded clay products, gas plants.

2. Based on estimate from 2002 (Danish Energy Authority, 2004). These sources are not included in the 2003-inventory.

The sub-sector *Mineral products* including the estimates (2A) constitute 47%, *Chemical industry* (2B) constitute 29%, and *Consumption of halocarbons and SF₆* (2F) constitute 24% of the industrial emissions of greenhouse gases. The total emission of greenhouse gases (excl LUCF) in Denmark is estimated to 74.01 Mt CO₂-eq. of which the industrial processes contribute with 3.13 Mt CO₂-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 and presented rounded.

Table 4.2 Emission of greenhouse gases from industrial processes in different sub-sectors from 1990-2003.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
CO₂ (kt CO₂)														
A. Mineral Products	1037	1209	1326	1336	1334	1335	1409	1576	1575	1494	1531	1556	1598	1486
B. Chemical Industry	1,74	1,74	1,74	1,74	1,74	1,74	1,74	1,87	1,42	1,76	2,68	3,10	3,12	2,67
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	0,00	0,00
N₂O (kt N₂O)														
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
HFC's (Gg CO₂-eq.)														
F. Consumption of Halocarbons and SF ₆	0,00	0,00	3,44	93,9	135	218	329	324	411	503	605	647	672	695
PFC's (Gg CO₂-eq.)														
F. Consumption of Halocarbons and SF ₆	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
SF₆ (Gg CO₂-eq.)														
F. Consumption of Halocarbons and SF ₆	44,5	63,5	89,1	101	122	107	61,0	73,1	59,5	65,4	59,2	30,4	25,0	31,4

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

4.2 Mineral products (2A)

4.2.1 Source category description

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

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

Production of cement is identified as a key source; see *Annex 1: Key sources*.

The time-series for emission of CO₂ from *Mineral products* (2A) are presented in Table 4.3. The emissions are extracted from the CRF tables and presented rounded.

Table 4.3 Time-series for emission of CO₂ (kt) from *Mineral products* (2A).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1. Production of Cement	882	1088	1192	1206	1192	1204	1282	1441	1452	1365	1406	1432	1452	1370
2. Production of Lime and Bricks	138	106	119	116	127	117	113	121	107	111	109	108	130	102
7. Other ¹	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
Total	1037	1209	1326	1336	1334	1335	1409	1576	1575	1494	1531	1556	1598	1486

1. Production of container glass and glass wool.

The increase in CO₂ emission is most significant for the production of cement. From 1990 to 2003 the CO₂ emission has increased from 882 to 1370 kt CO₂, i.e. 55%. 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 CO₂ emission from the production of cement has been estimated from the annual production of cement expressed as TCE (total cement equivalents¹) and an emission factor estimated by the company (Aalborg Portland, 2004). The emission factor has been estimated from the loss of ignition determined for the different kinds of clinkers produced combined with produced amount of grey and white cements. Determination of loss of ignition takes into account all the potential raw materials leading to release of CO₂ and omits the Ca-sources leading to generation of CaO in cement clinker without CO₂ 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 but it is the best available estimate based on expert knowledge at the company.

The CO₂ emission from the production of burnt lime (quicklime) as well as hydrated lime (slaked lime) has been estimated from the annual production registered by Statistics Denmark and emission factors. The emission factors applied are 0.785 kg CO₂/kg CaO as recommended by IPCC (IPCC (1996), vol. 3, p. 2.8) and 0.541 kg CO₂/kg (calculated from company information on composition of hydrated lime (Faxekalk, 2003)).

The CO₂ emission from the production of bricks and tiles has been estimated from information of annual production registered by Statistics Denmark corrected for amount of yellow bricks and tiles. This amount is unknown and therefore assumed to be 50%. The content of CaCO₃ and a number of other factors determine the colour of bricks and tiles, and in the present estimate the average content of CaCO₃ in clay has been assumed to be 18%. The emission factor (0.44 kg CO₂/kg CaCO₃) is based on stoichiometric determination.

For further details on the CO₂ estimation from the production of burnt lime and from the production of bricks, which constitutes a combined activity in the CRF sector activities, refer to Annex 3C.

The CO₂ emission from the production of container glass/glass wool has been estimated from production statistics published in environmental reports from the producers (Rexam Holmegaard,

¹ TCE (total cement equivalent) express the total amount of cement produced for sale and the theoretical amount of cement from the produced amount of clinkers for sale.

2004; Saint-Gobain Isover, 2004) and emission factors based on release of CO₂ from specific raw materials (stoichiometric determination).

4.2.3 Uncertainties and time-series consistency

The time-series are presented in Table 4.3. The methodology applied for the years 1990-2003 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 1990-2003. Further, the activity data originates for all the years from the same company.

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 either based on stoichiometric relations or on a standard assumption of CaCO₂-content of clay used for bricks. The source for the activity data is for all the 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 QA/QC and verification

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

The estimation of CO₂ 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 CO₂ 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 CaCO₃ content of raw material) has been compiled by DEA in order to allocate CO₂-quota to Danish companies with the purpose of future reduction. The result of the comparison is presented in Figure 4.1.

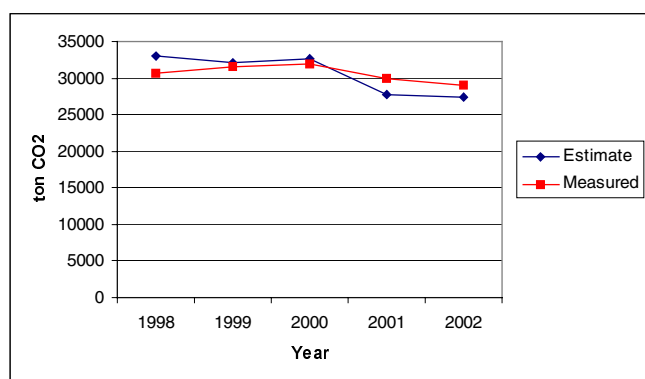


Figure 4.1 Estimated and “measured” CO₂ emission from tile-/brickworks; “measured” means information provided to Danish Energy Authority by the individual companies (Danish Energy Authority, 2004).

Figure 4.1 shows a reasonable correlation between the estimated and measured CO₂ emission.

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

4.2.5 Recalculations

No source specific recalculations have been performed regarding emissions from production of mineral products. However, a minor change has been introduced for lime, as the production of hydrated lime has been included in the inventory. The trend and the size of the recalculation can be found in Section 10.3.

4.2.6 Planned improvements

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

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

The emission of CO₂ from products of expanded clay as well as CO₂ emissions from other processes (e.g. flue gas cleaning, refineries, gas plants etc.) are not included at the moment, however, these sources will be investigated and included.

4.3 Chemical industry (2B)

4.3.1 Source category description

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

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

Production of nitric acid is identified as a key source.

The time-series for emission of CO₂ and N₂O from *Chemical industry* (2B) are presented in Table 4.4.

Table 4.4 Time-series for emission of greenhouse gases from *Chemical industry* (kt CO₂-eq.).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
2. Nitric acid production (N ₂ O)	1043	955	844	795	807	904	834	848	807	950	1004	885	774	895
5. Other ¹ (CO ₂)	1,74	1,74	1,74	1,74	1,74	1,74	1,74	1,87	1,42	1,76	2,68	3,10	3,12	2,67
Total	1045	957	845	797	808	906	836	850	808	952	1006	888	777	897

1. Production of catalysts/fertilisers.

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

The emission of N₂O from the nitric acid production is the most considerable source of GHG from the chemical industry. The trend for N₂O from 1990 to 2003 shows a decrease from 3.36 to 2.89 kt, i.e. -14%. However, the activity and the corresponding emission show considerable fluctuations in the considered period.

From 1996 to 2003 the emission of CO₂ from the production of catalysts/fertilisers has increased from 1.74 to 2.67 kt, i.e. 53% due to an increase in the activity.

4.3.2 Methodological issues

The N₂O emission from the production of nitric acid/fertiliser is based on measurement for 2002. For the previous years the N₂O emission has been estimated from annual production statistics from the company and an emission factor based on the measured 2002 emission (Kemira Growhow, 2004).

The CO₂ emission from the production of catalysts/fertiliser is based in information in an environmental report from the company (Haldor Topsøe, 2004). In the environmental report the company has estimated the amount of CO₂ from the process and the amount from the energy conversion. For the years 1990-1995 the production as well as the CO₂ emission has been assumed to be the same as in 1996.

4.3.3 Uncertainties and time-series consistency

The time-series are presented in Table 4.4. The applied methodology regarding N₂O is considered to be consistent. The activity data is based on information from the specific company and the applied emission factor has been constant from 1990 to 2001 and it is based on measurements in 2002. The production equipment has not been changed during the period.

The consistency of the methodology applied for determination can not be assessed from the available information as the specific company has given a general distribution of CO₂ from energy conversion and processes.

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 QA/QC and verification

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

4.3.5 Recalculations

No source specific recalculations have been performed regarding emissions from the chemical industry.

4.3.6 Planned improvements

The applied emission factor for N₂O from the production of nitric acid is based on measurement from one year. This factor was planned to be improved or validated. However, the production was stopped in the middle of 2004 and therefore improvements have been given up.

The emission of CO₂ from the production of catalysts/fertilisers will be validated by further contact to the company to get further detail on processes leading to generation of CO₂. The production statistics as well as emission of CO₂ will be completed for 1990-1995.

4.4 Metal production (2C)

4.4.1 Source category description

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

- Steelwork (SNAP 040207)

The time-series for emission of CO₂ from *Metal production* (2C) is presented in Table 5. The emissions are extracted from the CRF tables and presented rounded.

Table 5.5 Time-series for emission of CO₂ (kt) from *Metal production*.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
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	- ¹	- ¹

1. The activity has been stopped in the first half of 2002.

From 1990 to 2001 the CO₂ emission has increased from 28 to 47 kt, i.e. 68%. The increase in CO₂ emission is similar to the increase in the activity as the consumption of metallurgical coke per produced amount of steel sheets and bars nearly has been constant during the period.

4.4.2 Methodological issues

The CO₂ 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 CO₂ as the carbon content in the products is assumed to be the same as in the iron scrap. The emission factor (3.6 tonnes CO₂/ton metallurgical coke) is based on values in the IPCC-guideline (IPCC (1996), vol. 3, p. 2.26). Emissions of CO₂ 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 5 - is considered to be consistent as the same methodology has been applied for the whole period. The activity, i.e. produced amount of steel sheets and bars as well as consumption of metallurgical coke, has been published in environmental reports. The emission factor (consumption of metallurgical coke per tonnes of product) has been almost constant from 1994 to 2001. For the remaining years the same emission factor has been applied. In 2002 the production 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 QA/QC and verification

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

4.4.5 Recalculations

No source specific recalculations have been performed regarding emissions from the metal production.

4.4.6 Source-specific planned improvements

Production statistics and information on consumption of raw materials will be completed for 1990-1993. The mass balance (i.e. produced amounts of steel bars and steel sheets as well as consumption of metallurgical coke) for the steelworks will be improved/verified. The electro-steelwork is working again and the source will be included again in future NIR reports.

The emission of CO₂ from iron foundries is not included at the moment, however, this source will be investigated and included.

4.5 Production of Halocarbons and SF₆ (2E)

There is no production of Halocarbons and SF₆ in Denmark.

4.6 Metal Production (2C) and Consumption of Halocarbons and SF₆ (2F)

4.6.1 Source category description

The sub-sector *Consumption of halocarbons and SF₆* (2F) includes the following source categories and the following F-gases of relevance for Danish emissions:

- 2C: SF₆ used in Magnesium Foundries SNAP 040304 SF₆; see Table 4.6
- 2F: Refrigeration SNAP 060502 HFC32, 125, 134a, 152a, 143a, PFC (C₃F₈); see Table 4.7
- 2F: Foam blowing SNAP 060504 HFC134a, 152a; see Table 4.8
- 2F: Aerosols/Metered dose inhalers SNAP 060506 HFC134a; see Table 4.9
- 2F: Production of electrical equipment SNAP 060507 SF₆; see Table 4.10
- 2F: Other processes SNAP 060508 SF₆, PFC (C₃F₈); see Table 4.11

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

Table 4.6 SF₆ used in magnesium foundries (t).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
SF ₆	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

Table 4.7 Consumption of HFCs and PFC in refrigeration and air conditioning systems (t).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
HFC32	NE	NE	NE	NE	NE	0,11	0,84	1,77	2,72	3,77	5,75	7,33	8,44	10,1
HFC125	NE	NE	NE	NE	0,23	2,58	9,46	15,8	21,8	31,7	43,1	45,1	48,5	54,9
HFC134a	NE	NE	0,32	2,63	10,3	14,3	16,3	34,2	45,9	94,3	112	128	151	162
HFC152a	NE	NE	NE	NE	NE	0,00	0,00	0,05	0,36	0,49	0,58	0,58	0,51	0,41
HFC143a	NE	NE	NE	NE	0,22	2,43	8,65	13,7	19,3	29,1	39,6	40,1	43,2	49,0
PFC (C ₃ F ₈)	NE	NE	0,00	0,00	0,01	0,07	0,24	0,59	1,30	1,78	2,29	2,64	2,67	2,51

Table 4.8 Consumption of HFCs in foam blowing (t).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
HFC32	NE	NE	NE	NE	NE	NO	NO	NO	NO	NO	0,00	3,72	0,00	0,00
HFC125	NE	NE	NE	NE	NE	NO	NO	NO	NO	NO	0,00	3,72	0,00	0,00
HFC134a	NE	0,00	2,00	66,4	87,1	136	187	138	164	125	127	132	122	98,8
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

Table 4.9 Consumption of HFC in aerosols/metered dose inhalers (t).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
HFC134a	NO	NO	NO	NO	NO	NO	NO	NO	0,60	8,10	12,9	9,24	7,59	7,40

Table 4.10 Consumption of SF₆ in electrical equipment (t).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
SF ₆	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

Table 4.11 Consumption of SF₆ and PFC in other processes (t).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
SF ₆	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
PFC (C ₃ F ₈)	NO	NO	NO	NO	NO	NO	NO	NO	0,00	0,00	0,27	0,52	0,50	0,25

The emission of SF₆ has been decreasing in recent years due to the fact that no activity on Magnesium Foundry exists any longer and due to a decrease in the use of electric equipment. Also a decrease in "other" occurs, which for SF₆ is used in window plate production use, laboratory use and use in running shoes production.

The emission of HFCs increased rapidly in the 1990s and thereafter increased more modestly due to a modest increase for the use as a refrigerant and a decrease in foam blowing. The F-gases has been regulated in two ways since 1 March 2001. For some types of use there is a ban to use the gases in new installations and for other types of use there is taxation. These regulations seem to have the influence that emissions now only increase modestly.

Table 4.12 quantifies an overview of the emissions of the gases in CO₂-eq. The reference is the trend table as included in the CRF table for year 2003.

Table 4.12 Time-series for emission of HFCs, PFCs and SF₆ (kt CO₂-eq.).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
HFCs	0,00	0,00	3,44	93,9	135	218	329	324	411	503	605	647	672	695
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
SF ₆	44,5	63,5	89,1	101	122	107	61,0	73,1	59,5	65,4	59,2	30,4	25,0	31,4
Total	44,5	63,5	92,6	195	257	326	392	401	480	581	682	700	719	746

The decrease in the SF₆ emission has brought its emissions in CO₂-eq. down to the level of PFC. Seen together and for all uses the by far most dominant group is HFCs. In this grouping the HFCs constitute a key source both with regard to the key source level and trend analysis. In the level analysis the group of HFCs are number 17 out of 21 key sources and they contribute in 2003 to 1.2% of the national total.

4.6.2 Methodological issues

The data for emissions of HFCs, PFCs, and SF₆ 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 SF₆ contained in products and substances in stock form. This is in accordance with the IPCC-guideline (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 basically a Tier 2 bottom up approach is 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 2003 (Danish Environmental Protection Agency, 2005), there is a specification of the applied approach 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 SF₆

Suppliers and/or producers provide consumption data of F-gases. Emission factors are primarily defaults from 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 are relevant (MAC, fridge/freezers for household) are quantified on estimates from import/export statistic 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 SF₆ 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 the production, from products during their lifetimes, and from waste products.

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

The potential emissions have been calculated as follows:

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

The substances have 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 relations have been used; see Table 4.13.

Table 4.13 Content (w/w%) of "pure" HFC in HFC-mixtures, used as trade names.

	HFC-32	HFC-125	HFC-134a	HFC-143a	HFC-152a	HFC-227ea
HFC mixtures						
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, 2004; 2005). Furthermore detailed data and calculations are available and archived in 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 SF₆ 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.

There are no appropriate measures of uncertainties established and no uncertainty estimates following the GPG procedures have been developed so far for the F-gas calculations.

In general uncertainty in inventories will arise through at least three different processes:

- Uncertainties from definitions (e.g. meaning incomplete, unclear, or faulty definition of an emission or uptake);
- Uncertainties from natural variability of the process that produces an emission or uptake;
- 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 as 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 probably occurring in a short-term time period, while estimating emissions in individual years. But in a long time period – 10-15 years - these variabilities levels out in the total emission, because input data (consumption of F-gases) is known and is valid data and has no natural variability due to the chemicals stable nature.

Uncertainties that arise due to imperfect measurement and assessment are probably an issue for:

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

The source-specific uncertainties for consumption of halocarbons and SF₆ 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 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 sub-sectors 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 for this submission been carried out in connection to the process, which provided (1) data for the CRF background Tables 2(II).F. for the years (1993)-2002 and (2) provided data for potential emissions in CRF Tables 2(I). This pro-

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

4.6.4.3 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 SF₆ 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 are for 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

For year 2002 a minor recalculation has taken place due to new knowledge of a part of the SF₆ emission categorisation under "laboratories". Further, for 2002 PFC and HFC-emissions with even much less changes, have been recalculated due to corrections of small mistakes in transformation of data from the F-gas model to the databases.

4.6.6 Planned improvements

It is planned to improve uncertainty estimates.

4.7 Uncertainty

The source-specific uncertainties for industrial processes are presented in Table 4.14. The uncertainties are based on IPCC 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 many producers and a 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 number of yellow bricks. The last assumption has been verified (see Section 4.2.3). The combined uncertainty is assumed to be 5%.

The producers of glass and glass wool have registered the consumption of carbonate containing raw materials. The uncertainty is assumed to be 5%. The emission factors are based on stoichiometric relations and therefore the 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 N₂O is difficult and only done for one year and therefore the 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. IPCC propose an uncertainty at 30-40% for regional estimates. However, Danish statistics have been developed during many years and therefore the uncertainty on activity data is assumed to be 10%. The uncertainty on the emission factor is, however, assumed to be 50%. The base year for F-gases is for Denmark 1995.

Table 4.14 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 ₂ O %	HFCs ³ %	PFCs ³ %	SF ₆ ³ %
2A1. Production of Cement	1	2				
2A2. Production of Lime and Bricks	5	5				
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		2,115	25,080	50,99	50,99	50,99
Trend uncertainty		2,009	2,426	45,17	544,6	4,133

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 References

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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 – 2003 are summarised. The method is based on a chemical approach, and this implies that the SNAP category system is not applicable. Instead emissions will be related to specific chemicals, products, industrial sectors and households and to the CRF sectors mentioned before.

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 2003, 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 - 2003 is described in the following section. A linear extrapolation is made for the period 1985 – 1995. A decrease is seen throughout the sectors. Table 5.2 shows the used amounts of chemicals 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 used amount of products is derived from Table 5.2, by assessing the amount of chemicals that is 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 used amount of products more accurately.

In Table 5.4 the emission for 2003 is split into individual chemicals. Propane and butane are main contributors, which can be attributed to propellants in spraying cans. Turpentine is defined as a mixture of stoddard solvent and solvent naphtha, and it is these two chemicals that are considered in the inventory. 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	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985
Paint application (3A)	41,4	27,9	21,9	39,1	35,3	35,9	48,9	50,6	46,0	49,9	52,2	54,5	56,8	59,1	61,3	63,6	65,9	68,2	70,5
Degreasing and dry cleaning (3B)	8,50	8,77	9,65	10,8	9,73	10,1	10,9	11,6	10,8	11,8	12,1	12,5	12,8	13,1	13,4	13,8	14,1	14,4	14,7
Chemical products, manufacturing and processing (3C)	1,21	1,70	1,64	1,96	1,78	1,76	1,75	1,94	1,81	1,95	2,01	2,06	2,11	2,16	2,22	2,27	2,32	2,37	2,42
Other (3D)	16,1	11,8	10,2	18,2	16,6	16,7	24,3	22,9	21,0	24,2	25,5	26,9	28,2	29,5	30,8	32,2	33,5	34,8	36,2
Total NMVOC	67,2	50,2	43,4	70,0	63,4	64,4	85,9	87,1	79,6	87,9	91,9	95,9	99,9	104	108	112	116	120	124
Total CO ₂ ^a	209	157	135	218	198	201	268	271	248	274	286	299	311	324	336	349	361	373	386

^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	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985
Paint application (3A)	109	71,0	57,5	96,6	86,9	94,3	152	124	113	131	137	143	149	155	161	167	173	179	185
Degreasing and dry cleaning (3B)	47,5	50,2	48,6	52,9	51,2	51,2	58,8	56,9	56,4	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)	52,3	64,5	62,4	70,3	64,7	66,2	68,3	69,3	66,5	71,6	72,9	74,2	75,5	76,8	78,1	79,4	80,7	82,1	83,4
Other (3D)	90,0	79,3	74,7	91,2	87,4	80,0	106,4	93,3	90,8	96,2	97,9	99,5	101	103	104	106	108	109	111
Total NMVOC	299	265	243	311	290	292	385	344	327	357	367	378	388	398	408	419	429	439	449

Table 5.3 Used amounts of products in Gg pr year

Used amounts of products Gg pr year	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985
Paint application (3A)	725	474	383	644	579	629	1013	828	753	871	911	952	992	1032	1073	1113	1153	1194	1234
Degreasing and dry cleaning (3B)	95,1	100	97,2	106	102	102	118	114	113	118	120	123	125	127	130	132	135	137	140
Chemical products, manufacturing and processing (3C)	261	323	312	352	323	331	341	346	332	358	365	371	378	384	391	398	404	411	417
Other (3D)	450	396	374	456	437	400	532	466	454	481	489	497	505	513	521	530	538	546	554
Total products	1531	1293	1166	1557	1442	1462	2004	1755	1652	1827	1885	1942	2000	2057	2115	2172	2230	2287	2345

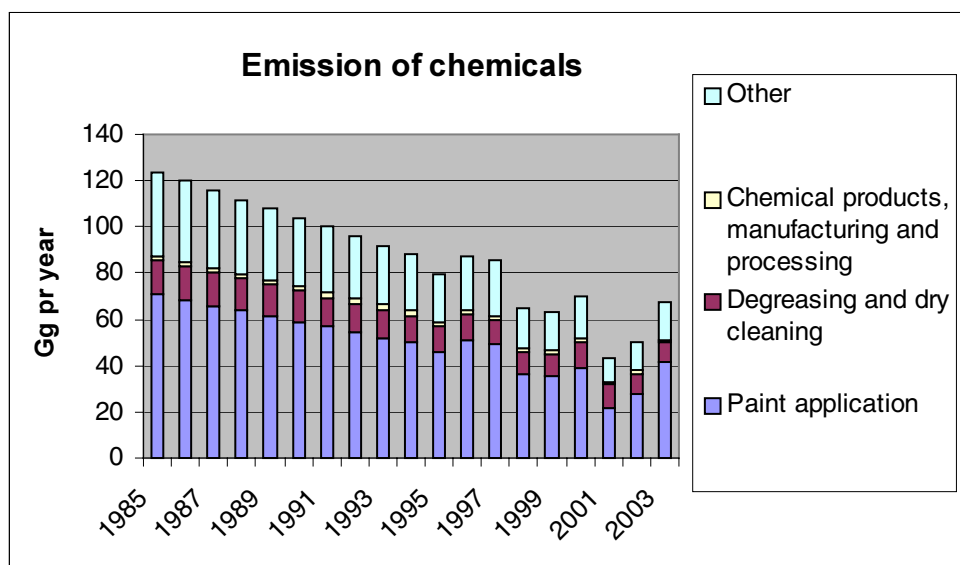


Figure 5.1 Emissions of chemicals in Gg pr year. The methodological approach for finding emissions in the period 1995 – 2003 is described in the text, and a linear extrapolation is made for 1985 – 1995. Figures can be seen in Table 5.1

Table 5.4 Chemicals with highest emissions 2003

Chemical	Emissions 2003 (1000 tonnes)	Emissions-factors (estimated from SFT, 1994) (%)	
		Consumption	Production processes
Propane	30,8	45	5
Butane	15,3	45	5
Turpentine	5,93	45	5
Aminooxygengroups	2,83	50	5
Methanol	1,99	5	1
Glycerol	1,64	10	5
Acetone	1,52	90	5
Etheralkoholes	1,47	60	5
Ethanol	0,910	7,5	1
Formaldehyde	0,788	5	1
Phenol	0,650	25	5
Naphthalene	0,563	5	1
Ethandiol	0,530	25	5
Monobutylether	0,301	95	5
Cyanates	0,268	50	5
Propylalcohol	0,246	10	5
Tetrachlorethylene	0,236	80	5
1-butanole	0,224	25	5
Propylenglycol	0,215	10	1
Xylene	0,194	5	1
Butanone	0,160	80	5
Toluendiisocyanate	0,153	5	1
Toluen	0,072	5	1
Dioctylphthalate	0,067	5	1
Acyclic monoamines	0,040	50	5
Butanoles	0,036	25	5
Methylbromide	0,032	80	5
Diethylenglycol	0,014	25	5
Triethylamine	0,011	50	5
Diamines	0,002	80	5

5.2.2 Methodological issues

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

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

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

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

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

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

A mass balance can be made for single substances or groups of substances, and the total amount of emitted chemical is obtained by summing up the individual contributions. It is important to perform an in-depth investigation in order to include all relevant emissions from the large amount of chemicals. The method for a single chemical approach is shown in Figure 5.2.

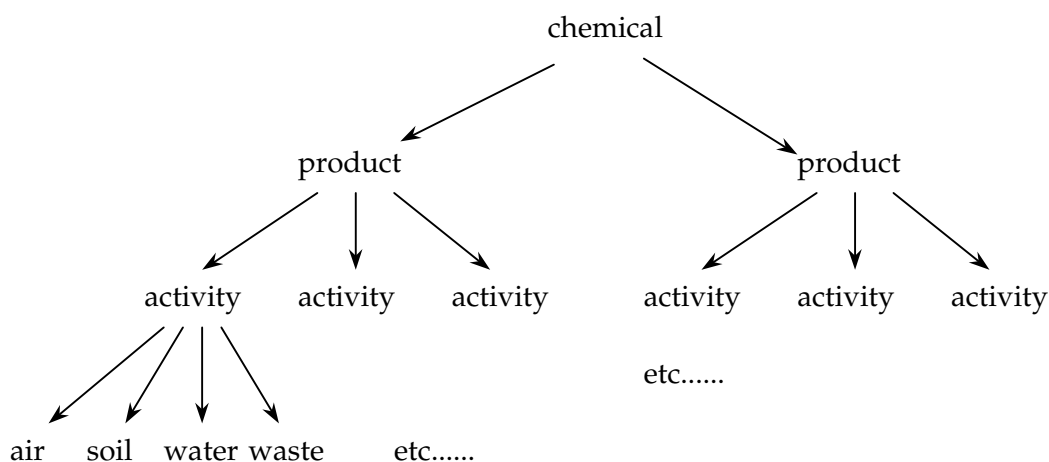


Figure 5.2 Methodological flow in a chemical based emission inventory.

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, CO₂, CH₄, CFCs and halons". The amount of chemicals that fulfil these criteria is large and a list of 650 single chemicals and a few chemical groups described in "National Atmospheric Emission Inventory", 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, 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 chemicals in the product must be estimated. It is important to distinguish the amount of chemicals that enters the mass balance as pure chemical and the amount that is associated to 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, a few groups and products is generated. For each of these a *use* amount in tonnes pr. year (from 1995 to 2003) is calculated. It is found that 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. The *use* amounts of individual chemicals are distributed 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 typically are 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,
- tidal (annual) 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

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 wherein 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 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 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 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 the 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.

5.2.4 QA/QC and verification

A general QA/QC procedure is currently being developed, and no source specific QA/QC and verification has been made.

5.2.5 Recalculations

The previous method was based on results from an agreement between the Danish Industry and the Danish Environmental Protection Agency (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 notice that not all use of solvents 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. But an increase in total emissions was expected due to the more comprehensive list of chemicals.

5.2.6 Planned improvements

The issues stated in the uncertainty section must be addressed in the future. The new approach is based on chemicals and as such, no chemical use is overlooked. Emphasis in the forthcoming improvements will be on gathering more detailed information from specific industrial sectors with respects to used products and chemicals and on their estimates of emission factors related to activities. It is, however, important to keep the detail of information on a realistic scale, since more information introduces more sources of uncertainty. It is not given that a more detailed information system yields a more precise result, if the available data is uncertain.

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 UNECE/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 the agricultural activities includes CH₄ emission from enteric fermentation and manure management and N₂O 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. CO₂ 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 are consequently not completed. Burning of plant residue has been prohibited since 1989 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

Given in CO₂ equivalents the agricultural sector - without LULUCF - contributes with 13% of the overall greenhouse gas emission (GHG) in 2003. Next to the energy sector the agricultural sector is the largest source of GHG emission in Denmark. The major part of the emission is related to the livestock production, which in Denmark is dominated by the production of cattle and pigs. In 2003 the N₂O emission contributed with 62% of the total GHG emission and CH₄ contributed with the remaining 38%.

From 1990 to 2003 the emissions have decreased from 12.8 Gg CO₂ eqv. to 9.9 Gg CO₂ eqv., which corresponds to a 23%-reduction (Table 6.1). Since the previous reporting (submission 2002) there has been a slight change. The change has effected the total emission with less than 0,5% (Section 6.8).

Table 6.1 Emission of GHG in the agricultural sector in Denmark 1990 – 2003 (CRF)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	Gg CO ₂ – eqv.													
CH ₄	3 853	3 884	3 893	3 977	3 942	3 938	3 960	3 870	3 913	3 792	3 809	3 854	3 774	3 706
N ₂ O	8 993	8 835	8 536	8 329	8 110	7 907	7 566	7 487	7 455	7 014	6 756	6 616	6 363	6 192
Total	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

Figure 6.1 shows the distribution of greenhouse gas emission on the main sources. The decreased emissions can be associated with a decrease of N₂O emissions from agricultural soils due to an proactive national environmental policy during the last twenty years. The environmental policy has introduced a series of measures to prevent loss of nitrogen from the agriculture to the aquatic environment. The measures include improved utilisation of nitrogen in husbandry manure, ban on manure application during autumn and winter, increased area with winter green fields to catch nitrogen, a maximum number of animals per hectare and a maximum nitrogen application rates to agricultural crops. The main part of the emission from the agricultural sector is related to the live-

stock production. The result of an active environmental policy is a decrease in the N-excretion and emission per produced animal, which has reduced the overall emission of GHG.

From 1990 to 2003 there is only a slight reduction in the total CH₄ emission. The emission from enteric fermentation has decreased due to a reduced number of cattle. On the other hand, the emission from manure management has increased due to a change towards more slurry based stable systems, which has a higher emission factor than systems with solid manure. By coincidence the decrease and the increase have a size as to balance, so the trend for CH₄ emissions from 1990 to 2003 has decreased less than 5%.

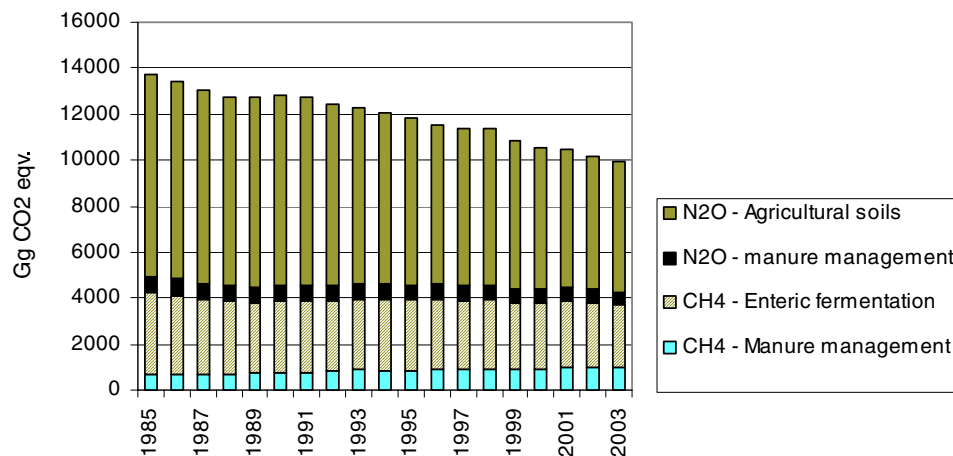


Figure 6.1 Danish greenhouse gas emissions 1990 – 2003

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 corporation with specialists and researchers at different institutes such as the Danish Institute of Agricultural Sciences, Statistics Denmark, the Danish Agricultural Advisory Centre, the Danish Plant Directorate and the Danish Environmental Protection Agency. In this way both data and methods will be evaluated continuously according to the latest knowledge and information.

Table 6.2 List of institutes involved to work out 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 Statistic	www.dst.dk	DS	- No. of animal - milk yield - slaughtering data - land use
Danish Institute of Agricultural Sciences	www.agrsci.dk	DIAS	- crop production - 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 bio gas 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 as shown in Figure 6.2 is implemented in great detail and it is used to cover both emissions of ammonia, particular matter and greenhouse gases. Thus, there is a direct coherence between the ammonia emission and the emission of N₂O. A more detailed description is published, but only in Danish (Mikkelsen et al. 2005). It is planned to publish an English edition.

This year NERI has established data agreements with the institutes and organisations to assure that the necessary data is available to work out the emission inventory in time. The main part of the emission is related to the livestock production and much of the data is based on Danish standards. The Danish Institute of Agricultural Sciences (DIAS) deliver Danish standards related to feeding consumption, manure type in different stable types, nitrogen content in manure etc. Previously the standards were updated and published every third or fourth year – the last one is Poulsen et al. from 2001. From year 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).

DIEMA – Danish Intergrated Emission Model for the Agricultural

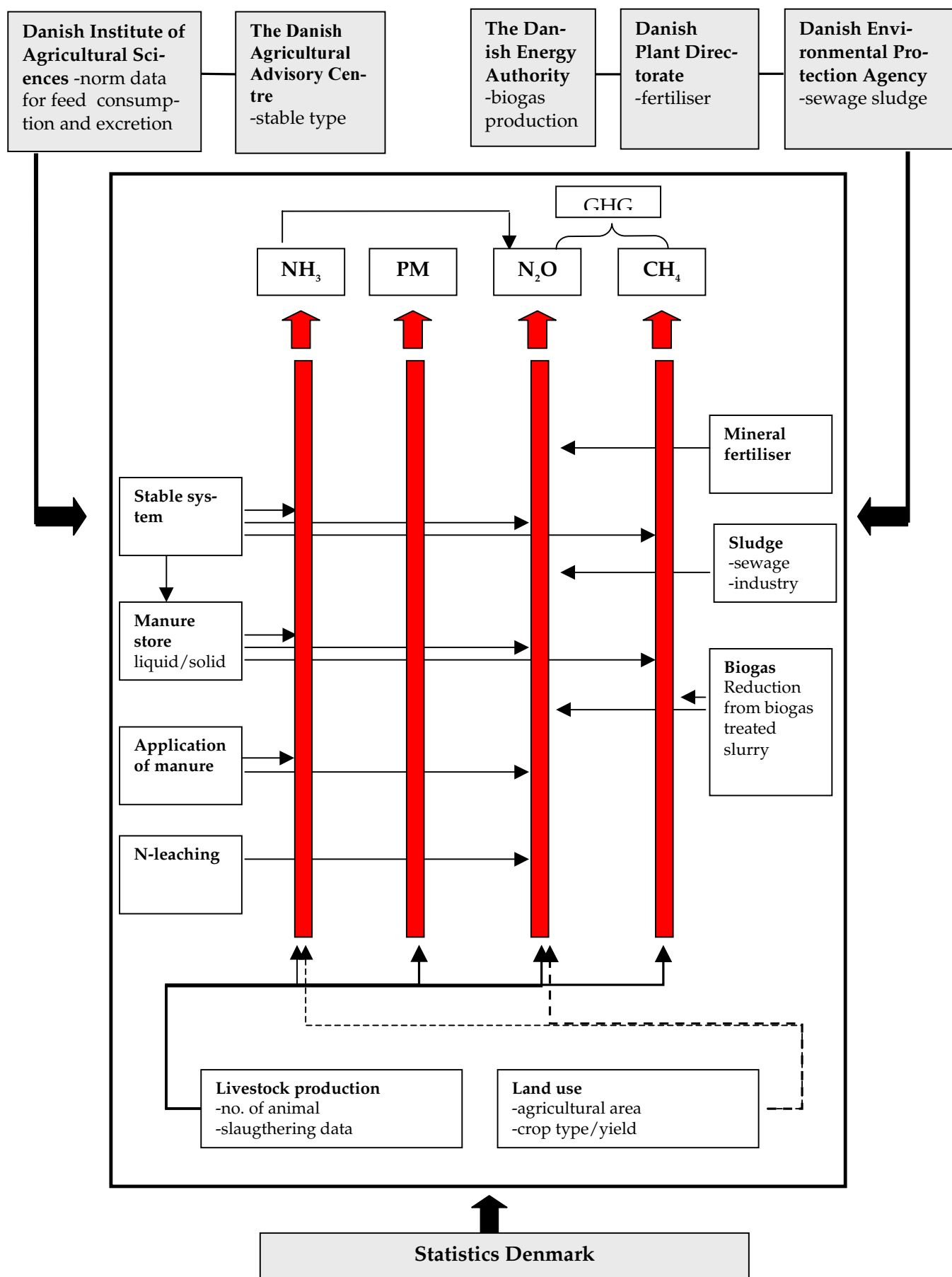


Figure 6.2 DIEMA – Danish Integrated Emission Model for Agriculture

NERI receives the data from different agricultural institutes and organisations shown as boxes with arrows pointing into the model in Figure 6.2. These data concerning livestock population, nitrogen excretion, feed consumption, stable type, manure type, land use, use of mineral fertiliser etc. are used as input data in DIEMA. The total emission from the agricultural sector is closely related to the livestock production.

DIEMA includes about 30 different livestock categories depending on livestock category, weight class and age. Each of these subcategories are subdivided according to stable type and manure type, which result in about 100 different combinations of subcategories and stable types. 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. It is important to point out, that changes in the emission and the implied emission factor over the years are not only a result of changes in number of animal, but also depending on changes in the allocation of subcategories, changes in feed consumption and changes in stable type.

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
Cattle¹		
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
	Slaughtering pigs	5

¹ For all subcategories distinguish between large breed and jersey cattle

6.1.2 Key source identification

Most of the agricultural emission sources can be considered as key sources both for emission level and trend (Table 6.4). The most important key source is N₂O emission from agricultural soils, which contributes with 8% of the total national GHG emission in 2003.

Table 6.4 Key source identification from the agricultural sector 2003

CRF table	Compounds	Emission source	Key source identification
4.A	CH ₄	Enteric fermentation	Level/trend
4.B(a)	CH ₄	Manure management	Level
4.B(b)	N ₂ O	Manure management	Level
4.D	N ₂ O	Indirect N ₂ O emission from nitrogen used in agriculture	Level/trend
4.D	N ₂ O	Direct N ₂ O emission from agricultural soils	Level/trend

6.2 CH₄ emission from Enteric Fermentation (CRF Sector 4A)

6.2.1 Description

The major part of the CH₄ emission origins from the digestive process. In 2003 this source accounts for 27% of the total GHG emission from the agricultural activities. The emission is primarily re-

lated to the ruminants and in Denmark particularly to cattle, which in 2003 contributed with 85% of the emission. The emission from the pig production is the second largest source and covering 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 a Tier 2 approach. The feeding consumptions for all animal categories are 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 feeding units or kg feed stuff and is converted to mega joule (MJ). In Annex 3 Table 1 and 2 shows the average feed intake for each livestock category from 1990 to 2003 used in the Danish emission inventory. Annex 3, Table 3-5 gives additional information about feeding, milk yield and digestibility for cattle. Default values for the methane conversion rate (Y_m) given by IPCC are used for all livestock categories. In CRF table 4.A. in category "Non-dairy Cattle" 6% is mentioned. However, 4% is used for estimating the emission from the subcategory bull calves.

Table 6.5 shows the implied emission factors for all IPCC livestock categories. Due to changed data for feeding consumption and allocation of subcategories the implied emission factor may vary between the years. Cattle and swine are the most important emission sources. The category "Non-Dairy Cattle" includes calves, heifer, bulls and suckler cows and the implied emission factor is a weighted average of these different subcategories (Annex 3 – Table 2). The category "Swine" includes the subcategories sows, piglets and slaughtering pigs.

There is no default values 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 – 2003 (CRF table 4.A)

CRF table 4.A	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	<u>Kg CH₄/head/yr</u>													
1a. Dairy Cattle	109.48	109.56	109.63	109.71	116.21	116.32	116.39	116.45	117.22	117.20	117.23	117.22	117.95	117.85
1b. Non-Dairy Cattle	34.04	34.26	34.41	34.62	34.51	34.64	34.68	35.02	35.01	35.44	35.64	35.89	36.20	36.13
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
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
6. Horses	23.90	23.90	23.90	23.90	23.90	23.90	23.90	23.90	23.90	23.90	23.90	23.90	23.90	23.90
8. Swine	1.07	1.10	1.12	1.10	1.10	1.07	1.11	1.10	1.10	1.13	1.11	1.07	1.08	1.07
9. Poultry	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

The increase for the implied emission factor (IEF) for dairy cattle from 1990-2003 is a result of an increasing feed consumption due to a rising milk yield. In average the milk yield has increase from 6200 litre per cow per year in 1990 to 7900 litre per cow per year in 2003 (Statistics Denmark) (Annex 3, Table 4). The relative big difference in the IEF between 1993 and 1994 is due to the availability of data from DIAS. For the years 1990-1993 the same data concerning the feed consumption is used (Laursen, 1987). In 1994 the data were updated (Laursen, 1994) and showed an increase by

approximately 6%, which nearly corresponds the increase in the milk yield in 1990-1994 (5%). In another way - the changes in feed intake from 1993 to 1994 for dairy cattle given in Annex 3 Table 1 does not reflect a one-year change, but reflect the development from 1990-1994.

For "Non-Dairy Cattle" there has been an increase in IEF. This is due to change in allocation of the subcategories. The share of calves, which has 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 to the default value given in IPCC Reference Manual. This is due to lower weight and lower feed intake and a higher digestibility of feed compared to the values given in IPCC.

Table 6.6 Subcategories for Non Dairy Cattle 2003

Non Dairy Cattle - subcategories	Weight*	Energy intake (MJ/day)*	Feed Digestibility (%)*		IEF – kg CH ₄ /head/yr
			summer	winter	
Calves, bull (0-6 month)		61.4	79	79	16.11
Calves, heifer (0-6 month)		42.5	78	78	16.72
Bull (6 month to slaughter)	large breed: 440 kg sl. weigh jersey: 330 kg sl. weight	115.8	75	78	30.38
Heifer (6 month to calving)		106.7	71	78	41.99
Suckling cattle		170.2	67	77	66.97
Average - Non-Dairy Cattle	max. 300				36.13

* The Danish Institute of Agricultural Science (Poulsen et al. 2001).

The implied emission factor for pigs is about the same level as in 1990. Improved fodder efficacy for sows has resulted in a lower emission factor. But 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.

6.2.2.2 Activity data

In Table 6.7 is given the development in number of animals from the Agricultural Statistic (Statistics Denmark) from 1990 to 2003. The emission from slaughter pigs and poultry is based on slaughter data from the Agricultural Statistics. Only farms larger than 5 hectares are included in the annual census. An approximate number of horses, goats and sheep on small farms are added to the number in the Agricultural Statistics in agreement with DAAC. The largest difference is found for horses. In the agricultural census the number is estimated to 42,700 horses in 2003. The total number of horses in 2003 is approximately 154,500, including horses on small farms and riding schools.

Since 1990 the number of swine and poultry has increased. Contrary to the number of cattle, which has decreased. Buffalo, camels and llamas, mules and donkeys do not occur in Denmark.

Table 6.7 Number of animals from 1990 to 2003 (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
IPCC livestock categories:	<u>1000 head</u>													
Dairy Cattle	753	742	712	714	700	702	701	670	669	640	636	623	610	596
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	1 128
Sheep*	92	107	102	88	80	81	94	78	83	83	81	92	74	83
Goats*	8	9	9	9	9	9	9	10	10	10	10	11	11	12
Horses*	135	137	138	140	141	143	144	146	147	149	150	152	153	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
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
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

* Including animals on small farms (less than 5 ha), which are not included in the Statistic Denmark.

6.2.3 Time-series consistency

The total emission from enteric fermentation is given in Table 6.8. From 1990 to 2003 the emission has decreased by 12%, which is primarily related to a decrease in the number of dairy cattle from 753,000 in 1990 to 596,000 in 2003. The number of pigs has increased from 9.5 M in 1990 to 12.9 M in 2003, but this increase is only of minor importance to the total emission.

Table 6.8 Emission of CH₄ from Enteric Fermentation 1990 – 2003 (CRF)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	<u>Gg CH₄</u>													
Dairy Cattle	82.45	81.25	78.05	78.35	81.29	81.71	81.55	78.06	78.43	75.03	74.50	73.07	71.90	70.24
Non-Dairy Cattle	50.59	50.70	50.86	51.29	48.50	48.08	48.30	46.71	45.80	44.19	43.92	46.07	42.95	40.77
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
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
Horses	3.23	3.26	3.30	3.33	3.37	3.41	3.44	3.48	3.51	3.55	3.59	3.62	3.66	3.69
Swine	10.14	10.74	11.74	12.71	12.03	11.91	12.03	12.53	13.28	13.09	13.26	13.52	13.79	13.89
Poultry	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
Total Gg CH ₄	148.09	147.90	145.82	147.30	146.69	146.61	147.06	142.24	142.58	137.40	136.78	138.00	133.71	130.17
Total Gg CO ₂ eqv.	3 110	3 106	3 062	3 093	3 080	3 079	3 088	2 987	2 994	2 885	2 872	2 898	2 808	2 734

6.3 CH₄ and N₂O emission from Manure Management (CRF Sector 4B)

6.3.1 Description

The emissions of CH₄ and N₂O 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 2003 and the major part of the emission originates from the production of swine (56%) followed by the cattle production (34%). The remaining part is mainly from poultry (7%).

6.3.2 Methodological issues

6.3.2.1 CH₄ emission

The IPCC Tier2 approaches are used for the estimation of the CH₄ 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 given in the IPCC guidelines for the methane production B₀ and MCF are used. For liquid systems the MCF on 10% in the Reference Manual (IPCC 1996) is used, which is based on Husted (1996). In Good Practice Guidance (IPCC 2000) 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 MCF on 10% reflects the Danish conditions better than MCF on 39%. Husted (1996) is, among others, 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.

Biogas plants using animal slurry reduce the emissions of CH₄ and N₂O (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 to the production of slurry.

In 2003 about 6% (0.72 M tonnes of cattle slurry and 0.88 M tonnes of pig slurry) were treated in biogas plants (DEA 2004), which correspond to 1,6 M tonnes of slurry. The reduction in the CH₄ emission is based on model calculations for an average size biogas plant with a capacity of 550 m³ 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 CH₄ is reduced by 0.93 Gg CH₄ (Table 6.9), which correspond a 2% reduction of the CH₄ emission from manure management in 2003.

Table 6.9 Reduced CH₄ emissions from biogas treated slurry 1990 – 2003

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
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	1.60
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	0.29
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	0.65
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	0.93

CH₄-implied emission factor

Table 6.10 shows the development in the implied emission factors from 1990 to 2003. 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 2003. Old tied-up stables with solid manure have been replaced by loose-holdings with slurry based systems. The MCF for liquid manure is ten times higher than solid manure. For pigs there has been a similar development with less solid manure and more slurry-based systems.

For non-dairy cattle there has been the opposite development. An increasing part of the bull-calves is raised in stables with deep litter, where the MCF is lower than liquid manure.

IEF for sheep and goats is including lamb and kid, which correspond the Danish normative data. This explains why the Danish IEF is nearly twice as big compared to the IPCC default value.

At present it is not possible to register the emission from fur farming in CRF Table 4.B(a). Implementation of the new CRF format will probably offer the opportunity to include emissions from other categories, e.g. fur farming.

Table 6.10 Implied emission factor – Manure Management 1990 – 2003 (CRF 4.B (a))

CRF Table 4.B(a)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	<u>Kg CH₄/head/yr</u>													
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	16.62	17.26	17.96
1b. Non-Dairy Cattle	2.21	2.11	2.03	1.97	1.88	1.80	1.77	1.73	1.69	1.71	1.68	1.69	1.64	1.80
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
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
6. Horses	1.74	1.74	1.74	1.74	1.74	1.74	1.74	1.74	1.74	1.74	1.74	1.74	1.74	1.74
8. Swine	2.26	2.40	2.53	2.50	2.54	2.51	2.62	2.62	2.65	2.75	2.70	2.61	2.63	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
Other – fur farming	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

* The CRF format gives no possibility to implement emission from “other” livestock categories – e.g. emission from fur farming. This source will be included when the new CRF format is implemented.

6.3.2.2 N₂O emission

The N₂O 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% of the total amount of nitrogen in manure.

The total amount of nitrogen in manure has decreased by 7% from 1990 to 2003 (Table 6.11) and the N₂O emission has followed this development despite an increasing production of pigs and poultry. This reduction is particularly due to an improvement in fodder efficiency and especially for slaughter pigs.

It is important to point out, that the excretion rates shown in Table 6.10 is a value weighted for the different subcategories (Table 6.3). 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 – 2003 (CRF table 4.B(b))

CRF table 4.B(b)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	<u>Kg N/head/yr</u>													
Livestock <u>cate-</u> <u>gory</u>														
Non-dairy cattle	36.57	36.68	36.80	36.92	36.64	36.56	36.62	36.74	36.77	37.00	37.15	37.77	37.87	37.81
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	126.58
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	16.95	16.95
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
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
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
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
Goats	21.18	21.33	21.47	21.61	21.76	21.90	20.11	18.32	16.53	14.75	16.95	16.95	16.36	16.36
	<u>M kg N/yr</u>													
N-excretion, total	293	291	293	293	283	274	275	274	279	270	270	274	277	273
N-excretion, stable	258	256	258	257	248	238	239	239	244	236	237	240	244	241

The effects from the biogas treated slurry are from this year included in the N₂O-emission. Investigation shows that it is possible to reduce the N₂O emission by approximately 36% from biogas treated cattle slurry and 40% from pig slurry (Nielsen et al. 2002, Sommer et al. 2001). The average nitrogen content in slurry is 0.00538% in cattle slurry and 0.00541% in pig slurry. The reduced emission is included in the N₂O emission from manure management.

Table 6.12 Reduced N₂O emissions from biogas treated slurry 1990 – 2003

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
No. of bio plants	230	388	473	556	658	772	830	1005	1222	1253	1408	1524	1703	
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	1.60
Reduced emission from slurry (Gg N ₂ O)	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	0.04

6.3.3 Time-series consistency

In Table 6.13 is given the total emission from manure management from 1990 to 2003. The N₂O emission has decreased with 17%. The total emission from manure management has nevertheless increased by 8% in CO₂-equivalent due to the increase in the CH₄ emission.

Table 6.13 Emissions of N₂O and CH₄ from Manure Management 1990 – 2003 (CRF)

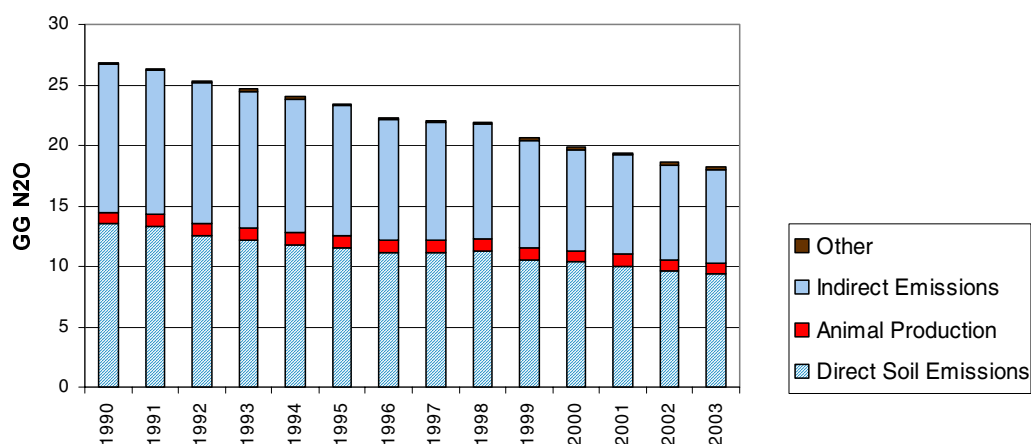
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
N₂O emission														
Liquid manure (Gg N ₂ O)*	0.31	0.30	0.30	0.30	0.28	0.27	0.27	0.26	0.26	0.25	0.26	0.26	0.26	0.26
Solid manure (Gg N ₂ O)	1.90	1.90	1.91	1.91	1.86	1.80	1.81	1.81	1.84	1.78	1.68	1.69	1.63	1.55
Total Gg N ₂ O	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	1.81
Total Gg CO₂ eqv.	685	681	684	683	663	642	642	643	652	631	601	604	588	560
CH₄ emission														
Total Gg CH ₄	35.37	37.08	39.55	42.09	41.03	40.93	41.53	42.05	43.75	43.18	44.62	45.53	46.02	46.28
Total Gg CO₂ eqv.	743	779	831	884	862	860	872	883	919	907	937	956	966	972
Total Manure Management														
Gg CO₂ eqv.	1428	1459	1515	1567	1525	1501	1515	1526	1571	1538	1538	1560	1555	1532

* Incl. the reduction from biogas treated slurry (Table 6.12).

6.4 N₂O emission from Agricultural Soils (CRF Sector 4D)

6.4.1 Description

The N₂O emissions from agricultural soils given in CRF Table 4.D, contribute with 57% of the total emission from the agricultural sector in 2003. Figure 6.6 shows the distribution and the development from 1990 to 2003 on different sources. The main part originates as direct emission of which the largest sources are manure and fertiliser applied on agricultural soil. Another large source is the indirect N₂O emission, where emission from nitrogen leaching is essential. The category "Other" includes emission from sewage sludge and sludge from the industry used as fertiliser.

Figure 6.6 N₂O emissions from agricultural soils 1990 - 2003.

6.4.2 Methodological issues

Emissions of N₂O are closely related to the nitrogen balance. The IPCC Tier1a methodology is used to calculate the N₂O emission. The N₂O emission factors for all sources are based on the default values given in IPCC (2000). National data for the evaporation of ammonia from the ammonia inventory is applied from the ammonia emission inventory (Illerup et al. 2004). A survey is given in Table 6.14. The estimated emissions from the different sub-sources are shortly described in the following text.

Table 6.14 Emissions factor - N₂O emission from the Agricultural Soils 1990 - 2003

Agricultural soils – emission sources CRF table 4.D	Ammonia emission (national data)	N ₂ O emission (IPCC default value)
kg N₂O -N/kg N		
1. Direct Soil Emissions		
Synthetic Fertiliser applied to soils	NH ₃ emission = 2%	0.0125
Animal Wastes Applied to Soils	NH ₃ emission = (31-25%)	0.0125
N-fixing Crops		0.0125
Crop Residue		0.0125
Cultivation of Histosols		8 kg N ₂ O-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 on soil by use of synthetic fertiliser is estimated from sale estimates by the Danish Plant Directorate. The amount of N is minus the ammonia emission based on national estimates from DIAS (Sommer and Christensen 1992, Sommer and Jensen 1994, Sommer and Ersbøll 1996). The Danish value for the FracGASF is estimated to 0.02 and is considerably lower than given in IPCC, i.e. 0.10. The ammonia emission depends on fertiliser type and the lower FracGASF is probably due to a small consumption of urea (<1%), which has a high emission factor (Table 6.15).

Table 6.15 Synthetic fertiliser consumption 2003 and the NH₃ 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	0.3
Ammonium sulphate	0.05	2.9
Calcium ammonium nitrate and other nitrate types	0.02	84.5
Ammonium nitrate	0.02	13.2
Liquid ammonia	0.01	5.8
Urea	0.15	0.5
Other nitrogen fertiliser	0.05	10.1
NPK-fertiliser	0.02	72.3
Diammonphosphate	0.05	0.4
Other NP fertiliser types	0.02	5.5
NK fertiliser	0.02	5.8
Total consumption of N in synthetic fertiliser		201.2
Total emission of NH ₃ -N (M kg)	4.44	
Average NH ₃ -N emission (FracGASF)	0.02	

¹ Danish Institute of Agricultural Sciences (Sommer and Christensen 1992, Sommer and Jensen 1994, 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 this use outside the agricultural area.

As a result of increasing demands to an improvement in use of nitrogen in livestock manure, the consumption of nitrogen in synthetic fertiliser has been halved from 1990 to 2003 (Table 6.16).

Table 6.16 Nitrogen applied as manure on agricultural soils 1990 - 2003

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
N content in synthetic fertiliser (kt N)	400	395	370	333	326	316	291	288	283	263	251	234	211	201
NH ₃ -N (kt NH ₃ -N)	9	8	8	8	8	8	7	6	6	6	6	5	5	4
N in fertiliser applied on soil (kt N)	392	386	362	325	318	308	284	281	277	257	246	229	206	197
N ₂ O emission (Gg N ₂ O)	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

Manure applied to soil

The amount of nitrogen applied on soil is estimated as the N-excretion in stables minus the emission of ammonia in stables, storage and in relation to 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 2003 has decreased by 7%. Despite this reduction in N-excretion, the amount of nitrogen applied on soil is nearly unaltered, which is due to a reduction in the ammonia emission.

Table 6.17 Nitrogen applied as manure on agricultural soils 1990 - 2003

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
N-excretion in stable (kt N)	258	256	258	257	248	238	239	239	244	236	237	240	244	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
N in manure applied on soil (kt N)	179	179	181	184	178	174	175	174	178	175	173	177	182	182
N ₂ O emission (Gg N ₂ O)	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

The FracGASM is estimated as the 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 2003 (Table 6.18). This is a result of an active strategy to improve the utilization of the nitrogen in manure.

Table 6.18 FracGASM 1990 - 2003

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Total N-excretion (kt N)	293	291	293	293	283	274	275	274	279	270	270	275	277	273
NH ₃ -N emission (kt NH ₃ -N)	77	75	75	73	69	65	64	64	65	63	63	63	62	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

N-fixing crops

To estimate the emission from N-fixing crops IPCC Tier1b is applied. The calculated emission is based on nitrogen content, the fraction of dry matter and the content of protein for each harvest crop type. Data for crop yield is based on Statistics Denmark. For nitrogen content in the plants the data is taken from Danish feedstuff tables (Danish Agricultural Advisory Centre). The estimates for the amount of fixed nitrogen in crops are estimated by Danish Institute of Agricultural Science (Kristensen 2003, Høgh-Jensen et al. 1998, Kyllingsbæk 2000). The inventory includes emission from clover-grass, despite the fact that this source is not mentioned in IPCC GPG. BNF from clover in grass fields contributes with 63% of the total in 2003. In Table 6.19 is given the background data for estimating the N-fixing. The emission from N-fixing crops decreases from 1990-2003, which is mainly due to a reduction in the agricultural area.

Table 6.19 Emissions from N-fixing crops 2003

N ₂ O emission from nitrogen fixing crops	N-fixing				
	Dry matter Fraction	N-Fraction	Variations 1990-2003 kg N/ha	2003 kg N/ha	2003 Kg N fix total
Pulses*	0.85	0.0337	96-179	149	4 663
Lucerne	0.21	0.0064	307-517	409	1 613
Cereals and pulses for green fodder	0.23	0.0061	16-38	22	2 465
Pulses, fodder cabbage etc.	0.23	0.0061	0-1	NO	NO
Peas for canning*	0.85	0.0337	76-139	119	403
Seeds for sowing	NE	NE	181-186**	182	779
Grass and clover field in rotation	0.13	0.0052	41-94	89	18 774
Grass and clover outside rotation	0.13	0.0052	6-11	8	1 460
Aftermath	0.13	0.0052	6-15	9	1 785
Total N-fix					31 942

* 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

N₂O emissions from crop residues are calculated as the total aboveground amount of crop residues returned to soil. For cereals the aboveground residues are calculated as the amount of straw plus stubble and husks. The total amount of straw is given in the annual census and reduced with the amount used for feeding, bedding and biofuel in power plants. Straw for feeding and bedding is subtracted in the calculation because this amount of removed nitrogen returns to the soil via manure. Data for nitrogen content in stubble and husks are provided by the Danish Institute of Agricultural Sciences (Djurhuus and Hansen 2003). Background data is given in Annex 3D, Table 11.

From 1990 to 2003 there have been some changes in the cultivation of crop types, but the total emission from crop residue is nearly unaltered (Table 6.20). The fraction of nitrogen in harvest crop residue has decreased due to a decrease in areas with sugarbeets, which is replaced by green maize.

Table 6.20 Emissions from crop residue 1990 – 2003.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
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
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
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
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
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
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
N ₂ O 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
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

Cultivation of histosols

In the previous emission inventory 10% of the organic soils was assumed to be in rotation. Due to lack of data this area is considered as unaltered from 1990 to 2003, which also means no changes in the emission from this source. Results from new investigations in relation to estimation of emission from the LULUCF sector are now available and will be used to re-estimate the N₂O emission from cultivated organic soils. In the next reporting the emission of N₂O from organic soils will be included in the LULUCF sector.

6.4.2.2 Animal Production

The amount of nitrogen deposit on grass is based on estimations from the ammonia inventory. It is assumed that 15% of the nitrogen from dairy cattle in average is excreted on grass (expert judgement from the Danish Institute of Agricultural Science – Poulsen et al 2001). The 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 - 2003

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
N-excretion, grass (kt N)	34	35	35	36	35	36	36	35	35	34	34	34	33	32
NH ₃ -N emission (kt NH ₃ -N)	2	2	2	3	2	2	3	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
N ₂ O 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

FracGRAZ is estimated as the volatile fraction by grassing animal compared to the total excreted nitrogen (N ab animal) (Table 6.22)

Table 6.22 FracGRAZ 1990 - 2003

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Total N-excretion (kt N)	293	291	293	293	283	274	275	274	279	270	270	275	277	273
N-excretion, grass (kt N)	34	35	35	36	35	36	36	35	35	34	34	34	33	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

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 emission from livestock manure, use of synthetic fertiliser, crops, ammonia treated straw used to feeding and sewage sludge and sludge from the industrial production applied on agricultural soils.

The emission from atmospheric deposition has decreased from 1990 – 2003 as a result of a reduction in the total ammonia emission from 109,400 tonnes of $\text{NH}_3\text{-N}$ in 1990.

Table 6.23 Ammonia emissions – submission 2003 (DIEMA)

Ammonia emission	2003
	<u>Tonnes $\text{NH}_3\text{-N}$</u>
Manure	61 191
Synthetic fertiliser	4 437
Crops	11 476
NH_3 treated straw	661
Sewage sludge and sludge from the industrial production	67
Emission total	77 832
N_2O emission (Gg)	1.22

Nitrogen leaching and Run-off

The amount of nitrogen lost by leaching and run-off from 1986 to 2003 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 study fields are taken into account. The result of these two calculations differs only marginally. The average of these two model predictions is used in the emission inventory.

Figure 6.8 shows the estimated leaching in relation to the nitrogen applied on agricultural soil as livestock manure, synthetic fertiliser and sludge. The average fraction of nitrogen leaching and run-off has decreased from 39% in the middle of the nineties to 34% in 2000. From 2000 to 2003 the fraction is nearly unaltered. The reduction is due to an improvement in the use of nitrogen in manure. The reduction of applied nitrogen is particularly caused by a fall in the use of synthetic fertiliser, which has been reduced with more than 50% from 1990 to 2003.

The fraction of N input to soils that are lost through leaching and runoff (FracLEACH) used in the Danish emission inventory is higher than the default value given in IPCC (30%). There is no simple explanation for this difference. In the Danish emission inventory the N-leaching is an important emission source and that explains why it has been chosen to use the national data. The data reflects the Danish conditions and are considered as best estimate.

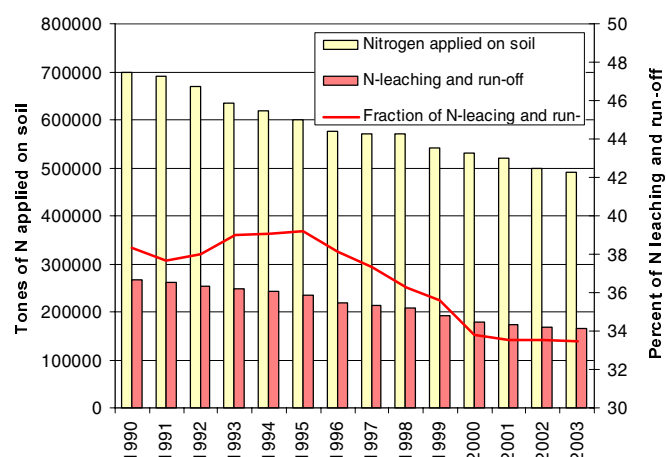


Figure 6.8 Nitrogen applied on agricultural soils and N-leaching from 1990 to 2003

6.4.2.4 Other Emissions

Under the category of “Other” is included sewage sludge and sludge from the industrial production applied on agricultural soils as fertiliser. Information about industrial waste, sewage sludge and the content of nitrogen is given by the Danish Environmental Protection Agency. It is assumed that 1.9% of N-input applied on soil volatisises as ammonia.

Table 6.24 Nitrogen in sludge applied on agricultural soils 1990 - 2003

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Nitrogen in sludge applied on soil (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
NH ₃ -N emission (kt NH ₃ -N)	58	60	72	93	83	87	85	74	70	69	68	66	67	67
N in sludge applied on 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
N ₂ O emission (Gg N ₂ O)	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

6.4.3 Activity data

In Table 6.25 is given an overview on activity data from 1990 to 2003 used in relation to the estimation of N₂O emission from agricultural soils. The amount of nitrogen applied on agricultural soil has decreased from 1088 M kg N to 747 M kg N corresponding to a 31% reduction.

Table 6.25 Activity data – estimation of N₂O emission from Agricultural Soils 1990 – 2003 (CRF Table 4.D)

CRF – table 4.D	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
<u>Gg N</u>														
Total amount of nitrogen applied on soil	1088	1068	1024	996	970	945	904	898	897	842	818	799	767	747
<u>1. Direct Emissions</u>														
Synthetic Fertiliser	392	386	362	325	318	308	284	281	277	257	246	229	206	197
Animal Waste Applied	179	179	181	184	178	174	175	174	178	175	173	177	182	182
N-fixing Crops	45	39	33	42	40	37	36	44	48	39	39	36	34	32
Crop Residue	59	58	50	52	52	56	57	56	56	55	56	57	53	53
Cultivation of Histosols	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<u>2. Animal Production</u>	32	33	33	33	33	33	33	32	32	31	31	32	31	30
<u>3. Indirect Emissions</u>														
Atmospheric Deposition	109	106	104	102	98	92	89	88	89	85	84	84	81	78
N-leaching and Run-of	267	261	254	248	241	235	219	213	207	192	179	174	168	164
<u>4. Other</u>														
Industrial Waste	2	3	3	5	5	5	5	5	5	4	5	7	8	8
Sewage sludge	3	3	4	5	4	5	4	4	4	4	4	3	4	4

6.4.4 Time-series consistency

The N₂O emissions from agricultural soils have been reduced by 32% from 1990 to 2003. This is mainly due to a decrease in the use of synthetic fertiliser and a decrease in N-leaching as a result of the 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 N₂O from Agricultural Soils 1990 – 2003 (CRF Table 4.D)

CRF – table 4.D	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
<u>Gg N₂O</u>														
Total N ₂ O emission	26.80	26.31	25.33	24.67	24.02	23.44	22.33	22.08	21.95	20.59	19.85	19.39	18.63	18.17
<u>1. Direct Emissions</u>	13.48	13.25	12.53	12.09	11.79	11.53	11.09	11.15	11.23	10.56	10.32	10.03	9.57	9.33
Synthetic Fertiliser	7.69	7.59	7.10	6.39	6.25	6.06	5.58	5.53	5.44	5.05	4.83	4.49	4.05	3.87
Animal Waste Applied	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	0.88	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	1.17	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	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
<u>2. Animal Production</u>	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
<u>3. Indirect Emissions</u>	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	7.67
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
N-leaching and Run-of	10.50	10.24	9.99	9.74	9.49	9.23	8.62	8.35	8.13	7.56	7.05	6.84	6.59	6.45
<u>4. Other</u>	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
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
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

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 given from Statistics Denmark. The emission factor for arable land crops (393 g NMVOC/ha) and grassland (2120 g NMVOC/ha) (Fenhann and Kilde 1994, (Priemé and Christensen 1991).

Table 6.27 NMVOC emission from agricultural soils 1990 - 2003

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Arable crops (1000 ha)	2 336	2 341	2 340	2 314	2 303	2 322	2 307	2 293	2 254	2 044	2 064	2 075	2 138	2 125
Grassland (1000 ha)	498	478	458	473	472	466	462	463	484	647	446	450	403	405
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

6.6 Uncertainties

Table 6.25 shows the estimated uncertainties for some of the emission sources based on expert judgement (Olesen et al. 2001, Gyldenkerne, pers. comm., 2004). The uncertainties for the number of animals and hectares grown with different crops are very small. 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 does a lot of research as well as collecting efficacy reports from the Danish farmers for dairy production, meat production, pig production etc. to optimise the productivity in Danish agriculture. In total feeding 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. The Normative System has been updated annually from 2000. For dairy cows approximately 800 feeding plans are used to develop the norm figures. The normative figures (Poulsen et al. 2001) are the arithmetic mean. Based on the feeding plans the standard deviation in N-excretion rates between farms can be estimated to $\pm 20\%$ for all animal types (Hanne D. Poulsen, DIAS, pers. comm.). However, 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. All cattle, sheep and goats have their own ID-number (ear tags) and hence the uncertainty in these number is almost absent. Statistics Denmark has estimated the uncertainty in the number of pigs to less than 1%. The combined effect of low uncertainty in actual animal numbers, feed consumption and excretion rates give a very low uncertainty in the activity data. The major uncertainty is therefore related to the emission factors.

In general the Tier1 uncertainty is used in the emission factors. A normal distribution is assumed. In the future Monte Carlo simulations will be made to increase the outcome from the uncertainty analysis.

The highest uncertainty is connected with manure management and nitrous oxide from leaching. The applied 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 CH₄ and N₂O

Source	Emission	Emission, Gg CO ₂ -eqv.	Activity data, %	Emission factor, %	Combined uncertainty	Total un- certainty, %	Uncertainty 95%, Gg CO ₂ -eqv.
4 Agriculture - total	CH₄ and N₂O	9921				17,0	1682,9
4.A Enteric Fermentation	CH ₄	2734	10	8	12,8	12,8	350,1
4.B Manure Management	CH ₄ and N ₂ O	1556				73,8	1147,9
	CH ₄ – table 4.B(a)	995	10	100	100,5		
	N ₂ O – table 4.B(b)	560	10	100	100,5		
4.D Agricultural Soils	N ₂ O	5632				21,0	1183,6
<u>4.D1 Direct soil emissions</u>	N ₂ O	2892				15,3	441,4
Synthetic Fertiliser	N ₂ O	1198	3	25	25,2		
Animal waste applied to soils	N ₂ O	1107	10	25	26,9		
N-fixing crops	N ₂ O	195	20	25	32,0		
Crop Residue	N ₂ O	320	20	25	32,0		
Cultivation of histosols	N ₂ O	72	20	25	32,0		
<u>4.D2 Animal Production</u>	N ₂ O	292	20	25	32,0		
<u>4.D3 Indirect soil emissions</u>	N ₂ O	2448				44,7	1094,2
Atmospheric deposition	N ₂ O	379	10	50	51,0		
N-Leaching and Run-off	N ₂ O	1999	20	50	53,9		
<u>4.D4 Other</u>							
4.D4 Sewage N	N ₂ O	21	20	50	53,9		
4.D4 Industrial waste used as fertiliser	N ₂ O	49	20	50	53,9		

6.7 Quality assurance and quality control - QA/QC

A general QA/QC plan for the agricultural sector has not yet been implemented. A plan to prepare a strategy for a QA/QC procedure is under development and the results will be represented in relation to next years reporting.

Until now some measurements have been taken to ensure the consistency in the emission inventory.

- Time-series for both activity data and emission factor have been worked out for 1990 – 2003 to check consistency in the methodology, to avoid errors, to identify and explain considerable variations from year to year.
- Activity data and emission factors are collected and discussed in corporation with specialists and researchers at different institutes and research sections. As a consequence both the data and methods are evaluated continuously according to the latest knowledge and information.
- The livestock population and use of mineral fertiliser is compared to data given in the FAO database.

- This years data delivery agreements with institutes/organisations are established to ensure that the necessary agricultural input data is available.

6.8 Recalculation

Compared to the previous emission inventory (submission 2002) few changes are made. These changes increase the total GHG emission from the agricultural sector with less than 0.5 % (Table 6.29).

Table 6.29 Changes in GHG emission in the agricultural sector compared to CRF reported last year

GHG emission	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
	<u>Gg CO₂ eqv.</u>												
Previous emission	12 826	12 702	12 411	12 285	12 036	11 834	11 514	11 346	11 360	10 800	10 564	10 470	10 134
Recalculated emission	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
Change Gg CO ₂ eqv.	20	18	18	22	16	12	12	11	8	6	1	0	3
Change in pct.	0,2	0,1	0,1	0,2	0,1	0,1	0,1	0,1	0,1	0,1	0,0	0,0	0,0

The changes are summarized below. There have been no changes in the methodology used to calculate the emissions.

- The N₂O emission from Manure Management (CRF Table 4s2, activity 4.B) now includes N₂O reduction from biogas treated slurry. It has almost no effect on the total N₂O emission.
- The activity data related to the emission from crop residue has been updated. The change has increased the N₂O emission from this source for all years with 2-5%. There is almost no effect on the total N₂O emission.
- The CH₄ emission (CRF table 4s1, activities 4.A and 4.B) has increased for all years from 1990 to 2002 but less than 1% of the total CH₄. The recalculation is due to small changes in slaughtering data for calves (bull). This does not effect the number of "Other Cattle", which is given from the Statistics Denmark. The change has a slight effect on both the total emission and the IEF.

6.9 Planned improvements

The Danish emission inventory for the agricultural sector mainly meets the request as set in the IPCC Good Practice Guidance. Nevertheless, working out a QA/QC plan and estimation of uncertainties are two important issues in which the inventory still needs to be improved. Further, the review team has pointed out the needs for more detailed documentation and explanation for some specific emission sources where national values are used in the calculation.

The QA/QC plan for the agricultural sector is still under development, but some measures have been formulated as general lines for the further work. The objectives for the quality planning, as given in the IPCC Good Practice Guidance, are to improve the transparency, consistency, comparability, completeness and confidence. For the agricultural sector this work will be followed up by a more specific description for a QC and QA procedure in according to the principle lines mentioned below:

- Review of existing data structure
 - complete and detailed overview from raw input data and emission factor to the total emission estimate

- Review of existing methods
 - Complete and detailed overview of applied methods in a schematic and transparent way
- Review of the uncertainty calculation
- Modifying data structure
- Filling up methodological gaps
- Setting up control measurements

As a response to the recommendations from ERT the uncertainties estimate is improved (Table 6.28) based on Tier1 approach. The further work concerning the uncertainties will focus on the possibilities to improve by using a Monte Carlo simulation, which can increase the outcome from the uncertainty analysis.

In the Danish inventory national data is used for N-excretion, ammonia emission, feed intake, stable type, nitrogen and dry matter content in crops. It is important to focus on documentation, especially on the national data and methodology used in the inventory. This year, in co-operation with the Danish Institute of Agricultural Science, a detailed description of the methodology used to calculate the emission of both the ammonia and greenhouse gases has been published (Mikkelsen et al. 2005). Presently, this report is only available in Danish, but will be translated into English. It is planned to review the report by external agricultural experts. This should, ideally, be in co-operation with another member states with agricultural conditions similar to the Danish. This review procedure could be useful for all involved countries to exchange knowledge and to identify the most important inventory improvements. Comparison between the Danish emission inventory and a calculation based on IPCC Tier1 approach could be a tool to improve the comparability, the transparency and the documentation.

Further, it is planned to re-estimate the N₂O from cultivation of histosols and this emission will, in the next reporting, be included in the LULUCF sector.

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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 UNFCCC in April 2004 Land Use and Land Use changes has been included in the inventory. The methodology is described in Gyldenkærne et al. (2005). Previously only forestry was included in this sector. The LULUCF sector differs from the other sectors in that it contains both sources and sinks of carbon dioxide. LULUCF are 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 opposite to the usual way of reporting as given in the remaining report. Emissions from LULUCF were estimated to be a sink of approximately 1,200 Gg CO₂ or 2% of the total reported Danish emission.

Approximately 2/3 of the total Danish land area is cultivated. Together with high numbers of cattle and pigs there is a high (environmental) pressure on the landscape. To reduce the impact an active policy has been adopted to protect the environment. The adopted policy is aiming at a doubling of the forest area within the next 80-100 years, re-establishing of former wetlands and establishing of protected national parks. In Denmark all natural habitats and forests are protected and therefore, in the inventory, no conversions from forest or wetlands into cropland or grassland are made, because in reality this 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 7.3 Cropland. A full matrix of the total land area still needs to be carried out.

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 these changes are considered to be negligible or not occurring in Denmark.

Fertilisation of forests and other land is very negligible and therefore reported as a 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 are reported under Cropland because only very limited amounts are used in forestry and on permanent grassland. At the moment there is no reporting on removals or sinks from mineral soils. Field burning of biomass is prohibited in Denmark and therefore reported as NO. Biomass burned in power plants is reported in the energy sector.

In Table 7.1 is given an overview of the emission from the LULUCF sector in Denmark measured in Gg CO₂-eqv. Forests are sinks in Denmark of approximately 3,500 Gg CO₂-eqv y⁻¹ and Cropland is estimated to have a net emission of 2,4 Gg CO₂. Only organic soils are reported at the moment and the emission is therefore related to cultivation of organic soils. From 1990 and onwards a decrease in the emission from Cropland is estimated due to a reduced agricultural area, an increase in hedgerows and a 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 CO₂) from the LULUCF sector in Denmark, 1990-2003

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
CO ₂	159.6	-107.7	-251.1	-461.2	-328.9	-230.2	-421.9	-445.0	-818.2	-865.5	1781.7	-1157.6	-1476.0	-1203.5
A. Forest Land	-2830.7	-3007.9	-2998.7	-3210.0	-3098.6	-2987.7	-3063.4	-3155.1	-3312.2	-3306.3	-652.9	-3538.6	-3813.3	-3532.2
B. Cropland	2988.3	2.98.3	2745.6	2746.8	2767.8	2755.6	2639.6	2708.2	2492.2	2439.8	2437.8	2386.0	2344.3	2338.7
C. Grassland	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
D. Wetlands	2.0	2.0	2.0	1.9	1.9	1.9	1.9	1.9	1.8	1.0	-3.3	-5.0	-7.0	-10.0
E. Settlements	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
F. Other 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	0.0	0.0
N ₂ O	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
A. Forest 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	0.0	0.0
B. Cropland	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
C. Grassland	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
D. Wetlands	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
E. Settlements	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
F. Other 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	0.0	0.0
G. Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Land Use, Land- Use Change and Forestry (Gg CO ₂ equivalent)	159.7	-107.6	-251.0	-461.1	-328.8	-230.1	-421.8	-444.9	-818.1	-865.4	1781.7	-1157.5	-1476.0	-1203.4

7.2 Forest Land

7.2.1 Source category description

Danish forests cover only a small part of the country (11%) as 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 the forest area). Contrary to the situation in the other Scandinavian countries, forestry does not contribute much 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 main part of the Danish forests will always remain forest. It is the ambition to enlarge the forested area to 20-25% of the country size by the end of the 21st century. Afforestation of arable land is therefore encouraged by use of subsidies to private landowners. Subsidized 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 censuses 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 about 411,000 ha (= 4,110 km²) or approximately 10% of the land area (Forestry Census, 1990). Broadleaved tree species made up 35% and coniferous species made up 65% of the forest area. See Table 7.2 for the distribution to specific tree species and species categories.

Table 7.2 Total wooded area, temporarily uncovered area and distribution of forested area 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

¹Area not yet replanted with trees following clear-cutting

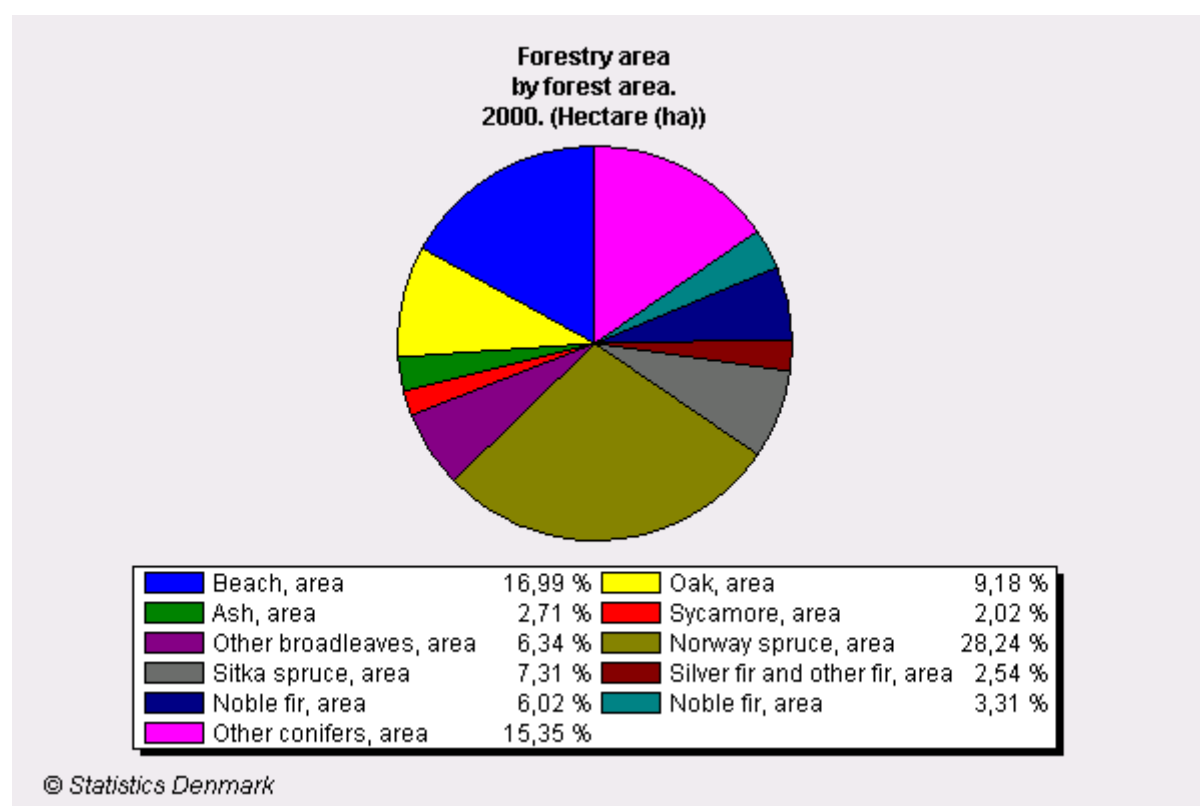


Figure 7.1 Tree species distribution to the total forested area in 2000. From Statistics Denmark (<http://www.statistikbanken.dk/>).

In 2000, the forested area with trees was 468,000 ha or approximately 11% of the land area. The number of respondents for this survey was 32,300, which is considerably higher than the number of 22,300 in the 1990 survey. The number of respondents may cause the changes in the forest area between 1990 and 2000 rather than real changes in the forest area. The increase in forested areas 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 7.1 or the distribution to specific tree species and species categories.

Compared with other sectors, forestry has a very low energy consumption. Green accounting and environmental management are being developed in the sector, partly with the intention to determine 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 aiming at achieving this objective. Firstly, a government subsidy scheme has been established that supports private afforestation on agricultural land. Secondly, also governmental and municipal afforestation is 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 periods 1990-99 and 2000-2002 are all obtained from the Forestry Census of 2000 (Larsen and Johannsen, 2002).

The Forestry Census has been carried out roughly every 10 years and is based on questionnaires to forest owners. Detailed information about the census and the methodology can be found in Larsen and Johannsen (2002), and further documentation is available from Danish Centre for Forest, Landscape and Planning⁷. In short, the estimates of standing volume and volume increments in the Forest Census from 1990 and from 2000 are based on questionnaire information from forest owners on forest area distributed to species and age classes, and information on site productivity. Based on standard yield table functions these input data are used to estimate standing volume and rate of increment for each tree species category.

In 1990, the standing stock of wood was 64.8 M m³ equivalent to 15.77 m³ per km², distributed on 40% broadleaved species and 60% coniferous species. This stock of wood was equivalent to 22,425 Gg C or 82,225 Gg CO₂. In 2000 the standing stock of wood was 77.9 M m³ equivalent to 16.65 m³ per km², distributed on 37% broadleaved species and 63% coniferous species. This stock of wood was equivalent to 26,803 Gg C or 98,278 Gg CO₂. These two figures cannot be compared directly due to different numbers of respondents in the two censuses. The number of respondents in the 2000 survey was 32,300, which is 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 forest inventory will replace the Forestry Census. The National Forest Inventory will be complete by 2006, and the first background data for use in the NIR is expected from 2007. This type of forest

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inventory will be quite similar to inventories used in other countries, e.g. Sweden. (see also section 7.2.6).

There is no information on applicable expansion factors for Danish conditions. Expansion factors are needed to convert stem volumes for conifers and total aboveground biomass for the broadleaves to total biomass. Therefore, stemwood volumes for conifers are converted to total biomass by an expansion factor of 1.8 based on Schöne and Schulte (1999), and aboveground biomass for broadleaves are converted to total biomass by an expansion factor of 1.2 based on Vande Walle et al. (2001) and Nihlgård and Lindgren (1977). These studies were chosen as basis for expansion factors due to the geographical closeness of study sites (Germany, Sweden and Belgium), and the studies concerned relevant Danish species like beech, oak and Norway spruce. However, stand management may of course be different from Danish “average” stand management, but variability in management may 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 available systematic information on soil organic carbon for the reporting.

7.2.2.2 Annual CO_2 -sequestration in forests planted before 1990

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

The estimated gross wood increment for the period 2000–2003 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 ($\text{m}^3 \text{ ha}^{-1}$) for the categories of tree species for the periods 1990–1999 and 2000–2009 are both provided in the Forestry Census of 2000. The gross annual increment for 1990–99 was estimated at $4.6 \text{ M m}^3 \text{ y}^{-1}$ and around $5.2 \text{ M m}^3 \text{ y}^{-1}$ 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 now could 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 annually harvested amount of wood (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% were added to the figures for commercial harvests of coniferous wood.

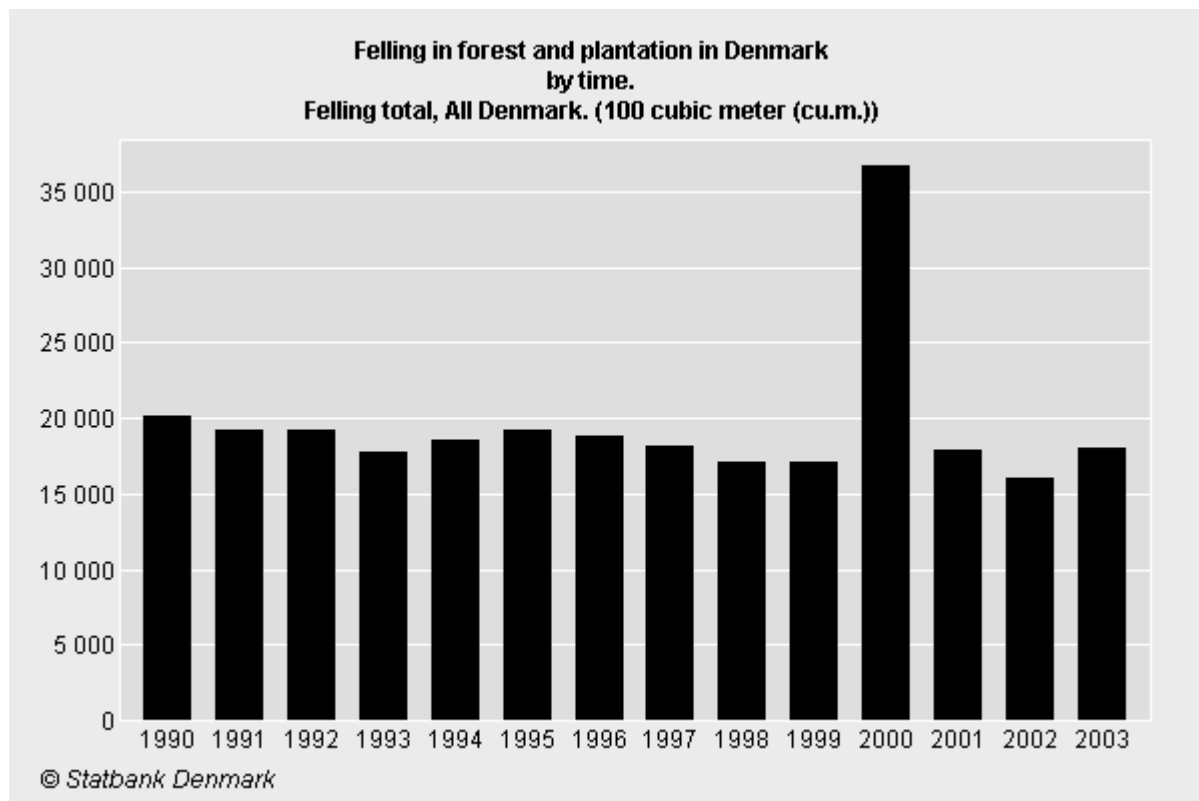


Figure 7.2 Total annual harvest of commercial wood in forests planted before 1990. The peak in 2000 is almost solely due to windthrow of conifers during the storm in Dec. 3, 1999. From Statistics Denmark (<http://www.statistikbanken.dk/>).

The net annual increment (gross wood increment minus harvested wood) was estimated to approximately $2.3 \text{ M m}^3 \text{ y}^{-1}$ for 1990–1999 and is estimated to approximately $2.7 \text{ M m}^3 \text{ y}^{-1}$ for 2000–2003 (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 with harvested wood and the resulting net sink for CO_2 are given in Table 7.2.3. The resulting net sink for CO_2 in existing forests in 1990 was around $3,000 \text{ Gg CO}_2 \text{ yr}^{-1}$ for the period 1990–1999 and somewhat higher (around $3,500 \text{ Gg CO}_2 \text{ yr}^{-1}$ for the period 2000–2002. In the year 2000 the sink was much lower than in all other years due to the storm in December 1999. The windthrow caused by this storm made the harvested amount of wood in 2000 more than two times higher than during an average year. The storm-felled amount of wood amounted to 3.6 M m^3 distributed over about 20,000 ha (Larsen and Johannsen, 2002).

Table 7.4 Data on gross uptake of CO₂, loss of CO₂ due to harvesting (Figure 7.2) and the resulting net annual sink for CO₂ for the period 1990 – 2002 in forests existing before 1990.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Gross uptake of CO ₂ (Gg yr ⁻¹)	-5743	-5743	-5743	-5743	-5743	-5743	-5743	-5743	-5743	-5743	-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
Net annual sink for CO ₂ (Gg yr ⁻¹)	-2832	-3012	-2997	-3210	-3092	-2982	-3048	-3129	-3279	-3268	-594	-3465	-3725	-3424

For 2000-2003, the gross uptake of CO₂ was slightly higher than for 1990-1999. This is mainly attributed to the higher number of respondents to the questionnaire, i.e. the included forest area was larger (440,000 ha vs. 411,000 ha in 1990. Annual gross increment per ha was similar for the two periods (11 m³ ha⁻¹ y⁻¹). The estimated increment in the period 2000-2003 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 windthrow as the age distribution changed towards low productive reforested stands. The loss of increment is estimated at 182,000 m³ yr⁻¹ for the period 2000-2009.

7.2.2.3 Annual CO₂ 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 1,837 ha yr⁻¹ for the period 1990-2002. Afforestation is carried out on soils formerly used for agriculture (cropland). The annually afforested area is specified in Table 7.5. 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 1999-2003 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 by which C-stock changes are based on area multiplied by uptake. Uptake is calculated using a simple carbon storage model based on the Danish yield tables for Norway spruce (representing conifers) and oak (representing broadleaves) (Møller 1933). The 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 in spite of different parent materials (Vesterdal et al., 2004). This is due to the nutrient-rich topsoil, which is a legacy of former agricultural fertilization

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 it 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), it is considered to further harmonize the calculation methods.

Table 7.5 Distribution of afforestation area (ha) on different landowners and tree species. Plantations of Nordmann's fir for Christmas trees and greenery are not included in the afforested area.

Year	State forests	Other publicly owned forests	Private forests with subsidies	Private without subsidies	Total area	Broadleaved	Coniferous
1990	107	12	0	611	730	320	410
1991	300	12	70	611	993	527	466
1992	562	12	70	611	1255	721	534
1993	450	149	70	611	1280	738	542
1994	553	149	178	611	1491	912	579
1995	396	141	178	611	1326	790	536
1996	407	146	212	611	1376	833	543
1997	414	267	968	611	2260	1614	646
1998	146	101	547	611	1405	912	493
1999	358	150	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	1558	611	2547	1991	556

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

So far, there have been no thinning operations in the stands afforested since 1990; thus there are no reported emissions of carbon so far. 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 done 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 so far. 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., 2004). There is currently no systematic data available to explore this further.

The annual CO₂ uptake and the cumulated CO₂ uptake and afforested area since 1990 are given in Table 7.6. As shown in the table, annual sequestration of CO₂ in forests established since 1990 has gradually increased to 73 Gg CO₂ in 2001, for further details see the Annex. The annual CO₂ 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 CO₂ uptake, cumulated CO₂ 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
Annual CO ₂ uptake (Gg yr ⁻¹)	0	-1	-3	-5	-8	-10	-16	-24	-34	-43	-59	-74	-88	-108
Cumulated CO ₂ uptake (Gg)	0	-1	-4	-10	-17	-28	-44	-68	-102	-145	-204	-278	-365	-473
Cumulated afforestation area (ha)	730	1723	2978	4258	5749	7075	8451	10711	12116	16539	19292	21416	23754	26301

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 CO₂. 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 2004–2012, but it is possible that other instruments in addition to subsidisation will make it possible to increase the rate of afforestation and eventually the sequestration of CO₂.

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 CO₂ stores and annual uptake in forests in Gg, 1990 – 2002. Uptake due to changes in forest biomass stocks in forests planted before 1990 and due to afforestation of former arable land since 1990.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
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
CO ₂ uptake in forests existing before 1990	-2832	-3012	-2997	-3210	-3092	-2982	-3048	-3129	-3279	-3268	-594	-3465	-3725	-3424
CO ₂ uptake due to afforestation since 1990	0	-1	-3	-5	-8	-10	-16	-24	-34	-43	-59	-74	-88	-108

7.2.3 Uncertainties and time-series consistency

7.2.3.1 Uncertainty of the reported sinks

In response to previous reviews a discussion has been added on the probably high but currently unknown uncertainty for CO₂ uptake in forestry. Uncertainty will be addressed for the inventory

data in detail when the first results from the new sample-based National Forest Inventory are available in 2007.

So far, the design of the presently used Danish Forestry Census has not made it possible to quantitatively address uncertainty of inventory data used to estimate the reported sink for CO₂ in Danish forests. The uncertainty of the volume and increment estimates in the Forestry Census 1990 and 2000 are related to a number of issues: The values of site productivity refer to fully stocked stands with no border effects and with a given thinning regime. However, a number of these issues are uncertain. The stands are not fully stocked as the estimates are based on a 90% stocking but it may be lower. The very fragmented shape of the Danish forest area results in many borders and hence a reduction in the actual productivity on the area as a whole. Furthermore, the yield table functions are based on a certain frequency of thinning, which in turn affect the standing volume. With the changing conditions for the forestry sector, these prescriptions are not followed, which in turn may lead to deviations, both positive and negative, from the estimated volume and increment. Further details and alternative estimates can be found in Johannsen (2002) and Dralle et al. (2002).

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

In recognition of the difficulties in analyses of uncertainty, the estimated uptake of CO₂ 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. We acknowledge the comment by the ERT for NIR 2004 on the complications caused by different numbers of respondents in the Forestry Census 1990 and 2000. The difference in gross uptake of CO₂ between 1990-1999 and 2000-2003 is almost solely due to the difference in numbers of respondents to the questionnaire (i.e. forest area) as annual gross increment per ha was similar for the two periods. However, as mentioned below (Section 7.2.6), we prefer to avoid recalculations of the present data based on the Forestry Census due to the coming large revision of the reported data brought on by the new National Forest Inventory.

In addition to this coming revision, we are currently considering to initiate work on a reconstruction of the land use matrix from 1990 (databases, remote sensing data and aerial photos). This is necessary in order to be able to apply the same forest definition (FAO-TBFRA) in 1990 as that used in the commitment period.

7.2.4 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 Danish Centre for Forest, Landscape and Planning.

7.2.5 Recalculations

Since the submission to UNFCCC in April 2004 no methodological revisions have been carried out, but this section has been amended with more information in response to the reviews.

For stands afforested since 1990 minor revision was made of the afforestation areas in the years 2001-2002. The Danish Forest and Nature Agency discovered some minor discrepancies in their database on land area of subsidized afforestation projects and afforestation by other public authorities. The afforestation areas were consequently slightly revised. The changes were as given below

1999: -10 ha subsidized private afforestation

2000: +32 ha other public afforestation

2001: -108 ha other public afforestation and +107 ha subsidized private afforestation.

2002: -52 ha other public afforestation and -42 ha subsidized private afforestation.

The total difference over the period is quite small (-73 ha) and this has had no visible effect on the CO₂ uptake in the period 1990-2003 as the involved stands are very young.

7.2.6 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 require 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 like: 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 the temporary). 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 September. We expect to finalise the first full measurement of all of Denmark 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 new background data from the sample-based NFI will provide much better estimates of the status of the forest area since 1990 and the development in the 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 follow 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 been included as part of the NFI so far. However, simple measurements of forest floor thickness in each plot enable estimation of carbon stock changes in the litter pool. 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 (subsidized afforestation area). The NFI is possibly not able to better gauge the relatively small afforestation area than the currently used data sources. 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 more scarce. So far 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 better basis for selecting root-top relationships for Norway spruce from the literature.

In addition work is currently being initiated on a reconstruction of the land use matrix by 1990 by use of databases, satellite photos and aerial photos.

7.3 Cropland

As mentioned in the overview 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 (1:25,000) a detailed GIS analysis has been made. The total Danish agricultural area of approximately 2.7 mio. hectares has been related to approximately 700,000 individual fields, which again is located at 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 2003.

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 2003 (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
Annual crops (CM) ¹	2239127	2223632	2206656	2011670	1958047	1971896	1982942	2051133	2016456	1958815	1939902	1952940	1972009	1950587
Grass in rotation (CM)	306325	308789	317246	355019	395993	310568	329496	307065	339597	323909	330834	326553	292566	302896
Permanent grass (GM)	217235	212030	207932	197229	191000	207122	192851	167600	156260	159530	166261	173702	177546	177635
Horticulture – vegetables (CM)	16428	15994	16747	15771	12886	12915	11053	9554	10202	10523	10803	9616	8903	9933
Horticulture – permanent (CM)	7892	7944	8975	8255	8665	8367	8457	7874	7505	7683	8010	8447	7976	8330
Set-a-side (CM)	3861	4694	4047	159200	221326	217801	191683	147877	141900	184141	192441	202757	206555	208893
Total	2790868	2773083	2761603	2747144	2787917	2728669	2716482	2691103	2671920	2644601	2648251	2674015	2665555	2658274

¹ CM refers to 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 is more common on organic soils than on mineral soils. The percentage distribution in Table 7.11 is used as parameters when estimating the land use between different categories for all years between 1990 and 2003.

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 are slightly different from table 7.8 due to 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 per cent 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 the organic soils are divided in shallow and deep organic soils. 38% of the organic soils are according to the Danish soil classification deep organic soils (Sven Elsnap Olesen, DIAS, pers. comm).

The emission/sink from mineral soils are not reported this year, but will be reported from next year.

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 emission factors for organic soils are shown in Table 7.12 Negative values indicates a built 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 indicates a built up.

	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

¹Percentage 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 7.3 shows the C:N-ratio for 160 different soils. Hence for organic soils are used a C:N-ratio of 20. As emission factor is used the IPCC Tier 1 value of 1.25%.

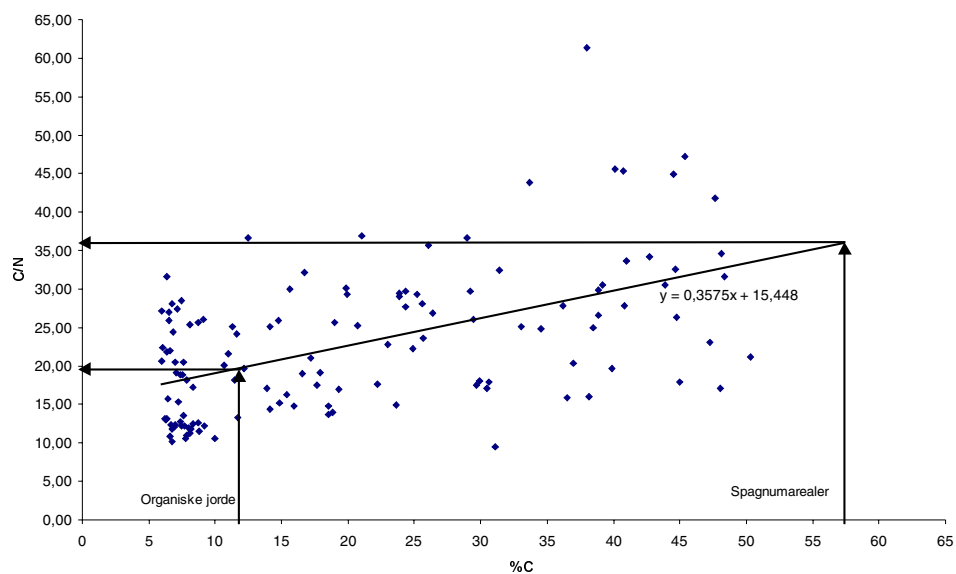


Figure 7.3 C:N-ratio in organic soils in relation to soil carbon content (Olesen 2004)

7.3.2.1 Emission from mineral soils

The removals/sinks from mineral soils are not reported this year due to methodological issues, but will be reported next year when a clarification of the methodology has been made.

7.3.2.2 Horticulture

Permanent horticultural plantations are reported separately under Cropland (Table 5.B). Permanent horticulture is only a minor production in Denmark. The total area for different main classes is given in Table 7.13. Due to the limited area and small changes between years the CO₂ removal/emission is calculated without a growth model for the different tree categories. Instead the average stock figures is used in Table 7.14 multiplied with 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 7.14. Expansion factors and densities are the same as used in forestry (Section 7.2).

Table 7.13 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
Apples, ha	2726	2462	3006	2209	2061	1658	1854	1697	1660	1623	1679	1783	1574	1624
Pears, ha	351	497	436	438	328	545	469	430	555	431	441	469	420	457
Cherries and Plumes, ha	2200	2200	2200	2222	2641	2854	3023	2794	2791	2956	3002	2903	2871	2967
Black currant, ha	1269	1486	2091	1919	2351	1827	1783	1531	1280	1411	1492	1850	1939	2028
Other, ha	250	250	250	449	337	348	343	323	235	272	412	376	384	448
Total, ha	6796	6895	7983	7237	7718	7232	7472	6775	6521	6693	7026	7381	7188	7524
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
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
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

Table 7.14 Parameters used to estimate the C-stock in perennial horticulture (Gyldenkerne 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

7.3.2.3 Hedgerows

Since the beginning of the early 1970s governmental subsidies has been given 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 erections. In 1990 75% of the old single-rowed Sitca-spruce hedgerows was replaced with 3- to 6-rowed broad-leaved hedges. In 2003 only 22% is replacements and the remaining is new hedges cf. Table 7.15. The figures are converted from kilometres to hectares according to the type of hedgerow. A simple linear growth model has been made to calculate the sink/removal from hedgerows. The parameters are given in Table 7.16. New hedgerows account for approximately 0.7% of the standing accounted C-stock. In 1990 there was a net emission because the removed hedgerows were 12-15 meters tall Sitca-spruce. From 1994 there has been a net sink in the new hedgerow due to increasing area and the decreasing replacing rate.

Table 7.15 Areas with new hedgerows, C stock and stock changes 1990-2003. (De danske Plantningsforeninger, 2004)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Replaced, %	75	75	75	75	77	36	27	32	30	28	27	25	23	22
Replaced, km	696	830	804	706	610	291	278	351	307	279	292	298	63	187
Replaced, ha	174	207	201	177	152	73	70	88	77	70	73	74	16	47
New hedges, ha	464	553	536	471	460	482	610	628	576	579	626	682	207	474
Removed hedge, Gg C y-1	-29	-34	-33	-29	-25	-12	-11	-14	-13	-11	-12	-12	-3	-8
Sink in new hedge, Gg C y-1	22	24	25	27	28	30	32	34	35	37	39	41	42	43
Stock change, Gg C y-1	-7	-10	-8	-2	3	18	20	19	23	26	27	29	39	36
Stock in new hedges, Gg C	155	179	204	231	259	289	320	354	389	427	466	507	549	592

Table 7.16 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

7.3.2.4 Emission from organic soils

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 7.17. The emission factors are given in Table 7.12. For 1990 to 2003 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 given by Statistics Denmark.

Table 7.17 C-emission from organic soils, Gg C y⁻¹.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Cropland, Gg C y ⁻¹	-602	-600	-601	-605	-614	-580	-590	-584	-595	-581	-582	-584	-569	-571
Grassland, Gg C y ⁻¹	-53	-52	-51	-48	-47	-50	-47	-41	-38	-39	-41	-42	-43	-43
Total organic soils	-655	-652	-652	-653	-660	-631	-637	-624	-633	-620	-623	-626	-612	-614

7.3.2.5 Nitrous oxide from organic soils

N₂O from organic soils are reported under the agricultural sector (Chapter 6.4) In the next reporting this emission will be included in the LULUCF sector.

7.4 Grassland

The area with grassland is defined as the area with permanent grass given in the annual census from Statistics Denmark (Table 7.8). In 2003 177,000 hectares is reported as permanent grassland. Based on the GIS analysis it is concluded that 34,640 hectares are organic and the remaining grassland is on mineral soils. For mineral soils the changes in C-stock are assumed to be zero. For the organic soils an CO₂-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 built up of organic matter is assumed (Table 7.12).

In Table 7.17 the annual emissions are given. The emission from grassland is reduced from 53 Gg CO₂ in 1990 to 43 Gg in 2003 due to a reduced area with permanent grass.

The submitted CRF emission from organic soils from Grassland (CRF Table 5.C) is included in the emission from organic soils under Cropland (CRF Table 5.B) due to an error. The total emission is however reported correctly. This has no influence on the total emission.

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 1,067 hectares decreasing to 885 hectares in 2003. 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 Finish data, a higher emission factor than recommended is chosen. This is in accordance with the difference in temperatures between Denmark and Finland (see Section 7.3) increased to 0.5 t C ha⁻¹ y⁻¹. The nitrous oxide emission from peat land is estimated from the total N-turnover multiplied with a standard emission factor of 1,25%. The C:N-ratio in the peat is estimated to 36 in an analysis from the Danish Plant Directorate (PDIR 2004). Hence the N₂O emission is estimated to 0.546 kg N₂O per t C.

Table 7.18 Annual emission from the surface area where peat extraction takes place, Gg C y⁻¹ and N₂O y⁻¹.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
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
Emission, Mg N ₂ O 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

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 has been reported to NERI. The total area converted to wetlands up to the year 2003 is 4,792 hectares and 3,767 hectares with raised water table. The area with raised water table will be unsuitable for annual cropping and protected by the legislation against future changes. Figure 7.4 shows the distribution of the areas in Denmark.

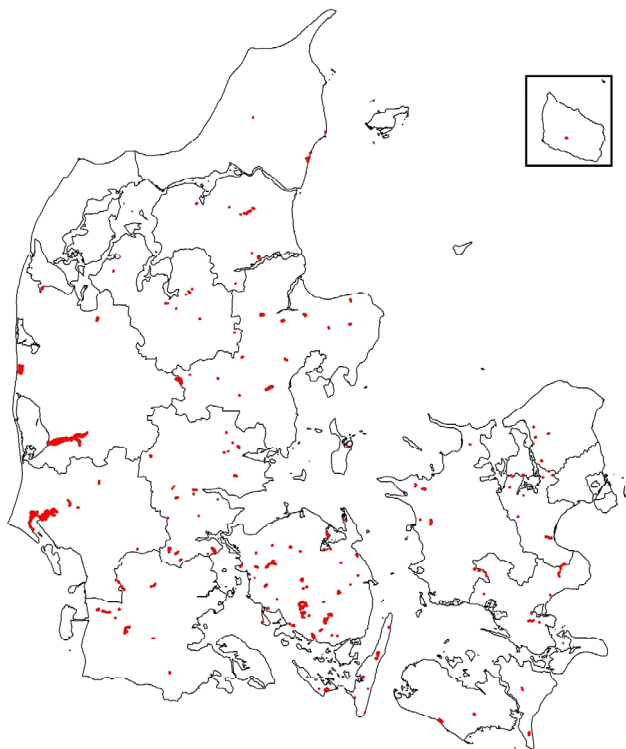


Figure 7.4 Areas with established wetlands and increased water tables from 1997 to 2003.

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 between mineral and organic soils differs (Table 7.19 and 7.20). In wetlands 68% of the area is on former cropland or grassland and in the areas with raised water table 81% 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. Furthermore, these areas have a higher percentage with organic soils. Only the areas with annual crops, set-aside, grass in rotation and permanent grassland are included in the emission estimates in the inventory. The parameters used to estimate the emission is given in Table 7.12.

Table 7.19 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	1824	863	243	274	168	1548	85%
Dry organic	1661	801	323	221	79	1424	86%
Wet mineral	412	34	21	52	31	138	33%
Wet organic	389	43	42	55	5	146	38%
Other	505	9	5	6	3	23	4%
Total	4792	1750	634	608	286	3279	68%

Table 7.20 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	1522	439	264	469	148	1319	87%
Dry organic	861	208	122	329	74	733	85%
Wet mineral	927	34	16	580	82	712	77%
Wet organic	369	19	27	176	45	267	72%
Other	89	8	4	13	3	28	32%
Total	3767	709	433	1567	351	3060	81%

The net-accumulation of C, with a standard sink factor of $0.5 \text{ t C ha y}^{-1}$ 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 to 3.17 Gg C (only former cropland and grassland is included) (Table 7.21). The decreased oxidation of organic matter of the organic soils (due to the re-wetting) is included in Table 5.B and 5.C as a decreased total area. Until a full matrix for the Danish area is performed there will be some inconsistency in the total area.

Table 7.21 Carbon sink in anthropogenic established wetlands, 1990-2003, Gg C y^{-1} .

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
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

7.6 Settlements

C-stocks in settlements are not estimated. The annual changes in C-stock in settlements are assumed to be negligible, but because no estimates have been made it is reported as 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 it is reported as 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 annually published the lime consumption for agricultural purposes since 1960 (Table 7.22). DAAC are collecting 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 are corrected for acid neutralisation contents for each product and thus given in pure CaCO_3 . For that reason there is no need to differ 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 the 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 $2,300 \text{ CaCO}_3 \text{ y}^{-1}$ in private gardens. This figure has been used for all years.

Only a very little 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 disappear as CO_2 the same year as the lime is applied.

The amount of lime used for agricultural purposes has declined with 60% since 1990. This is mainly due to a decreased need for acid neutralisation due to less SO_x deposition in Denmark and a reduced consumption of fertilisers containing ammonium. The inter-annual variation is primarily due to weather conditions (if it is possible to drive in the fields) and the economy in agriculture.

Table 7.6.1 Lime application on cropland and grassland and in forests, 1990-2003.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Agriculture, t CaCO_3	1283	1049	810	695	832	1125	891	1065	571	600	590	454	528	512
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
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
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

7.9 Planned improvements

Coming improvements will be the incorporation of a matrix for all LULUCF areas and implementation of C-stock changes in mineral soils. Furthermore, use of lime in animal fodder will be incorporated. N_2O emission from organic soils is currently reported under "Agriculture". This will be changed to LULUCF. Forests are described separately in Chapter 7.2.

7.10 Uncertainties

A Tier 1 uncertainty analysis has been made for part of the LULUCF sector cf. Table 7.23. The uncertainty in the activity data is rather low. The highest uncertainty is associated to the emission factors. Especially the emission from organic soils has a high influence on the overall uncertainty.

The LULUCF sector contributes to a large part of the total estimated uncertainty.

Table 7.23 Tier 1 uncertainty analysis for LULUCF. No estimates are given for forestry and mineral soils.

		Emission/sink, Gg CO ₂ -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		-2112.4				48.0	1014.7
Mineral soils	CO ₂	NE	NE	NE	NE		
Organic soils	CO ₂	-2251.5	10	50	51.0	51.0	1148.1
Hedgerows	CO ₂	131.0	5	20	20.6	20.6	27.0
Perennial horticultural	CO ₂	8.0	10	10	14.1	14.1	1.1
5.D Wetlands		1.7				63.5	1.1
Land for peat extraction	CO ₂	-0.4	10	50	51.0	51.0	0.2
Land for peat extraction	N ₂ O	0.1	10	100	100.5	100.5	0.1
Reestablished wetlands	CO ₂	2.1	10	50	51.0	51.0	1.1
Liming		226.2	5	50	50.2	50.2	113.7

7.11 QA/QC and verification

7.11.1 Other areas

The area estimates given in the above sections are very precise due to unrestricted access to detailed data from EUs 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. Together with detailed soil maps this gives a unique possibility 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 subsidiaries. The re-establishment of wetlands is based on vector maps received from every county in Denmark. Hardcopies, spreadsheets and digital maps are filed in secure files at NERI.

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. A formal agreement between other institutions and NERI is made on data collection, calculations and how data are interpreted.

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Appendix

A1. Emission from organic soils. Litterature 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	Kasimir 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	Kasimir 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	Kasimir et al.(1997) e. Berglund(1989)

A2 Output of Excel model used for calculation of the amounts of CO₂ sequestered due to afforestation since 1990.

Table A2.1. Main output table giving areas and annual and cumulated uptake of CO₂.

CO₂-sinks due to national afforestation programme

Planting year	Years after establishment	Afforestation area, ha				Total CO ₂ uptake	
		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							Stored wood for bioenergy, t CO2/ha
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, CO2/ha	t	Increment, t CO2/ha/yr	Storage, t CO2/ha			
1990	0	0	0	0	0	0	0	0	0	0	0	0		
1991	1	2	2	2	2	2	1	1	1	1	1	1	0	
1992	2	2	4	2	4	2	1	3	1	3	1	3	0	
1993	3	2	6	2	6	2	1	4	1	4	1	4	0	
1994	4	2	9	2	9	2	1	6	1	6	1	6	0	
1995	5	2	11	2	11	2	1	7	1	7	1	7	0	
1996	6	6	17	6	17	6	7	14	7	14	7	14	0	
1997	7	6	24	6	24	6	7	21	7	21	7	21	0	
1998	8	6	30	6	30	6	7	28	7	28	7	28	0	
1999	9	6	36	6	36	6	7	35	7	35	7	35	0	
2000	10	6	43	6	43	6	7	41	7	41	7	41	0	
2001	11	9	51	9	51	9	12	54	12	54	12	54	0	
2002	12	9	60	9	60	9	12	66	12	66	12	66	0	
2003	13	9	68	9	68	9	12	79	12	79	12	79	0	

Tables used to calculate total uptake of CO₂ based on annual cohorts of broadleaved and coniferous stands.

Table A2.3

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

Year	Age	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
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	Age (yr)	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
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

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* CH₄ emissions are considered in the following as a result of continuation of previously used and reported methodology.

For 6.B. *Wastewater Handling* the CH₄ and N₂O emissions are considered as a result of a survey carried out recently and since the NIR 2004 submission.

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

For the source sector 6.D. *Other* emissions from combustion of biogas in biogas production plants are included. The emissions are very small for all years: below 0.03 Gg CO₂ equivalent, taken as the sum of the GHG contributions.

In Table 8.1 an overview of the emissions is given. The emissions are taken from the CRF-tables and are presented rounded. The contribution from 6.D is not included, since the small contribution (refer above) is not to be seen in the digits chosen for this overview.

Table 8.1. Emissions (Gg CO₂ eqv.) for the waste sector.

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
6 A. Solid Waste Disposal on Land	CH ₄	1334	1358	1366	1379	1335	1286	1274	1208	1162	1191	1192	1188	1156	1153
6 B. Wastewater Handling	CH ₄	200	204	208	213	217	222	226	252	235	234	217	229	277	244
6 B. Wastewater Handling	N ₂ O	88	83	73	91	92	85	69	65	66	62	65	57	58	61
6. Waste	total	1622	1645	1648	1683	1645	1593	1570	1525	1463	1487	1475	1475	1492	1457

6.A *Solid Waste Disposal on Land* is the dominant source of the sector contributing around 80% of the total Gg CO₂ eqv. Through the time-series the emissions are decreasing due to the decreasing amounts of waste deposited.

6.B. *Wastewater Handling*. For this source CH₄ is the most contributing GHG and it contributes with about 12-19% to the sectoral total, with an increasing contribution through the time-series. Also, in absolute figures the CH₄ emissions from this source have 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 little recovery of methane potential by biogas production. N₂O from this source contributes with about 4-5% of the sectoral total. In absolute figures N₂O emissions decreases through the time-series. The decrease is due to the technical upgrade of the wastewater treatment plants resulting in a decrease in effluent wastewater loads, i.e. decrease in activity data, determining the indirect emission of N₂O, which is the major contributor to the emission of N₂O.

As a result the sectoral total in CO₂-equivalents decreases through the time-series. Compared with 1990 the 2003 emission is about 10% lower, Table 8.1.

8.2 Solid Waste Disposal on Land (CRF Source Category 6A)

8.2.1 Source category description

For the past many years only managed waste disposal sites have existed in Denmark. Unmanaged and illegal disposals of waste are considered to play a negligible role in this context.

The CH₄ emission from solid waste disposal on land at managed Solid Waste Disposal Sites (SWDS) constitutes a key source category both as regards level and trend. In the key source level analysis it is number 11 of 21 key sources and it contributes with 1.6% to the national total. As regards the key source trend analysis it is number 17 in the list where 22 are keys (Cf. Annex 1).

A quantitative overview of this source category is shown in Table 8.2 with the amounts of land-filled waste, the annual CH₄ emissions from the waste, the CH₄ 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 CH₄ emission can be found in the CRF tables submitted.

The amount of deposited waste has decreased markedly for 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% of all waste, to incinerate 24% of all waste and to 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 Strategy 2004-2008" report.

The decrease of the emission through the time-series is markedly, but much less than the decrease in amount deposited. This is due to the time involved in the processes generating the CH₄, which is reflected in the model used for emission calculation.

Table 8.2. Waste amounts in landfills and their CH₄ emissions 1990-2003.

Year	Waste kt	Annual emission	Biogas collected kt CH ₄	Annual net emission	
		kt CH ₄		kt CH ₄	kt CO ₂ -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	10,0	55,1	1156,2
2003	966,0	63,2	8,3	54,9	1152,8

Disposal of waste takes place at 135 registered sites (2003). The organic part of the deposited waste at these sites generates CH₄ gas, some of which 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 and 2005). 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 CH₄ 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
- Card-board
- 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
Card-board	0.40
Paper	0.40
Wet card-board and paper	0.20
Plastics	0.85
Other Combustible	0.20 - 0.57
Glass	0
Other not Combustible	0

Since, the Danish SWDSs are well-managed it is assumed that 10% of the CH₄ produced by the waste is oxidised (OX = 0.1; refer GPG page 5.10) and a further consequence of the SWDSs being managed is that a methane correction factor of 1 is used (GPG page 5.9, Table 5.1). Further, as the fraction of DOC dissimilated is used 0.50, which is considered good practice (GPG page 5.9). Finally, the fraction of CH₄ 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. CH₄ emission factors according to waste types.

Waste type	DOC-fraction of waste (1)	Fraction of waste emitted as CH ₄ 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 tonnes of waste food: 54 kg of CH ₄ is emitted		

The emission estimates are build upon a composition of the deposited waste, as shown in Table 8.6, and which are according to Danish investigations.

Table 8.6. ISAG waste types and their content (fraction) of waste types with calculated emission factor.

	Waste food	Card-board	Paper	Wet Card-board and paper	Plastics	Other Combustible	Glass	Metal	Other not Combustible	Sum
Materiale fractions in										
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 worked out (Table 8.5). This composition is kept for the whole time-series.

The emission factors for the ISAG waste types are now 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 CH₄/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 have also been given since we do not find it descriptive for the Danish data and for the methodology used to estimate and to fill out the part of CRF Table 6A,C called “additional information” on composition of waste.

8.2.2.2 The model and its results

The CH₄ 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 is used a Half-life time of the carbon of 10 years, corresponding to (refer GPG page 5.7):

$$k = \ln 2 / 10 = 0.0693 \text{ year}^{-1}$$

which is in line with values mentioned in the GPG and close to the GPG default value of 0.05.

The model calculations are not performed per dumping site, but for all waste dumped 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. This emission is withdrawn the CH₄ captured by biogas installations at some of the sites. The result is annual net emissions. The captured amounts of CH₄ are according to the Danish energy statistics. The waste amounts and the calculated CH₄ emissions are shown in Table 8.8.

Table 8.8. Amounts of waste and CH₄ emissions for 1990-2003.

Year	Dome- stic Waste	Bulky Waste	Garden Waste	Com- mercial & office Waste	Indu- strial Waste	Building & cons- truction Waste	Sludge	Ash & slag	Waste Total kt	Potential emission kt CH ₄	Annual emission kt CH ₄	Biogas collected kt CH ₄	Annual net emission kt CH ₄
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	10,0	55,1
2003	24,0	143,0	4,0	131,0	379,0	170,0	55,0	60,0	966,0	37,6	63,2	8,3	54,9

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. Doing so and referring to the discussion of waste amounts in GPG at page 5.8 it is clear that these amounts is not really characteristics of the term of Municipal Solid Waste. Further, it should be noted that these amounts are used to calculate the waste amount produced per capita in the Table 6A,C of the CRF and that these per capita amounts therefore may not be comparable to other parties using different approaches.

The implied emission factor (IEF) in the CRF tables reflects an aggregated emission factor for the model. So far this IEF has been increasing from 1990 to 2001 despite the decreasing amount of waste since 1995. This is due to the time lag of emissions from the deposited waste calculated by the model.

In Annex 3.E further details on the model for CH₄ 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 8.9. 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 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 GPG.

As regards the uncertainty given in the GPG for the methane generation constant, k , (-40%, +300%) this uncertainty can not be included in simple equations for the total uncertainties like 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. Based on these runs on the actual poten-

tial emissions, actual mean differences on calculated CH₄ emissions for 1990-2003 are found to be – 17.8% +9.8%.

The final uncertainty on the emission factor is from uncertainty estimates in Table 8.9 and with the use of GPG Equation 6.4 calculated to

Uncertainty of emission factor total % = $\text{SQRT}(50^2+30^2+10^2+10^2+17,8^2) = 40.8\%$

Table 8.9. Uncertainties for main parameters of emissions of CH₄ 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	17,8%	see the text

8.2.3.2 Time-series consistency and completeness

The registration of the amount of waste has been done since the beginning of the 1990s in order to measure the effects of action plans. The activity data is therefore considered to be consistent long enough to make the activity data input to the FOD model reliable.

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 IPCC GL and GPG. The Half-life time parameter used is within the intervals recommended by IPCC GPG.

As regards completeness the waste amounts used, as registered in the ISAG system, does 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 QC-procedure

QC-procedure on data input and handling is when the CH₄ emission results of the runs from the FOD model are compared/adjusted to the CH₄ emissions in the CRF-tables.

8.2.4.2 QA-procedure

It is good practice and a QA-procedure to compare the emission estimates included in the inventories with the IPCC default methodology.

In Table 8.10 default methodology is used combining the GPG and the IPCC GL according to the referring text in the table. The used parameters are (as on the pages of the IPCC GL and IPCC GPG) referred to in the table. As for the calculation of DOC in the default methodology the Danish data is not suited for direct use. Referring to the formula in GPG p5.9 we assume (referring to the Table 8.6) that A is "Cardboard", "Paper", "Wet Cardboard and Paper", that B is "Plastic", "Other

Combustible” and “Other not Combustible” and that C is “Waste food”. And we calculated a mean fraction of those categories to be used in the default methodology.

Table 8.10. IPCC default methodology for CH₄ emissions from SWDS for 1990-2003

Parameter	Reference	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
MSW	Population 1000 cap	5140	5153	5170	5188	5208	5228	5248	5268	5287	5305	5322	5338	5351	5384
MSWT	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
MSWF	Waste generation GL Table 6-1 Gg/year	2364	2370	2378	2386	2395	2404	2414	2423	2431	2440	2448	2455	2461	2476
MCF	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
DOC	Methan Corr Factor GPG p 5.8	1	1	1	1	1	1	1	1	1	1	1	1	1	1
DOCF	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
F	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
Lo	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
R	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
OX	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	10,0	8,3
CH4 emissions	Oxid. Factor GPG p5.10 Gg CH4/year	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
		29,7	29,6	29,1	28,9	26,4	24,0	23,5	20,9	19,2	20,8	21,3	22,3	22,4	24,1

The table shows that the default methodology underestimates both the amounts of deposited waste and the CH₄ emissions by a factor 2-3. The reason is that the default methodology does not seem to include Industrial Waste, which to a high degree is deposited in Denmark, Table 8.8.

A further option in the default methodology is to include the registered total waste amount with the generation rate of waste for total waste and include the fraction of deposited waste to SWDS, Table 8.11. The fraction as well as the generation rate for total waste is included in the CRF Table 6 A,C “Additional inf”.

Table 8.11. As Table 8.10 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
MSW	Population 1000 cap	5140	5153	5170	5188	5208	5228	5248	5268	5287	5305	5322	5338	5351	5384
MSWT	Waste generation rate ISAG kg/cap/year	5,4	5,5	5,6	5,7	5,8	6,0	6,7	6,7	6,3	6,3	6,7	6,6	6,7	6,5
MSWF	Waste generation GL Table 6-1 Gg/year	10169	10403	10637	10871	11105	11466	12912	12857	12233	12233	13031	12768	13105	12835
MCF	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
DOC	Methan Corr Factor GPG p 5.8	1	1	1	1	1	1	1	1	1	1	1	1	1	1
DOCF	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
F	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
Lo	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
R	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
OX	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	10,0	8,3
CH4 emissions	Oxid. Factor GPG p5.10 Gg CH4/year	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
		194,9	187,4	178,9	170,2	158,7	168,8	157,4	121,2	105,2	83,3	81,5	72,4	66,2	58,0

The result of this adjusted default methodology is CH₄ 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 to the results of the FOD model. One explanation is that the FOD model reflects the ongoing process through the years with the generation of CH₄ 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 2005 recalculations were carried out as compared to the final submission in 2004 of inventories 1990-2002. The recalculation is a minor correction and solely due to updates in the energy statistics of the uptake of CH₄ by installations at SWDS' for energy production. For 1998 the correction of the actual CH₄ emission is -4.8% and for the other years the numeric correction is below 3%, refer to recalculation tables of the CRF submitted in parallel to this NIR.

8.2.6 Planned improvements

In the response to the expert review team on the 2004 submissions the methodology has not been changed but effort has been made to improve the description, perform QA comparisons and perform uncertainty analyses.

It is planned to analyse the influence of a changed distribution through the time-series of the composition of the deposited waste. Data availability and expert judgement of the evidence for such a change is part of the planned investigation.

8.2.7 References

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>

Danish Environmental Protection Agency 1998: Waste Statistics 1997.

http://www.mst.dk/udgiv/Publications/1998/87-7909-106-7/html/default_eng.htm

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 CH₄ and N₂O from wastewater handling. CH₄ is emitted from anaerobic treatment processes, while N₂O may be emitted from anaerobic as well as from 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. The data material defines which calculations and

which disaggregation level that can be achieved in the estimation of emissions from wastewater handling and thus, as a part of the source description, the next section outlines the data.

8.3.1.1 Key data sources used in the emission calculations

The data used for the amount of industrial and municipal wastewater inlet and outlet amounts and treatment processes is according to the official registration performed by DEPA in the report series *Wastewater from municipal and private wastewater treatment plants* (Danish title: *Spildevandsslam fra kommunale og private renselanlæg*), DEPA 1989, 1999, 2001, 2003 and 2004, and *Point sources* (Danish title: *Punktkilder*), DEPA 1994, 1996, 1997, 1998, 1999, 2001, 2002 and 2003. Some of the data can be found in the DEPA database *Environment Data* and for point sources before 2003 in the Statistics Denmark's database *StatBank Denmark*. For the check method data on population is found in *Statbank Denmark*. Data on protein consumption is found in the FAOSTAT database. Based on the national registered wastewater data it is not possible to discriminate between industrial and municipal wastewater in the country-specific calculations.

Until 2002 the Statistics Denmark was registering the load of nitrogen, phosphor and organic matter in effluent wastewater from different types of point sources. Data on the nitrogen in effluents is extracted from the Statistics Denmark's database and point source data reported within the Danish Monitoring programme by the DEPA (report series from the DEPA with English title *Point Sources*).

8.3.1.2 Summary of results

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 2003 is given in Table 8.12

Table 8.12. CH₄ 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	18.03	9.52
1991	2.41	4.60	1.34	0.27	8.62	18.34	9.72
1992	2.43	4.52	1.49	0.30	8.73	18.66	9.93
1993	2.44	4.44	1.63	0.32	8.84	18.98	10.14
1994	2.46	4.36	1.78	0.35	8.95	19.30	10.35
1995	2.47	4.29	1.92	0.38	9.06	19.63	10.57
1996	2.49	4.21	2.07	0.40	9.17	19.95	10.78
1997	2.19	4.42	1.23	0.46	8.29	20.28	11.99
1998	2.52	4.05	2.36	0.45	9.39	20.60	11.21
1999	2.25	4.29	2.67	0.55	9.76	20.92	11.16
2000	3.64	3.12	3.61	0.51	10.88	21.24	10.36
2001	2.74	4.28	3.19	0.43	10.63	21.55	10.92
2002	1.91	3.47	2.87	0.41	8.65	21.86	13.21
2003	2.61	3.67	3.08	0.58	9.94	21.39	11.45

Note 1: For 1990-2002 the data corresponds with exception of rounding to data in the CRF submitted. For 2003 the CH₄ emission in CRF is 11.62. The reason for this minor discrepancy is that the CRF had to be finalised on data, which for 2003 was preliminary. Correction will be made in next CRF submission.

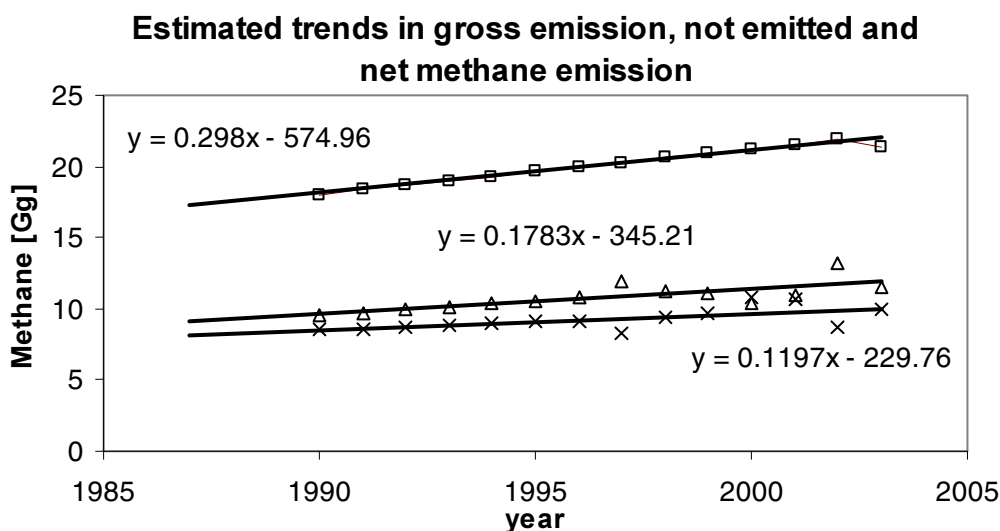


Figure 8.1. Estimated time trends for the gross emission of methane (open squares), not emitted; i.e. sum of column 2 to 5 in Table 8.12 (crosses) and net emission (open triangles).

Based on the data estimated, Table 8.1, a time trend analysis has been carried out (Figure 8.1). This analysis shows that the net emission of methane increases about 0.2 Gg per year, which is a result of an increase in the gross emission of on average 0.3 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 42% in the years from 1997 to 2003. In addi-

tion, technical upgrades of the WWTPs (with the goal of reducing the effluent loads of nutrient according to the Water Environment Action Plan) which was launched by the Danish parliament (cf. Annex 3E) may result in an increased emission from anaerobic treatment processes. Based on the above figures, on average 50% of the methane potential are combusted through out the period 1990-2003. The decrease in the internal combustion is accompanied by a parallel increase in the external combustion and combustion processes included in the production and reuse of sludge in sandblasting products.

The emission of N₂O by wastewater handling is calculated as a sum of contributions from wastewater treatment processes at the WWTPs and from sewage effluents. Emissions from effluent wastewater are derived from registered activity data of effluent wastewater nitrogen loads from point sources as given in Table 8.13, which includes a summary of the results of the N₂O estimation.

Table 8.13. N₂O emission from: effluents from point sources, wastewater treatment processes and in total [tonnes].

Year	N ₂ O, effluent from separate industry discharges	N ₂ O, rainwater conditioned effluent	N ₂ O, effluent from scattered houses	N ₂ O, effluent from mariculture and fish farming	N ₂ O, effluent from municipal and private WWTPs	N ₂ O, effluents in total Tonnes	N ₂ O, WWTP, direct	N ₂ O, 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

Note 1: For 1990-2002 the data corresponds with exception of rounding to data in the CRF submitted. For 2003 the N₂O-emission in CRF is 0.20 Gg (=196 tonnes). The reason for this minor discrepancy is that the CRF had to be finalised on data, which for 2003 was preliminary. Correction will be made in next CRF submission.

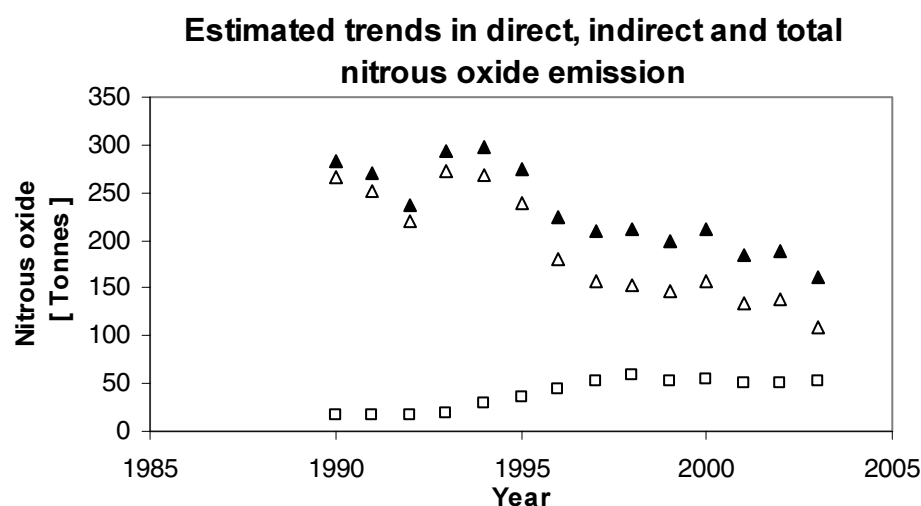


Figure 8.2. Time trends for direct emission of N_2O (open squares), indirect emission, i.e. from wastewater effluents (open triangles) and total N_2O emission (black triangles).

The estimated data (Table 8.13) regarding the indirect, direct and total emission of N_2O is shown in Figure 8.2 as time trends. The direct emission is slightly increasing reaching a stable level from 1997 and forward. The decrease in the indirect emission from effluent wastewater is due to the technical upgrade of the WWTPs and resulting decrease effluent wastewater nitrogen loads. The indirect emission, which is the major contributor to the emission of nitrous oxide, is not expected to decrease much more as effluent reduction of N has increased from 65% in 1993 to about 80% in 2003.

8.3.2 Methodological issues

This section is divided into methodological issues related to the CH_4 and N_2O emission calculations, respectively. In each of the subsections there are italic underlined headlines describing key elements of the calculation procedures.

8.3.2.1 Methodological issues related to the estimation of CH_4 emissions

There has not previously been any complex or high aggregation country-specific methodologies developed for estimating CH_4 emissions from wastewater handling in Denmark. The methodology developed for this submission for estimating emission of methane from wastewater handling is following the IPCC Guidelines (1996) and IPCC Good Practice Guidance (2000).

According to 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 IPCC default methodology for household wastewater has been applied by accounting and correcting for the industrial influent load (cf. Annex 3.E).

Based on TOW data an estimate of the gross emission of CH_4 is derived. The gross emission of CH_4 is calculated by using national data on total organic degradable waste (BOD) 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 anaerobic have been used as a measure of the Methane Conversion Factor (MCF),

assuming that the treatment is 100% anaerobic. The MCF was multiplied by default value of 0.6 kg CH₄/kg BOD for the maximum CH₄ producing capacity B₀ to calculate EF. A representative value of 0.15 kg CH₄/kg BOD as EF was obtained for the Danish WWTPs (cf. Table 8.15 and Annex 3.E).

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 CO₂. These fractions have been subtracted from the calculated (theoretical) gross emission of CH₄. 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 the 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 EF for calculation of the gross emission of CH₄

Available activity data for calculating the gross CH₄ emission are given in Table 8.14 and 8.15.

Table 8.14. Total degradable organic waste (TOW) calculated by use of country-specific data.

year	1993	1999	2000	2001	2002	2003
BOD (mg/L)	129.6*	160	175	203	189	300
Influent water (million m ³ / year)	-	825	825	720	809	611
TOW (tonnes BOD/year)	129600	132000	144375	167475	155513	247500
TOW (tonnes BOD/year)**		148500	138600	163350	163020	216810

*BOD for the year 1993 is given in 1000 tonnes, whereas the amount of influent water is not given (DEPA, Point Sources 2002 (2003)).

** Calculated from country-specific COD data by use of BOD=COD/2.5.

No data has been found regarding the maximum CH₄ producing capacity of specific types of wastewater or sludge types, therefore the default value, given in the IPCC Good Practice Guidance, of 0.6 kg CH₄/kg BOD is used. The emission factor is calculated by multiplying the maximum methane producing capacity (B₀) with the fraction of BOD that will ultimately degrade anaerobic, i.e. the methane conversion factor (MCF).

The fraction of sludge, in wet weight (ww), treated anaerobic 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 anaerobic is treated 100% anaerobic and therefore no weighted MCF is calculated. The per cent sludge that is treated anaerobic and the calculated emission factor for every year - where MCF data is available - is given in Table 8.15.

Table 8.15. Emission factors (EFs) calculated as the maximum CH₄ producing capacity multiplied by MCF.

Year*		1997	1999	2000	2001	2002
Stabilization 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	per cent	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 CH ₄ /kg BOD	0.19	0.14	0.15	0.15	0.12

*The Danish EPA has not yet released Data for 2003

The average fraction of sludge treated anaerobe 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 1997 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 WWT processes. It seems reasonable to assume a constant emission factor of 0.15 kg CH₄ / kg BOD based on the ww fraction of sludge treated anaerobic.

Data gap filling procedures for arriving at gross emissions from 1990 to 2003 are given in Annex 3.E. For additional information see Thomsen & Lyck (2005).

Activity data and EF for calculation of the amount of recovered or not emitted CH₄ potential

Available activity data and EF for calculating the amount of recovered and flared CH₄ potential (theoretical negative methane emission) is given in Table 8.16 and in the text below.

Table 8.16. Sludge in per cent of the total amount of sludge and tonnes dry weights (dw) according to disposal categories of relevance to CH₄ recovery.

Unit	Year	Combustion internal	Combustion external	Biogas	Other*
per cent	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 IPCC GPG background paper (2003) estimates the maximum methane producing capacity to be 200 kg CH₄/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= B₀ * MCF). The fraction of the gross CH₄ emission, not emitted in reality, is then the dry weight of the category biogas multiplied by an EF of 200 kg CH₄/tonnes raw dry solids. For comparison, the biogas yield, i.e. EF is given to be within 250 to 350 m³/tonnes organic solids for sewage sludge in a report on biogas systems by IEA Bioenergy (x, undated). The density of methane gas is 0.715 kg/m³ at standard conditions, which gives an average EF of 214.5 kg CH₄/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 8.16.

As seen from Table 8.16 there are gaps in the data. See Annex 3.E for details concerning data gap-filling.

8.3.3 Methodological issues related to the estimation of N₂O emissions

While CH₄ is only produced under anaerobic conditions, N₂O may be generated by nitrification (aerobic process) and denitrification (anaerobic process) 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. N₂O is an

intermediate of both processes. Danish investigation indicates that N₂O is formed during aeration steps in the sludge treatments process as well as during anaerobic treatments; the former contributing most to the N₂O emissions during sludge treatment (Gejlsberg et al, 1999).

Methodology - Direct N₂O emission

A methodology for estimating the direct emission of N₂O from wastewater treatment processes has been derived. The EF is derived from a factor of 3.2 g N₂O/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 N₂O is (3.52*3.2) 11.3 g N₂O/capita per year.

The correction factor of 3.52 is derived from the difference in average nitrogen influent load at large and medium size 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 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 N₂O/capita per year is used in the calculations. The influent load of nitrogen is assumed to increase similar to the industrial influent loads of BOD given in per cent in Table 8.17. The estimated Danish emission factors as function of the increase in industrial influent load in the Danish WWTPs are given in Table 8.17.

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 number, $F_{connected}$ is the fraction of the Danish population connected to the municipal sewer system (0.9) and $EF_{N_2O,WWTP,direct}$ is the emission factors given in Table 8.17.

Activity data and EF for calculating the direct N₂O emission

Table 8.17. EF and activity data used for calculating the direct emission of N₂O from wastewater treatment processes at Danish WWTPs.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
N-pop (1000)	5140	5153	5170	5188	5208	5228	5248	5268	5287	5305	5322	5338	5351	5383
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
% industrial load	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	42.0
Danish EF*	3.8	3.8	3.8	4.2	6.2	7.8	9.4	11.0	12.3	11.0	11.2	10.0	10.4	11.3

*where data are available for calculating EF, the average value, of the calculated by national data and by regression, is given.

The industrial loads of wastewater influent loads given in Table 8.17 for years 1990-2003 have been estimated from the original and registered data (Table 3.E.3, Annex 3.E). For the year 1990 to 1992 the industrial influent load is set to an average of 2.5 %. From the year 1993 to 1997 the percentages are assumed to continue to increase as shown in Table 8.17. The Danish emission factors are based on a regression of per cent 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 1997 and forward. This is consistent with a fairly constant fraction of industrial wastewater influent from 1997 and forward.

Methodology – Indirect emissions - from sewage effluents

The IPCC default methodology only includes N₂O emissions from human sewage based on annual per capita protein intake. The methodology only accounts for nitrogen intake, i.e. faeces and urine and neither the industrial nitrogen input nor non-consumption protein from kitchen, bath and laundry discharges are included. The default methodology used for the ten per cent 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 ten per cent of the Danish population not connected to the municipal sewer system. The effluent N load is added 10 per cent 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:

$$E_{N_2O,WWTP,effluent} = \left[(P \cdot F_N \cdot N_{pop} \cdot F_{nc} \cdot F) + (D_{N,WWTP} + (D_{N,WWTP} \cdot 0.1)) \right] \cdot EF_{N_2O,WWTP,effluent} \cdot \frac{M_{N_2O}}{2 \cdot M_N}$$

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 (added ten per cent to account for data not included in the statistics)

$EF_{N_2O,WWTP,effluent}$ is the IPCC default emission factor of 0.01 kg N₂O-N/kg sewage-N produced (IPCC GL, p 6.28)

M_{N_2O} and M_N are the mass ratio i.e. 44/28 to convert the discharged units in mass of total N to emissions in mass N₂O

Activity data used for calculation of the indirect N₂O emission

In Table 8.18 activity data is referring to $D_{N,WWTP}$, the effluent discharged nitrogen load.

Table 8.18. Discharges* of nitrogen from point sources [tonnes].

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Separate industrial discharges				2574	2737	2471	1729	1800	1428	863	897	812	752	509
Rainwater conditioned effluent		921	882	1025	1207	867	629	800	968	975	762	758	1005	685
Scattered houses				1280	1210	1141	1143	1123	997	972	979	1005	968	957
Mariculture and fish farming				1737	1684	1735	1543	1494	1241	1418	2714	1757	1487	1162
Municipal and private WWTPs	16884	15111	13071	10787	10241	8938	6387	4851	5162	5135	4653	4221	4528	3614

*It should be mentioned that it is not possible to estimate any direct emissions from industrial on-site wastewater treatment processes.

8.3.4 Uncertainties and time-series consistency

The parameters considered in the uncertainty analyses and the estimated uncertainties of the parameters are shown in Table 8.19. For all uncertainties symmetric values based on maximum numeric value are estimated (cf. e.g. section 8.2.3.1 of this chapter).

Table 8.19. Uncertainties for main parameters of emissions for wastewater handling.

Parameter	Uncertainty	Reference / Note	Emission type
TOW	±30%	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	
EF _{N₂O,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 ₂ O emission
F _{connected}	±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 / Our estimate	Indirect N ₂ O 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 / Our estimate	
D _{N,WWTP} is the effluent discharged sewage nitrogen load	±30%	Not known / Our estimate	
EF _{N₂O,WWTP,effluent} is the IPCC default emission factor of 0.01 kg N ₂ O-N/kg sewage-N produced	±30%	Not known / Our estimate	
M _{N₂O}	0%	Empirical number without uncertainty	

At this point information regarding industrial on-site wastewater treatment processes is not available at a level of data that allows for calculation of the on-site industrial contribution to CH₄ or N₂O 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 8.19, and with the use of GPG Equation 6.3 and 6.4, is as follows:

Methane:

Uncertainty in estimating the gross emission of CH₄, U_{gross}:

$$U_{\text{gross}} = \text{SQRT}(28^2 + 30^2 + 30^2) = 50.8\%$$

Uncertainty in estimating the recovered or not emitted CH₄, U_{not emitted} is estimated to be equal for all four categories at this stage:

$$U_{\text{not emitted}} = \text{SQRT}(30^2 + 50^2) = 58.3\%$$

The total uncertainty, U_{total} , on the CH_4 emission estimates is estimated to be about 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 anaerobic or by final sludge categories leading to a reduction in the gross emission.

Nitrous oxide:

Uncertainty estimates for the direct N_2O emission, U_{direct} :

$$U_{\text{direct}} = \text{SQRT}(30^2 + 5^2 + 5^2) = 30.8\%$$

Uncertainty in the indirect N_2O emission, U_{indirect} , has been calculated as the uncertainty in the emission from people connected and not connected to a WWTP, respectively, by use of Eq. 6.3 in the IPCC GPG.

The uncertainty in the emission of N_2O based on the fraction of people not connected to a WWTP:

$$U_{\text{not connected}} = \text{SQRT}(30^2 + 5^2 + 5^2 + 30^2 + 30^2) = 52.4\%$$

The uncertainty in the emission from wastewater based on the fraction of people connected to a WWTP:

$$U_{\text{connected}} = \text{SQRT}(30^2 + 30^2) = 42.4\%$$

The resulting total uncertainty in the N_2O emission is estimated to be about 26% at this stage. The total uncertainty has been estimated based on uncertain quantities equal to the fraction of people connected and not connected respectively multiplied by the average effluent N from household and WWTPs including industry 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).

8.3.5 QA/QC and verification

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

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 was in agreement. The total emissions when aggregated to CRF source categories are in agreement with the totals based on SNAP source categories.

Methane emissions

1. Comparison of country-specific TOW data with the default European method for calculating TOW given in the 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 are 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 Check method and the default IPCC method (cf. Annex 3.E)

The IPCC GPG provides a check method for calculating the CH₄ 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 check method is used as reference for the two other methods for the purpose of quality assurance and validity assistance. Results are given in Table 8.20.

Table 8.20 Annual CH₄ emissions based on the check method and the country specific method for CH₄ 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 is ranging from approximately 27 to 28 Gg per year. The default fraction of organic matter that degrades anaerobic is too high, i.e. 0.8, whereas 0.2-0.4 is more realistic according to national data (cf. Table 8.16). On the other hand, the check method does not account for 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 the late year 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

As there are no check method given in the IPCC and 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, these calculations are more or less straightforward.

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.

8.3.6 Recalculations

The emissions from wastewater handling were previously reported as zero. The methodology used for the CRF Source Category 6B for CH₄ and N₂O emissions is included for the first time in this submission.

8.3.7 Planned improvements

Improvements in the calculation of the maximum methane producing potential with focus on disaggregation into sewage and sludge treatment processes will be investigated. Improvements in

methodology for calculating the direct emission of N₂O, by improved data availability of nitrogen, will be investigated. Consideration will be given to uncertainty analysis by ways of the Monte Carlo analysis.

8.3.8 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 are used in the energy production.

The amounts of waste incinerated are given in the CRF-table 6A,C.

As regards further on waste incineration (cf. the Energy sector in this report).

8.5 Waste Other (CRF Source Category 6D)

8.5.1 Source category description

Emission from 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)

Chapter 9 is not relevant to this NIR report

10 Recalculations and improvements

10.1 Explanations and justifications for recalculations

Explanations and justifications for the recalculations included in the data in the CRF-format submitted April 15, 2005, and performed since the submission May 19, 2004 are given in the following sector chapters:

Energy:

- Stationary Combustion Chapter 3.2.5
- Transport Chapter 3.3.7

Industry

- Mineral Products Chapter 4.2.5
- Consumption of F-gases Chapter 4.6.5

Solvents and Other Product Use Chapter 5.2.5

Agriculture Chapter 6.8

LULUCF Chapter 7

Waste

- Solid Waste Disposal on Land Chapter 8.2.5
- Wastewater Chapter 8.3.6

10.2 Implications for emission levels

The implication of the CRF data, submitted April 15, 2005, and in parallel to the submission of this NIR as compared to the latest submitted data is shown as the recalculation data, see CRF Table 8 for 1990-2002. In these tables the differences between the April 15, 2005 submission and the latest submission are calculated. The latest submission of CRF-tables for 1990-2002 was May 17, 2004. However, the May 17, 2004 submission represented no change in emission values as compared to the submission April 15, 2004. The calculation of differences is in per cent so that positive and negative values of this percentage reflect that the April 15, 2005 submission represents bigger respectively smaller emissions than the latest submitted emission value from May 17, 2004. Results from these CRF tables as regards national totals are presented in Table 10.1.

For the *National Total CO₂ Equivalent Emissions without Land-Use Change and Forestry* the general impact of the recalculations performed is small. All the differences for this national total for the time-series as taken from the recalculation tables of the CRF tables for 1990-2002 varies between +0.84% (1990) and -0.50% (1997).

For the *National Total CO₂ Equivalent Emissions with Land-Use Change and Forestry* the general impact of the recalculations is rather small, although the impact is bigger than without LULUCF due to recalculations in the LULUCF Sector. The differences are positive for all years. The differences vary between 2.75% (1996) and 5.41% (1990). These differences refer to recalculated estimates with major changes in the forestry sector for those years, see Chapter 7.

Table 10.1 Recalculation performed in year 2005 for inventories 1990-2002 compared to submission May 17, 2004. National totals with and without LULUCF.

			Total CO2 Equivalent Emissions with Land-Use Change and Forestry	Total CO2 Equivalent Emissions without Land-Use Change and Forestry
1990	Previous submission	CO2 equiva	65.917,86	68.749,86
	Latest submission		69.486,51	69.328,22
	Difference	(%)	5,41	0,84
1991	Previous submission	CO2 equiva	76.458,40	79.471,40
	Latest submission		79.879,12	79.991,87
	Difference	(%)	4,47	0,65
1992	Previous submission	CO2 equiva	70.258,84	73.258,84
	Latest submission		73.538,97	73.791,36
	Difference	(%)	4,67	0,73
1993	Previous submission	CO2 equiva	72.410,00	75.625,00
	Latest submission		75.706,85	76.173,08
	Difference	(%)	4,55	0,72
1994	Previous submission	CO2 equiva	76.573,07	79.673,07
	Latest submission		79.375,88	79.706,14
	Difference	(%)	3,66	0,04
1995	Previous submission	CO2 equiva	73.963,41	76.955,41
	Latest submission		76.465,54	76.699,99
	Difference	(%)	3,38	-0,33
1996	Previous submission	CO2 equiva	87.214,31	90.278,31
	Latest submission		89.610,16	90.032,61
	Difference	(%)	2,75	-0,27

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 equiva	77.519,91	80.672,91
	Latest submission		79.830,05	80.272,92
	Difference	(%)	2,98	-0,50
1998	Previous submission	CO2 equiva	72.344,39	75.657,39
	Latest submission		75.260,30	76.079,36
	Difference	(%)	4,03	0,56
1999	Previous submission	CO2 equiva	69.241,31	72.552,31
	Latest submission		72.029,87	72.900,07
	Difference	(%)	4,03	0,48
2000	Previous submission	CO2 equiva	67.155,16	67.808,16
	Latest submission		70.095,31	68.313,78
	Difference	(%)	4,38	0,75
2001	Previous submission	CO2 equiva	65.774,30	69.313,30
	Latest submission		68.566,08	69.724,02
	Difference	(%)	4,24	0,59
2002	Previous submission	CO2 equiva	64.677,98	68.490,98
	Latest submission		67.520,61	68.996,35
	Difference	(%)	4,40	0,74

10.3 Implications for trends, including time-series consistency

It is a high priority in the considerations leading to the performed recalculations back to 1990 to have and preserve consistency of the time-series of activity data and emissions. As a consequence activity data, emission factors and methodologies are carefully chosen to represent the emissions for the time-series correctly. It is often considerations regarding the time-series consistency that have led to recalculations for single years when activity data and/or emission factors have been changed or corrected. Further, when new sources are considered, activity data and emissions are introduced to the inventories for the whole time-series with as much basis as possible on the same methodology.

In Section 10.2 it was mentioned that for the *National Total CO₂ 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 -0.50 and +0.84%. 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 CO₂-equivalents. Memo items are not shown. The table is made on CRF source categories where recalculations have been performed. Also the difference on the level of national total without LULUCF is shown. E.g. in Table 10.2 the contributions for the source categories to the national total result on recalculation differences can be directly considered in absolute CO₂-equivalents. The table is based on extracted data from 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).

From Table 10.2 it can be seen that the biggest and major recalculation has taken place for the CRF category CO₂ *Emissions and Removals from Soil*.

In general terms the second largest recalculation is the category *Wastewater Handling* and CH₄ emission. *Wastewater Handling* is a source introduced with this submission. Introducing this source also leads to another considerable recalculation, which is N₂O emission from *Wastewater Handling*, in general terms, the third largest recalculation. However, none of these sources are key sources. Refer to Chapter 8, Section 3, for details on emissions from *Wastewater Handling*.

The category *Solvent and Other Product Use* with CO₂ emissions constitutes another considerable recalculation. This recalculation is a result of the introduction of new methodology.

Other considerable recalculations are for CO₂ emissions for the category *Energy 1.A.2. Manufacturing Industries and Construction* with a varying difference through the time-series and for CO₂ emissions for *Energy 1.A.4. Other sectors*. The dominating reason for these recalculations is new and updated energy statistics.

For CH₄ from *Solid Waste Disposal on Land* some minor recalculations have been performed due to updates on the energy statistics leading to new data for CH₄ recovery.

In conclusion the recalculations performed for some single activities and sectors (especially CO₂ *Emissions and Removal from Soils*, *Wastewater* and *Manufacturing Industries and Construction*) are of importance and have considerable impact for the whole time-series 1990-2002. For the *National Total CO₂ Equivalent Emissions without Land-Use Change and Forestry* the recalculations are rather small and varying around zero, since the recalculations from single activities by coincidence to some extent counteract.

Table 10.2. Recalculation performed year 2005 for years 1990-2002. Differences (Gg CO₂-eqv) between 2005 submission and the May 17, 2004 submission. Memo items not shown. Activities with no emissions neither in the 2005 submission nor the April 15, 2005 submission are not shown.

GREENHOUSE GAS SOURCE AND SINK CATEGORIE		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
		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
1.A.1.	Energy Industries	-3,9	-9,5	-13,3	-15,6	-1,6	-123,8	-55,5	-310,7	-89,9	25,4	43,5	22,7	4,5
1.A.2.	Manufacturing Industries and Construction	-6,8	-1,1	-142,9	-136,7	-463,6	-574,6	-637,6	-531,7	18,3	38,7	46,3	44,1	1,4
1.A.3.	Transport	26,2	2,8	1,4	1,5	1,0	0,4	-0,9	-0,8	-0,6	0,4	-2,2	-6,3	18,7
1.A.4.	Other Sectors	-23,1	-30,2	154,0	112,6	81,5	44,7	43,8	25,1	168,3	-56,7	32,7	32,1	53,4
1.B.2.	Oil and Natural Gas	23,4	23,4	23,4	23,4	0,0	0,0	0,0	0,0	0,0	-4,9	1,1	0,0	0,0
2.A.	Mineral Products	16,3	14,9	13,0	10,0	8,0	8,6	7,3	6,8	4,1	4,1	4,4	4,9	6,5
3.	Solvent and Other Product Use	193,3	182,2	171,1	154,5	148,9	124,8	148,9	147,0	81,2	78,8	100,5	18,3	39,5
5.D.	CO ₂ Emissions and Removals from Soil	2990,3	2900,2	2747,6	2748,8	2769,7	2757,5	2641,5	2710,1	2493,9	2440,8	2434,5	2381,1	2337,3
		CH ₄	CH ₄	CH ₄	CH ₄	CH ₄	CH ₄	CH ₄	CH ₄	CH ₄	CH ₄	CH ₄	CH ₄	CH ₄
1.A.1.	Energy Industries	0,9	2,1	3,1	19,7	2,0	2,4	0,5	3,1	-25,7	2,6	-2,1	-2,4	-3,8
1.A.2.	Manufacturing Industries and Construction	-0,1	-0,3	-0,5	-0,6	-2,6	-3,4	-6,3	-6,0	4,7	-1,4	-0,5	-0,9	-2,8
1.A.3.	Transport	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,2	0,1	0,1
1.A.4.	Other Sectors	1,7	2,0	7,8	15,3	-5,5	-5,3	-8,7	-7,7	1,6	2,3	-1,3	1,9	1,0
1.B.2.	Oil and Natural Gas	17,7	9,3	10,5	17,0	-13,3	-7,3	-5,3	-9,3	0,9	-19,2	4,8	1,4	12,0
4.A.	Enteric Fermentation	10,1	9,7	9,1	8,7	7,8	7,2	7,1	6,5	6,1	5,7	5,5	8,5	10,0
4.B.	Manure Management	0,4	0,4	0,4	0,3	0,3	0,3	0,3	0,3	0,2	0,2	0,2	0,3	0,4
6.A.	Solid Waste Disposal on Land	24,3	20,2	5,1	21,4	-39,3	-30,6	-31,7	-35,5	-58,5	-32,2	-14,4	-0,2	24,9
6.B.	Wastewater Handling	199,9	204,1	208,5	212,9	217,4	221,9	226,4	251,7	235,3	234,4	217,5	229,3	277,5
6.D.	Other	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,003	0,004	0,003	0,002	0,003
		N ₂ O	N ₂ O	N ₂ O	N ₂ O	N ₂ O	N ₂ O	N ₂ O	N ₂ O	N ₂ O	N ₂ O	N ₂ O	N ₂ O	N ₂ O
1.A.1.	Energy Industries	0,9	-0,1	0,0	0,1	-1,5	-2,5	0,3	-0,6	6,0	8,9	10,4	9,5	11,1
1.A.2.	Manufacturing Industries and Construction	0,1	-0,2	-1,3	-1,3	-6,7	-7,6	-8,3	-7,6	0,9	-1,3	-1,2	-1,4	-4,8
1.A.3.	Transport	0,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,5
1.A.4.	Other Sectors	-0,4	-0,4	1,1	0,9	0,4	0,2	0,0	0,4	1,4	-0,2	-0,8	0,4	0,7
4.B.	Manure Management	-1,5	-2,6	-3,1	-3,7	-4,3	-5,1	-4,4	-6,6	-10,0	-9,2	-11,5	-14,3	-17,3
4.D.	Agricultural Soils ⁽²⁾	10,8	10,1	11,6	16,6	12,1	9,1	9,0	10,6	11,7	9,5	7,0	5,5	10,2
6.B.	Wastewater Handling	87,6	83,5	73,4	90,9	92,2	85,2	69,4	65,2	65,9	61,9	65,4	57,2	58,2
6.D.	Other	0,000	0,000	0,000	0,000	0,001	0,003	0,003	0,003	0,022	0,027	0,025	0,017	0,019
		HFCs	HFCs	HFCs	HFCs	HFCs	HFCs	HFCs	HFCs	HFCs	HFCs	HFCs	HFCs	HFCs
2.F.	Consumption of Halocarbons and SF ₆	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	-0,038
		PFCs	PFCs	PFCs	PFCs	PFCs	PFCs	PFCs	PFCs	PFCs	PFCs	PFCs	PFCs	PFCs
2.F.	Consumption of Halocarbons and SF ₆	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	-0,001
		SF ₆	SF ₆	SF ₆	SF ₆	SF ₆	SF ₆	SF ₆	SF ₆	SF ₆	SF ₆	SF ₆	SF ₆	SF ₆
2.F.	Consumption of Halocarbons and SF ₆	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	3,382
Total CO ₂ Equivalent Emissions without LULUCF		578,4	520,5	532,5	548,1	33,1	-255,4	-245,7	-400,0	422,0	347,8	505,6	410,7	505,4

10.4 Recalculations, incl. in response to the review process, and planned improvement to the inventory

The review process following several years of submissions, and the review reports have been very valuable for the improvements made and the recalculations performed. The final outcome of the most recent review process on the 2004 submissions is the review report available as http://unfccc.int/files/national_reports/annex_i_ghg_inventories/inventory_review_reports/application/pdf/2004_irr_centralized_review_denmark.pdf

This review was a centralised review. The review team met on October 18-22, 2004. The draft report was available to us January 24, 2005. The review report referred to above is dated March 23, 2005.

In the review process for the 2004 submissions we answered questions raised by the review team and we wrote a note with comments to the draft version of the review report. This note is unpublished but can be made available upon request. The note included the following comments, that we found important and relevant to be included here:

"The information and data documentation we provided in our submission in 2004 were comprehensive. Both as regards the questions raised during the week the review team met in Bonn and as regards some of the comments in the draft report, we found that answers and information were already given in the material submitted. We consider for future submissions how to improve and highlight the information as regards those questions and comments."

and

"The draft review report was available to us rather late in the process preparing the submissions for 2005 as regards data in CRF and documentation in the NIR. As a consequence not all of the suggestions and comments made in the draft report which we consider to take notice of and work upon for next submissions will be implemented in the 2005 submissions, but will have to await further considerations and work for future submissions."

For the response to the review report on sector level, see the sector chapters of this NIR. Below is only response on cross-cutting and 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 the uncertainty analyses have been improved for this submission. For sectors where missing uncertainty analyses were pointed out in the review report these analyses have now been carried out. As regards the response to the comment on the lack of incorporation of GHG inventories for the Faroe Island and Greenland, these inventories - as far as they are available - have now been included in a separate version of CRFs for Denmark, Faroe Island and Greenland for 1990-2003. As regards QA with independent reviewers, such reviews have been performed for *Energy* and *Transport*, and for *Agriculture* and *Wastewater* these reviews are ongoing.

For the *Energy* sector as regards disaggregation of energy consumption for *Manufacturing Industries and Construction*, this disaggregation has now been carried out according to new splits in the energy statistics.

For the *Industrial Sector* uncertainty analysis has now been performed and included.

For *Solvent and Other Product Use* new methodology has been worked out and implemented

For the *Agricultural Sector* all of the comments of the review team have been carefully considered and action been taken.

For the *LULUCF Sector* in this submission the structure of the NIR has been improved and now follows the UNFCCC reporting guidelines. The category *CO₂ Emissions and Removals from Soils* has been considered and emission estimates are included in the CRFs and described in this NIR.

For the *Waste Sector* methodologies for estimation of CH₄ and N₂O emissions from *Wastewater Handling* have been worked out and implemented for this submission. The description in this NIR of the methodology for estimation of CH₄ from *Solid Waste Disposal on Land* has been improved and default methodology has been used for comparison and as part of the QA-procedures.

In conclusion considerations have been made of all of the review reports suggestions, comments, recommendations and corrections. Some improvements in the inventories on the items pointed out by reviewers were to be made in a rather short timeframe, but all that was possible as regards the suggestions we thought most important were done regarding implementation or further work on the suggestions. The time frame for considering and implementing suggestions to data and data improvements has to be seen in connection to the time when data in the CRF-format had to be delivered to the European Commission, which was January 15, 2005. Only gap filling etc. of data could be carried out until March 15, 2005.

Annexes to Denmark's NIR 1990 - 2003

- Annex 1 Key Source Analyses
- Annex 2 Detailed discussion of methodology and data for estimating CO₂ 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
 - 3D Agriculture
 - 3E Waste
 - 3F Solvents
- Annex 4 CO₂ 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 1990-2003 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 CO₂, CH₄, N₂O and 1995 for the greenhouse F-gases HFC, PFC and SF₆. The base year is unadjusted to electricity trade. The analysis was made for the inventory for the year 2003.

The present key source analysis follows the same approach as the analyses for the years 2000, 2001 and 2002 as presented in the NIR2002, 2003 and 2004 respectively. The approach is a Tier 1 quantitative analysis. As suggested in the Good Practice Guidance the analysis is carried out without considering LULUCF.

The level assessment of the key source analysis is a ranking of the source categories in accordance to their contributions to the national total of greenhouse gases calculated in CO₂-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 which sum constitutes 95% of the national total.

The trend assessment of the key source analysis is a ranking of the source categories according to their contribution to the trend of the national total of greenhouse gases calculated in CO₂-equivalent units from the base year to the year considered. The trend of the source category is calculated relative to the trend of the national totals and the trend is weighted with the contribution according to the level assessment. The ranking is performed in descending order on this contribution to trend. As for the level assessment the cut of line is 95% for the sum of contribution to the trend and the source categories from the top of the list to the cut of line are trend key sources.

Information on the level of disaggregation

The starting point for the choice of source categories is the one presented in the 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 that emissions from a single category are estimated with the same method and the same emission factor. Therefore for categories in this table, 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 the Table 7.1 in the Good Practice Guidance.

The source categories for energy and stationary combustion are defined according to the fuels and their emission factors, which are (year 2003)

CO ₂ emission factors, fossil	kg/GJ
COAL	95
BROWN COAL BRI.	94.6
COKE OVEN COKE	108
PETROLEUM COKE	92
PLASTIC WASTE	17.6
RESIDUAL OIL	78
GAS OIL	74
KEROSENE	72
ORIMULSION	80
NATURAL GAS	57.19
LPG	65
REFINERY GAS	56.9

In the analyses carried out for 2002, 2001 and 2000 coal, brown coal and coke oven coke were aggregated in the key source analyses, because this split of fuels was not available for the whole time-series. However, the split is now available and the activities constitute in the key source analysis source categories according to the mentioned fuels due to the difference in emission factors.

For energy and mobile combustion the basis for the source categories is the activities:

Mobile combustion	Civil Aviation
Mobile combustion	Road Transportation
Mobile combustion	Railways
Mobile combustion	Navigation
Mobile combustion	Military
Mobile combustion	National fishing
Mobile combustion	Agriculture
Mobile combustion	Forestry
Mobile combustion	Other Mobil and machinery/industry
Mobile combustion	Household and gardening

These categories have been chosen as source categories for the 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 for the analysis is well argued from the intentions of the analysis in the GPG and we have chosen to keep the selection not to loose the comparison to the key source analysis performed for the years 2000, 2001 and 2002. Our choice of categories for the analysis identifies 67 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 2002 (refer NIR 2004) with 63 categories, 4 additional categories have been identified. This is a consequence of the presently available split of fuel for coal (see above) giving 2 additional categories and a consequence of CH₄ and N₂O emissions now being estimated for wastewater handling (see Chapter 8.3).

The result of the key source analyses for Denmark for the year 2003

The result of the key source level assessment for Denmark for 2003 is shown in Table 1. A number of 21 key sources were identified and marked as shaded in the Table. In 2002 the number of key sources was also 21, in 2001 and 2000 the number was 20. The entries to Table 1 and 2 for the year 1990 and 2003 are composed from the databases producing the CRF inventory for those years in this report. Note that base year estimates are not used in the level assessment analysis, but are only included in Table 1 to make it uniform with Table 2.

The result of the key source trend assessment for Denmark for 2003 is shown in Table 2. A number of 22 key sources (17 in 2002, 17 in 2001 and 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 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 order to allow **reference to the key source table** (Table 7) to be used 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 67 source categories chosen for this analysis, 25 are identified as key source categories either in the level or in the trend analysis or in both. In 2002 this number was also 25 out of 63 categories, while in 2001 and 2000 out of 59 categories 23 and 22 were key sources, respectively. In the key source analysis for 2003 18 key sources were keys in both level and trend as compared to 15 in 2002, and 14 in both 2001 and 2000. In 2003 3 sources were key sources in level only (7 in 2002 and 6 in 2001 and in 2000) In 2003 4 sources were key sources in trend only (3 in 2002, 3 in 2001 and 2 in 2000).

The **Energy Sector and CO₂ emission from Stationary Combustion** contributes with 6 key source categories in 2003 with respect to level and trend (7 in 2002, 7 in 2001 and 5 in 2000). These 6 key sources are as in 2001 the major fuels Coal, Residual Oil, Gas Oil and Natural Gas and Plastic Waste, while Orimulsion is not a key sources any longer as it was in 2002 in the trend analysis. For those key sources the trend in emission estimates, comparing 1990 and 2003, 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 2003 with 30.5% of the national total (Table 1). Also in 2002 and 2001 coal was the most contributing category. This contribution is at a maximum in 2003, since in 2002 it was 24.4% where it had increased from 24.0% in 2001 and 23.0% in 2000. Natural gas is in 2003 as in 2002 and in 2001 the third largest contributor with 15.1% in 2003 (16.6% in 2002, 16.0% in 2001 and 15.5% in 2000). Gas Oil is in 2003 the 4th largest contributor with 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 contribute each below 3% of the national total in 2003.

The **Energy Sector and CO₂ emission from Mobile Combustion** contribute with road transportation as a key source for level and trend with increased emission estimates from year 1990 to 2003. This category is in year 2003 as in 2002, in 2001 and in 2000 the second largest contributor with a level contribution of 16.0% in 2003 as compared to 16.6% in 2002, 16.2% in 2001 and 16.4% in 2000. It is new to the key source analysis performed for this submission that the sources CO₂ from mobile combustion national fishing and CO₂ from mobile combustion agriculture become keys with respect to both level and trend. Previously they were keys only according to level. The former of these two sources shows a decreasing trend from 1990 to 2003 while the latter in-

creases, their contributions in 2003 are 0.9% and 0.8% respectively. It is also new to this analysis that CO₂ from mobile combustion navigation is a key source according to level, it contributes with 0.8% in 2003.

In the **Industrial Sector**, 3 sources are in 2003 - as in 2002 - keys with respect to both level and trend. The 3 keys in 2003 and in 2002 are CO₂ emissions from cement production, emission from substitutes for ozone depleting substances (HFCs and PFCs) and N₂O emission from nitric acid production. The latter source was new in 2002. The trends from year 1990 to 2003 for these sources are increasing emissions from the cement production and from substitutes for the ozone depleting substances (HFCs and PFCs) (trend from 1995), while N₂O emissions from nitric acid production decrease. As regards the level assessment the cement production contributes with 1.9% (2.1% in 2002), nitric acid production with 1.0% (1.1% in 2002) and substitutes for ozone depleting substances (HFCs and PFCs) with 1% (as in 2002).

In the **Agricultural Sector**, 5 sources, which includes all sources in the categorisation used, are keys with respect both to level and trend. In 2002, 2001 and 2000 only 3 sources of those sources were keys. These 3 key categories are direct N₂O emissions from agriculture soils, indirect N₂O emissions from nitrogen used in agriculture and CH₄ from enteric fermentation. The emission estimates for these 3 sources represent a reduced emission from 1990 to 2003. According to level assessment these sources are among the 7 most contributing sources, with direct N₂O emissions from agriculture soils contributing with 3.9% (in 2002 4.3% and in 2001 6.5%), indirect N₂O emissions from nitrogen used in agriculture contributing with 3.7% (in 2002 4.1% and in 2001 4.3%) and CH₄ from enteric fermentation with 3.7% (in 2002 4.1% and in 2001 4.0%). The sources CH₄ emission from manure management and N₂O from manure management has in this analyses also become key sources for level and trend, in 2002 they were key sources for level only. The emission estimates of CH₄ from manure management represent an increasing trend in 1990-2003 and the emission estimates of N₂O from manure management represents a decreasing trend in 1990-2003. According to the level assessment the contribution in 2003 from these two sources is 1.3% and 0.8%, respectively.

In the **Waste Sector**, 1 source - CH₄ emissions from solid disposal of waste – is a key source both with respect to level and trend. The contribution from 1990 to 2003 is decreasing, the level in 2003 being 1.6%. The other sources, which are new to this submission - CH₄ and N₂O from wastewater handling - are not key sources.

Tables 7.A1 – 7.A3 of the Good Practice Guidance

Table 1. Key source analysis 1990-2003, 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 CO ₂ -eq	D Year 2003 Estimate Mt CO ₂ -eq	E Year 2003 Level Assess- ment	F Year 2003 Cumul. total of Col. E
Energy	CO ₂ Emission from stationary Combustion	Coal	CO ₂	24,077	22,609	0,305	0,31
Energy	Mobile combustion	Road Transportation	CO ₂	9,351	11,864	0,160	0,47
Energy	CO ₂ Emission from stationary Combustion	Natural gas	CO ₂	4,330	11,152	0,151	0,62
Energy	CO ₂ Emission from stationary Combustion	Gas oil	CO ₂	4,564	2,918	0,039	0,66
Agriculture	Direct N ₂ O emissions from Agriculture soils		N ₂ O	4,180	2,892	0,039	0,69
Agriculture	Indirect N ₂ O emissions from Nitrogen used in agriculture		N ₂ O	4,127	2,741	0,037	0,73
Agriculture	Enteric fermentation		CH ₄	3,110	2,734	0,037	0,77
Energy	CO ₂ Emission from stationary Combustion	Residual oil	CO ₂	2,505	2,120	0,029	0,80
Industrial Processes	CO ₂ emissions from Cement production		CO ₂	0,882	1,370	0,019	0,82
Energy	Mobile combustion	agriculture	CO ₂	1,318	1,219	0,016	0,83
Waste	Emission from Solid Waste Disposal sites		CH ₄	1,334	1,153	0,016	0,85
Agriculture	Manure management		CH ₄	0,743	0,972	0,013	0,86
Energy	CO ₂ Emission from stationary Combustion	Refinery gas	CO ₂	0,806	0,942	0,013	0,87
Industrial Processes	Nitric Acid Production		N ₂ O	1,043	0,895	0,012	0,89
Energy	CO ₂ Emission from stationary Combustion	Petroleum coke	CO ₂	0,410	0,779	0,011	0,90
Energy	Mobile combustion	other mobil and machinery	CO ₂	0,778	0,742	0,010	0,91
Industrial Processes	Emission from substitutes for ODS (Consumption..)		HFC and	0,218	0,715	0,010	0,92
Energy	CO ₂ Emission from stationary Combustion	Plastic waste	CO ₂	0,349	0,649	0,009	0,93
Energy	Mobile combustion	national fishing	CO ₂	0,771	0,632	0,009	0,93
Energy	Mobile combustion	Navigation	CO ₂	0,551	0,565	0,008	0,94
Agriculture	N ₂ O from Manure management		N ₂ O	0,685	0,560	0,008	0,95
Energy	Fugitive emissions	Oil and Natural Gas	CO ₂	0,263	0,550	0,007	0,96
Energy	Non-CO ₂ Emission from stationary Combustion		CH ₄	0,121	0,521	0,007	0,96
Energy	Non-CO ₂ Emission from stationary Combustion		N ₂ O	0,398	0,440	0,006	0,97
Energy	Mobile combustion	Road Transportation	N ₂ O	0,131	0,416	0,006	0,97
Waste	Emission from Waste Water Handling		CH ₄	0,200	0,244	0,003	0,98
Energy	Mobile combustion	Railways	CO ₂	0,297	0,218	0,003	0,98
Solvent and Other Product Use			CO ₂	0,317	0,206	0,003	0,98
Energy	CO ₂ Emission from stationary Combustion	Orimulsion	CO ₂	0,000	0,154	0,002	0,99
Energy	Mobile combustion	Civil Aviation	CO ₂	0,243	0,138	0,002	0,99
Energy	CO ₂ Emission from stationary Combustion	Coke Oven Coke	CO ₂	0,138	0,108	0,001	0,99
Industrial Processes	CO ₂ emissions from Lime production		CO ₂	0,138	0,102	0,001	0,99
Energy	Fugitive emissions	Solid Fuels	CH ₄	0,072	0,093	0,001	0,99
Energy	Mobile combustion	Military	CO ₂	0,119	0,092	0,001	0,99
Energy	Fugitive emissions	Oil and Natural Gas	CH ₄	0,038	0,084	0,001	0,99
Energy	Mobile combustion	household and gardening	CO ₂	0,087	0,082	0,001	1,00
Energy	CO ₂ Emission from stationary Combustion	LPG	CO ₂	0,164	0,074	0,001	1,00
Energy	Mobile combustion	Road Transportation	CH ₄	0,055	0,062	0,001	1,00
Waste	Emission from Waste Water Handling		N ₂ O	0,088	0,061	0,001	1,00
Energy	CO ₂ Emission from stationary Combustion	Kerosene	CO ₂	0,366	0,024	<0,001	1,00
Industrial Processes	SF ₆ from other sources of SF ₆		SF ₆	0,068	0,022	<0,001	1,00
Energy	Mobile combustion	agriculture	N ₂ O	0,017	0,016	<0,001	1,00
Industrial Processes	CO ₂ emissions Glass/Glass Wool Production		CO ₂	0,017	0,013	<0,001	1,00
Energy	Mobile combustion	national fishing	N ₂ O	0,015	0,012	<0,001	1,00
Energy	Mobile combustion	other mobil and machinery	N ₂ O	0,010	0,010	<0,001	1,00
Industrial Processes	SF ₆ from electrical equipment		SF ₆	0,004	0,010	<0,001	1,00
Energy	Mobile combustion	Navigation	N ₂ O	0,010	0,009	<0,001	1,00
Energy	Mobile combustion	forestry	CO ₂	0,005	0,004	<0,001	1,00
Energy	Mobile combustion	other mobil and machinery	CH ₄	0,003	0,003	<0,001	1,00
Energy	Fugitive emissions	Oil and Natural Gas	N ₂ O	0,001	0,003	<0,001	1,00
Energy	Mobile combustion	household and gardening	CH ₄	0,003	0,003	<0,001	1,00
Industrial Processes	CO ₂ emissions Catalysts/Fertilizers and Pesticides		CO ₂	0,002	0,003	<0,001	1,00
Energy	Mobile combustion	Navigation	CH ₄	0,001	0,003	<0,001	1,00
Energy	Mobile combustion	Civil Aviation	N ₂ O	0,003	0,003	<0,001	1,00
Energy	Mobile combustion	agriculture	CH ₄	0,002	0,002	<0,001	1,00
Energy	Mobile combustion	Railways	N ₂ O	0,003	0,002	<0,001	1,00
Energy	Mobile combustion	Military	N ₂ O	0,001	0,001	<0,001	1,00
Energy	Mobile combustion	household and gardening	N ₂ O	0,001	0,001	<0,001	1,00
Energy	Mobile combustion	national fishing	CH ₄	0,000	0,000	<0,001	1,00
Energy	CO ₂ Emission from stationary Combustion	Brown Coal Bri	CO ₂	0,011	0,000	<0,001	1,00
Energy	Mobile combustion	forestry	CH ₄	0,000	0,000	<0,001	1,00
Energy	Mobile combustion	Railways	CH ₄	0,000	0,000	<0,001	1,00
Energy	Mobile combustion	Civil Aviation	CH ₄	0,000	0,000	<0,001	1,00
Energy	Mobile combustion	Military	CH ₄	0,000	0,000	<0,001	1,00
Energy	Mobile combustion	forestry	N ₂ O	0,000	0,000	<0,001	1,00
Industrial Processes	CO ₂ emissions Iron and Steel Production		CO ₂	0,028	0,000	<0,001	1,00
Industrial Processes	SF ₆ from magnesium Production		SF ₆	0,036	0,000	<0,001	1,00
Total				69,61	74,01	1,00	
(1) The base year is 1995 for HFC, PFC and SF ₆ ; and 1990 for the other greenhouse gases. The base year is unadjusted to electricity trade.							

Table 2. Key source analysis 1990-2003, 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 2003 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	11,15	0,0832	28,5	28,5
Energy	CO2 Emission from stationary Combustion	Coal	CO2	24,08	22,61	0,0380	13,0	41,5
Energy	CO2 Emission from stationary Combustion	Gas oil	CO2	4,56	2,92	0,0246	8,4	49,9
Energy	Mobile combustion	Road Transportation	CO2	9,35	11,86	0,0244	8,4	58,3
Agriculture	Indirect N2O emissions from Nitrogen used in agriculture		N2O	4,13	2,74	0,0209	7,2	65,5
Agriculture	Direct N2O emissions from Agriculture soils		N2O	4,18	2,89	0,0197	6,8	72,2
Agriculture	Enteric fermentation		CH4	3,11	2,73	0,0073	2,5	74,7
Energy	CO2 Emission from stationary Combustion	Residual oil	CO2	2,51	2,12	0,0069	2,4	77,1
Industrial Processes	Emission from substitutes for ODS (Consumption...)		HFC and	0,22	0,71	0,0061	2,1	79,2
Industrial Processes	CO2 emissions from Cement production		CO2	0,88	1,37	0,0055	1,9	81,1
Energy	Non-CO2 Emission from stationary Combustion		CH4	0,12	0,52	0,0050	1,7	82,8
Energy	CO2 Emission from stationary Combustion	Kerosene	CO2	0,37	0,02	0,0046	1,6	84,4
Energy	CO2 Emission from stationary Combustion	Petroleum coke	CO2	0,41	0,78	0,0044	1,5	85,9
Energy	CO2 Emission from stationary Combustion	Plastic waste	CO2	0,35	0,65	0,0035	1,2	87,1
Energy	Mobile combustion	Road Transportation	N2O	0,13	0,42	0,0035	1,2	88,3
Energy	Fugitive emissions	Oil and Natural Gas	CO2	0,26	0,55	0,0034	1,2	89,5
Waste	Emission from Solid Waste Disposal sites		CH4	1,33	1,15	0,0034	1,2	90,6
Industrial Processes	Nitric Acid Production		N2O	1,04	0,89	0,0027	0,9	91,5
Energy	Mobile combustion	national fishing	CO2	0,77	0,63	0,00239	0,8	92,4
Agriculture	Manure management		CH4	0,74	0,97	0,00232	0,8	93,2
Energy	Mobile combustion	agriculture	CO2	1,32	1,22	0,00231	0,8	93,9
Agriculture	N2O from Manure management		N2O	0,68	0,56	0,00213	0,7	94,7
Energy	CO2 Emission from stationary Combustion	Orimulsion	CO2	0,00	0,15	0,0020	0,7	95,3
Solvent and Other Product Use			CO2	0,32	0,21	0,0017	0,6	95,9
Energy	Mobile combustion	Civil Aviation	CO2	0,24	0,14	0,0015	0,5	96,4
Energy	CO2 Emission from stationary Combustion	LPG	CO2	0,16	0,07	0,0013	0,4	96,9
Energy	Mobile combustion	Railways	CO2	0,30	0,22	0,0012	0,4	97,3
Energy	Mobile combustion	other mobil and machinery	CO2	0,78	0,74	0,0011	0,4	97,7
Energy	CO2 Emission from stationary Combustion	Refinery gas	CO2	0,81	0,94	0,0011	0,4	98,0
Industrial Processes	SF6 from other sources of SF6		SF6	0,07	0,02	0,0006	0,2	98,3
Industrial Processes	CO2 emissions from Lime production		CO2	0,14	0,10	0,0006	0,2	98,5
Energy	Fugitive emissions	Oil and Natural Gas	CH4	0,04	0,08	0,0005	0,2	98,6
Energy	CO2 Emission from stationary Combustion	Coke Oven Coke	CO2	0,14	0,11	0,0005	0,2	98,8
Industrial Processes	SF6 from magnesium Production		SF6	0,04	0,00	0,0005	0,2	99,0
Energy	Mobile combustion	Military	CO2	0,12	0,09	0,0004	0,2	99,1
Waste	Emission from Waste Water Handling		N2O	0,09	0,06	0,0004	0,1	99,3
Waste	Emission from Waste Water Handling		CH4	0,20	0,24	0,0004	0,1	99,4
Industrial Processes	CO2 emissions Iron and Steel Production		CO2	0,03	0,00	0,0004	0,1	99,5
Energy	Mobile combustion	Navigation	CO2	0,55	0,57	0,0003	0,1	99,6
Energy	Non-CO2 Emission from stationary Combustion		N2O	0,40	0,44	0,0002	0,1	99,7
Energy	Fugitive emissions	Solid Fuels	CH4	0,07	0,09	0,0002	0,1	99,8
Energy	CO2 Emission from stationary Combustion	Brown Coal Bri	CO2	0,01	0,00	0,0001	0,0	99,8
Energy	Mobile combustion	household and gardening	CO2	0,09	0,08	0,0001	0,0	99,9
Industrial Processes	SF6 from electrical equipment		SF6	0,00	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	national fishing	N2O	0,02	0,01	<0,0001	0,0	99,9
Energy	Mobile combustion	Road Transportation	CH4	0,06	0,06	<0,0001	0,0	99,9
Energy	Mobile combustion	agriculture	N2O	0,02	0,02	<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	Navigation	CH4	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	other mobil and machinery	N2O	0,01	0,01	<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
Industrial Processes	CO2 emissions Catalysts/Fertilizers and Pesticides		CO2	0,00	0,00	<0,0001	0,0	100,0
Energy	Mobile combustion	forestry	CO2	0,00	0,00	<0,0001	0,0	100,0
Energy	Mobile combustion	household and gardening	CH4	0,00	0,00	<0,0001	0,0	100,0
Energy	Mobile combustion	agriculture	CH4	0,00	0,00	<0,0001	0,0	100,0
Energy	Mobile combustion	Military	N2O	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	Railways	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	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	forestry	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	forestry	N2O	0,00	0,00	<0,0001	0,0	100,0
total				69,61	74,01	0,2919	100,0	
(1) The base year is 1995 for HFC, PFC and SF6; and 1990 for the other greenhouse gases. The base year is unadjusted to electricity trade.								

(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 1990-2003, summary.

Table 7.A3 (of Good Practice Guidance) Source Category Analysis Summary (DK-inventory)					
Quantitative method used: Tier 1					
A IPCC Source Categories (LULUCF not included)		B Direct Greenh. Gas	C Key Source 2003	D If C is yes criteria for identification	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	Waste Incineration
CO2 Emission from stationary Combustion	Residual oil	CO2	Yes	Level, Trend	See text
CO2 Emission from stationary Combustion	Gas oil	CO2	Yes	Level, Trend	See text
CO2 Emission from stationary Combustion	Kerosene	CO2	Yes	Trend	
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	
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	Yes	Level	
Mobile combustion	Military	CO2	No		
Mobile combustion	national fishing	CO2	Yes	Level, 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	
Mobile combustion	household and gardening	CO2	No		
Fugitive emissions	Oil and Natural Gas	CO2	Yes	Trend	
Non-CO2 Emission from stationary Combustion		CH4	Yes	Trend	
Mobile combustion	Civil Aviation	CH4	No		
Mobile combustion	Road Transportation	CH4	No		
Mobile combustion	Railways	CH4	No		
Mobile combustion	Navigation	CH4	No		
Mobile combustion	Military	CH4	No		
Mobile combustion	national fishing	CH4	No		
Mobile combustion	agriculture	CH4	No		
Mobile combustion	forestry	CH4	No		
Mobile combustion	other mobil and machinery/industry	CH4	No		
Mobile combustion	household and gardening	CH4	No		
Fugitive emissions	Solid Fuels	CH4	No		
Fugitive emissions	Oil and Natural Gas	CH4	No		
Non-CO2 Emission from stationary Combustion		N2O	No		
Mobile combustion	Civil Aviation	N2O	No		
Mobile combustion	Road Transportation	N2O	Yes	Trend	
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 Glass 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 P	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, Trend	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	
Emission from Waste Water Handling		CH4	No		
Emission from Waste Water Handling		N2O	No		

Annex 2 Detailed discussion of methodology and data for estimation CO₂ 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

Annex 3B Transport

Annex 3C Industry

Annex 3D Agriculture

Annex 3E Waste

Annex 3F Solvents

Annex 3A

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.

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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 – being 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 by 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 (COrRe INventory on AIR emissions) system, which is a European program for air emission inventories. CORINAIR includes methodology structure and software for inventories. The methodology is described in the EMEP/Corinair Emission Inventory Guidebook 3rd edition, prepared by the UNECE/EMEP Task Force on Emissions Inventories and Projections (EMEP/Corinair 2004). Emission data are stored in an Access database, from which data are transferred to the reporting formats.

The emission 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 to 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 sector 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 the 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 emission 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 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 CO₂ 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 2003, 70 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 fuel consumption of stationary combustion plants registered as large point sources is 414 PJ (2003). This corresponds to 67% of the overall fuel consumption for stationary combustion.

A list of the large point sources for 2003 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 2003.

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.

SO₂ 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 SO₂ and NO_x from power plants >25MW_e prepared for the Danish Energy Authority due to Danish legislative requirement
- 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 data sets. 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 (CO₂, CH₄ and N₂O) 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 2004a). 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 reportings 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 refers to the DEA database (DEA 2004c).

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 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 CO₂

The CO₂ emission factors applied for 2003 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 1990-2003.

In reporting for the Climate Convention, the CO₂ 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 CO₂ 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 CO₂ 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 CO₂ 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, because it is only relevant for CO₂. Thus, the full consumption of municipal waste is included in the fuel category, *Biomass*, and the full amount of non-CO₂ emissions from municipal waste combustion is also included in the *Biomass*-category.

The CO₂ 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 CO₂ emission from power plants in 2003 and 2004 (Lov nr. 376 1999) is based on standard CO₂ emission factors for each fuel. Thus, so far power plant operators have not been encouraged to estimate CO₂ 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 of improved emission factors for national emission inventories in future. The plants will report CO₂ emissions for 2005 according to this legislation.

Table 3A-3 CO₂ emission factors 2003.

Fuel	Emission factor		Unit	Reference type	IPCC fuel Category
	Biomass	Fossil fuel			
Coal			95 kg/GJ	Country specific	Solid
Brown coal briquettes			94,6 kg/GJ	IPCC reference manual	Solid
Coke oven coke			108 kg/GJ	IPCC reference manual	Solid
Petroleum coke			92 kg/GJ	Country specific	Liquid
Wood	102		kg/GJ	Corinair	Biomass
Municipal waste	94,5	17,6 kg/GJ		Country specific	Biomass / Other fuels
Straw	102		kg/GJ	Country specific	Biomass
Residual oil			78 kg/GJ	Corinair	Liquid
Gas oil			74 kg/GJ	Corinair	Liquid
Kerosene			72 kg/GJ	Corinair	Liquid
Fish & rape oil	74		kg/GJ	Country specific	Biomass
Orimulsion			80 kg/GJ	Country specific	Liquid
Natural gas			57,19 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 CO₂ 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 1990-2003.

Brown coal briquettes

The emission factor 94,6 kg/GJ is based on a default value from the IPCC guidelines assuming full oxidation. The default value in the IPCC guidelines is 25,8 t C/TJ, corresponding to $25,8 \cdot (12 + 2 \cdot 16) / 12 = 94,6$ kg CO₂/GJ assuming full oxidation.

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 $29,5 \cdot (12 + 2 \cdot 16) / 12 = 108$ kg CO₂/GJ assuming full oxidation.

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 1990-2003.

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 1990-2003.

Municipal waste

The CO₂ 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 CO₂ 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 Haushaltsabfällen, 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 CO₂ emission factor for municipal waste incineration has been determined to be 112,1 kg/GJ. The CO₂ emission from the biomass part is the total CO₂ emission minus the CO₂ emission from the plastic part.

Thus, in 2003 the CO₂ emission factor for the plastic content of waste was estimated to be 185g/kg municipal waste (Table 3A-4). The CO₂ emission per GJ of waste is calcu-

lated based on the lower heating values for waste listed in Table 3A-5 (DEA 2004b). It has been assumed that the plastic content in weight per cent is constant, resulting in a decreasing energy per cent since the lower heating value (LHV) is increasing. However, the increasing LHV may be a result of increasing plastic content in the municipal waste. Time-series for the CO₂ 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 unoxidised fraction of the carbon content is assumed to originate from the biomass content, and all carbon originating from plastic are assumed to be oxidised.

Table 3A-5 CO₂ 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

1) DEA 2004b

2) Based on data from Jørgensen & Johansen 2003

3) From Table 3A-4

Straw

The emission factor for straw, 102 kg/GJ refers to 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 Collector database. The same emission factor is applied for 1990-2003.

Residual oil

The emission factor 78 kg/GJ refers to Fenhann & Kilde 1994. The factor is based on the interval stated in the EMEP/Corinair Guidebook (EMEP/Corinair; 2004). The factor is slightly higher than the IPCC default emission factor for residual fuel oil (77,4 kg/GJ assuming full oxidation). The CO₂ 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 1990-2003.

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 CO₂ 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 1990-2003.

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 1990-2003.

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 CO₂ emission factors have been confirmed by the only major power plant operator using orimulsion (Andersen 1996). The same emission factor is applied for 1990-2003.

Natural gas

The emission factor for natural gas is estimated by the Danish gas transmission company, Gastra¹ (Lindgren 2004). Only natural gas from the Danish gas fields is utilised in Denmark. The calculation is based on gas analysis carried out daily by Gastra. Gastra and the Danish Gas Technology Centre have calculated emission factors for 2000-2003. 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). Time-series for the CO₂ emission factors is provided in Table 3A-6.

Table 3A-6 CO₂ 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

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 1990-2003.

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 1990-2003.

Biogas

The emission factor 83,6 kg/GJ is based on a biogas with 65% (vol.) CH₄ and 35% (vol.) CO₂. Danish Gas Technology Centre has stated that this is a typical manure-based biogas as utilised in stationary combustion plants (Kristensen 2001).

¹ Former part of DONG. From 2005 part of the new national electricity and gas transmission company Energinet.dk

2.5.2 CH₄

The CH₄ emission factors applied for 2003 are presented in Table 3A-7. In general, the same emission factors have been applied for 1990-2003. 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 CH₄ emission than other stationary combustion plants. The relatively high emission factor for gas engines is well-documented and further discussed below.

Table 3A-7 CH₄ emission factors 1990-2003.

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 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 for CHP plants <25MW_e have been estimated. The work was reported in 2003 (Nielsen & Illerup 2003) and the results have been fully implemented in the inventory reported in 2004.

The work included municipal waste incineration plants, CHP plants combusting wood and straw, natural gas and biogas-fuelled (reciprocating) engines, and natural gas fuelled gas turbines. CH₄ 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 data sets was comprehensive. Emission factors for subgroups of each plant type were estimated, e.g. the CH₄ emission factor for different gas engine types have 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 - 2003. The emission factor for natural gas engines was based on 291 emission measurements on 114 different plants. The plants from which emission measurements were available represented 44% of the total gas consumption in gas engines (year 2000). The emission factor was estimated based on fuel consumption of 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 emission of total unburned hydrocarbon (CH₄ + NMVOC). A constant disaggregation factor was estimated based on a number of emission measurements including both CH₄ 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 prechamber engine types differ considerably.

The installation of natural gas engines in decentralised CHP plants in Denmark has taken place since 1990. The first engines installed were relatively small open-chamber engines and in later years mainly prechamber engines were installed. As mentioned above, prechamber engines have a higher emission factor than open-chamber engines, therefore, the emission factor has changed during the period 1990-2003. 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 CH₄ emission from gas engines carried out in 1997 (Nielsen & Wit 1997)

Table 3A-8 Time-series for the CH₄ 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

Gas engines, biogas

SNAP 010105, 010505, 020105, 020304 and 030105

The emission factor for biogas engines was estimated to 323 g/GJ in 2000 and the same emission factor has been applied for 2001 - 2003. 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 prechamber engines. A time-series for the emission factor has been estimated (Nielsen & Illerup 2003).

Table 3A-9 Time-series for the CH₄ 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

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 1,5 g/GJ has been applied for all years. The emission factor was based on emission measurements on 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 2 g/GJ has been applied for all years. The emission factor was based on emission measurements on 3 plants.

CHP, straw

SNAP 010102 and 010103

The emission factor for CHP plants combusting straw was estimated to be below 0,5g/GJ and the emission factor 0,5g/GJ has been applied for all years. The emission factor was based on emission measurements on 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 0,59g/GJ has been applied for all years. The emission factor was based on emission measurements on 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 Gruijthuisen & Jensen 2000. The same emission factors are applied for 1990-2003.

2.5.3 N₂O

The N₂O emission factors applied for the 2003 inventory are listed in Table 3A-10. The same emission factors have been applied for 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 on Danish plants (Nielsen & Illerup 2003). Other emission factors refer to the EMEP/Corinair Guidebook (EMEP/Corinair 2004).

Table 3A-10 N₂O emission factors 1990-2003.

Fuel	ipcc_id	SNAP_id	Emission factor [g/GJ]	Reference
COAL	all	all	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

2.5.4 SO₂, NO_x, NMVOC and CO

Emission factors for SO₂, 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 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.

The industrial fuel consumption is considered in 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 2003 total fuel consumption for stationary combustion plants was 622 PJ of which 537 PJ was 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 - 64% - of all fuels is combusted in the sector, *Public electricity and heat production*. Other sectors with high fuel consumption are *Residential* and *Industry*.

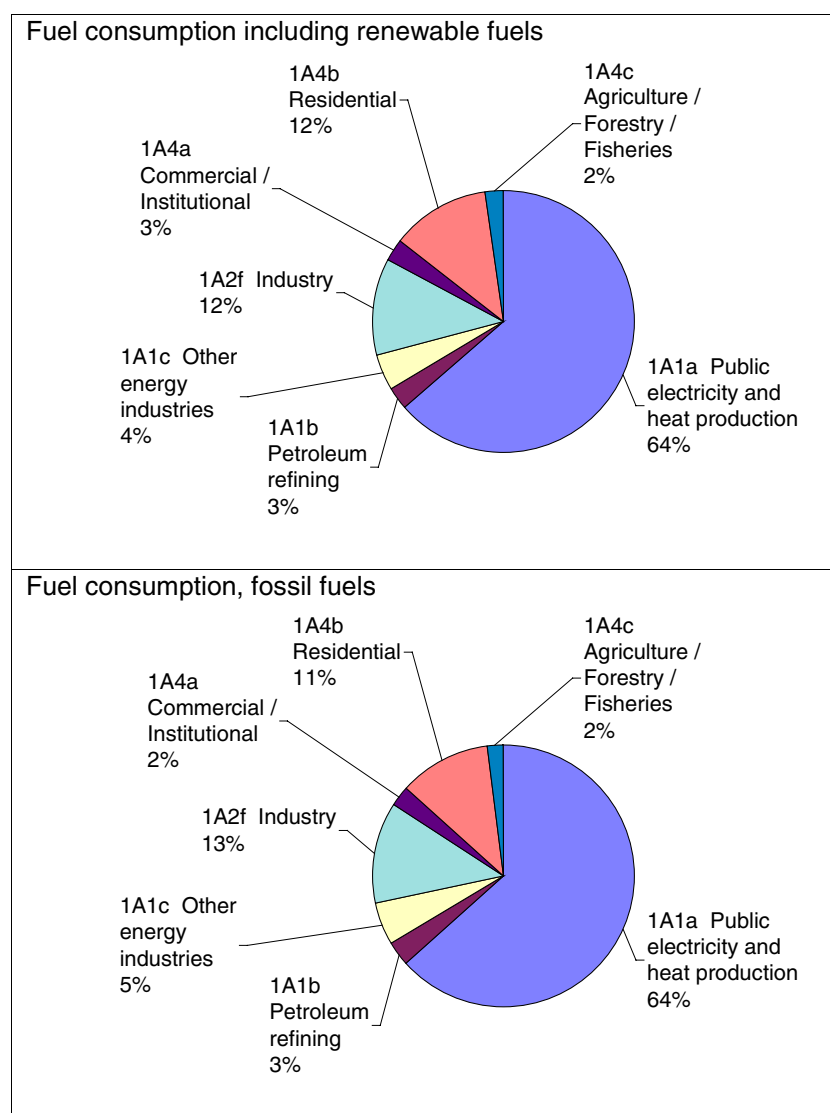


Figure 3A-1 Fuel consumption rate of stationary combustion, 2003 (based on DEA 2004a).

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.

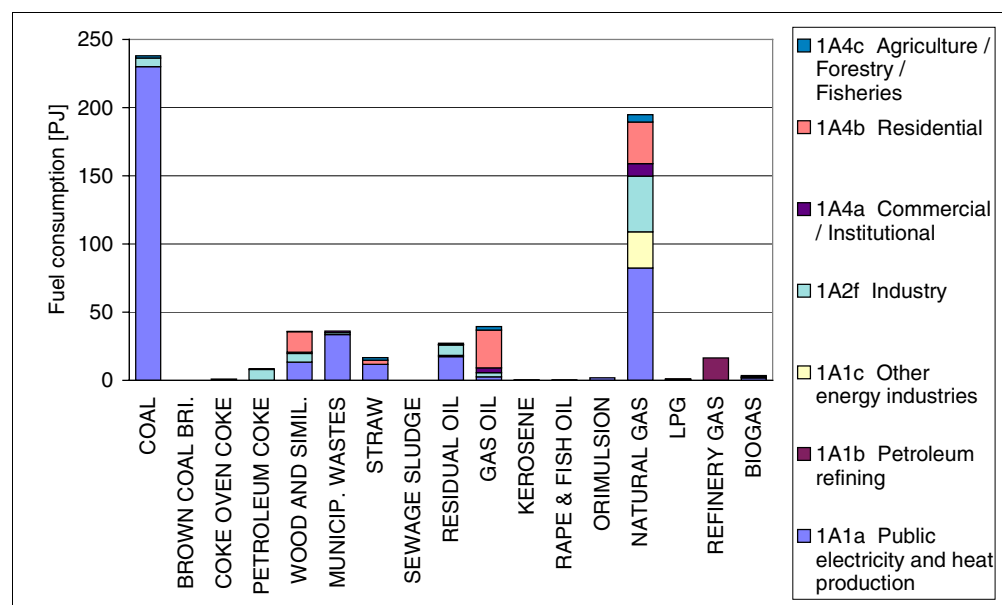


Figure 3A-2 Fuel consumption of stationary combustion plants 2003 (based on DEA 2004a).

Fuel consumption time-series for stationary combustion plants are presented in Figure 3A-3. The total fuel consumption has increased by 25% from 1990 to 2003, while the fossil fuel consumption has only increased by 18%. The consumption of natural gas and renewable fuels has increased since 1990 whereas coal consumption has decreased.

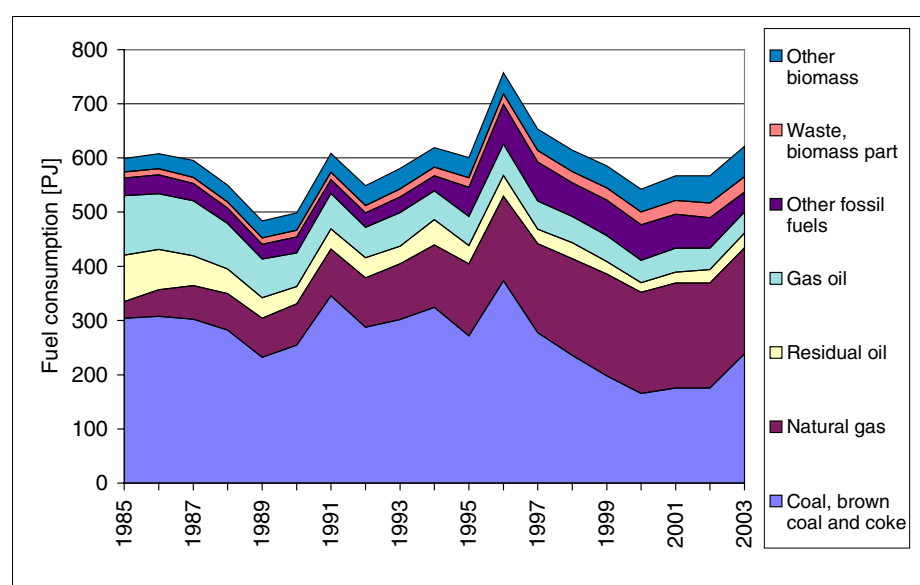


Figure 3A-3 Fuel consumption time-series, stationary combustion (based on DEA 2004a).

The fluctuations in the time-series for fuel consumption are a result mainly of electricity import/export activity, but also of outdoor temperature variations from year to year. This, in turn, leads to fluctuations in emission levels. The fluctuations in elec-

tricity 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 2003 the net electricity export was 30760 TJ which is much higher than in 2002. The high electricity export in 2003 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.

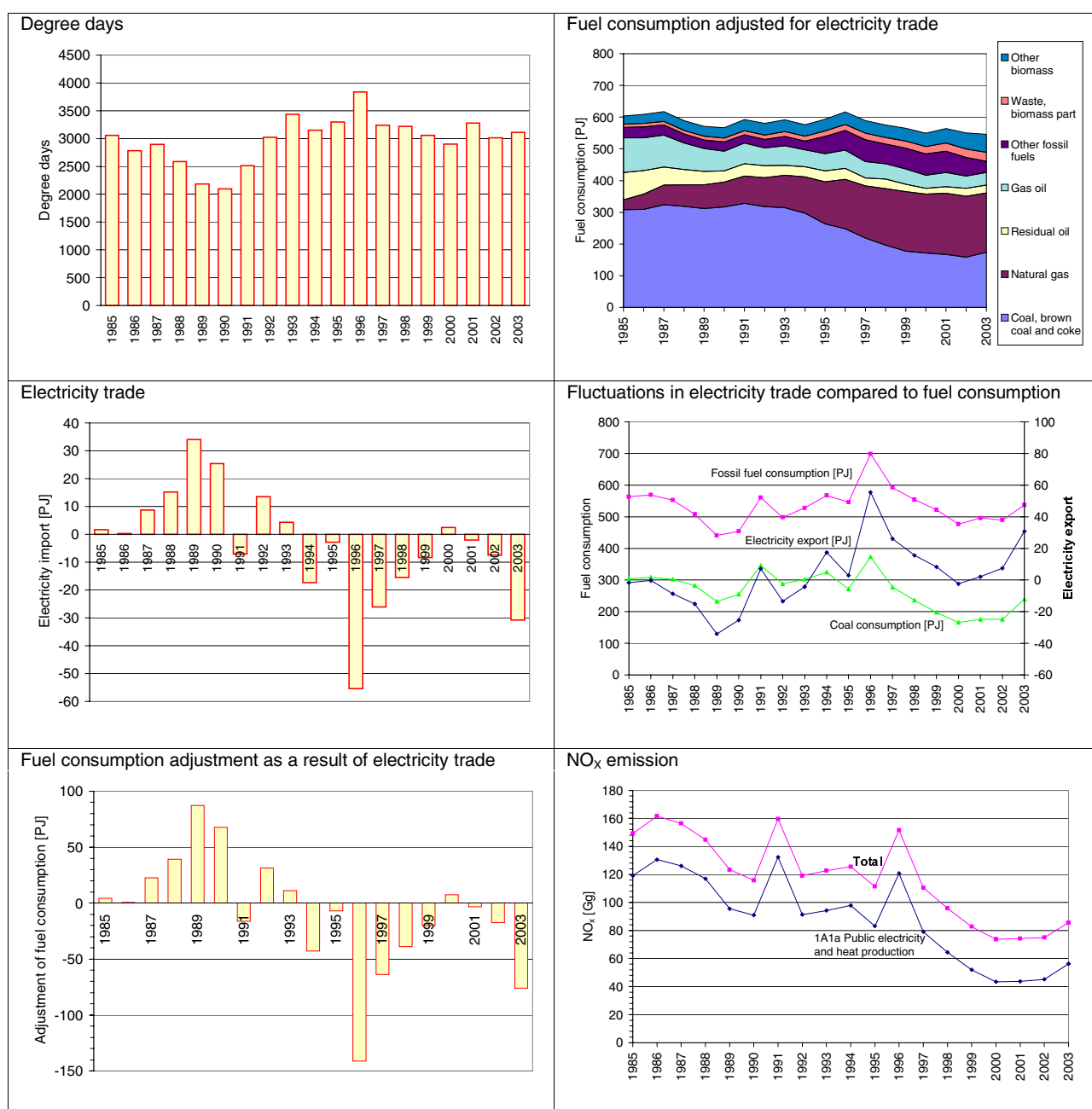


Figure 3A-4 Comparison of time-series fluctuations for electricity trade, fuel consumption and NO_x emission (DEA 2004b).

4 Greenhouse gas emission

The total Danish greenhouse gas (GHG) emission in the year 2003 was 74.008 Gg CO₂ equivalent not including land-use change and forestry or 72.804 Gg CO₂ equivalent including land-use change and forestry. The greenhouse gas pollutants HFCs, PFCs and SF₆ are not emitted from combustion plants and, as such, only the pollutants CO₂, CH₄ and N₂O are considered below.

The global warming potentials of CH₄ and N₂O applied in greenhouse gas inventories refer to the second IPCC assessment report (IPCC 1995):

- 1 g CH₄ equals 21 g CO₂
- 1 g N₂O equals 310 g CO₂

The GHG emissions from stationary combustion are listed in Table 3A-11. The emission from stationary combustion accounts for 57% of the total Danish GHG emission.

The CO₂ emission from stationary combustion plants accounts for 70% of the total Danish CO₂ emission (not including land-use change and forestry). CH₄ accounts for 9% of the total Danish CH₄ emission and N₂O for only 5% of the total Danish N₂O emission.

Table 3A-11 Greenhouse gas emission for the year 2003 ¹⁾.

	CO ₂	CH ₄	N ₂ O
	Gg CO ₂ equivalent		
1A1 Fuel consumption, Energy industries	31402	330	328
1A2 Fuel consumption, Manufacturing Industries and Construction ¹⁾	4662	31	46
1A4 Fuel consumption, Other sectors ¹⁾	5465	160	67
Total emission from stationary combustion plants	41529	521	440
Total Danish emission (gross)	59329	5873	8060
	%		
Emission share for stationary combustion	70	9	5

1) Only stationary combustion sources of the sector is included

CO₂ is the most important GHG pollutant and accounts for 97,7% of the GHG emission (CO₂ eq.). This is a much higher share than for the total Danish GHG emissions where CO₂ only accounts for 81% of the GHG emission (CO₂ eq.).

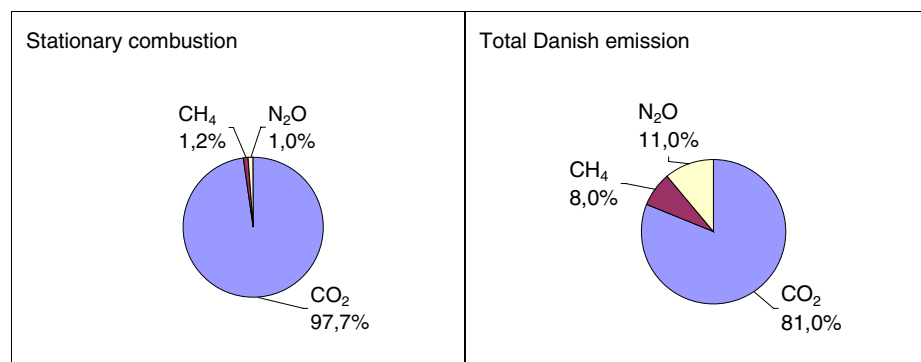


Figure 3A-5 GHG emission (CO₂ equivalent), contribution from each pollutant.

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 is higher in 2003 than in 1990, CO_2 by 10% and GHG by 11%. However, fluctuations in the GHG emission level are large.

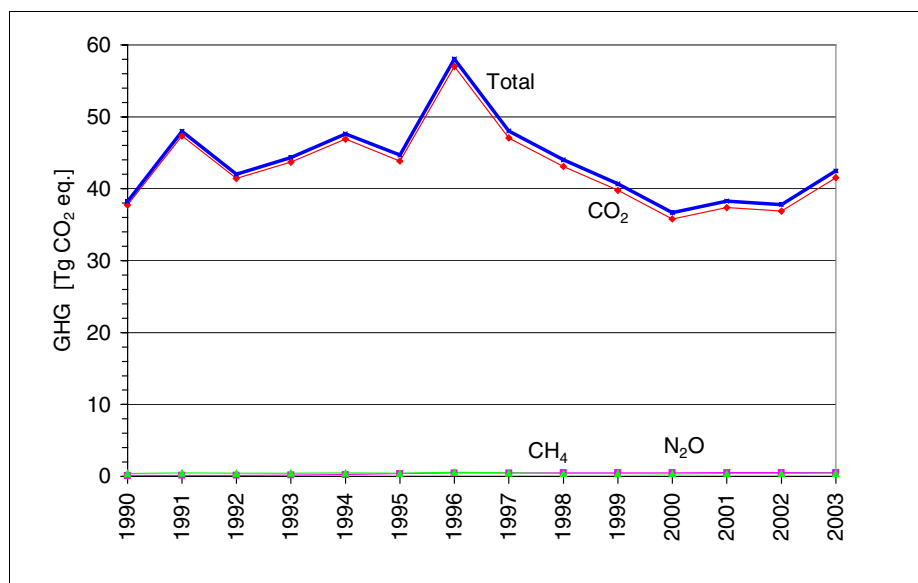


Figure 3A-6 GHG emission time-series for stationary combustion.

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 0.

Figure 3A-7 shows the corresponding time-series for degree days, electricity trade and CO_2 emission. As mentioned in Chapter 0, 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 20% since 1990, and the CO_2 emission by 21%.

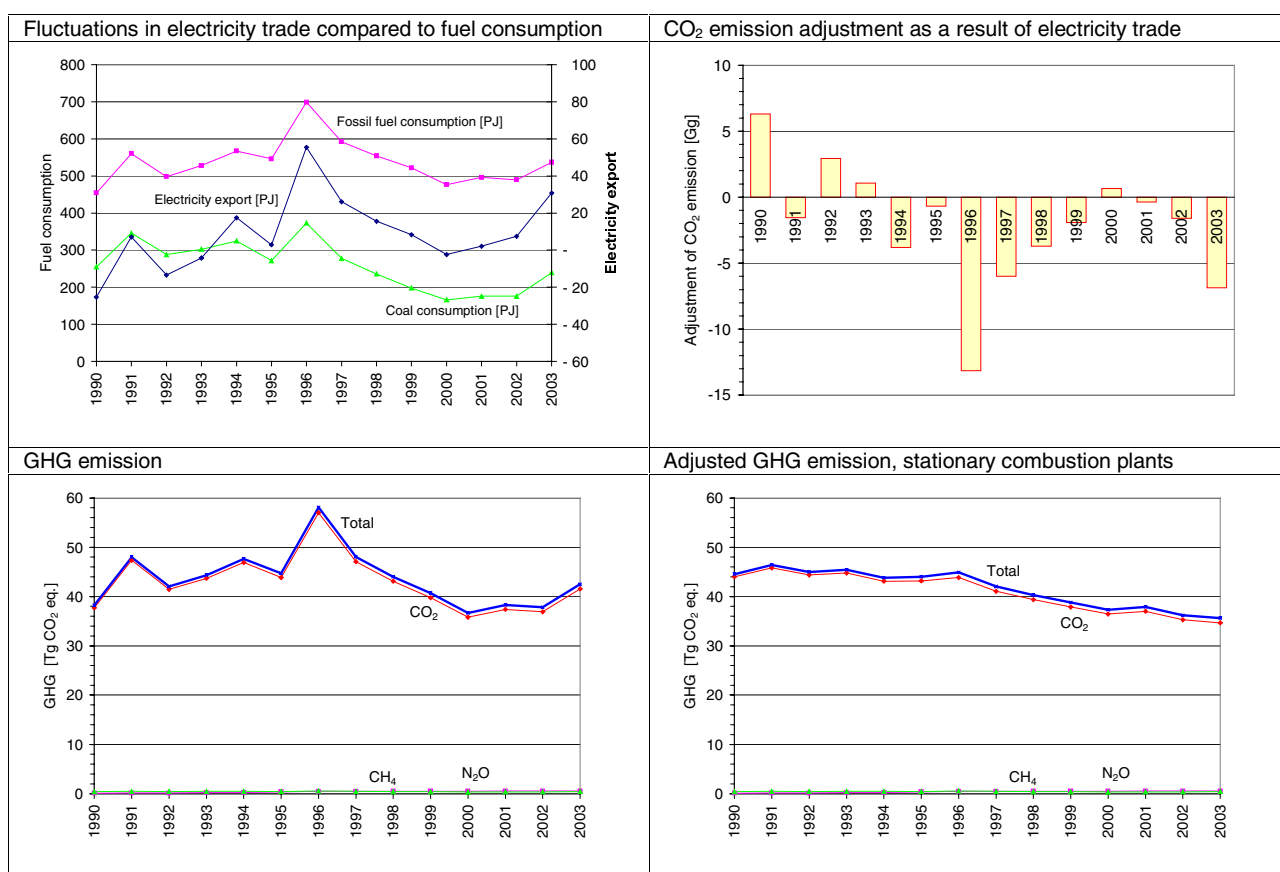


Figure 3A-7 GHG emission time-series for stationary combustion, adjusted for electricity import/export (DEA 2004b).

4.1 CO₂

The CO₂ emission from stationary combustion plants is one of the most important GHG emission sources. Thus the CO₂ emission from stationary combustion plants accounts for 70% of the total Danish CO₂ emission. Table 3A-12 lists the CO₂ emission inventory for stationary combustion plants for 2003. Figure 3A-8 reveals that *Electricity and heat production* accounts for 70% of the CO₂ emission from stationary combustion. This share is somewhat higher than the fossil fuel consumption share for this sector, which is 64% (Figure 3A-1). Other large CO₂ 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 CO₂ emission from stationary combustion plants 2003 ¹⁾

CO ₂	2003	
1A1a Public electricity and heat production	28869	Gg
1A1b Petroleum refining	1013	Gg
1A1c Other energy industries	1520	Gg
1A2 Industry	4662	Gg
1A4a Commercial / Institutional	854	Gg
1A4b Residential	3890	Gg
1A4c Agriculture / Forestry / Fisheries	721	Gg
Total	41529	Gg

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

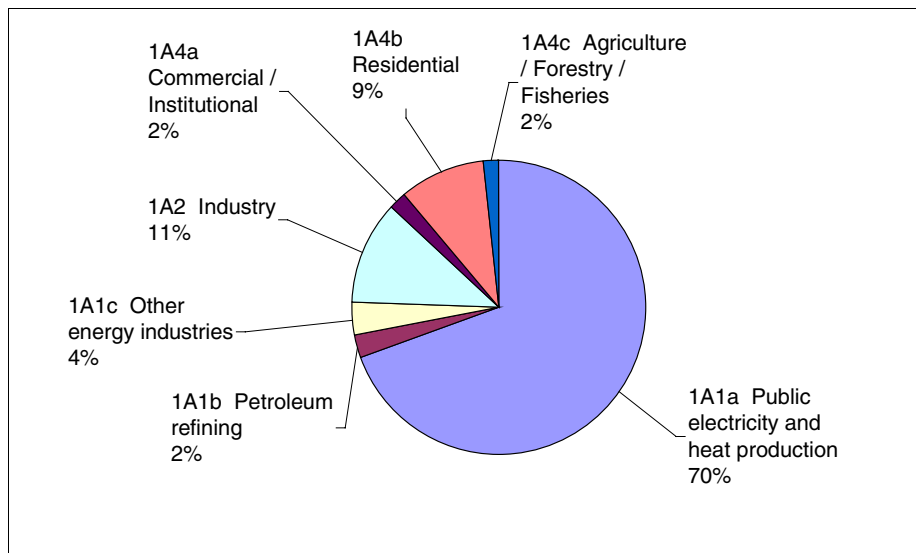


Figure 3A-8 CO₂ emission sources, stationary combustion plants, 2003.

The sector *Electricity and heat production* consists of the SNAP source sectors: *Public power* and *District heating*. The CO₂ emissions from each of these subsectors are listed in Table 3A-13. The most important subsector is power plant boilers >50MW.

Table 3A-13 CO₂ emission from subsectors to 1A1a *Electricity and heat production*.

SNAP source	SNAP name	2003	
0101	Public power	0	Gg
010101	Combustion plants ≥ 300MW (boilers)	23365	Gg
010102	Combustion plants ≥ 50MW and < 300 MW (boilers)	939	Gg
010103	Combustion plants <50 MW (boilers)	177	Gg
010104	Gas turbines	2515	Gg
010105	Stationary engines	1561	Gg
0102	District heating plants	-	Gg
010201	Combustion plants ≥ 300MW (boilers)	-	Gg
010202	Combustion plants ≥ 50MW and < 300 MW (boilers)	41	Gg
010203	Combustion plants <50 MW (boilers)	260	Gg
010204	Gas turbines	-	Gg
010205	Stationary engines	10	Gg

CO₂ emission from combustion of biomass fuels is not included in the total CO₂ emission data, because biomass fuels are considered CO₂ neutral. The CO₂ emission from biomass combustion is reported as a memo item in Climate Convention reporting. In 2003 the CO₂ emission from biomass combustion was 9108 Gg.

In Figure 3A-9 the fuel consumption share (fossil fuels) is compared to the CO₂ emission share disaggregated to fuel origin. Due to the higher CO₂ emission factor for coal than oil and gas, the CO₂ emission share from coal combustion is higher than the fuel consumption share. Coal accounts for 45% of the fossil fuel consumption and for 55% of the CO₂ emission. Natural gas accounts for 36% of the fossil fuel consumption but only 27% of the CO₂ emission.

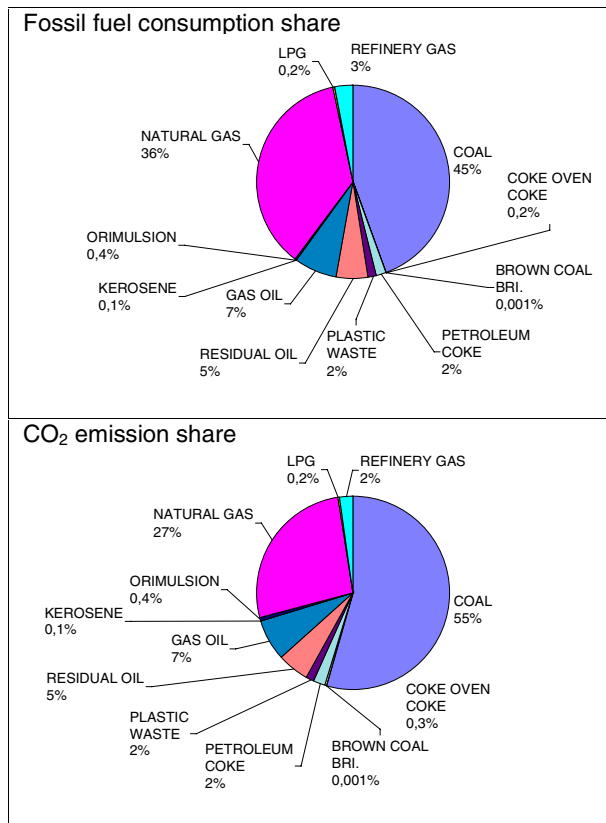


Figure 3A-9 CO₂ emission, fuel origin.

Time-series for CO₂ emission are provided in Figure 3A-10. Despite an increase in fuel consumption of 25% since 1990, CO₂ emission from stationary combustion has increased by only 10% due to of the change in fuel type used.

The fluctuations in total CO₂ emission follow the fluctuations in CO₂ emission from *Electricity and heat production* (Figure 3A-10) and in coal consumption (Figure 3A-11). The fluctuations are a result of electricity import/export activity as discussed in Chapter 0.

Figure 3A-11 compares time-series for fossil fuel consumption and the CO₂ emission. As mentioned above, the consumption of coal has decreased whereas the consumption of natural gas, with a lower CO₂ emission factor, has increased. Total fossil fuel use increased by 18% between 1990 and 2003.

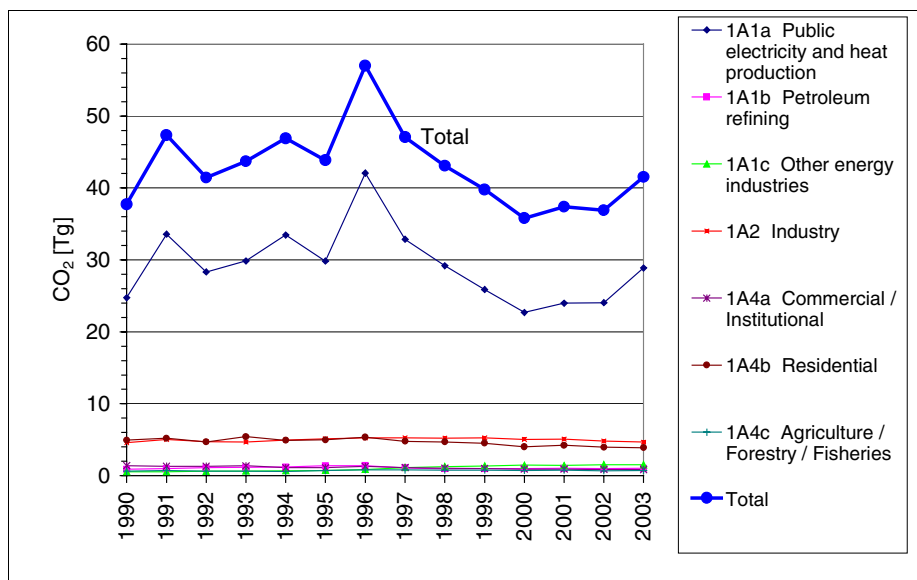


Figure 3A-10 CO₂ emission time-series for stationary combustion plants.

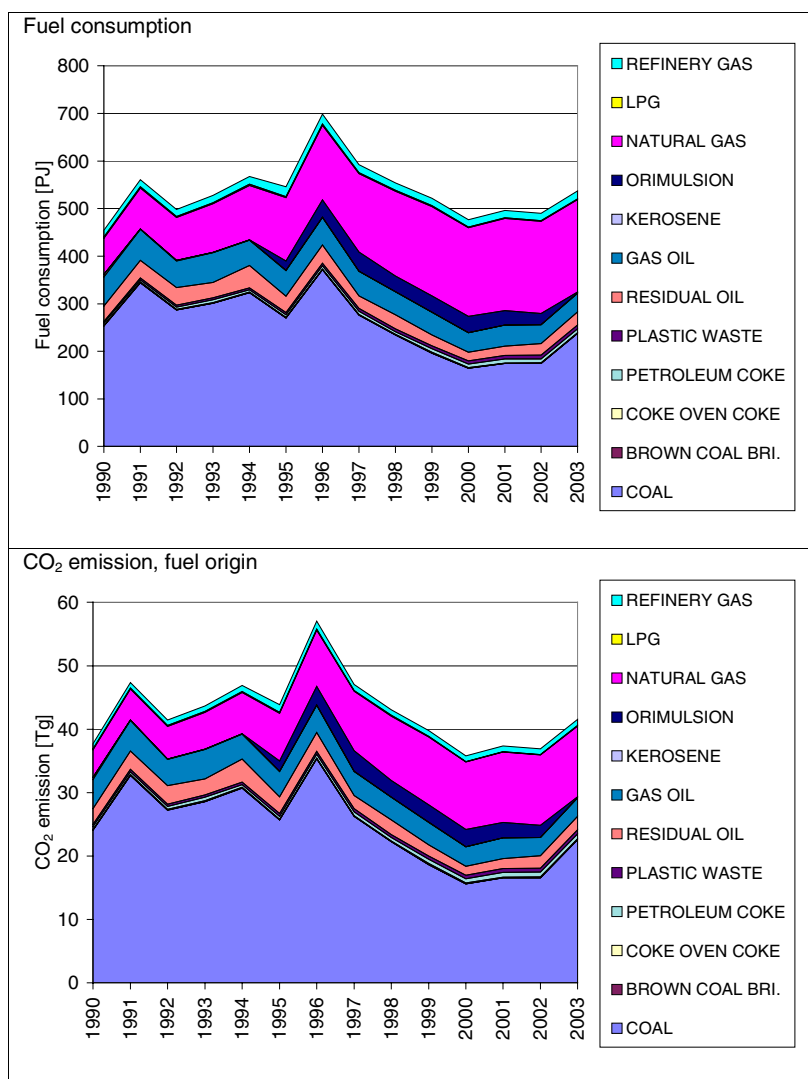


Figure 3A-11 Fossil fuel consumption and CO₂ emission time-series for stationary combustion.

4.2 CH₄

CH₄ emission from stationary combustion plants accounts for 9% of the total Danish CH₄ emission. Table 3A-14 lists the CH₄ emission inventory for stationary combustion plants in 2003. Figure 3A-12 reveals that *Electricity and heat production* accounts for 64% of the CH₄ emission from stationary combustion, this being closely aligned with fuel consumption share.

Table 3A-14 CH₄ emission from stationary combustion plants 2003 ¹⁾.

CH ₄	2003	
1A1a Public electricity and heat production	15647	Mg
1A1b Petroleum refining	2	Mg
1A1c Other energy industries	58	Mg
1A2 Industry	1485	Mg
1A4a Commercial / Institutional	961	Mg
1A4b Residential	4562	Mg
1A4c Agriculture / Forestry / Fisheries	2094	Mg
Total	24809	Mg

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

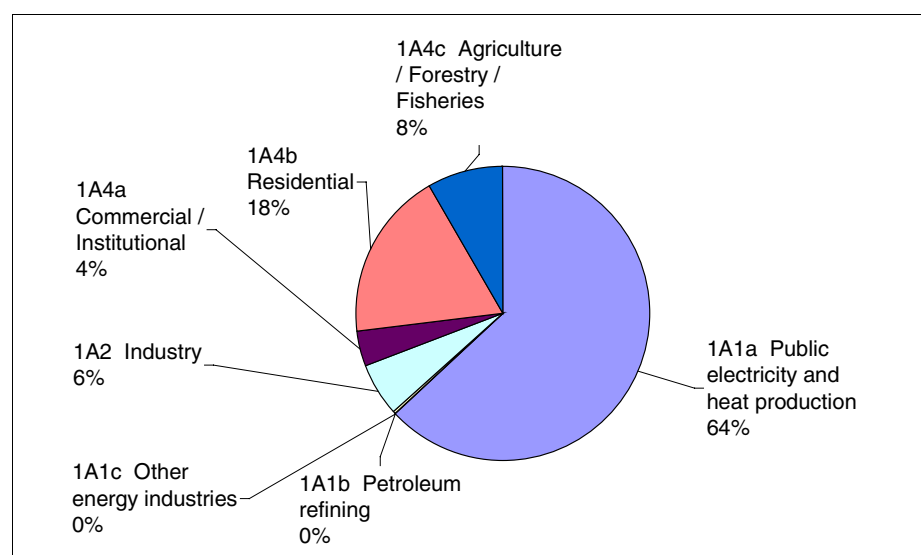


Figure 3A-12 CH₄ emission sources, stationary combustion plants, 2003.

The CH₄ 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 4.5.2. A considerable number of lean-burn gas engines are in operation in Denmark and these plants account for 75% of the CH₄ 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.

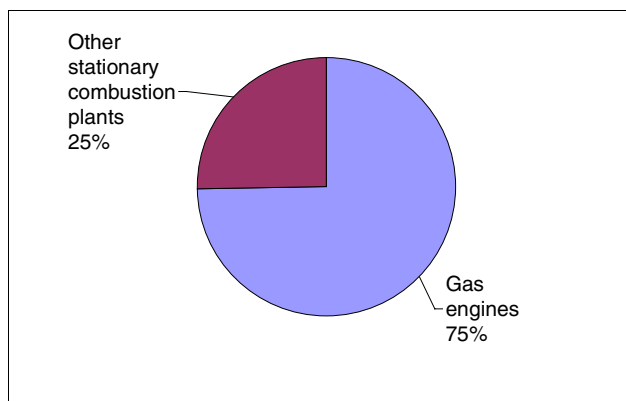


Figure 3A-13 Gas engine CH₄ emission share, 2003.

The CH₄ 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 of CH₄ emission.

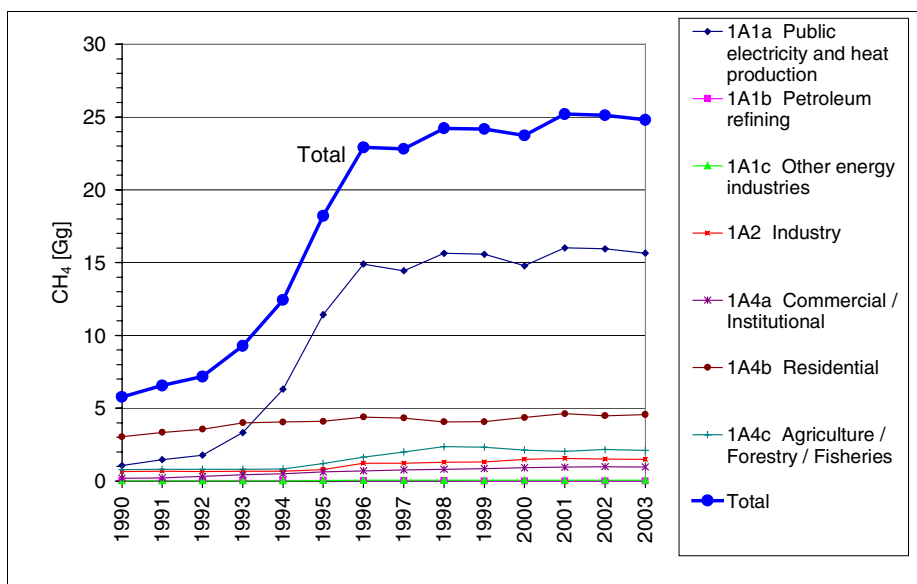


Figure 3A-14 CH₄ emission time-series for stationary combustion plants.

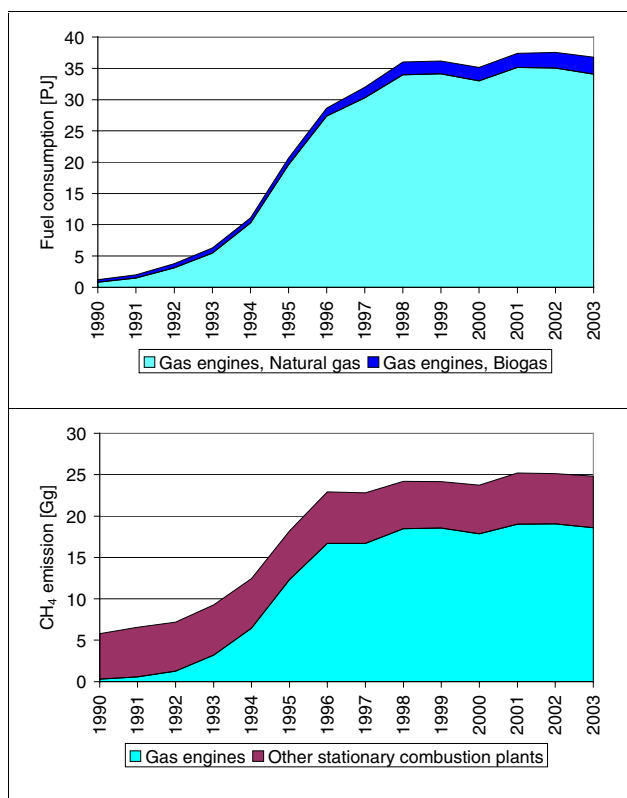


Figure 3A-15 Fuel consumption and CH₄ emission from gas engines, time-series.

4.3 N₂O

The N₂O emission from stationary combustion plants accounts for 5% of the total Danish N₂O emission. Table 3A-15 lists the N₂O emission inventory for stationary combustion plants in the year 2003. Figure 3A-16 reveals that *Electricity and heat production* accounts for 68% of the N₂O emission from stationary combustion. This is only a little higher than the fuel consumption share.

Table 3A-15 N₂O emission from stationary combustion plants 2003 ¹⁾.

N ₂ O	2003	
1A1a Public electricity and heat production	963	Mg
1A1b Petroleum refining	36	Mg
1A1c Other energy industries	58	Mg
1A2 Industry	149	Mg
1A4a Commercial / Institutional	27	Mg
1A4b Residential	161	Mg
1A4c Agriculture / Forestry / Fisheries	27	Mg
Total	1420	Mg

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

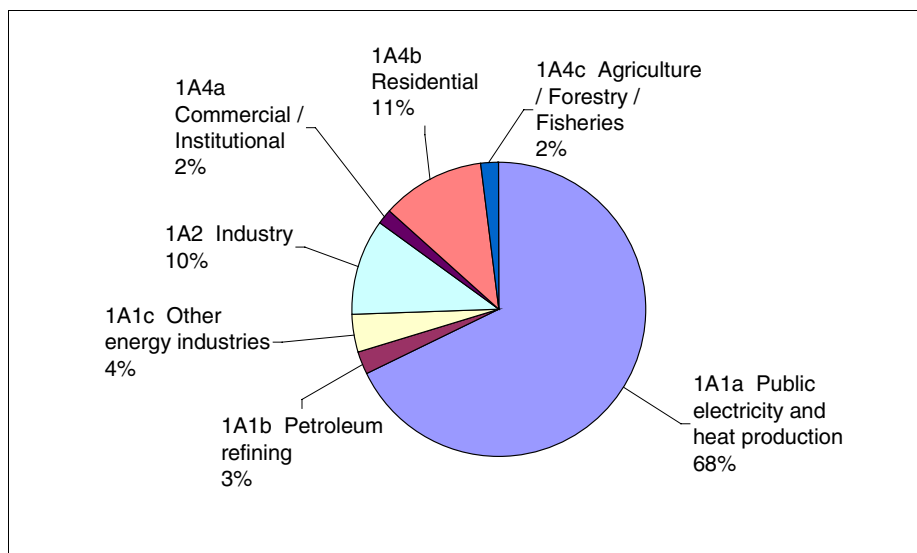


Figure 3A-16 N₂O emission sources, stationary combustion plants, 2003.

Figure 3A-17 shows time-series for N₂O emission. The N₂O emission from stationary combustion increased by 11% from 1990 to 2003, but again fluctuations in emission level due to electricity import/export are considerable.

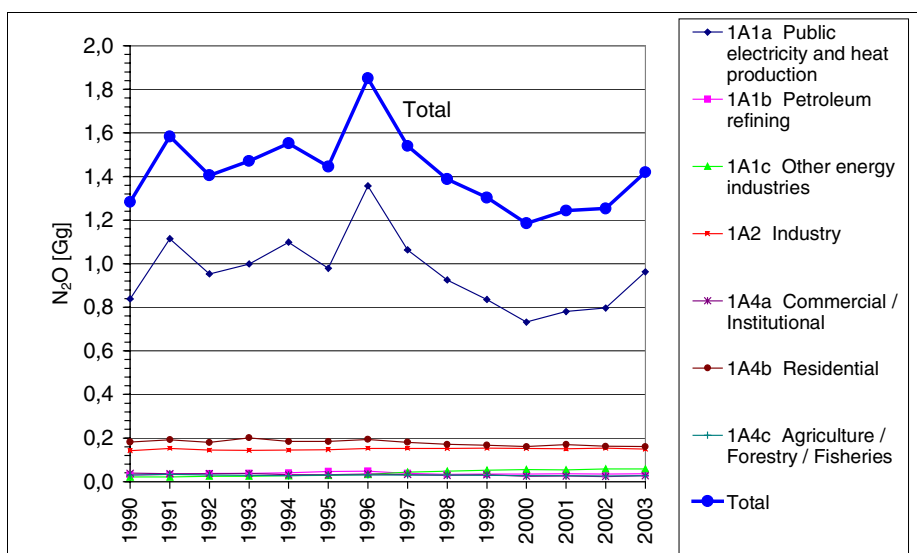


Figure 3A-17 N₂O emission time-series for stationary combustion plants.

5 SO₂, NO_x, NMVOC and CO

The emissions of SO₂, NO_x, NMVOC and CO from Danish stationary combustion plants 2003 are presented in Table 3A-16. The emission of these pollutants are also included in the report to the Climate Convention.

SO₂ from stationary combustion plants accounts for 89% of the total Danish emission. NO_x, CO and NMVOC account for 43%, 31% and 12% of total Danish emissions, respectively.

Table 3A-16 SO₂, NO_x, NMVOC and CO emission from stationary combustion 2003 ¹⁾.

Pollutant	NO _x Gg	CO Gg	NMVOC Gg	SO ₂ Gg
1A1 Fuel consumption, Energy industries	64,5	12,6	4,3	17,5
1A2 Fuel consumption, Manufacturing Industries and Construction (Stationary combustion)	13,4	12,3	0,7	5,9
1A4 Fuel consumption, Other sectors (Stationary combustion)	7,7	158,8	13,5	3,6
Total emission from stationary combustion plants	85,6	183,7	18,5	26,9
Total Danish emission	198,7	591,0	158,0	30,1
	%			
Emission share for stationary combustion	43	31	12	89

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

5.1 SO₂

Stationary combustion is the most important emission source for SO₂ accounting for 89% of the total Danish emission. Table 3A-17 and Figure 3A-18 present the SO₂ emission inventory for the stationary combustion subsectors.

Electricity and heat production is the largest emission source accounting for 63% of the emission, however, the SO₂ emission share is almost the same as the fuel consumption share for this sector, which is 64%. This is possibly due to effective flue gas desulphurisation equipment installed in power plants combusting coal. Figure 3A-19 shows the SO₂ emission from *Electricity and heat production* on a disaggregated level. Power plants >300MW_{th} represent the main emission source, accounting for 83% of the emission.

The fuel origin of the SO₂ 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 (61%). Most remarkably is the emission share from residual oil combustion, which is 20%. This emission is very high compared to 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 SO₂ emission from *Industry* is 22%, 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 is also a considerable emission source. Some years ago, SO₂ 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 SO₂ emission from stationary combustion are shown in Figure 3A-21. The SO₂ emission from stationary combustion plants has decreased by 94% from 1980 and 78% 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 63% of the total emission from stationary combustion, as mentioned above. The emission from other sectors also decreased considerably since 1980.

Table 3A-17 SO₂ emission from stationary combustion plants 2003 ¹⁾.

SO ₂	2003	
1A1a Public electricity and heat production	16958	Mg
1A1b Petroleum refining	495	Mg
1A1c Other energy industries	9	Mg
1A2 Industry	5851	Mg
1A4a Commercial / Institutional	364	Mg
1A4b Residential	1738	Mg
1A4c Agriculture / Forestry / Fisheries	1511	Mg
Total	26924	Mg

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

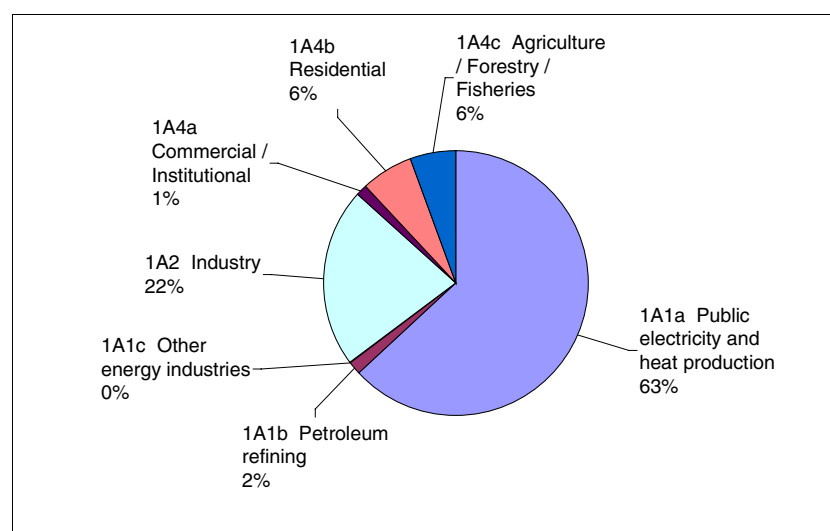


Figure 3A-18 SO₂ emission sources, stationary combustion plants, 2003.

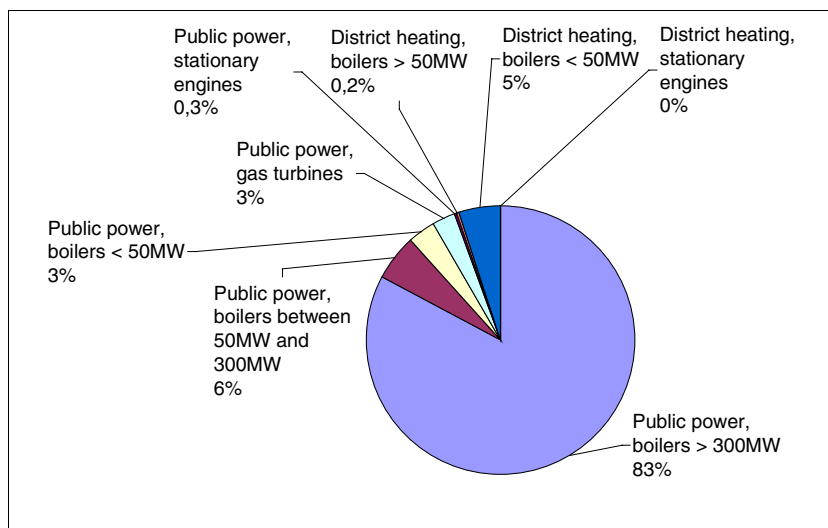


Figure 3A-19 Disaggregated SO₂ emissions from *Energy and heat production*.

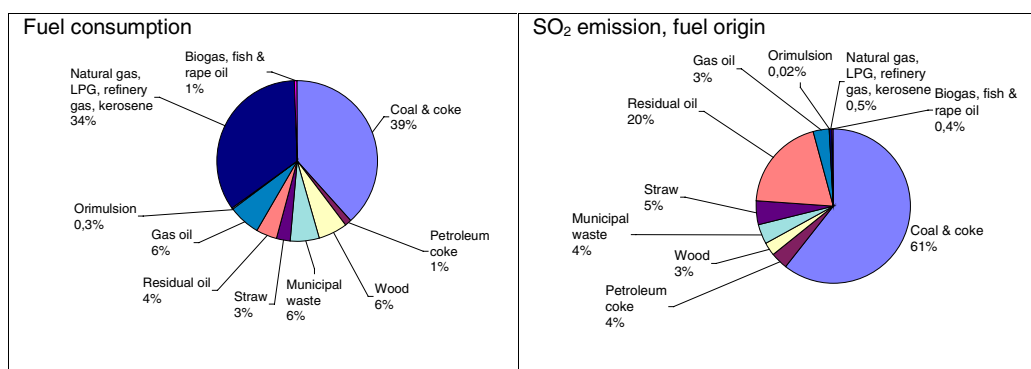


Figure 3A-20 Fuel origin of the SO₂ emission from stationary combustion plants.

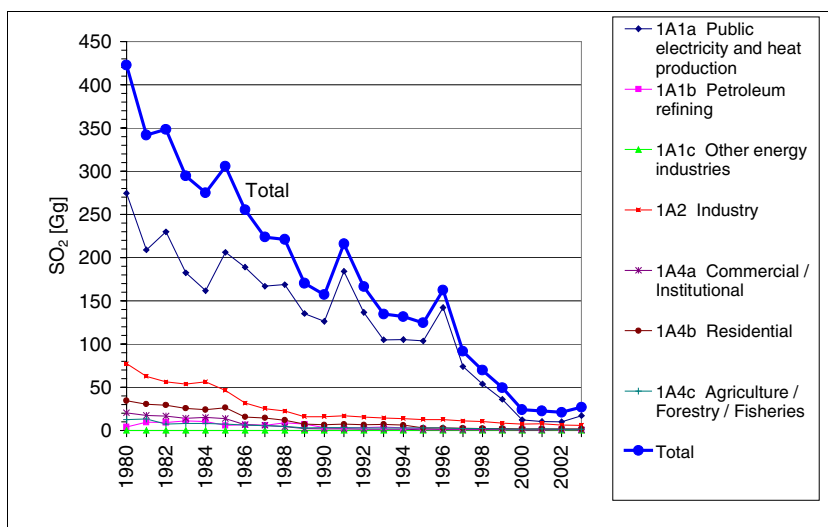


Figure 3A-21 SO₂ emission time-series for stationary combustion.

5.2 NO_x

Stationary combustion accounts for 43% 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 65% of the emission from stationary combustion plants. Power plants $>50\text{MW}_{\text{th}}$ are the main emission source in this sector accounting for 78% of the emission.

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 16% of the emission. The main industrial emission source is cement production, accounting for 63% of the emission.

Residential plants accounts for 6% of the NO_x emission. The fuel origin of this emission is mainly wood, gas oil and natural gas accounting for 37%, 29% and 23% of the residential plant emission, respectively.

Time-series for NO_x emission from stationary combustion are shown in Figure 3A-24. NO_x emission from stationary combustion plants has decreased by 43% from 1985 and 23% from 1995. The reduced emission is mainly a result of the reduced emission from *Electricity and heat production* due to installation of low NO_x burners and selective catalytic reduction (SCR) units. The fluctuations 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 2003 ¹⁾.

	2003	
1A1a Public electricity and heat production	56247	Mg
1A1b Petroleum refining	1645	Mg
1A1c Other energy industries	6615	Mg
1A2 Industry	13419	Mg
1A4a Commercial / Institutional	1245	Mg
1A4b Residential	4865	Mg
1A4c Agriculture / Forestry / Fisheries	1544	Mg
Total	85581	Mg

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

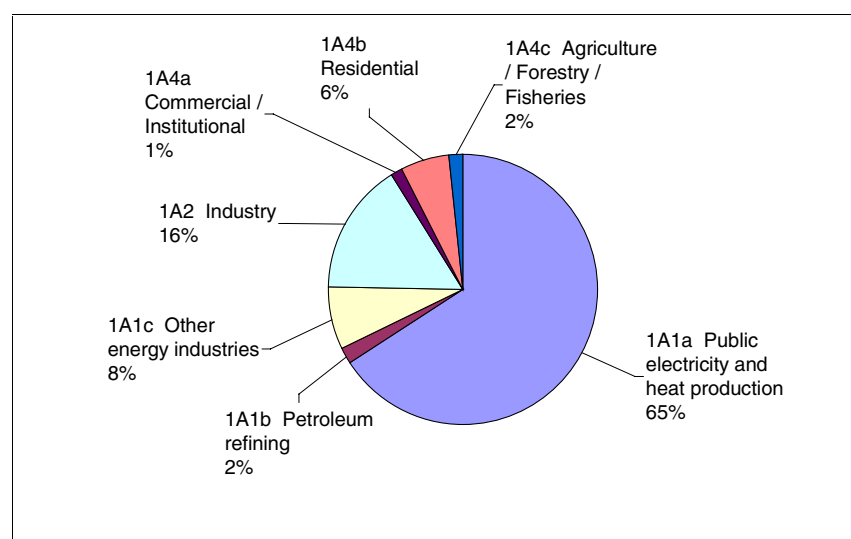


Figure 3A-22 NO_x emission sources, stationary combustion plants, 2003.

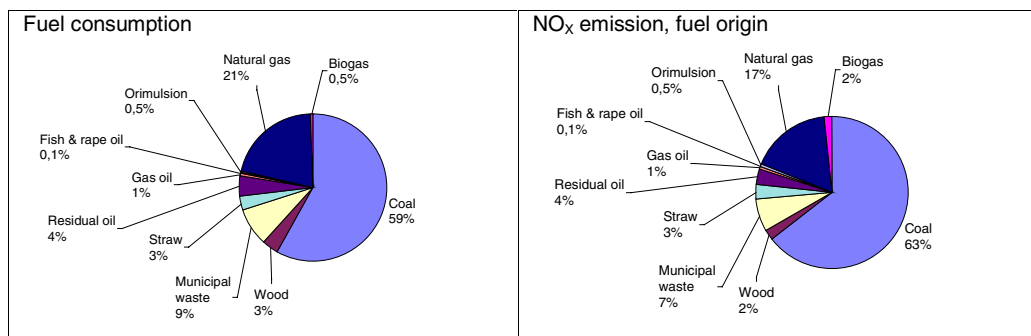


Figure 3A-23 NO_x emissions from 1A1a Electricity and heat production, fuel origin.

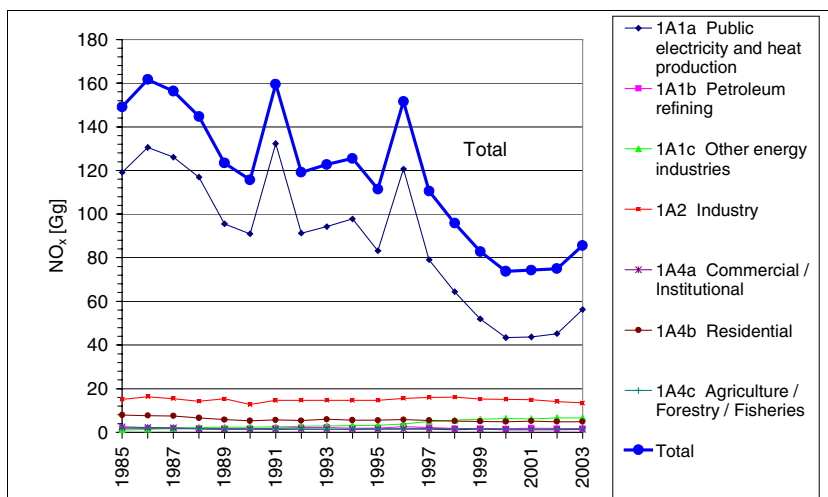


Figure 3A-24 NO_x emission time-series for stationary combustion.

5.3 NMVOC

Stationary combustion plants account for 12% 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 60% 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 23% 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 43% from 1985 and 15% 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 23% higher in 2003 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 farm-house 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 2003 ¹⁾.

	2003	
1A1a Public electricity and heat production	4222	Mg
1A1b Petroleum refining	2	Mg
1A1c Other energy industries	39	Mg
1A2 Industry	721	Mg
1A4a Commercial / Institutional	751	Mg
1A4b Residential	11115	Mg
1A4c Agriculture / Forestry / Fisheries	1629	Mg
Total	18478	Mg

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

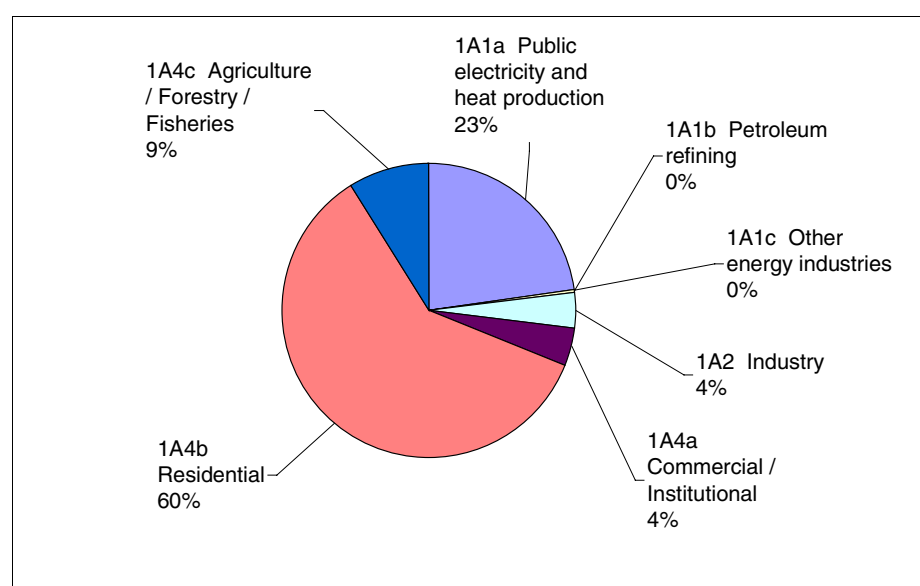


Figure 3A-25 NMVOC emission sources, stationary combustion plants, 2003.

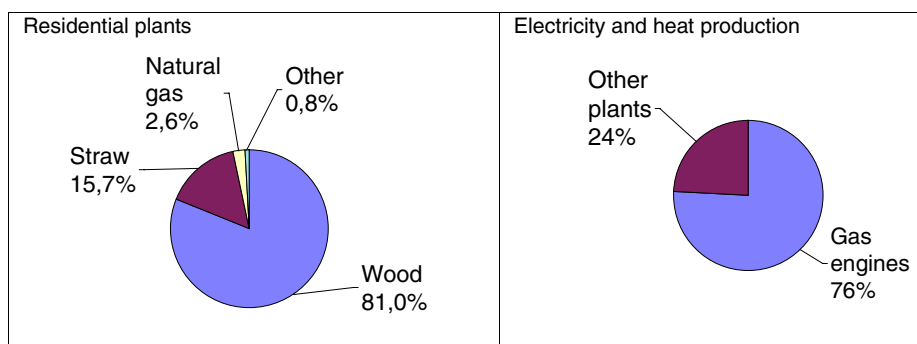


Figure 3A-26 NMVOC emission from residential plants and from electricity and heat production, 2003.

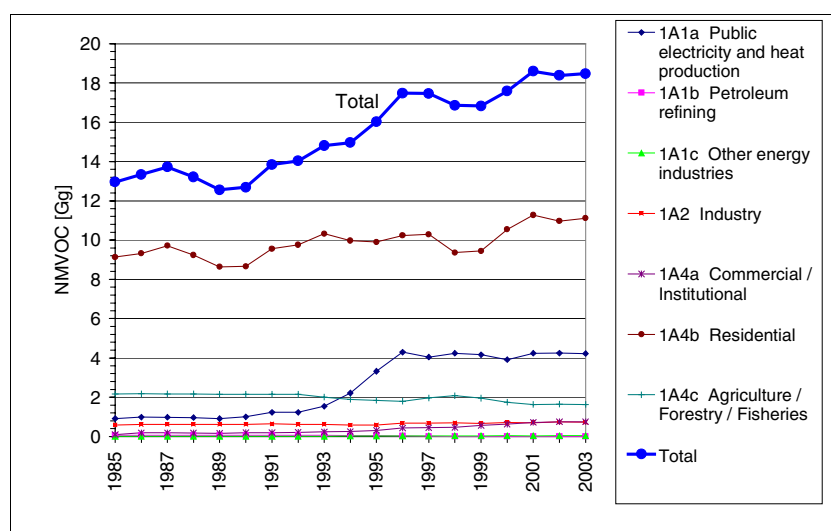


Figure 3A-27 NMVOC emission time-series for stationary combustion.

5.4 CO

Stationary combustion accounts for 31% of the total Danish CO emission. Table 3A-20 and Figure 3A-28 presents the CO emission inventory for stationary combustion sub-sectors.

Residential plants are the largest emission source, accounting for 80% of the emission. Wood combustion accounts for 90% of the emission from residential plants, see Figure 3A-29. This is in spite of the fact that the fuel consumption share is only 19%. Combustion of straw is also a considerable emission source whereas the emission from other fuels used in residential plants is almost negligible.

Time-series for CO emission from stationary combustion are shown in Figure 3A-30. The emission has increased by 2% from 1985 and decreased 3% 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 68% since 1990 leading to an increase in the CO emission. The increase in 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 2003 ¹⁾.

	2003	
1A1a Public electricity and heat production	12205	Mg
1A1b Petroleum refining	242	Mg
1A1c Other energy industries	183	Mg
1A2 Industry	12308	Mg
1A4a Commercial / Institutional	937	Mg
1A4b Residential	149242	Mg
1A4c Agriculture / Forestry / Fisheries	8599	Mg
Total	183715	Mg

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

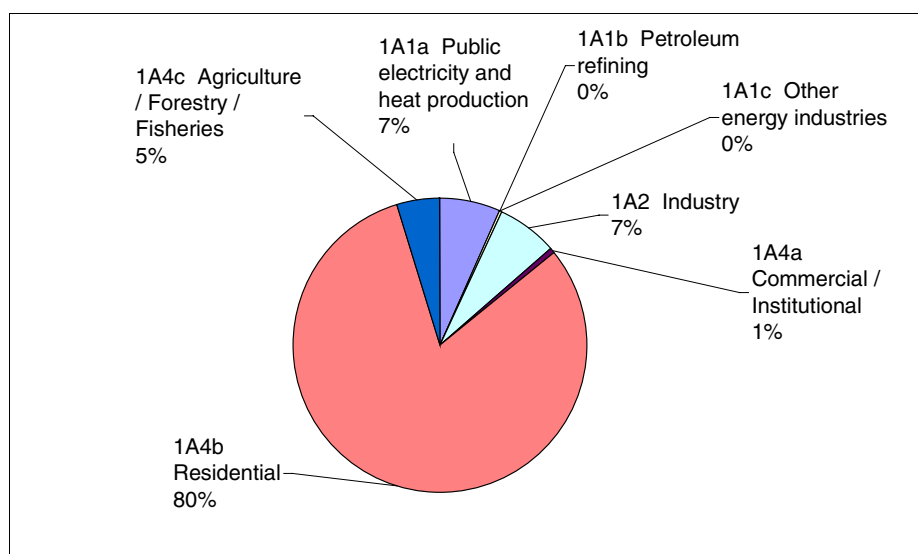


Figure 3A-28 CO emission sources, stationary combustion plants, 2003.

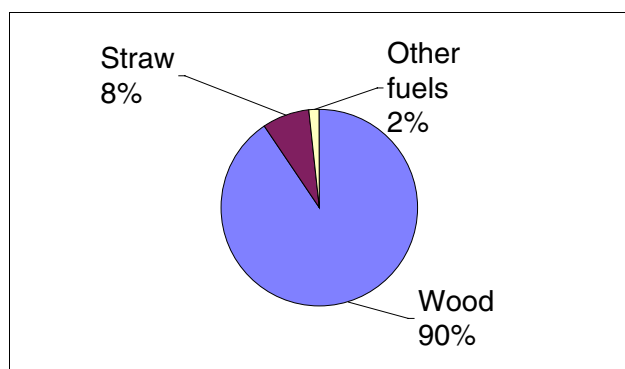


Figure 3A-29 CO emission sources, residential plants, 2003.

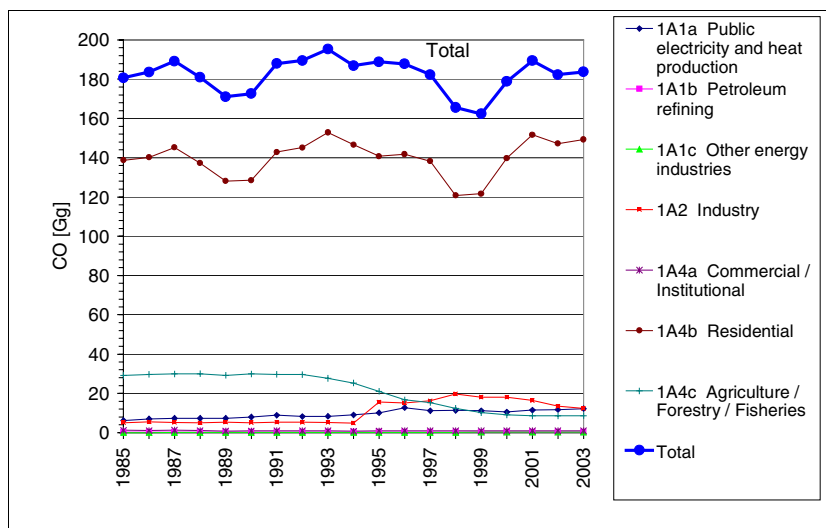


Figure 3A-30 CO emission time-series for stationary combustion.

6 QA/QC and validation

The elaboration of a formal QA/QC plan started in 2004. A first draft QA/QC plan (in Danish) for stationary combustion has been developed and this draft version is now applied as one of two sector specific QA/QC cases. Adaptation to the general QA/QC plan will be performed in 2005.

The draft QA/QC plan for stationary combustion includes:

- Documentation concerning external data sources, including contacts, contracts with data supplier, archiving and suggested QC.
- Compilation of the data for the emission database, including current QC and suggested QC
- Data input to the emission database, including information on whether the data transfer is manual or not, current QC during and after data input, suggested QC.
- Emission inventory, including current and suggested QC of the emission inventory (consistency and completeness)
- Data transfer from the emission database to the reporting formats, including current and planned QC and archiving.
- A suggestion for the future archiving structure
- A time schedule for the QC plan
- QA
- Verification

The QC is not implemented yet. This year the QC procedures applied are the same as those applied last year. The QC includes:

- Checking of time-series in the IPCC and SNAP source categories. Considerable changes are controlled and explained.
- Comparison with the inventory of the previous year. Any major changes are verified.
- Total emission, when aggregated to IPCC and LRTAP reporting tables, is compared with totals based on SNAP source categories (control of data transfer).
- A manual log table in the emission databases is applied to collect information about recalculations.

- The IPCC reference approach validates the fuel consumption rates and CO₂ emissions of fuel combustion. Fuel consumption rates and CO₂ emissions differ by less than 1,5% (1990-2003). The reference approach is further discussed below.
- 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 factor 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 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 dk-Teknik² both run accredited laboratories for emission measurements.

6.1 Reference approach

In addition to the sector-specific CO₂ emission inventories (the national approach), the CO₂ 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 CO₂ 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 home page (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, the 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 CO₂ 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.

Three fuels are used for non-energy purposes: lube oil, bitumen and white spirit. The total consumption for non-energy purposes is relatively low – 10,8 PJ in 2003.

In 2003 the fuel consumption rates in the two approaches differ by 0,28% and the CO₂ emission differs by 0,04%. In the period 1990-2003 fuel consumption differs by less than 1,5%, and the CO₂ emission by less than 1,4%. 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 2003 and the comparison

² Now FORCE

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-31.

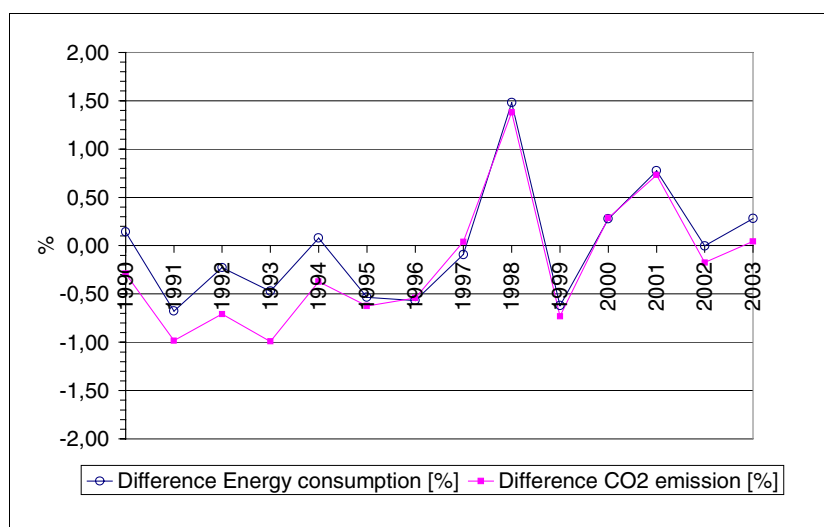


Figure 3A-31 Comparison of the reference approach and the national approach.

6.2 External review

The first national external review of the annually updated sector report for stationary combustion was performed in 2004 by Jan Erik Johnsson, Technology University of Denmark. The review was performed after the reporting in 2004 and thus the improvements of emission factors suggested by Jan Erik Johnsson have been included the inventory presented in this report.

National review of the data reported to the Climate Convention will be performed after the reporting of emission data.

6.3 Key source analysis

As part of the reportings 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-21. The CO₂ emission from eight different fuels is key source in the Danish inventory. Furthermore, CH₄ emission is a trend key source due to the increased electricity production based on gas engines.

The key source analysis will be considered in the future QC for stationary combustion.

Table 3A-21 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	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 $\pm 11\%$ and the increase in the GHG emission since 1990 has been estimated to be $11,1\% \pm 1,7\%$ 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:

- CO₂ emission from each of the applied fuel categories
- CH₄ emission from gas engines
- CH₄ emission from all other stationary combustion plants
- N₂O emission from all stationary combustion plants

The separate uncertainty estimation for gas engine CH₄ emission and CH₄ emission from other plants does not follow the recommendations in the IPCC Good Practice Guidance. Disaggregation is applied, because in Denmark the CH₄ emission from gas engines is much larger than the emission from other stationary combustion plants, and the CH₄ 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 3A-22 Uncertainty rates for activity rates and emission factors.

IPCC Source category	Gas	Activity data uncertainty %	Emission factor uncertainty %
Stationary Combustion, Coal	CO ₂	1 ¹⁾	5 ³⁾
Stationary Combustion, 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 ₂ O	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 2003 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-23. The uncertainty for fuel consumption in stationary combustion plants was assumed to be 2%.

Table 3A-23 Uncertainty rates for emission factors [%].

SNAP sector	SO ₂	NO _x	NM VOC	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-24. Detailed calculation sheets are provided in Appendix 3A-7.

The uncertainty interval for GHG is estimated to be $\pm 11\%$ and the uncertainty for the trend in GHG emission is $\pm 1,7\%$ -age points. The main sources of uncertainty for GHG

emission are N₂O emission (all plants) and CO₂ emission from coal combustion. The main source of uncertainty in the trend in GHG emission is CO₂ emission from the combustion of coal and natural gas.

The total emission uncertainty is 7% for SO₂, 16% for NO_x, 38% for NMVOC and 43% for CO.

Table 3A-24 Danish uncertainty estimates, 2003.

Pollutant	Uncertainty Total emission	Trend 1990-2003	Uncertainty Trend
	[%]	[%]	[%-age points]
GHG	10,8	+11,1	± 1,7
CO ₂	2,9	+10,1	± 1,7
CH ₄	39	+330	± 320
N ₂ O	1000	+10,7	± 3,4
SO ₂	7	-82,9	±0,5
NO _x	16	-26	±2
NMVOC	38	46	±15
CO	43	6,4	±4,1

8 Improvements/recalculations since reporting in 2004

Improvements and recalculations since the 2004 emission inventory include:

- Update of fuel rates according to the latest energy statistics. The update included the years 1980-2002.
- Disaggregation of fuel consumption and emissions to industrial subsectors. In addition to fuel consumption the following pollutants have been disaggregated: CO₂, CH₄, N₂O, SO₂, NO_x, NMVOC and CO. The disaggregation itself does not change the reported totals.
- A contract between NERI and the Danish Energy Authority specifying the content of the data supply for the emission inventory and deadlines has been signed. This contract also specifies that NERI will get access to the plant specific CO₂ data that will be collected by DEA from 2006.
- Brown coal and coke oven coke are not included in fuel category coal as in the former inventories.
- Improved emission factors for fish & rape oil have been estimated
- As a result of the first national external review a few emission factors have been improved. These changes do not change the estimated total emissions considerably.

Furthermore, a few minor errors for large point sources have been corrected. These corrections do not affect greenhouse gases.

9 Future improvements

Some planned improvements of the emission inventories are discussed below.

1) Improved documentation for CO₂ emission factors

The CO₂ 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 CO₂ emission based on plant specific CO₂ emission factors (2006).

2) Improved documentation for other emission factors

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. Implementation will start in 2005.

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.

The uncertainty of the N₂O emission factor from stationary combustion plants is a default value from the IPCC GPG. This uncertainty is a major uncertainty in the total Danish GHG inventory. Several of the applied N₂O emission factors are, however, based on emission measurements on a considerable number of Danish plants, and thus the uncertainty is considered overestimated. A country specific uncertainty estimate for N₂O will be estimated next year.

5) Other improvements

- The criteria for including a plant as a point source should be defined and the list of plants updated annually.
- White spirit will be dislocated to the fuel category Other oil in the IPCC reference approach.

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 25% - fossil fuel consumption, however, by only 18%. 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 57% of the total Danish GHG emission. 70% of the Danish CO₂ emission originates from stationary combustion plants whereas stationary combustion plants account for 9% of the CH₄ emission and 5% of the N₂O emission.

Public power plants are the most important stationary combustion emission source for CO₂, SO₂ and NO_x.

Lean-burn gas engines installed in decentralised CHP plants are the largest stationary combustion emission source for CH₄. 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 CO₂ emission development closely. Both the CO₂ and the total GHG emission was higher in 2003 than in 1990, CO₂ by 10% and GHG by 11%. However fluctuations in the GHG emission level are great. The fluctuations in the time-series are a result of electricity import/export and of outdoor temperature variations from year to year.

The CH₄ 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.

SO₂ emission from stationary combustion plants has decreased by 78% from 1995. The considerable emission decrease is mainly 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 23% 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 of the Danish greenhouse gas emission from stationary combustion is estimated to be within a range of ±11% and the trend uncertainty within a range of ±1,7%-age points. The sources contributing the most to the uncertainty estimates are the N₂O emission (all plants) and the CO₂ 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 CO₂ 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 2003 reported to the Climate Convention

Table 3A-25 The Danish emission inventory for the year 2003 reported to the Climate Convention in 2005 (Illerup et al. 2005a).

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO ₂ ⁽¹⁾	CH ₄	N ₂ O	HFCs	PFCs	SF ₆	Total
	CO ₂ equivalent (Gg)						
Total (Net Emissions)⁽¹⁾	58,124,39	5,873,26	8,059,69	695,48	19,34	31,37	72,803,53
1. Energy	57,634,90	770,94	911,89				59,317,73
A. Fuel Combustion (Sectoral Approach)	57,085,08	594,27	908,91				58,588,26
1. Energy Industries	31,401,90	329,84	327,56				32,059,30
2. Manufacturing Industries and Construction	5,404,21	34,02	55,80				5,494,03
3. Transport	12,785,27	65,09	428,94				13,279,30
4. Other Sectors	7,401,72	165,23	95,16				7,662,12
5. Other	91,98	0,09	1,45				93,52
B. Fugitive Emissions from Fuels	549,82	176,67	2,98				729,46
1. Solid Fuels	0,00	93,10	0,00				93,10
2. Oil and Natural Gas	549,82	83,57	2,98				636,36
2. Industrial Processes	1,488,18	0,00	894,66	695,48	19,34	31,37	3,129,04
A. Mineral Products	1,485,51	0,00	0,00				1,485,51
B. Chemical Industry	2,67	0,00	894,66	0,00	0,00	0,00	897,33
C. Metal Production	0,00	0,00	0,00		0,00	0,00	0,00
D. Other Production	NE						0,00
E. Production of Halocarbons and SF ₆				0,00	0,00	0,00	0,00
F. Consumption of Halocarbons and SF ₆				695,48	19,34	31,37	746,19
G. Other	0,00	0,00	0,00	0,00	0,00	0,00	0,00
3. Solvent and Other Product Use	205,59		0,00				205,59
4. Agriculture	0,00	3,705,53	6,192,47				9,898,00
A. Enteric Fermentation		2,733,61					2,733,61
B. Manure Management		971,93	560,31				1,532,24
C. Rice Cultivation		0,00					0,00
D. Agricultural Soils ⁽²⁾		0,00	5,632,16				5,632,16
E. Prescribed Burning of Savannas		0,00	0,00				0,00
F. Field Burning of Agricultural Residues		0,00	0,00				0,00
G. Other		0,00	0,00				0,00
5. Land-Use Change and Forestry⁽¹⁾	-1,204,28	0,00	0,00				-1,204,28
6. Waste	0,00	1,396,79	60,67				1,457,46
A. Solid Waste Disposal on Land	0,00	1,152,81					1,152,81
B. Wastewater Handling		243,97	60,67				304,65
C. Waste Incineration	0,00	0,00	0,00				0,00
D. Other	0,00	0,00	0,00				0,00
7. Other (please specify)	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Memo Items:							
International Bunkers	5,317,55	2,38	84,92				5,404,85
Aviation	2,187,52	0,89	23,63				2,212,04
Marine	3,130,03	1,49	61,28				3,192,81
Multilateral Operations	0,00	0,00	0,00				0,00
CO₂ Emissions from Biomass	9,107,71						9,107,71

⁽¹⁾ For CO₂ emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).

⁽²⁾ See footnote 4 to Summary 1.A of this common reporting format.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO ₂ emissions	CO ₂ removals	Net CO ₂ emissions / removals	CH ₄	N ₂ O	Total emissions
Land-Use Change and Forestry	CO₂ equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	0,00	-3,533,00	-3,533,00			-3,533,00
B. Forest and Grassland Conversion	0,00		0,00	0,00	0,00	0,00
C. Abandonment of Managed Lands	0,00	0,00	0,00			0,00
D. CO ₂ Emissions and Removals from Soil	2,477,81	-149,09	2,328,72			2,328,72
E. Other	0,00	0,00	0,00	0,00	0,00	0,00
Total CO₂ Equivalent Emissions from Land-Use Change and Forestry	2,477,81	-3,682,09	-1,204,28	0,00	0,00	-1,204,28

Total CO ₂ Equivalent Emissions without Land-Use Change and Forestry ^(a)	74,007,81
Total CO ₂ Equivalent Emissions with Land-Use Change and Forestry ^(b)	72,803,53

^(a) The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry.

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 $\geq$ 300 MW (boilers)	1A1a
010102	Combustion plants $\geq$ 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 $\geq$ 300 MW (boilers)	1A1a
010202	Combustion plants $\geq$ 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 $\geq$ 300 MW (boilers)	1A1b
010302	Combustion plants $\geq$ 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 $\geq$ 300 MW (boilers)	1A1c
010402	Combustion plants $\geq$ 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 $\geq$ 300 MW (boilers)	1A1c
010502	Combustion plants $\geq$ 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 $\geq$ 300 MW (boilers)	1A4a
020102	Combustion plants $\geq$ 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 $\geq$ 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 $\geq$ 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 $\geq$ 300 MW (boilers)	1A2f
030102	Combustion plants $\geq$ 50 and $<$ 300 MW (boilers)	1A2f
030103	Combustion plants $<$ 50 MW (boilers)	1A2f
030104	Gas turbines	1A2f
030105	Stationary engines	1A2f
030106	Other stationary equipments (n)	1A2f
0302	Process furnaces without contact	

030203	Blast furnace cowpers	1A2a
030204	Plaster furnaces	1A2f
030205	Other furnaces	1A2f
0303	Processes with contact	
030301	Sinter and pelletizing plants	1A2a
030302	Reheating furnaces steel and iron	1A2a
030303	Gray iron foundries	1A2a
030304	Primary lead production	1A2b
030305	Primary zinc production	1A2b
030306	Primary copper production	1A2b
030307	Secondary lead production	1A2b
030308	Secondary zinc production	1A2b
030309	Secondary copper production	1A2b
030310	Secondary aluminium production	1A2b
030311	Cement (f)	1A2f
030312	Lime (includ. iron and steel and paper pulp industr.)(f)	1A2f
030313	Asphalt concrete plants	1A2f
030314	Flat glass (f)	1A2f
030315	Container glass (f)	1A2f
030316	Glass wool (except binding) (f)	1A2f
030317	Other glass (f)	1A2f
030318	Mineral wool (except binding)	1A2f
030319	Bricks and tiles	1A2f
030320	Fine ceramic materials	1A2f
030321	Paper-mill industry (drying processes)	1A2d
030322	Alumina production	1A2b
030323	Magnesium production (dolomite treatment)	1A2b
030324	Nickel production (thermal process)	1A2b
030325	Enamel production	1A2f
030326	Other	1A2f
08 1)	Other mobile sources and machinery	
0804 1)	Maritime activities	
080403 1)	National fishing	1A4c
0806 1)	Agriculture	1A4c
0807 1)	Forestry	1A4c
0808 1)	Industry	1A2f
0809 1)	Household and gardening	1A4b

1) Not stationary combustion. Included in a IPCC sector that also includes stationary combustion plants

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
102	COAL	253443653	344304910	286838436	300798816	323397473	270346016	371908021	276277339	234284905	196471582	164707939	174308631	174654028	237988396
106	BROWN COAL BRI.	115932	166823	95324	128246	91500	74609	56053	54331	47745	37607	25748	32903	18922	3056
107	COKE OVEN COKE	1275912	1449734	1181054	1154538	1226146	1272910	1226000	1253015	1346306	1422574	1187177	1109591	1068454	995409
110	PETROLEUM COKE	4459523	4403568	4814028	6179382	4308896	4849824	6381422	6523131	5797915	7283513	7291583	8313464	8281655	8465315
111	WOOD AND SIMIL.	18246814	20042438	21030661	22220199	21939961	21844810	23389205	23459226	22937838	24402570	26744717	28699132	31173732	35915081
114	MUNICIP. WASTES	15499033	16744033	17797251	19409907	20312344	22906324	24952440	26770061	26590826	29138335	30351595	32233660	35056955	36174969
117	STRAW	12481150	13306150	13880150	13366000	12662374	13053146	13545635	13911770	13903702	13668183	12219993	13698193	15651212	16718510
118	SEWAGE SLUDGE											40162	0	64508	55369
203	RESIDUAL OIL	32115776	37019676	37331786	32498181	46701347	34069407	38484607	26693239	29479704	22987286	18041774	20248414	24751387	27181710
204	GAS OIL	61673851	65356000	55971755	62121901	53387561	53919044	57780170	51428302	48289913	47661150	41310063	43981473	39146911	39429204
206	KEROSENE	5086021	943393	783765	771272	649577	580777	539748	436636	417009	255606	169963	286786	256128	338430
210	NAPHTA														
215	RAPE & FISH OIL	744000	744000	744000	800000	245419	250912	60409	13751	13620	27148	49046	191475	126772	258882
225	ORIMULSION						19913113	36766527	40488416	32580001	34190632	34148181	30243677	23846404	1921399
301	NATURAL GAS	76092457	86106669	90466659	102475053	114585627	132698633	156276599	164489313	178706886	187876815	186121969	193826826	193718209	195004805
303	LPG	2529846	2444287	2165623	2168768	2152828	2361756	2558236	2012873	2049212	1779679	1456930	1184179	1062049	1133994
308	REFINERY GAS	14169000	14537000	14865000	15405000	16359999	20837864	21476000	16945381	15225340	15723812	15556268	15755428	15197000	16554512
309	BIOGAS	752001	910000	898999	1077001	1279488	1753646	1985110	2390005	2635029	2612573	2870670	3020152	3331898	3542571
Total		498684968	608478681	548864491	580574264	619300540	600732790	757386181	653146789	614305951	585539065	542293778	567133984	567406224	621681612

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
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
1A1a	102	COAL	010102	2118951	2653700	2250130	2269060	8604699	8380814	9032905	8671429	9022776	8238010	6224846	4970502	4684578	4578267
1A1a	102	COAL	010103					837469	526213	149470	38928	24301	33747	35480	24354	15476	33831
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
1A1a	102	COAL	010203					377837	316754	228340	48919	48071	6562	3551	439	0	0
1A1a	110	PETROLEUM COKE	0101				1239000										
1A1a	110	PETROLEUM COKE	0102														
1A1a	111	WOOD AND SIMIL.	0101			172000	515000										
1A1a	111	WOOD AND SIMIL.	010101					42966				263719	0		920	65930	304980
1A1a	111	WOOD AND SIMIL.	010102			0	0	1053223	865377	861821	1001257	1371873	2377322	2274825	2186568	3175531	5854505
1A1a	111	WOOD AND SIMIL.	010103					623575	671570	578451	644712	575350	732058	669817	747047	780123	446474
1A1a	111	WOOD AND SIMIL.	010104					78890	4410							120031	1656898
1A1a	111	WOOD AND SIMIL.	010105										1674	53468	60394	61748	369
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
1A1a	111	WOOD AND SIMIL.	010203					3337730	3490933	3857403	3795439	3971995	3928219	3882223	4297719	4650874	5066279
1A1a	114	MUNICIP. WASTES	0101	990000	3563000	5578000	8433000										
1A1a	114	MUNICIP. WASTES	010101									1288015	1278184	1230861	2809020	3502130	143440
1A1a	114	MUNICIP. WASTES	010102		0	0	0	5110126	6527009	7152947	10831534	11715082	16937780	18305718	17902293	19002825	22524122
1A1a	114	MUNICIP. WASTES	010103					2909656	3755268	5002562	3074395	1957053	4039009	8361289	8343163	8321439	7848203
1A1a	114	MUNICIP. WASTES	010104					1665338	2027577	3191968	3025187	2806452	2452693	416975	0	0	625367
1A1a	114	MUNICIP. WASTES	010105											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
1A1a	117	STRAW	0101	479000	985000	1487000	1643000										
1A1a	117	STRAW	010101					100254	82215	610291	740153	1013770	1339800	1119600	1587710	2643060	3191917
1A1a	117	STRAW	010102	0	0	0	0	621557	1286956	1704388	1845052	1751935	1819429	1826796	1746166	1640945	1712033
1A1a	117	STRAW	010103					1126908	1297258	1361686	1174181	1180826	1058038	640340	1905033	1754340	1927521
1A1a	117	STRAW	010104												101730	1215692	1706623
1A1a	117	STRAW	0102	3524000	3843000	3915000	3806000	0	0	0	0						
1A1a	117	STRAW	010201					22040									
1A1a	117	STRAW	010202					57304	179931	114376	95990	136489	141564	150510	97600	0	0
1A1a	117	STRAW	010203					3378461	3409001	3699694	3564019	3525786	3565456	3290636	3418313	3555625	3338866
1A1a	203	RESIDUAL OIL	0101	774830	364138	1742448	741228							0	0	0	0
1A1a	203	RESIDUAL OIL	010101	7171573	10052580	8691120	8420050	22142392	11174241	16072213	7736420	11557361	7213503	4045724	5950549	5018057	7329328
1A1a	203	RESIDUAL OIL	010102	42265	16950	27100	24390	180490	253891	443479	420683	510374	762923	513002	253635	278953	334256
1A1a	203	RESIDUAL OIL	010103					252297	173028	201180	159318	115535	101551	108599	117384	120150	106040
1A1a	203	RESIDUAL OIL	010104					320163	347198	237194	302167	355440	118177	117319	1767903	6694775	9358988
1A1a	203	RESIDUAL OIL	010105	9332	9332	9332	9332	11554	4323	4888	2415	5984	4137	17206	533	656	5900
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
1A1a	203	RESIDUAL OIL	010203					858909	938696	1201058	874538	779146	961623	617493	611104	547566	323210
1A1a	204	GAS OIL	0101	239170	416396	641323	245263							0	0	0	0
1A1a	204	GAS OIL	010101					12386	51300	41614	194854	108730	258004	135602	122718	92395	956997
1A1a	204	GAS OIL	010102	0	0	0	0	42898	30019	153012	113506	82184	158532	278595	366847	279069	114717
1A1a	204	GAS OIL	010103					59149	40405	78104	41727	44468	61232	0	34258	36567	16629
1A1a	204	GAS OIL	010104	43987	43987	43987	43987	43987	75632	81094	54042	146795	60385	103191	40026	75242	79241
1A1a	204	GAS OIL	010105	16843	32617	34690	34750	116493	136913	99083	100449	133710	108002	68733	84634	66390	63501
1A1a	204	GAS OIL	0102	1941000	813000	744000	947000	0	0	0	0						
1A1a	204	GAS OIL	010201					27268	7000								

1A1a	204	GAS OIL	010202					174046	360676	799818	514978	418139	257831	694229	830045	166763	256178
1A1a	204	GAS OIL	010203					843648	444369	554844	509625	652349	296296	233116	354842	306816	1125856
1A1a	204	GAS OIL	010205					717					1055	0	0	0	0
1A1a	210	NAPHTA	0101														
1A1a	215	RAPE & FISH OIL	010103					33707	24000	21799	188	5213	6974				2168
1A1a	215	RAPE & FISH OIL	0102	744000	744000	744000	800000										
1A1a	215	RAPE & FISH OIL	010202														18807
1A1a	215	RAPE & FISH OIL	010203					211712	226912	38610	13563	8407	20174	48900	190810	126336	237665
1A1a	225	ORIMULSION	010101					19913113	36766527	40488416	32580001	34190632	34148181	30243677	23846404	1921399	
1A1a	301	NATURAL GAS	0101							5511	21264	16787	14558	11364	2	1188	
1A1a	301	NATURAL GAS	010101	4005028	4394781	3279455	4422200	8437973	10453816	12217008	14600070	20808855	21307826	23541558	20514966	19246614	20165293
1A1a	301	NATURAL GAS	010102	0	0	0	0	295111	299964	1346036	5620044	5987198	2416146	1589836	4250088	2893468	1877463
1A1a	301	NATURAL GAS	010103					2487008	1775265	1558418	1138214	958646	716525	683789	733694	657392	1057907
1A1a	301	NATURAL GAS	010104	1859206	2396900	4806049	7327221	7776734	8547713	14500109	12220262	13002948	21614378	22973678	25003005	30030786	29928352
1A1a	301	NATURAL GAS	010105	677767	1291319	2199496	4168579	8358415	16419956	22162423	24109208	26700713	26833951	25639911	27865345	27701651	27012113
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
1A1a	301	NATURAL GAS	010203					6160497	5525191	3803076	2420020	1988837	1873511	1427019	1768484	1482319	1849960
1A1a	301	NATURAL GAS	010205					131795	338556	377124	230400	235829	226189	203414	228049	207211	171691
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
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
1A1a	309	BIOGAS	010103					54324	118012	79237	111449	86924	103711	134968	123991	90125	97272
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
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
1A1a	309	BIOGAS	010205					40607									
1A1b	203	RESIDUAL OIL	010306	1309202	2038140	3568653	3490237	3336717	2333787	2244019	1622382	1106086	1089501	1322995	1442929	1362640	907082
1A1b	204	GAS OIL	010306		40029	44476	29125	49319	33321	21879	87482						3085
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
1A1b	308	REFINERY GAS	010306	13520108	13485940	13236820	13213580	14004999	18548164	16336522	12771044	12202506	11551206	11648701	11776506	11341800	12750415
1A1c	204	GAS OIL	010505													151	116
1A1c	301	NATURAL GAS	010502	0	0	0	0	0	399247	390587	417415	413342	409043	340514	352650	379362	322831
1A1c	301	NATURAL GAS	010504	9482284	9703068	11118697	11235480	12267791	12506433	14849859	19454575	21636547	23561526	25015663	24413386	26179968	26247274
1A1c	301	NATURAL GAS	010505	1760	3520	3520	3520	2570	4494	7551	4939	15340	13883	13889	11887	11473	12396
1A1c	309	BIOGAS	010505	6803	6803	6803	6803	5946	51779	60257	57462	31144	29028	32507	28627	31216	31791
1A2f	102	COAL	0301	8850301	8982254	6751419	7698631	5866929	4832666	4460978	4494493	4676030	3714902	3667193	3358610	2126818	1536650
1A2f	102	COAL	030102					614624	1051344	1449890	1466575	1405667	1411682	1063375	997381	998229	1569871
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
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
1A2f	107	COKE OVEN COKE	030318					937440	885600	930960	1006560	1030320	943920	883440	786240	693360	
1A2f	110	PETROLEUM COKE	0301	300247	0	56107	122868	0	98156	110026	33598	25842	38999	285426	127924	223785	229902
1A2f	110	PETROLEUM COKE	030311	2499252	2991306	3234048	3230652	3469025	3707398	4966161	5229890	4774684	6398880	6474743	7656733	7543476	7714392
1A2f	111	WOOD AND SIMIL.	0301	5783743	5690367	5750550	5821715	4464819	4254327	4097885	4166034	4273637	4250138	4450170	4410404	5854411	5970723
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
1A2f	114	MUNICIP. WASTES	0301	28033	28033	37251	38907	26336	28516	27942	23857	28854	35287				
1A2f	114	MUNICIP. WASTES	030102									0				0	4602
1A2f	114	MUNICIP. WASTES	030311										505233	795492	1787613	1406393	
1A2f	117	STRAW	0301									446	446				
1A2f	117	STRAW	030103					3085									
1A2f	117	STRAW	030105											386	91	0	0

1A2f	118	SEWAGE SLUDGE	030311											40162	0	64508	55369
1A2f	203	RESIDUAL OIL	0301	16528584	17769972	17383144	14202407	13060233	11277994	11328646	9336208	8615100	7973673	7362935	7287922	7207646	5361504
1A2f	203	RESIDUAL OIL	030102					741775	911133	788578	789663	663124	695536	714099	791893	808652	1644621
1A2f	203	RESIDUAL OIL	030103					200248	207326	165590	122783	121633	135661	140375	89987	0	0
1A2f	203	RESIDUAL OIL	030104								54439		0	0	0	0	0
1A2f	203	RESIDUAL OIL	030105												22	10	787
1A2f	203	RESIDUAL OIL	030311	1762853	2152997	2366678	2397243	2618777	2840311	1771379	1863965	2538540	885967	858853	784	591804	587464
1A2f	204	GAS OIL	0301	665894	1575562	0	0	522742	1582383	2123771	2078532	1729346	2532751	2209631	3180458	2615282	3015931
1A2f	204	GAS OIL	030102						3438			440	1327	3138	5071	199	3574
1A2f	204	GAS OIL	030103					1678	1453	11390	1015	1623	64	82107	19	0	0
1A2f	204	GAS OIL	030104								244	377	6787	51	0	897	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
1A2f	204	GAS OIL	030315								1040	603	4950	1650	2009	681	933
1A2f	206	KEROSENE	0301	69635	45692	38315	35461	30485	24464	30937	27840	16078	8909	7552	25543	65146	48233
1A2f	215	RAPE & FISH OIL	030105													334	242
1A2f	301	NATURAL GAS	0301	22280195	23780869	23887554	25535326	29248293	30317634	29252137	29423362	29114015	31167462	28607520	30073159	29817088	29031473
1A2f	301	NATURAL GAS	030102					862925	2661779	2464665	2971625	2961903	3100115	2690206	2869052	1190136	2273628
1A2f	301	NATURAL GAS	030103					300216	64308	146812	169825	131608	126872	116411	117965	14707	118562
1A2f	301	NATURAL GAS	030104	506337	608907	664092	729919	761202	909952	2562511	3366152	5106083	6501018	6756339	6138931	6724143	6526151
1A2f	301	NATURAL GAS	030105	187	187	187	187	11210	172920	873431	960232	1157405	1160055	1556394	1641970	1545466	1543942
1A2f	301	NATURAL GAS	030106	136059	24239	37695	70154	53489	24415	15283	5288	31735	38608	50809	53712	25558	17229
1A2f	301	NATURAL GAS	030315								924066	903336	1005440	1101274	1089048	1016242	945777
1A2f	301	NATURAL GAS	030318					624960	590400	620640	671040	686880	629280	588960	524160	552240	
1A2f	303	LPG	0301	1522719	1603834	1466190	1273678	1337017	1486636	1636596	1277738	1299081	991730	632947	387254	308697	353256
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
1A2f	309	BIOGAS	030102					6534	16370	16478	19080	16361	16116	15755	59220	71672	95546
1A2f	309	BIOGAS	030104						1053	1265	1137						
1A2f	309	BIOGAS	030105									381	269	1487	23805	18459	14205
1A4a	102	COAL	0201	87539	9010	95877	75870	90286	66065	41261	43063	2306					
1A4a	106	BROWN COAL BRI.	0201	1025	1720		8217	769	622	421	309						
1A4a	110	PETROLEUM COKE	0201	62023	104190	90150	96354	0	70415	90528	97770	70544	50434	12070	12086	5355	9003
1A4a	111	WOOD AND SIMIL.	0201	204488	204488	204488	204488	216160	273035	449435	471415	492803	642041	775926	918817	972914	973866
1A4a	111	WOOD AND SIMIL.	020105									2096	2057		97	796	0
1A4a	114	MUNICIP. WASTES	0201	914000	1011000	1071000	1099000	1182354	1274551	1222406	1179697	709930	1472645	122160	175985	0	977733
1A4a	114	MUNICIP. WASTES	020103					30550	30923	9595	7979	9588	7344	13770	12669	12594	74825
1A4a	203	RESIDUAL OIL	0201	1070494	865011	600545	517393	718786	677072	717757	729305	383913	450237	343022	173185	478286	170881
1A4a	203	RESIDUAL OIL	020103					87533	78081								
1A4a	204	GAS OIL	0201	11794783	10622868	10421008	10011485	7156617	6556065	6619841	6093376	5442142	5781168	4957566	4685349	4031236	3625867
1A4a	204	GAS OIL	020102					190782		215		75					
1A4a	204	GAS OIL	020103					72		57796	58202	53618	39101	71306	44010	43890	29646
1A4a	204	GAS OIL	020105			1361	1485	733	20330	1754	294	21	66	1277	673	743	727
1A4a	206	KEROSENE	0201	569083	209843	206978	188910	154647	124344	103314	96459	127964	117233	63008	79642	69668	74131
1A4a	301	NATURAL GAS	0201	6376293	6934201	7382035	8908566	7343015	8436587	11247402	9106736	8661696	7525335	7233923	7908341	7264139	8020520
1A4a	301	NATURAL GAS	020103					2177			2434	49460	10801	43211	67208	165296	11053
1A4a	301	NATURAL GAS	020104		0			11946	25798	31397	25514	22995	30739	23335	31001	42862	33669
1A4a	301	NATURAL GAS	020105	45985	88875	278287	350372	473892	609395	681480	866185	959184	985839	1033132	1044813	1079590	1023163
1A4a	303	LPG	0201	82757	77097	76519	122201	125183	131001	137989	128417	116413	109573	121621	119345	136552	169985
1A4a	303	LPG	020103									9					
1A4a	303	LPG	020105									803	771				
1A4a	309	BIOGAS	0201	199072	179112	83895	64492	112893	169712	173026	271951	225094	292653	310904	354917	358989	290434
1A4a	309	BIOGAS	020103							14474	39396	71226	74379	86680	84512	74286	85295
1A4a	309	BIOGAS	020104					27092									
1A4a	309	BIOGAS	020105	270479	290438	386655	406059	349088	410626	389678	404594	439292	436918	506512	504222	528119	531465
1A4b	102	COAL	0202	589051	1125243	866285	785646	618696	376645	85595	86470	127147	79262	14443	12906	15370	318
1A4b	106	BROWN COAL BRI.	0202	50600	66685	39107	80209	75963	62403	47324	48550	43847	37607	25748	32903	18922	3056
1A4b	107	COKE OVEN COKE	0202	106594	98682	103400	81220	62995	48785	36742	26634	20364	11486	5010	2871	2813	25667
1A4b	110	PETROLEUM COKE	0202	760877	697484	961122	990337	839871	734273	928841	839269	725791	705961	513190	513393	509008	511264
1A4b	111	WOOD AND SIMIL.	0202	8954433	10412433	10720473	11859633	11564240	11760665	12668890	12569083	11134265	11615183	13847545	15248320	14769200	15003101
1A4b	117	STRAW	0202	5086890	5086890	5086890	4750200	4413510	4076820	3633120	3891945	3773190	3442590	3111555	2901450	2901450	2901450
1A4b	203	RESIDUAL OIL	0202	216927	218605	167748	129878	95249	62794	66254	45933	43266	50365	35611	26881	148870	47430

1A4b	204	GAS OIL	0202	46463224	50638393	42913606	49967084	43678618	43287857	45295557	39595464	37849748	35675468	30275667	31506271	28997757	27510588
1A4b	206	KEROSENE	0202	4404777	659635	512024	520836	437788	410845	382564	287211	251843	118954	91190	159051	110143	205243
1A4b	301	NATURAL GAS	0202	17362132	20432645	21439693	24903983	24736624	26947401	30412122	28361811	29137977	28981613	27568914	29562248	28081591	29027446
1A4b	301	NATURAL GAS	020202							25676	24503	18059	31289	55319	69007	30105	63281
1A4b	301	NATURAL GAS	020204	0	7932	499046	776351	1022812	1094868	1448246	1488432	1575546	1554382	1439173	1450266	1392257	1451228
1A4b	303	LPG	0202	669665	521639	442269	672725	588599	628367	653211	510109	545681	624403	650995	648947	607682	596053
1A4c	102	COAL	0203	2457889	2853706	2203581	2106300	2294953	1797999	1446423	1238716	903571	708372	1079213	1234026	856215	1503478
1A4c	106	BROWN COAL BRI.	0203	59933	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
1A4c	111	WOOD AND SIMIL.	0203	87150	87150	87150	68363	68363	68363	86804	96800	230244	230875	170093	147164	147000	147000
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
1A4c	117	STRAW	020302								5800	5800	5800	5800	5800	5800	5800
1A4c	203	RESIDUAL OIL	0203	1223716	1295951	1634018	1687023	1942109	2616552	3070977	2492455	2563430	2396266	1778526	1640210	1365228	910801
1A4c	203	RESIDUAL OIL	020302									9051	1105	3269	2069	1964	6081
1A4c	203	RESIDUAL OIL	020304									9345	11104	4017	4570	3335	3417
1A4c	204	GAS OIL	0203	502852	1166512	1117213	837382	455397	1280853	1829800	1972963	1609942	2347866	2181257	2711181	2420922	2612416
1A4c	204	GAS OIL	020302								7						
1A4c	204	GAS OIL	020304							3855	2324			4774	2723	4846	6315
1A4c	206	KEROSENE	0203	42526	28223	26448	26065	26657	21124	22933	25126	21124	10510	8213	22550	11171	10823
1A4c	215	RAPE & FISH OIL	020304											146	665	102	0
1A4c	301	NATURAL GAS	0203	2222000	2680002	2385006	2462538	2485322	2559680	2666407	2644836	2476128	2241939	2383877	2687167	2543009	2531111
1A4c	301	NATURAL GAS	020303						0	5959	26127	65805	77171	61906	59503	64374	53821
1A4c	301	NATURAL GAS	020304	104224	104224	135847	160657	282141	961133	1796227	2620381	3354165	3379285	3109418	2934589	3116038	2855572
1A4c	303	LPG	0203	245705	227717	165045	97164	91293	99974	109786	78117	87225	53193	51121	28633	9118	14700
1A4c	309	BIOGAS	0203					2750	4455	132108	26121	34614	30392	76487	80321	162277	163605
1A4c	309	BIOGAS	020304	9647	9647	9647	9647	6897	15795	17005	17897	25943	41304	76539	108819	239386	455766
Total				498684968	608478681	548864491	580574264	619300540	600732790	757386181	653146789	614305951	585539065	542293778	567133984	567406224	621681612

Appendix 3A-4 Emission factors

Table 3A-29 CO₂ emission factors.

Fuel	Emission factor		Unit	Reference type	IPCC fuel Category
	Biomass	Fossil fuel			
Coal			95 kg/GJ	Country specific	Solid
Brown coal briquettes			94,6 kg/GJ	IPCC reference manual	Solid
Coke oven coke			108 kg/GJ	IPCC reference manual	Solid
Petroleum coke			92 kg/GJ	Country specific	Liquid
Wood	102		kg/GJ	Corinair	Biomass
Municipal waste	94,5		17,6 kg/GJ	Country specific	Biomass / Other fuels
Straw	102		kg/GJ	Country specific	Biomass
Residual oil			78 kg/GJ	Corinair	Liquid
Gas oil			74 kg/GJ	Corinair	Liquid
Kerosene			72 kg/GJ	Corinair	Liquid
Fish & rape oil	74		kg/GJ	Country specific	Biomass
Orimulsion			80 kg/GJ	Country specific	Liquid
Natural gas			57,19 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 CO₂ 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

Table 3A-31 CH₄ emission factors and references 2003.

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	Gruithuijsen & 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	Gruithuijsen & 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 below

Time-series for CH₄ emission factors for gas engines are shown below. All other CH₄ emission factors are the same for 1990-2003.

Table 3A-32 CH₄ 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

Table 3A-33 N₂O emission factors and references 2003.

Fuel	ipcc_id	SNAP_id	Emission factor [g/GJ]	Reference
COAL	all	all	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 N₂O emission factors are applied for 1990-2003

Table 3A-34 SO₂, NO_x, NMVOC and CO emission factors and references 2003.

Fuel	IPCC sector	SNAP	SO ₂ [g/GJ]	Ref.	NO _x [g/GJ]	Ref.	NMVO C [g/GJ]	Ref.	CO [g/GJ]	Ref.
COAL	1A1a	010101, 010102, 010103	61	18	144	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	130	22, 21, 4	48	1	50	3
WOOD AND SIMIL.	1A1a, 1A2f	010202, 010203, 0301, 030102, 030103	25	22, 21	130	22, 21, 4	48	1	240	4
WOOD AND SIMIL.	1A4a, 1A4c	0201, 020105, 0203	25	22, 21	130	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	153	4, 28	50	1	325	4, 5
STRAW	1A4b, 1A4c	0201, 0203	130	5	153	4, 28	600	1	4000	1,6,7
RESIDUAL OIL	1A1a	0101, 010101, 010102, 010103, 010104, 010105	290	9	144	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	115	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	54	4	4	1	36	4

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Time-series for emission factors for SO₂, NO_x, NMVOC and CO that are not the same in 1990-2003 are shown below. All other factors are constant in 1990-2003.

Table 3A-35 SO₂, 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
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
SO2	COAL	010102	1A1a	506	571	454	386	343	312	420	215	263	193	64	47	45	61
SO2	COAL	010103	1A1a					343	312	420	215	263	193	64	47	45	61
SO2	COAL	010104	1A1a					343	312	420	215						
SO2	COAL	0102	1A1a	574	574	574	574	574	574	574	574						
SO2	COAL	0201	1A4a	574	574	574	574	574	574	574	574	574					
SO2	COAL	0202	1A4b	574	574	574	574	574	574	574	574	574	574	574	574	574	574
SO2	COAL	0203	1A4c	574	574	574	574	574	574	574	574	574	574	574	574	574	574
SO2	COAL	0301	1A2f	574	574	574	574	574	574	574	574	574	574	574	574	574	574
SO2	BROWN COAL BRI.	0201	1A4a	574	574		574	574	574	574	574						
SO2	BROWN COAL BRI.	0202	1A4b	574	574	574	574	574	574	574	574	574	574	574	574	574	574
SO2	BROWN COAL BRI.	0203	1A4c	574	574	574	574	574	574	574	574	574					
SO2	BROWN COAL BRI.	0301	1A2f	574	574	574	574	574	574	574	574	574					
SO2	COKE OVEN COKE	0202	1A4b	574	574	574	574	574	574	574	574	574	574	574	574	574	574
SO2	COKE OVEN COKE	0301	1A2f	574	574	574	574	574	574	574	574	574	574	574	574	574	574
SO2	PETROLEUM COKE	0201	1A4a	787	787	787	787	787	787	787	787	787	787	787	605	605	605
SO2	PETROLEUM COKE	0202	1A4b	787	787	787	787	787	787	787	787	787	787	787	605	605	605
SO2	PETROLEUM COKE	0203	1A4c	787	787	787	787	787	787	787	787	787	787	787	605	605	605
SO2	PETROLEUM COKE	0301	1A2f	787	787	787	787	787	787	787	787	787	787	787	605	605	605
SO2	MUNICIP. WASTES	0101	1A1a	116	116	95	73										
SO2	MUNICIP. WASTES	010102	1A1a		116	95	73	52	30			26	25	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
SO2	MUNICIP. WASTES	010104	1A1a					52	30	29	28	26	25	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	67
SO2	MUNICIP. WASTES	0201	1A4a	138	131	124	117	110	103	95	88	81	74	67	67	67	67	67	67
SO2	MUNICIP. WASTES	020103	1A4a					110	103	95	88	81	74	67	67	67	67	67	67
SO2	MUNICIP. WASTES	0301	1A2f	138	131	124	117	110	103	95	88	81	74						
SO2	MUNICIP. WASTES	030102	1A2f									81					67	67	
SO2	RESIDUAL OIL	0101	1A1a	446	470	490	475								403	315	290	290	
SO2	RESIDUAL OIL	010101	1A1a						351	408	344	369	369	369	403	315	290	290	
SO2	RESIDUAL OIL	010102	1A1a	446	470	490	475	1564	351	408	344	369	369	369	403	315	290	290	
SO2	RESIDUAL OIL	010103	1A1a					1564	351	408	344	369	369	369	403	315	290	290	
SO2	RESIDUAL OIL	010104	1A1a					1564	351	408	344	369	369	369	403	315	290	290	
SO2	RESIDUAL OIL	010105	1A1a	446	470	490	475	1564	351	408	344	369	369	369	403	315	290	290	
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				649	649	649	649	649	649	649	537	
SO2	RESIDUAL OIL	0201	1A4a	495	495	495	495	495	495	495	344	344	344	344	344	344	344	344	
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	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	
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										
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	
SO2	GAS OIL	010306	1A1b		94	94	94	94	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	
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	
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		
NOX	COAL	010102	1A1a	342	384	294	289	267	239	250	200	177	152	129	122	130	144		
NOX	COAL	010103	1A1a					267	239	250	200	177	152	129	122	130	144		
NOX	COAL	010104	1A1a					267	239	250	200								
NOX	COAL	010202	1A1a					200	200	200	200	200	200	95	95	95	95		
NOX	COAL	010203	1A1a					200	200	200	200	200	200	95	95	95	95		
NOX	COAL	0202	1A4b	200	200	200	200	200	200	200	200	200	200	95	95	95	95		
NOX	COAL	0203	1A4c	200	200	200	200	200	200	200	200	200	200	95	95	95	95		
NOX	COAL	0301	1A2f	200	200	200	200	200	200	200	200	200	200	95	95	95	95		
NOX	BROWN COAL BRI.	0202	1A4b	200	200	200	200	200	200	200	200	200	200	95	95	95	95		
NOX	COKE OVEN COKE	0202	1A4b	200	200	200	200	200	200	200	200	200	200	95	95	95	95		
NOX	COKE OVEN COKE	0301	1A2f	200	200	200	200	200	200	200	200	200	200	95	95	95	95		
NOX	PETROLEUM COKE	0301	1A2f	200	200	200	200	200	200	200	200	200	200	95	95	95	95		
NOX	RESIDUAL OIL	0101	1A1a	342	384	294	289								129	122	130	144	
NOX	RESIDUAL OIL	010101	1A1a						239	250	200	177	152	129	122	130	144		
NOX	RESIDUAL OIL	010102	1A1a	342	384	294	289	267	239	250	200	177	152	129	122	130	144		
NOX	RESIDUAL OIL	010103	1A1a					267	239	250	200	177	152	129	122	130	144		
NOX	RESIDUAL OIL	010104	1A1a					267	239	250	200	177	152	129	122	130	144		
NOX	RESIDUAL OIL	010105	1A1a	342	384	294	289	267	239	250	200	177	152	129	122	130	144		
NOX	GAS OIL	0101	1A1a	220	220	220	220								220	220	220	249	
NOX	GAS OIL	010101	1A1a					220	220	220	220	220	220	220	220	220	220	249	
NOX	GAS OIL	010102	1A1a	220	220	220	220	220	220	220	220	220	220	220	220	220	220	249	
NOX	GAS OIL	0102	1A1a	100	95	90	85	80	75	70	65								
NOX	GAS OIL	010201	1A1a					80	75										
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								
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	
NOX	NATURAL GAS	0101	1A1a								115	115	115	115	115	115	115	115	
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
NOX	NATURAL GAS	0102	1A1a	42	42	42	42	42	42	42	42	42					
NOX	NATURAL GAS	010205	1A1a					199	194	193	170	167	167	168	168	168	168
NOX	NATURAL GAS	010505	1A1c	276	241	235	214	199	194	193	170	167	167	168	168	168	168
NOX	NATURAL GAS	0201	1A4a	30	30	30	30	30	30	30	30	30	30	30	30	30	30
NOX	NATURAL GAS	020104	1A4a		157			145	141	138	134	131	127	124	124	124	124
NOX	NATURAL GAS	020105	1A4a	276	241	235	214	199	194	193	170	167	167	168	168	168	168
NOX	NATURAL GAS	0202	1A4b	30	30	30	30	30	30	30	30	30	30	30	30	30	30
NOX	NATURAL GAS	020204	1A4b	276	241	235	214	199	194	193	170	167	167	168	168	168	168
NOX	NATURAL GAS	0203	1A4c	30	30	30	30	30	30	30	30	30	30	30	30	30	30
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
NOX	NATURAL GAS	0301	1A2f	42	42	42	42	42	42	42	42	42	42	42	42	42	42
NOX	NATURAL GAS	030104	1A2f	161				145	141	138	134	131	127	124	124	124	124
NOX	NATURAL GAS	030105	1A2f	276	241	235	214	199	194	193	170	167	167	168	168	168	168
NOX	NATURAL GAS	030106	1A2f	42	42	42	42	42	42	42	42	42	42	42	42	42	42
NOX	BIOGAS	010105	1A1a	711	696	681	665	650	635	616	597	578	559	540	540	540	540
NOX	BIOGAS	010505	1A1c	711	696	681	665	650	635	616	597	578	559	540	540	540	540
NOX	BIOGAS	020105	1A4a	711	696	681	665	650	635	616	597	578	559	540	540	540	540
NOX	BIOGAS	020304	1A4c	711	696	681	665	650	635	616	597	578	559	540	540	540	540
NOX	BIOGAS	030105	1A2f									578	559	540	540	540	540
NMVOC	NATURAL GAS	010105	1A1a	58	67	78	122	136	137	134	120	118	118	117	117	117	117
NMVOC	NATURAL GAS	010205	1A1a					136	137	134	120	118	118	117	117	117	117
NMVOC	NATURAL GAS	010505	1A1c	58	67	78	122	136	137	134	120	118	118	117	117	117	117
NMVOC	NATURAL GAS	020105	1A4a	58	67	78	122	136	137	134	120	118	118	117	117	117	117
NMVOC	NATURAL GAS	020204	1A4b	58	67	78	122	136	137	134	120	118	118	117	117	117	117
NMVOC	NATURAL GAS	020304	1A4c	58	67	78	122	136	137	134	120	118	118	117	117	117	117
NMVOC	NATURAL GAS	030105	1A2f	58	67	78	122	136	137	134	120	118	118	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
CO	WOOD AND SIMIL.	010203	1A1a					293	267	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
CO	WOOD AND SIMIL.	0203	1A4c	400	373	347	320	293	267	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
CO	WOOD AND SIMIL.	030103	1A2f					293	267	240	240	240	240	240	240	240	240
CO	MUNICIP. WASTES	0102	1A1a	100	85	70	55	40	25	10	10						
CO	MUNICIP. WASTES	010202	1A1a					40	25								
CO	MUNICIP. WASTES	010203	1A1a					40	25	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
CO	MUNICIP. WASTES	020103	1A4a					40	25	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
CO	STRAW	010203	1A1a					417	371	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
CO	STRAW	0203	1A4c	8500	8500	8500	8500	8500	7500	6500	5500	4500	4000	4000	4000	4000	4000
CO	NATURAL GAS	010105	1A1a	181	202	203	217	216	212	211	174	174	174	175	175	175	175
CO	NATURAL GAS	010205	1A1a					216	212	211	174	174	174	175	175	175	175
CO	NATURAL GAS	010505	1A1c	181	202	203	217	216	212	211	174	174	174	175	175	175	175
CO	NATURAL GAS	020105	1A4a	181	202	203	217	216	212	211	174	174	174	175	175	175	175
CO	NATURAL GAS	020204	1A4b	181	202	203	217	216	212	211	174	174	174	175	175	175	175
CO	NATURAL GAS	020304	1A4c	181	202	203	217	216	212	211	174	174	174	175	175	175	175
CO	NATURAL GAS	030105	1A2f	181	202	203	217	216	212	211	174	174	174	175	175	175	175
CO	BIOGAS	010105	1A1a	230	234	239	243	248	252	256	260	265	269	273	273	273	273
CO	BIOGAS	010505	1A1c	230	234	239	243	248	252	256	260	265	269	273	273	273	273
CO	BIOGAS	020105	1A4a	230	234	239	243	248	252	256	260	265	269	273	273	273	273
CO	BIOGAS	020304	1A4c	230	234	239	243	248	252	256	260	265	269	273	273	273	273
CO	BIOGAS	030105	1A2f									265	269	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 consumption [GJ]	IPCC source
001	Amagervaerket	01	010101	102	COAL	4372370	1A1a
001	Amagervaerket	01	010101	203	RESIDUAL OIL	187970	1A1a
001	Amagervaerket	02	010101	102	COAL	1847481	1A1a
001	Amagervaerket	02	010101	117	STRAW	36157	1A1a
001	Amagervaerket	02	010101	203	RESIDUAL OIL	803381	1A1a
001	Amagervaerket	03	010101	102	COAL	15278680	1A1a
001	Amagervaerket	03	010101	203	RESIDUAL OIL	101118	1A1a
002	Svanemoellevaerket	05	010101	203	RESIDUAL OIL	8511	1A1a
002	Svanemoellevaerket	05	010101	301	NATURAL GAS	1382528	1A1a
002	Svanemoellevaerket	07	010104	301	NATURAL GAS	4911978	1A1a
003	H.C.Oerstedsvaerket	03	010101	203	RESIDUAL OIL	475381	1A1a
003	H.C.Oerstedsvaerket	03	010101	301	NATURAL GAS	1888909	1A1a
003	H.C.Oerstedsvaerket	07	010101	203	RESIDUAL OIL	699400	1A1a
003	H.C.Oerstedsvaerket	07	010101	301	NATURAL GAS	2280826	1A1a
004	Kyndbyvaerket	21	010101	203	RESIDUAL OIL	708241	1A1a
004	Kyndbyvaerket	22	010101	203	RESIDUAL OIL	694267	1A1a
004	Kyndbyvaerket	26	010101	203	RESIDUAL OIL	157631	1A1a
004	Kyndbyvaerket	28	010101	203	RESIDUAL OIL	168012	1A1a
004	Kyndbyvaerket	41	010105	204	GAS OIL	2035	1A1a
004	Kyndbyvaerket	51	010104	204	GAS OIL	14539	1A1a
004	Kyndbyvaerket	52	010104	204	GAS OIL	10722	1A1a
005	Masnedoevaerket	12	010102	111	WOOD AND SIMIL.	129622	1A1a
005	Masnedoevaerket	12	010102	117	STRAW	466590	1A1a
005	Masnedoevaerket	31	010104	204	GAS OIL	18945	1A1a
007	Stigsnaesvaerket	01	010101	102	COAL	4973380	1A1a
007	Stigsnaesvaerket	01	010101	203	RESIDUAL OIL	233254	1A1a
007	Stigsnaesvaerket	02	010101	102	COAL	14494500	1A1a
007	Stigsnaesvaerket	02	010101	203	RESIDUAL OIL	137880	1A1a
008	Asnaesvaerket	01	010101	203	RESIDUAL OIL	53407	1A1a
008	Asnaesvaerket	02	010101	102	COAL	7395263	1A1a
008	Asnaesvaerket	02	010101	203	RESIDUAL OIL	84665	1A1a
008	Asnaesvaerket	04	010101	102	COAL	10578939	1A1a
008	Asnaesvaerket	04	010101	203	RESIDUAL OIL	74661	1A1a
008	Asnaesvaerket	05	010101	102	COAL	19696621	1A1a
008	Asnaesvaerket	05	010101	203	RESIDUAL OIL	1275842	1A1a
008	Asnaesvaerket	05	010101	225	ORIMULSION	1921399	1A1a
009	Statoil Raffinaderi	01	010306	203	RESIDUAL OIL	279129	1A1b
009	Statoil Raffinaderi	01	010306	308	REFINERY GAS	8030099	1A1b
010	Avedoerevaerket	01	010101	102	COAL	12743451	1A1a
010	Avedoerevaerket	01	010101	203	RESIDUAL OIL	133010	1A1a
010	Avedoerevaerket	01	010101	204	GAS OIL	593077	1A1a
010	Avedoerevaerket	02	010104	111	WOOD AND SIMIL.	1505813	1A1a
010	Avedoerevaerket	02	010104	117	STRAW	1706623	1A1a
010	Avedoerevaerket	02	010104	203	RESIDUAL OIL	9316307	1A1a
010	Avedoerevaerket	02	010104	301	NATURAL GAS	7609397	1A1a
011	Fynsvaerket	03	010101	102	COAL	1778840	1A1a
011	Fynsvaerket	03	010101	114	MUNICIP. WASTES	143440	1A1a
011	Fynsvaerket	03	010101	203	RESIDUAL OIL	105670	1A1a
011	Fynsvaerket	03	010101	301	NATURAL GAS	3481430	1A1a
011	Fynsvaerket	07	010101	102	COAL	15646110	1A1a
011	Fynsvaerket	07	010101	203	RESIDUAL OIL	231590	1A1a
011	Fynsvaerket	08	010102	114	MUNICIP. WASTES	2642140	1A1a
011	Fynsvaerket	08	010102	204	GAS OIL	17291	1A1a
012	Studstrupvaerket	03	010101	102	COAL	14661460	1A1a
012	Studstrupvaerket	03	010101	203	RESIDUAL OIL	238470	1A1a
012	Studstrupvaerket	04	010101	102	COAL	17260700	1A1a
012	Studstrupvaerket	04	010101	117	STRAW	1456510	1A1a
012	Studstrupvaerket	04	010101	203	RESIDUAL OIL	154990	1A1a
014	Vendsysselvaerket	02	010101	102	COAL	9036830	1A1a
014	Vendsysselvaerket	02	010101	203	RESIDUAL OIL	122030	1A1a
014	Vendsysselvaerket	03	010101	102	COAL	22488770	1A1a
014	Vendsysselvaerket	03	010101	203	RESIDUAL OIL	238700	1A1a
014	Vendsysselvaerket	03	010101	204	GAS OIL	5070	1A1a
016	Kemira Danmark	03	030104	301	NATURAL GAS	899788	1A2f
017	Shell Raffinaderi	01	010306	203	RESIDUAL OIL	627953	1A1b
017	Shell Raffinaderi	01	010306	308	REFINERY GAS	4720316	1A1b
017	Shell Raffinaderi	05	010304	308	REFINERY GAS	2670246	1A1b
018	Skaerbaekvaerket	03	010101	204	GAS OIL	340150	1A1a
018	Skaerbaekvaerket	03	010101	301	NATURAL GAS	11131600	1A1a
019	Enstedvaerket	03	010101	102	COAL	31756460	1A1a
019	Enstedvaerket	03	010101	203	RESIDUAL OIL	119150	1A1a
019	Enstedvaerket	04	010101	111	WOOD AND SIMIL.	304980	1A1a
019	Enstedvaerket	04	010101	117	STRAW	1699250	1A1a

019	Enstedvaerket	04	010101	204	GAS OIL	18700	1A1a
020	Esbjergvaerket	03	010101	102	COAL	21387080	1A1a
020	Esbjergvaerket	03	010101	203	RESIDUAL OIL	112140	1A1a
022	Oestkraft	05	010102	203	RESIDUAL OIL	17222	1A1a
022	Oestkraft	06	010102	102	COAL	725648	1A1a
022	Oestkraft	06	010102	111	WOOD AND SIMIL.	45403	1A1a
022	Oestkraft	06	010102	203	RESIDUAL OIL	28847	1A1a
023	Danisco Ingredients	01	030102	102	COAL	527257	1A2f
023	Danisco Ingredients	01	030102	301	NATURAL GAS	6433	1A2f
024	Dansk Naturgas Behandlingsanlaeg	01	010502	301	NATURAL GAS	322830,99	1A1c
025	Horsens Kraftvarmevaerk	01	010102	111	WOOD AND SIMIL.	77910	1A1a
025	Horsens Kraftvarmevaerk	01	010102	114	MUNICIP. WASTES	897730	1A1a
025	Horsens Kraftvarmevaerk	02	010104	301	NATURAL GAS	880180	1A1a
026	Herningvaerket	01	010102	111	WOOD AND SIMIL.	2239420	1A1a
026	Herningvaerket	01	010102	203	RESIDUAL OIL	36430	1A1a
026	Herningvaerket	01	010102	301	NATURAL GAS	1441710	1A1a
027	Vestforbraendingen	01	010102	114	MUNICIP. WASTES	2171692	1A1a
027	Vestforbraendingen	01	010102	204	GAS OIL	8680	1A1a
027	Vestforbraendingen	02	010102	114	MUNICIP. WASTES	3062799	1A1a
028	Amagerforbraendingen	01	010102	114	MUNICIP. WASTES	4312579	1A1a
029	Randersvaerket	01	010102	102	COAL	2829054	1A1a
029	Randersvaerket	01	010102	111	WOOD AND SIMIL.	339631	1A1a
029	Randersvaerket	01	010102	114	MUNICIP. WASTES	25700	1A1a
029	Randersvaerket	01	010102	309	BIOGAS	21787	1A1a
029	Randersvaerket	02	010102	204	GAS OIL	51483	1A1a
030	Grenaavaerket	01	010102	102	COAL	1023565	1A1a
030	Grenaavaerket	01	010102	111	WOOD AND SIMIL.	161708	1A1a
030	Grenaavaerket	01	010102	114	MUNICIP. WASTES	40500	1A1a
030	Grenaavaerket	01	010102	117	STRAW	818223	1A1a
030	Grenaavaerket	01	010102	203	RESIDUAL OIL	69771	1A1a
030	Grenaavaerket	01	010102	204	GAS OIL	8739	1A1a
031	Hilleroedvaerket	01	010104	301	NATURAL GAS	3057446	1A1a
032	Helsingoeruvaerket	01	010104	301	NATURAL GAS	1812439	1A1a
032	Helsingoeruvaerket	02	010105	301	NATURAL GAS	23496	1A1a
033	Staalvalsevaerket	01	030102	301	NATURAL GAS	1246687	1A2f
034	Stora Dalum	01	030102	301	NATURAL GAS	1020508	1A2f
035	Assens Sukkerfabrik	01	030102	102	COAL	400360	1A2f
035	Assens Sukkerfabrik	01	030102	203	RESIDUAL OIL	354876	1A2f
035	Assens Sukkerfabrik	01	030102	309	BIOGAS	24852	1A2f
036	Kolding Kraftvarmevaerk	01	010103	114	MUNICIP. WASTES	808370	1A1a
036	Kolding Kraftvarmevaerk	02	010103	114	MUNICIP. WASTES	282337	1A1a
037	Maabjergvaerket	02	010102	111	WOOD AND SIMIL.	409920	1A1a
037	Maabjergvaerket	02	010102	114	MUNICIP. WASTES	1759520	1A1a
037	Maabjergvaerket	02	010102	117	STRAW	427220	1A1a
037	Maabjergvaerket	02	010102	301	NATURAL GAS	205870	1A1a
038	Soenderborg Kraftvarmevaerk	01	010102	114	MUNICIP. WASTES	771028	1A1a
038	Soenderborg Kraftvarmevaerk	02	010104	301	NATURAL GAS	1207138	1A1a
039	Kara Affaldsforbraendingsanlaeg	01	010102	114	MUNICIP. WASTES	1713119	1A1a
039	Kara Affaldsforbraendingsanlaeg	01	010102	301	NATURAL GAS	9375	1A1a
040	Viborg Kraftvarmevaerk	01	010104	301	NATURAL GAS	2147962	1A1a
042	Nordforbraendingen	01	010102	114	MUNICIP. WASTES	1020319	1A1a
045	Aalborg Portland	01	030311	102	COAL	3368675	1A2f
045	Aalborg Portland	01	030311	110	PETROLEUM COKE	7714392	1A2f
045	Aalborg Portland	01	030311	114	MUNICIP. WASTES	1406393	1A2f
045	Aalborg Portland	01	030311	118	SEWAGE SLUDGE	55369	1A2f
045	Aalborg Portland	01	030311	203	RESIDUAL OIL	587464	1A2f
046	Aarhus Nord	01	010102	111	WOOD AND SIMIL.	18	1A1a
046	Aarhus Nord	01	010102	114	MUNICIP. WASTES	1748000	1A1a
047	Reno Nord	01	010103	114	MUNICIP. WASTES	1443472	1A1a
048	Silkeborg Kraftvarmevaerk	01	010104	301	NATURAL GAS	3285422	1A1a
049	Rensningsanlaegget Lynetten	01	020103	114	MUNICIP. WASTES	74825	1A4a
049	Rensningsanlaegget Lynetten	01	020103	204	GAS OIL	29646	1A4a
049	Rensningsanlaegget Lynetten	01	020103	309	BIOGAS	85295	1A4a
050	I/S Fasan	01	010203	114	MUNICIP. WASTES	925586	1A1a
051	AVV Forbraendingsanlaeg	01	010103	114	MUNICIP. WASTES	632342	1A1a
052	I/S REFA Kraftvarmevaerk	01	010103	114	MUNICIP. WASTES	1072953	1A1a
053	Svendborg Kraftvarmevaerk	01	010102	114	MUNICIP. WASTES	573143	1A1a
053	Svendborg Kraftvarmevaerk	01	010102	301	NATURAL GAS	3270	1A1a
054	Kommunekemi	01	010102	114	MUNICIP. WASTES	685813	1A1a
054	Kommunekemi	01	010102	203	RESIDUAL OIL	50794	1A1a
054	Kommunekemi	01	010102	204	GAS OIL	14134	1A1a
054	Kommunekemi	02	010102	114	MUNICIP. WASTES	619308	1A1a
054	Kommunekemi	02	010102	203	RESIDUAL OIL	30525	1A1a
054	Kommunekemi	02	010102	204	GAS OIL	8668	1A1a
054	Kommunekemi	03	010102	114	MUNICIP. WASTES	480732	1A1a
054	Kommunekemi	03	010102	203	RESIDUAL OIL	20431	1A1a
054	Kommunekemi	03	010102	204	GAS OIL	5722	1A1a
054	Kommunekemi	04	010104	301	NATURAL GAS	15	1A1a
055	I/S Fælles Forbrænding	01	010203	114	MUNICIP. WASTES	263588	1A1a
056	Vestfyns Forbrænding	01	010203	114	MUNICIP. WASTES	230108	1A1a
058	I/S Reno Syd	01	010103	114	MUNICIP. WASTES	624003	1A1a
059	I/S Kraftvarmevaerk Thisted	01	010103	111	WOOD AND SIMIL.	3878	1A1a
059	I/S Kraftvarmevaerk Thisted	01	010103	114	MUNICIP. WASTES	538325	1A1a

059	I/S Kraftvarmeværk Thisted	01	010103	117	STRAW	4916	1A1a
060	Knudmoseværket	01	010103	114	MUNICIP. WASTES	391451	1A1a
060	Knudmoseværket	01	010103	301	NATURAL GAS	39698	1A1a
061	Kavo I/S Energien	01	010103	114	MUNICIP. WASTES	649194	1A1a
062	VEGA	01	010203	114	MUNICIP. WASTES	594392	1A1a
065	Haderslev Kraftvarmeværk	01	010103	114	MUNICIP. WASTES	665025	1A1a
065	Haderslev Kraftvarmeværk	01	010103	301	NATURAL GAS	166	1A1a
066	Frederikshavn Affaldskraftvarmeværk	01	010103	114	MUNICIP. WASTES	374121	1A1a
066	Frederikshavn Affaldskraftvarmeværk	01	010103	204	GAS OIL	1005	1A1a
067	Vejen Kraftvarmeværk	01	010103	114	MUNICIP. WASTES	366610	1A1a
068	Bofa I/S	01	010203	114	MUNICIP. WASTES	193475	1A1a
069	DTU	01	010104	301	NATURAL GAS	765102	1A1a
070	Næstved Kraftvarmeværk	01	010104	301	NATURAL GAS	347670	1A1a
071	Maricogen	01	030104	301	NATURAL GAS	2235321	1A2f
072	Hjørring KVV	01	010104	301	NATURAL GAS	1375744	1A1a
075	Rockwool A/S Hedeusene	01	030318	301	NATURAL GAS	90000	1A2f
076	Rockwool A/S Vamdrup	01	030318	107	COKE OVEN COKE	375840	1A2f
076	Rockwool A/S Vamdrup	01	030318	301	NATURAL GAS	250560	1A2f
077	Rockwool A/S Doense	01	030318	107	COKE OVEN COKE	317520	1A2f
077	Rockwool A/S Doense	01	030318	301	NATURAL GAS	211680	1A2f
078	Rexam Glass Holmegaard A/S	01	030315	204	GAS OIL	933	1A2f
078	Rexam Glass Holmegaard A/S	01	030315	301	NATURAL GAS	945777	1A2f
081	Haldor Topsøe	02	0301	301	NATURAL GAS	457200	1A2f
081	Haldor Topsøe	02	0301	303	LPG	300	1A2f
082	Danisco Sugar Nakskov	02	030102	102	COAL	642254	1A2f
082	Danisco Sugar Nakskov	02	030102	203	RESIDUAL OIL	562311	1A2f
082	Danisco Sugar Nakskov	02	030102	204	GAS OIL	2941	1A2f
082	Danisco Sugar Nakskov	02	030102	309	BIOGAS	12150	1A2f
083	Danisco Sugar Nykøbing	02	030102	203	RESIDUAL OIL	727434	1A2f
083	Danisco Sugar Nykøbing	02	030102	309	BIOGAS	58544	1A2f

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	NM VOC	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		
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		
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	Staalalsevaerket	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	Rensningsanlaegget 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 (Vestforbrænding Taastrup)	01	1A1a	010203	x	x		x
065	Haderslev Kraftvarmeværk	01	1A1a	010103	x	x		x
066	Frederikshavn 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
Total					18270	56439	20	9690

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 Gg CO ₂ eq	Input data Gg CO ₂ eq	Input data %	Input data %	%	%	%	%	%	%	%
Stationary Combustion, Coal	CO ₂	24077	22609	1	5	5,099	2,713	-0,108	0,591	-0,539	0,836	0,995
Stationary Combustion, BKB	CO ₂	11	0	3	5	5,831	0,000	0,000	0,000	-0,002	0,000	0,002
Stationary Combustion, Coke	CO ₂	138	108	3	5	5,831	0,015	-0,001	0,003	-0,006	0,012	0,013
Stationary Combustion, Petroleum coke	CO ₂	410	779	3	5	5,831	0,107	0,008	0,020	0,042	0,086	0,096
Stationary Combustion, Plastic waste	CO ₂	349	649	5	5	7,071	0,108	0,007	0,017	0,034	0,120	0,125
Stationary Combustion, Residual oil	CO ₂	2505	2120	2	2	2,828	0,141	-0,017	0,055	-0,035	0,157	0,161
Stationary Combustion, Gas oil	CO ₂	4564	2918	4	5	6,403	0,440	-0,056	0,076	-0,281	0,432	0,515
Stationary Combustion, Kerosene	CO ₂	366	24	4	5	6,403	0,004	-0,010	0,001	-0,050	0,004	0,050
Stationary Combustion, Orimulsion	CO ₂	0	154	1	2	2,236	0,008	0,004	0,004	0,008	0,006	0,010
Stationary Combustion, Natural gas	CO ₂	4330	11152	3	1	3,162	0,830	0,166	0,292	0,166	1,237	1,248
Stationary Combustion, LPG	CO ₂	164	74	4	5	6,403	0,011	-0,003	0,002	-0,014	0,011	0,018
Stationary Combustion, Refinery gas	CO ₂	806	942	3	5	5,831	0,129	0,001	0,025	0,006	0,105	0,105
Stationary combustion plants, gas engines	CH ₄	6	391	2,2	40	40,060	0,368	0,010	0,010	0,401	0,032	0,402
Stationary combustion plants, other	CH ₄	115	130	2,2	100	100,024	0,307	0,000	0,003	0,007	0,011	0,013
Stationary combustion plants	N ₂ O	398	440	2,2	1000	1000,002	10,360	0,000	0,012	-0,045	0,036	0,058
Total		38239	42490				115,855					3,043
Total uncertainties	Overall uncertainty in the year (%):						10,764	Trend uncertainty (%):				1,744

Table 3A-41 Uncertainty estimation, CO₂.

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	22609	1	5	5,099	2,713	-0,108	0,591	-0,539	0,836	0,995	
Stationary Combustion, BKB	CO ₂	11	0	3	5	5,831	0,000	0,000	0,000	-0,002	0,000	0,002	
Stationary Combustion, Coke	CO ₂	138	108	3	5	5,831	0,015	-0,001	0,003	-0,006	0,012	0,013	
Stationary Combustion, Petroleum coke	CO ₂	410	779	3	5	5,831	0,107	0,008	0,020	0,042	0,086	0,096	
Stationary Combustion, Plastic waste	CO ₂	349	649	5	5	7,071	0,108	0,007	0,017	0,034	0,120	0,125	
Stationary Combustion, Residual oil	CO ₂	2505	2120	2	2	2,828	0,141	-0,017	0,055	-0,035	0,157	0,161	
Stationary Combustion, Gas oil	CO ₂	4564	2918	4	5	6,403	0,440	-0,056	0,076	-0,281	0,432	0,515	
Stationary Combustion, Kerosene	CO ₂	366	24	4	5	6,403	0,004	-0,010	0,001	-0,050	0,004	0,050	
Stationary Combustion, Orimulsion	CO ₂	0	154	1	2	2,236	0,008	0,004	0,004	0,008	0,006	0,010	
Stationary Combustion, Natural gas	CO ₂	4330	11152	3	1	3,162	0,830	0,166	0,292	0,166	1,237	1,248	
Stationary Combustion, LPG	CO ₂	164	74	4	5	6,403	0,011	-0,003	0,002	-0,014	0,011	0,018	
Stationary Combustion, Refinery gas	CO ₂	806	942	3	5	5,831	0,129	0,001	0,025	0,006	0,105	0,105	
Total	CO ₂	37720	41529				8,693					2,920	
Total uncertainties		Overall uncertainty in the year (%):					2,948	Trend uncertainty (%):					1,709

Table 3A-42 Uncertainty estimation, CH₄.

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 Mg CH ₄	Input data Mg CH ₄	Input data %	Input data %	%	%	%	%	%	%	%	
Stationary combustion plants, gas engines	CH ₄	305	18601	2,2	40	40,060	30,036	2,993	3,221	119,728	10,023	120,147	
Stationary combustion plants, other	CH ₄	5470	6208	2,2	100	100,024	25,029	-2,967	1,075	-296,668	3,345	296,687	
Total	CH ₄	5774	24809				1528,6					102459	
Total uncertainties		Overall uncertainty in the year (%):					39,098	Trend uncertainty (%):					320,091

Table 3A-43 Uncertainty estimation, N₂O.

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 Gg N ₂ O	Input data Gg N ₂ O	Input data %	Input data %	%	%	%	%	%	%	%	
Stationary combustion plants	N ₂ O	1,283	1,420	2,200	1000,000	1000,002	1000,002	0,000	1,107	0,000	3,444	3,444	
Total	N ₂ O	1,283	1,420				1000005					11,858	
Total uncertainties		Overall uncertainty in the year (%):					1000,002	Trend uncertainty (%):					3,444

Table 3A-44 Uncertainty estimation, SO₂.

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 Mg SO ₂	Input data Mg SO ₂	Input data %	Input data %	%	%	%	%	%	%	%
01	SO ₂	129579	17461	2	10	10,198	6,614	-0,030	0,111	-0,301	0,315	0,435
02	SO ₂	11500	3612	2	20	20,100	2,697	0,010	0,023	0,209	0,065	0,219
03	SO ₂	15921	5851	2	10	10,198	2,216	0,020	0,037	0,199	0,105	0,225
Total SO ₂		157000	26924				55,924					0,288
Total uncertainties				Overall uncertainty in the year (%):			7,478	Trend uncertainty (%):				0,536

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 Mg NO _x	Input data Mg NO _x	Input data %	Input data %	%	%	%	%	%	%	%
01	NO _x	94953	64508	2	20	20,100	15,150	-0,049	0,5575	-0,980	1,577	1,856
02	NO _x	8056	7654	2	50	50,040	4,475	0,015	0,0661	0,732	0,187	0,756
03	NO _x	12709	13419	2	20	20,100	3,152	0,035	0,1160	0,694	0,328	0,768
Total NO _x		115718	85581				259,498					4,607
Total uncertainties				Overall uncertainty in the year (%):			16,109	Trend uncertainty (%):				2,146

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 Mg NMVOC	Input data Mg NMVOC	Input data %	Input data %	%	%	%	%	%	%	%
01	NMVOC	1073	4263	2	50	50,040	11,545	0,213	0,3361	10,631	0,951	10,674
02	NMVOC	10996	13494	2	50	50,040	36,544	-0,197	1,0638	-9,866	3,009	10,314
03	NMVOC	615	721	2	50	50,040	1,951	-0,014	0,0568	-0,689	0,161	0,707
Total NMVOC		12685	18478				1472,543					220,819
Total uncertainties				Overall uncertainty in the year (%):			38,374	Trend uncertainty (%):				14,860

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 Mg CO	Input data Mg CO	Input data %	Input data %	%	%	%	%	%	%	%
01	CO	8256	12629	2	20	20,100	1,382	0,022	0,073	0,445	0,207	0,491
02	CO	159295	158778	2	50	50,040	43,248	-0,062	0,920	-3,083	2,601	4,034
03	CO	5082	12308	2	20	20,100	1,347	0,040	0,071	0,799	0,202	0,824
Total CO		172633	183715				1874,073					17,193
Total uncertainties				Overall uncertainty in the year (%):			43,291	Trend uncertainty (%):				4,146

Appendix 3A-7 Lower Calorific Value (LCV) of fuels

Table 3A-48 Time-series for calorific values of fuels (Danish Energy Authority, DEA 2004b).

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
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
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
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
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
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
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
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
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
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
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
		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
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
		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
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
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
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
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
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
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
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
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
Town Gas	GJ / 1000 m3							17,00	17,00	17,00	17,00	17,01	16,88	17,39	16,88
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
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
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
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
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
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
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
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
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
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
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
Biogas	GJ / 1000 m3								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
Liquid Biofuels											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

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) CO₂ from plastic part included in Other fuels

Appendix 3A-8 Adjustment of CO₂ emission

Table 3A-50 Adjustment of CO₂ emission (ref. Danish Energy Authority).

Degree Days		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Actual Degree Days	Degree days	2093	2515	3022	3434	3148	3297	3837	3236	3217	3056	2902	3279	3011	3111
Normal Degree Days	Degree days	2691	2691	3370	3370	3370	3370	3370	3370	3370	3370	3370	3370	3370	3370
Net electricity import	TJ	25 373	-7 099	13 486	4 266	-17 424	-2 858	-55 444	-26 107	-15 552	-8 327	2 394	-2 071	-7 453	-30 760
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
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

Appendix 3A-9 Reference approach

TABLE 1.A(b) SECTORAL BACKGROUND DATA FOR ENERGY
CO₂ 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	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)
Liquid Fossil	Primary Fuels	Crude Oil	TJ	780,551.93	150,155.48	574,098.98		3,057.86	353,550.58	1.00	NCV	353,550.58	20.00	7,071.01		7,071.01	1.00	25,927.04
		Orimulsion	TJ	0.00	0.00	0.00		-1,921.40	1,921.40	1.00	NCV	1,921.40	22.00	42.27		42.27	1.00	154.99
		Natural Gas Liquids	TJ	0.00	0.00	0.00		0.00	0.00	1.00	NCV	0.00	17.20	0.00		0.00	1.00	0.00
	Secondary Fuels	Gasoline	TJ		38,197.16	44,363.08	18.16	-1,072.69	-5,111.39	1.00	NCV	-5,111.39	18.90	-96.61		-96.61	1.00	-354.22
		Jet Kerosene	TJ		22,975.27	21,494.43	29,710.44	-4,039.03	-24,190.57	1.00	NCV	-24,190.57	19.50	-471.72		-471.72	1.00	-1,729.63
		Other Kerosene	TJ		0.00	0.00	0.00	0.00	0.00	1.00	NCV	0.00	19.60	0.00		0.00	1.00	0.00
		Shale Oil	TJ		0.00	0.00	0.00	0.00	0.00	1.00	NCV	0.00	20.00	0.00		0.00	1.00	0.00
		Gas / Diesel Oil	TJ		82,301.53	48,524.02	20,729.77	1,467.11	11,580.63	1.00	NCV	11,580.63	20.20	233.93	0.00	233.93	1.00	857.74
		Residual Fuel Oil	TJ		37,489.83	47,253.02	20,461.87	1,912.75	-32,137.81	1.00	NCV	-32,137.81	21.10	-678.11		-678.11	1.00	-2,486.40
		LPG	TJ		103.13	4,769.19		-20.15	-4,645.91	1.00	NCV	-4,645.91	17.20	-79.91	0.00	-79.91	1.00	-293.00
		Ethane	TJ		0.00	0.00		0.00	0.00	1.00	NCV	0.00	16.80	0.00	0.00	0.00	1.00	0.00
		Naphtha	TJ		759.81	360.22		18.91	380.68	1.00	NCV	380.68	20.00	7.61	5.99	1.62	1.00	5.94
		Bitumen	TJ		8,061.33	125.81		-260.17	8,195.70	1.00	NCV	8,195.70	22.00	180.31	186.14	-5.83	1.00	-21.39
		Lubricants	TJ		2,054.61	217.04	103.95	-83.84	1,817.45	1.00	NCV	1,817.45	20.00	36.35	19.56	16.78	1.00	61.54
		Petroleum Coke	TJ		9,267.71	284.96		804.25	8,178.51	1.00	NCV	8,178.51	27.50	224.91		224.91	1.00	824.67
		Refinery Feedstocks	TJ		2,806.54	2,210.92		-964.12	1,559.75	1.00	NCV	1,559.75	20.00	31.19		31.19	1.00	114.38
		Other Oil	TJ		0.00	0.00		0.00	0.00	1.00	NCV	0.00	20.00	0.00		0.00	1.00	0.00
Liquid Fossil Totals												321,099.01		6,501.24	211.70	6,289.55		23,061.68
Solid Fossil	Primary Fuels	Anthracite ⁽²⁾	TJ	0.00	0.00	0.00		0.00	0.00	1.00	NCV	0.00	26.80	0.00		0.00	1.00	0.00
		Coking Coal	TJ	0.00	0.00	0.00		0.00	0.00	1.00	NCV	0.00	25.80	0.00	0.00	0.00	1.00	0.00
		Other Bit. Coal	TJ	0.00	235,910.66	3,765.13	0.00	-4,194.81	236,340.34	1.00	NCV	236,340.34	25.80	6,097.58		6,097.58	1.00	22,357.80
		Sub-bit. Coal	TJ	0.00	0.00	0.00	0.00	0.00	0.00	1.00	NCV	0.00	26.20	0.00		0.00	1.00	0.00
		Lignite	TJ	0.00	0.00	0.00		0.00	0.00	1.00	NCV	0.00	27.60	0.00		0.00	1.00	0.00
		Oil Shale	TJ	0.00	0.00	0.00		0.00	0.00	1.00	NCV	0.00	29.10	0.00		0.00	1.00	0.00
		Peat	TJ	0.00	0.00	0.00		0.00	0.00	1.00	NCV	0.00	28.90	0.00		0.00	1.00	0.00
		BKB & Patent Fuel	TJ		5.82	8.89		-3.07	0.00	1.00	NCV	0.00	25.80	0.00		0.00	1.00	0.00
	Secondary Fuels	Coke Oven/Gas Coke	TJ		932.97	0.00		59.51	873.46	1.00	NCV	873.46	29.50	25.77		25.77	1.00	94.48
Solid Fuel Totals											237,213.80		6,123.35	0.00	6,123.35		22,452.28	
Gaseous Fossil		Natural Gas (Dry)	TJ	301,555.94	0.00	108,622.54		-2,199.96	195,133.35	1.00	NCV	195,133.35	15.30	2,985.54	0.00	2,985.54	1.00	10,946.98
Total												753,446.16		15,610.13	211.70	15,398.44		56,460.93
Biomass total												92,700.68		2,746.35	0.00	2,746.35		10,069.93
		Solid Biomass	TJ	82,753.81	6,368.76	0.00		0.00	89,122.57	1.00	NCV	89,122.57	29.90	2,664.76		2,664.76	1.00	9,770.80
		Liquid Biomass	TJ	1,692.00	0.00	1,692.00		0.00	0.00	1.00	NCV	0.00	20.00	0.00		0.00	1.00	0.00
		Gas Biomass	TJ	3,578.11	0.00	0.00		0.00	3,578.11	1.00	NCV	3,578.11	22.80	81.58		81.58	1.00	299.13

TABLE 1A(c) COMPARISON OF CO₂ EMISSIONS FROM FUEL COMBUSTION
(Sheet 1 of 1)

Denmark
2003
2005, Mar15

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)	321,10	23.061,68	305,55	22.493,76	5,09	2,52
Solid Fuels (excluding international bunkers)	237,21	22.452,28	238,99	22.716,70	-0,74	-1,16
Gaseous Fuels	195,13	10.946,98	195,00	11.152,32	0,07	-1,84
Other ⁽³⁾	-10,82	649,16	1,00	722,30	-1.179,48	-10,13
Total ⁽³⁾	742,63	57.110,09	740,54	57.085,08	0,28	0,04

⁽¹⁾ "National approach" is used to indicate the approach (if different from the Reference approach) followed by the Party to estimate its CO₂ 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 CO₂ 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	Naphtha	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 2003 based on SNAP sectors

Table 3A-52 Emission inventory 2003 based on SNAP sectors.

SNAP 2)	SO2 [Mg]	NOX [Mg]	NM VOC [Mg]	CH4 [Mg]	CO [Mg]	CO ₂ 1) [Gg]	N ₂ O [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	17461	64508	4263	15706	12629	37354	1057	1432	1141	953	458	215	503	615	716	3326	1906	1028	13338	242	33	15	8	19	8
101	-	0	-	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10101	14017	39525	411	491	2936	23735	722	746	601	495	128	18	240	142	214	1902	256	948	40	23	5	1	1	4	2
10102	969	4161	56	45	706	3841	51	134	89	72	162	79	98	218	156	232	903	48	8656	2	0	0	0	0	0
10103	568	1360	16	23	255	1169	14	56	39	32	134	34	29	107	124	148	438	1	2702	4	0	0	0	0	0
10104	482	3768	78	78	585	2917	89	154	151	126	6	4	4	8	5	51	79	5	249	19	5	1	1	2	2
10105	44	5500	3191	14597	5199	1704	36	25	6	5	0	0	0	0	0	4	0	0	1	4	1	1	0	0	0
102	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10201	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10202	40	67	11	9	65	63	2	5	4	4	2	3	3	3	2	54	3	2	30	1	0	0	0	0	0
10203	837	1837	440	315	2429	1379	49	181	130	103	14	65	99	126	211	353	205	10	1658	186	20	11	5	12	4
10204	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10205	0	29	20	89	30	10	0	0	0	0	-	-	-	-	-	-	-	-	0	0	-	-	-	-	-
103	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10301	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10302	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10303	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10304	8	626	2	2	24	216	8	19	19	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10305	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10306	487	1020	-	-	219	796	27	109	100	96	13	12	30	12	4	582	21	11	3	2	0	0	0	0	0
104	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10401	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10402	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10403	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10404	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10405	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10406	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10407	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
105	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10501	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10502	0	34	1	2	9	18	0	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10503	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10504	8	6562	37	39	163	1501	58	3	2	1	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0
10505	1	19	2	17	11	3	0	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10506	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total 02	3612	7654	13494	7617	158778	7830	215	12323	11683	11048	71	146	113	219	273	821	327	173	3032	13724	3742	1224	2879	3877	2139
201	248	765	622	257	607	1005	25	168	166	157	10	19	41	44	69	166	150	19	527	792	217	72	165	223	117
20101	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20102	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20103	106	17	1	1	5	18	1	22	19	15	5	1	3	13	25	3	4	0	27	1	0	-	0	0	-
20104	0	4	0	0	0	2	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20105	11	459	127	704	324	103	2	2	0	0	-	-	-	-	-	-	-	-	0	0	0	0	-	0	0
20106	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
202	1737	4619	10945	3807	148987	5629	159	11600	11004	10417	35	111	30	140	155	52	129	130	2392	12355	3372	1124	2574	3485	1816

20201	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
20202	0	2	0	1	1	4	0	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
20203	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
20204	0	244	170	755	254	83	2	1	0	0	-	-	-	-	-	-	-	-	0	0	0	-	0	0	
20205	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
203	1497	805	1288	461	7971	780	23	526	492	459	21	15	37	23	24	594	43	24	85	574	153	27	140	168	205
20301	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
20302	3	2	0	0	2	1	0	0	0	0	0	0	0	0	0	4	0	0	0	1	0	0	0	0	0
20303	0	7	0	0	0	3	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20304	11	731	341	1632	625	202	4	4	1	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
20305	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total 03	5851	13419	721	1485	12308	5452	149	1023	683	407	193	169	368	177	237	4684	1154	791	1542	3468	92	16	26	8	7
301	3253	3120	394	417	2540	3148	77	251	185	136	86	114	186	120	71	3453	165	81	883	166	12	10	1	3	3
30101	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30102	1241	490	33	43	132	416	10	129	40	13	28	22	59	26	10	1063	49	21	23	27	2	2	0	1	1
30103	7	43	14	11	74	37	1	6	4	3	-	2	-	2	2	-	1	-	40	1	0	0	-	0	-
30104	2	610	9	10	40	373	14	1	0	0	-	-	-	-	-	-	-	-	0	-	0	-	0	0	0
30105	1	267	181	807	274	90	2	1	0	0	0	0	0	0	-	1	0	0	-	0	0	0	-	0	0
30106	0	1	0	0	1	1	0	0	0	0	0	-	0	0	0	-	0	0	0	0	-	-	-	-	-
302	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30203	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30204	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30205	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
303	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30301	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30302	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30303	-	-	-	-	-	-	-	175	52	8	26	12	96	-	-	113	629	437	437	-	-	-	-	-	-
30304	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30305	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30306	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30307	-	-	-	-	-	-	-	2	1	1	-	0	-	1	-	-	9	-	-	-	-	-	-	-	-
30308	-	-	-	-	-	-	-	1	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30309	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30310	-	-	-	-	-	-	-	24	21	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30311	882	8401	77	177	1103	1225	40	175	157	70	51	18	25	25	153	51	25	18	127	3264	78	3	25	2	2
30312	-	-	-	-	-	-	-	30	15	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30313	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30314	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30315	0	397	2	6	6	54	1	26	23	21	-	-	-	-	-	-	272	234	25	-	-	-	-	-	-
30316	-	-	-	-	-	-	-	102	92	71	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30317	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30318	464	89	10	14	8137	106	3	103	92	72	2	0	2	2	1	3	4	0	7	10	1	1	0	0	0
30319	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30320	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30321	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30322	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30323	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30324	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30325	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30326	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30327	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

1) Including CO₂ emission from biomass

2) SNAP sector codes are shown in Appendix 3A-2

Annex 3B Transport

Annex 3B-1: Fleet data 1990-2003 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	46209	44014	42804	36466
Passenger Cars	Gasoline <1.4 l	ECE 15/00-01	1970	1978	333715	319741	297372	247513	217970	187912	161642	139010	119424
Passenger Cars	Gasoline <1.4 l	ECE 15/02	1979	1980	105027	82699	76343	98297	93397	86959	80041	73306	66422
Passenger Cars	Gasoline <1.4 l	ECE 15/03	1981	1985	345142	373558	358057	307504	306014	300791	294878	288227	280146
Passenger Cars	Gasoline <1.4 l	ECE 15/04	1986	1990	0	46574	114381	206105	245261	272012	270182	268686	268154
Passenger Cars	Gasoline <1.4 l	Euro I	1991	1996	0	1	1	1	1	10000	49608	87121	122067
Passenger Cars	Gasoline <1.4 l	Euro II	1997	2000	0	0	0	0	0	0	0	0	0
Passenger Cars	Gasoline <1.4 l	Euro III	2001	2005	0	0	0	0	0	0	0	0	0
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	218180	211819	199591	168672	148281	127631	109641	94188	80844
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	210574	222174	211066	178826	177842	174545	170750	166596	161592
Passenger Cars	Gasoline 1.4 - 2.0 l	ECE 15/04	1986	1990	0	31049	74328	131279	159911	180298	178950	177873	177525
Passenger Cars	Gasoline 1.4 - 2.0 l	Euro I	1991	1996	0	0	0	0	0	10000	45647	82427	119744
Passenger Cars	Gasoline 1.4 - 2.0 l	Euro II	1997	2000	0	0	0	0	0	0	0	0	0
Passenger Cars	Gasoline 1.4 - 2.0 l	Euro III	2001	2005	0	0	0	0	0	0	0	0	0
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	18532	17532	16673	14345	12566	10781	9234	7914	6781
Passenger Cars	Gasoline >2.0 l	ECE 15/02	1979	1980	8730	6326	4456	4966	4718	4392	4043	3702	3355
Passenger Cars	Gasoline >2.0 l	ECE 15/03	1981	1985	31066	33256	31914	25237	25111	24667	24157	23595	22912
Passenger Cars	Gasoline >2.0 l	ECE 15/04	1986	1990	0	4085	9932	19410	22964	15679	15524	15390	15339
Passenger Cars	Gasoline >2.0 l	Euro I	1991	1996	0	0	0	0	0	10000	13961	17871	21674
Passenger Cars	Gasoline >2.0 l	Euro II	1997	2000	0	0	0	0	0	0	0	0	0
Passenger Cars	Gasoline >2.0 l	Euro III	2001	2005	0	0	0	0	0	0	0	0	0
Passenger Cars	Diesel <2.0 l	Euro I	1991	1996	0	0	0	0	0	0	4041	8031	11912
Passenger Cars	Diesel <2.0 l	Euro II	1997	2000	0	0	0	0	0	0	0	0	0
Passenger Cars	Diesel <2.0 l	Euro III	2001	2005	0	0	0	0	0	0	0	0	0
Passenger Cars	Diesel <2.0 l	Conventional	0	1990	75828	78431	79759	80201	80187	79709	75788	72288	68529
Passenger Cars	Diesel >2.0 l	Euro I	1991	1996	0	0	0	0	0	0	213	423	627
Passenger Cars	Diesel >2.0 l	Euro II	1997	2000	0	0	0	0	0	0	0	0	0

Passenger Cars	Diesel >2.0 l	Euro III	2001	2005	0	0	0	0	0	0	0	0	0
Passenger Cars	Diesel >2.0 l	Conventional	0	1990	3451	3568	3629	3649	3707	3702	3556	3425	3281

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	45486
Light Duty Vehicles	Gasoline <3.5t	Euro I	1995	1998	0	0	0	0	0	0	0	0	0
Light Duty Vehicles	Gasoline <3.5t	Euro II	1999	2001	0	0	0	0	0	0	0	0	0
Light Duty Vehicles	Gasoline <3.5t	Euro III	2002	2006	0	0	0	0	0	0	0	0	0
Light Duty Vehicles	Diesel <3.5 t	Conventional	0	1994	121431	135248	145954	151822	154198	155543	158781	162324	167129
Light Duty Vehicles	Diesel <3.5 t	Euro I	1995	1998	0	0	0	0	0	0	0	0	0
Light Duty Vehicles	Diesel <3.5 t	Euro II	1999	2001	0	0	0	0	0	0	0	0	0
Light Duty Vehicles	Diesel <3.5 t	Euro III	2002	2006	0	0	0	0	0	0	0	0	0
Heavy Duty Vehicles	Gasoline >3.5 t	Conventional	0	9999	251	261	262	255	254	250	255	260	268
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Conventional	0	1993	5140	5338	5353	5228	5194	5108	5214	5330	5488
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Euro I	1994	1996	0	0	0	0	0	0	0	0	0
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Euro II	1997	2001	0	0	0	0	0	0	0	0	0
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Euro III	2002	2006	0	0	0	0	0	0	0	0	0
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Conventional	0	1993	10350	10750	10779	10528	10460	10286	10500	10734	11052
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Euro I	1994	1996	0	0	0	0	0	0	0	0	0
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Euro II	1997	2001	0	0	0	0	0	0	0	0	0
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Euro III	2002	2006	0	0	0	0	0	0	0	0	0
Heavy Duty Vehicles	Diesel 16 - 32 t	Conventional	0	1993	13115	13623	13659	13342	13255	13034	13306	13602	14005
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro I	1994	1996	0	0	0	0	0	0	0	0	0
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro II	1997	2001	0	0	0	0	0	0	0	0	0
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro III	2002	2006	0	0	0	0	0	0	0	0	0
Heavy Duty Vehicles	Diesel >32t	Conventional	0	1993	11517	11962	11994	11715	11640	11446	11684	11944	12298
Heavy Duty Vehicles	Diesel >32t	Euro I	1994	1996	0	0	0	0	0	0	0	0	0
Heavy Duty Vehicles	Diesel >32t	Euro II	1997	2001	0	0	0	0	0	0	0	0	0
Heavy Duty Vehicles	Diesel >32t	Euro III	2002	2006	0	0	0	0	0	0	0	0	0

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	4490
Buses	Urban Buses	Euro I	1994	1996	0	0	0	0	0	0	0	0	0
Buses	Urban Buses	Euro II	1997	2001	0	0	0	0	0	0	0	0	0
Buses	Urban Buses	Euro III	2002	2006	0	0	0	0	0	0	0	0	0
Buses	Coaches	Conventional	0	1993	3298	3337	3339	3332	3307	3327	2868	3007	3086
Buses	Coaches	Euro I	1994	1996	0	0	0	0	0	0	0	0	0
Buses	Coaches	Euro II	1997	2001	0	0	0	0	0	0	0	0	0
Buses	Coaches	Euro III	2002	2006	0	0	0	0	0	0	0	0	0
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	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	6209	6280	6368	6368	6488	6617	6804	6904	7111
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	7037	7118	7218	7217	7353	7499	7712	7824	8059
Motorcycles	4-stroke <250 cm ³	97/24/EC	2000	2003	0	0	0	0	0	0	0	0	0
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	0	0	0	0	0	0	0	0	0
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	0	0	0	0	0	0	0	0	0

Sector	Subsector	Tech	FYear	LYear	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Passenger Cars	Gasoline <1.4 l	PRE ECE	0	1969	39959	37597	37130	3434	2761	2103	1744	1614	1475	1392
Passenger Cars	Gasoline <1.4 l	ECE 15/00-01	1970	1978	80742	67991	53302	44338	31104	22511	17980	15837	14155	13149
Passenger Cars	Gasoline <1.4 l	ECE 15/02	1979	1980	50119	43384	35052	26097	17585	10873	7348	5544	4203	3145
Passenger Cars	Gasoline <1.4 l	ECE 15/03	1981	1985	261998	250043	235177	215301	183113	147111	118929	97930	79016	60706
Passenger Cars	Gasoline <1.4 l	ECE 15/04	1986	1990	265860	262990	259954	265188	264791	254032	235890	219216	194543	171430
Passenger Cars	Gasoline <1.4 l	Euro I	1991	1996	177991	230063	282488	289374	275572	273582	270268	267260	261791	255242
Passenger Cars	Gasoline <1.4 l	Euro II	1997	2000	0	0	0	58502	119142	170981	209279	205833	201734	199841
Passenger Cars	Gasoline <1.4 l	Euro III	2001	2005	0	0	0	0	0	0	0	34695	73385	104983
Passenger Cars	Gasoline 1.4 - 2.0 l	PRE ECE	0	1969	31079	29242	28879	2671	2148	1635	1356	1255	1147	1083
Passenger Cars	Gasoline 1.4 - 2.0 l	ECE 15/00-01	1970	1978	54600	45991	36079	30465	21520	15647	12537	11077	9923	9230
Passenger Cars	Gasoline 1.4 - 2.0 l	ECE 15/02	1979	1980	31712	27445	22173	16509	11141	6870	4642	3500	2659	1987
Passenger Cars	Gasoline 1.4 - 2.0 l	ECE 15/03	1981	1985	150612	143386	133413	122642	103931	83270	67222	55300	44572	34238
Passenger Cars	Gasoline 1.4 - 2.0 l	ECE 15/04	1986	1990	176045	174195	172298	176155	179510	172582	160800	149915	133745	118448
Passenger Cars	Gasoline 1.4 - 2.0 l	Euro I	1991	1996	184854	250826	322960	330407	315731	313279	309587	306414	300335	293205
Passenger Cars	Gasoline 1.4 - 2.0 l	Euro II	1997	2000	0	0	0	80440	163821	235099	287758	283021	277385	274781
Passenger Cars	Gasoline 1.4 - 2.0 l	Euro III	2001	2005	0	0	0	0	0	0	0	47705	100904	144352
Passenger Cars	Gasoline >2.0 l	PRE ECE	0	1969	2960	2785	2750	254	205	156	129	120	109	103
Passenger Cars	Gasoline >2.0 l	ECE 15/00-01	1970	1978	4567	3849	3022	2619	1881	1366	1110	986	885	825
Passenger Cars	Gasoline >2.0 l	ECE 15/02	1979	1980	2531	2191	1770	1318	888	549	371	280	212	159
Passenger Cars	Gasoline >2.0 l	ECE 15/03	1981	1985	21429	20432	19053	17571	14934	12016	9722	8009	6459	4964
Passenger Cars	Gasoline >2.0 l	ECE 15/04	1986	1990	15120	14844	14546	14977	23975	22975	21251	19699	17377	15265
Passenger Cars	Gasoline >2.0 l	Euro I	1991	1996	28044	34257	40813	41567	31121	30887	30519	30193	29586	28866
Passenger Cars	Gasoline >2.0 l	Euro II	1997	2000	0	0	0	7313	14893	21373	26160	25729	25217	24980
Passenger Cars	Gasoline >2.0 l	Euro III	2001	2005	0	0	0	0	0	0	0	4337	9173	13123
Passenger Cars	Diesel <2.0 l	Euro I	1991	1996	18412	24751	31440	31580	31998	35415	39518	43826	48984	53830
Passenger Cars	Diesel <2.0 l	Euro II	1997	2000	0	0	0	7316	15312	24505	33856	37328	41736	46572
Passenger Cars	Diesel <2.0 l	Euro III	2001	2005	0	0	0	0	0	0	0	6313	15219	24513
Passenger Cars	Diesel <2.0 l	Conventional	0	1990	62139	58843	55000	48153	43893	43004	42861	42885	42300	40702
Passenger Cars	Diesel >2.0 l	Euro I	1991	1996	969	1303	1655	1662	1684	1864	2087	2313	2583	2838
Passenger Cars	Diesel >2.0 l	Euro II	1997	2000	0	0	0	385	806	1290	1789	1971	2202	2456
Passenger Cars	Diesel >2.0 l	Euro III	2001	2005	0	0	0	0	0	0	0	332	801	1290
Passenger Cars	Diesel >2.0 l	Conventional	0	1990	3040	2905	2746	2461	2266	2237	2228	2229	2187	2096

Sector	Subsector	Tech	FYear	LYear	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
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	289	301	311	172	97	44	32	63	21	15
Passenger Cars	2-Stroke	Conventional	0	9999	3029	2443	1665	1248	761	400	300	200	150	100
Light Duty Vehicles	Gasoline <3.5t	Conventional	0	1994	47261	44601	41519	37209	34454	31489	28488	25423	21615	18838
Light Duty Vehicles	Gasoline <3.5t	Euro I	1995	1998	0	4259	8524	12645	17212	16632	15979	15527	15049	13949
Light Duty Vehicles	Gasoline <3.5t	Euro II	1999	2001	0	0	0	0	0	4705	9299	14017	13917	13805
Light Duty Vehicles	Gasoline <3.5t	Euro III	2002	2006	0	0	0	0	0	0	0	0	5140	10719
Light Duty Vehicles	Diesel <3.5 t	Conventional	0	1994	173650	163877	152553	142109	131572	122992	115695	105397	92990	82927
Light Duty Vehicles	Diesel <3.5 t	Euro I	1995	1998	0	15648	31318	48292	65727	64964	64894	64370	64743	61406
Light Duty Vehicles	Diesel <3.5 t	Euro II	1999	2001	0	0	0	0	0	18376	37766	58112	59870	60771
Light Duty Vehicles	Diesel <3.5 t	Euro III	2002	2006	0	0	0	0	0	0	0	0	22112	47186
Heavy Duty Vehicles	Gasoline >3.5 t	Conventional	0	9999	279	288	295	261	274	253	257	249	249	247
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Conventional	0	1993	5205	4891	4532	3999	3692	3079	2406	1979	1739	1407
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Euro I	1994	1996	497	1004	1506	1440	1435	1269	1057	951	956	813
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Euro II	1997	2001	0	0	0	529	1087	1487	1703	1990	2064	1872
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Euro III	2002	2006	0	0	0	0	0	0	0	0	484	941
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Conventional	0	1993	10482	9850	9126	7800	6603	5613	5085	4210	3136	2571
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Euro I	1994	1996	1001	2022	3033	2808	2566	2314	2235	2024	1724	1486
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Euro II	1997	2001	0	0	0	1032	1945	2710	3600	4234	3724	3421
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Euro III	2002	2006	0	0	0	0	0	0	0	0	872	1720
Heavy Duty Vehicles	Diesel 16 - 32 t	Conventional	0	1993	13283	12481	11564	10720	9832	8982	7933	6814	5525	4571
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro I	1994	1996	1268	2562	3844	3859	3821	3702	3486	3276	3037	2642
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro II	1997	2001	0	0	0	1419	2896	4336	5616	6853	6560	6082
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro III	2002	2006	0	0	0	0	0	0	0	0	1537	3058
Heavy Duty Vehicles	Diesel >32t	Conventional	0	1993	11664	10960	10154	9337	8720	8180	7361	6527	5486	4716
Heavy Duty Vehicles	Diesel >32t	Euro I	1994	1996	1114	2250	3376	3362	3389	3371	3234	3138	3016	2726
Heavy Duty Vehicles	Diesel >32t	Euro II	1997	2001	0	0	0	1236	2568	3949	5211	6564	6514	6275
Heavy Duty Vehicles	Diesel >32t	Euro III	2002	2006	0	0	0	0	0	0	0	0	1526	3156

Sector	Subsector	Tech	FYear	LYear	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Buses	Urban Buses	Conventional	0	1993	4083	3635	3261	2946	2792	2542	2319	2319	1977	1859
Buses	Urban Buses	Euro I	1994	1996	390	746	1084	1060	972	913	852	852	752	713
Buses	Urban Buses	Euro II	1997	2001	0	0	0	390	729	1053	1345	1345	1525	1447
Buses	Urban Buses	Euro III	2002	2006	0	0	0	0	0	0	0	0	346	670
Buses	Coaches	Conventional	0	1993	2927	4507	4156	3662	3369	3007	2724	2724	2165	1962
Buses	Coaches	Euro I	1994	1996	280	925	1381	1318	1173	1080	1001	1001	823	752
Buses	Coaches	Euro II	1997	2001	0	0	0	485	879	1246	1579	1579	1670	1527
Buses	Coaches	Euro III	2002	2006	0	0	0	0	0	0	0	0	379	706
Mopeds	<50 cm ³	Conventional	0	1999	105000	114167	123333	132500	141667	150833	143607	136249	128209	120305
Mopeds	<50 cm ³	97/24/EC I	2000	2002	0	0	0	0	0	0	16393	28751	42791	40611
Mopeds	<50 cm ³	97/24/EC II	2003	9999	0	0	0	0	0	0	0	0	0	8084
Motorcycles	2-stroke >50 cm ³	Conventional	0	1999	7406	7672	8214	8980	9598	10385	11054	11367	11582	11850
Motorcycles	2-stroke >50 cm ³	97/24/EC	2000	2003	0	0	0	0	0	0	0	0	0	0
Motorcycles	4-stroke <250 cm ³	Conventional	0	1999	8394	8695	9310	10177	10878	11769	11916	11367	12882	13380
Motorcycles	4-stroke <250 cm ³	97/24/EC	2000	2003	0	0	0	0	0	0	613	1074	1348	1806
Motorcycles	4-stroke 250 - 750 cm ³	Conventional	0	1999	23083	23911	25602	27986	29914	32365	32768	33910	35424	36794
Motorcycles	4-stroke 250 - 750 cm ³	97/24/EC	2000	2003	0	0	0	0	0	0	1685	2953	3707	4967
Motorcycles	4-stroke >750 cm ³	Conventional	0	1999	10492	10869	11637	12721	13597	14712	14894	15414	16102	16725
Motorcycles	4-stroke >750 cm ³	97/24/EC	2000	2003	0	0	0	0	0	0	766	1342	1685	2258

Annex 3B-2: Mileage data 1990-2003 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	9654	9441	9348	9515	9557	10352	11120	11847	12282
Passenger Cars	Gasoline <1.4 l	ECE 15/00-01	1970	1978	12879	12266	11854	11652	11251	12073	12735	13119	13036
Passenger Cars	Gasoline <1.4 l	ECE 15/02	1979	1980	16201	15060	13954	13614	13193	13225	13605	14495	15028
Passenger Cars	Gasoline <1.4 l	ECE 15/03	1981	1985	19010	17912	17078	16606	15707	16370	16830	16920	16820
Passenger Cars	Gasoline <1.4 l	ECE 15/04	1986	1990	0	20553	19951	19628	19313	19941	20341	20763	20356
Passenger Cars	Gasoline <1.4 l	Euro I	1991	1996	0	1	1	1	1	22535	23984	25041	25397
Passenger Cars	Gasoline <1.4 l	Euro II	1997	2000	0	0	0	0	0	0	0	0	0
Passenger Cars	Gasoline <1.4 l	Euro III	2001	2005	0	0	0	0	0	0	0	0	0
Passenger Cars	Gasoline 1.4 - 2.0 l	PRE ECE	0	1969	9654	9441	9348	9515	9557	10352	11120	11847	12282

Passenger Cars	Gasoline 1.4 - 2.0 l	ECE 15/00-01	1970	1978	12879	12266	11854	11652	11251	12073	12735	13119	13036
Passenger Cars	Gasoline 1.4 - 2.0 l	ECE 15/02	1979	1980	16201	15060	13954	13614	13193	13225	13605	14495	15028
Passenger Cars	Gasoline 1.4 - 2.0 l	ECE 15/03	1981	1985	19010	17912	17078	16606	15707	16370	16830	16920	16820
Passenger Cars	Gasoline 1.4 - 2.0 l	ECE 15/04	1986	1990	0	20553	19951	19628	19313	19941	20341	20763	20356
Passenger Cars	Gasoline 1.4 - 2.0 l	Euro I	1991	1996	0	0	0	0	0	22535	23984	25041	25397
Passenger Cars	Gasoline 1.4 - 2.0 l	Euro II	1997	2000	0	0	0	0	0	0	0	0	0
Passenger Cars	Gasoline 1.4 - 2.0 l	Euro III	2001	2005	0	0	0	0	0	0	0	0	0
Passenger Cars	Gasoline >2.0 l	PRE ECE	0	1969	9654	9441	9348	9515	9557	10352	11120	11847	12282
Passenger Cars	Gasoline >2.0 l	ECE 15/00-01	1970	1978	12879	12266	11854	11652	11251	12073	12735	13119	13036
Passenger Cars	Gasoline >2.0 l	ECE 15/02	1979	1980	16201	15060	13954	13614	13193	13225	13605	14495	15028
Passenger Cars	Gasoline >2.0 l	ECE 15/03	1981	1985	19010	17912	17078	16606	15707	16370	16830	16920	16820
Passenger Cars	Gasoline >2.0 l	ECE 15/04	1986	1990	0	20553	19951	19628	19313	19941	20341	20763	20356
Passenger Cars	Gasoline >2.0 l	Euro I	1991	1996	0	0	0	0	0	22535	23984	25041	25397
Passenger Cars	Gasoline >2.0 l	Euro II	1997	2000	0	0	0	0	0	0	0	0	0
Passenger Cars	Gasoline >2.0 l	Euro III	2001	2005	0	0	0	0	0	0	0	0	0
Passenger Cars	Diesel <2.0 l	Euro I	1991	1996	0	0	0	0	0	0	44822	44911	43972
Passenger Cars	Diesel <2.0 l	Euro II	1997	2000	0	0	0	0	0	0	0	0	0
Passenger Cars	Diesel <2.0 l	Euro III	2001	2005	0	0	0	0	0	0	0	0	0
Passenger Cars	Diesel <2.0 l	Conventional	0	1990	30188	30188	30188	30188	30484	30874	30888	30400	29591
Passenger Cars	Diesel >2.0 l	Euro I	1991	1996	0	0	0	0	0	0	44822	44911	43972
Passenger Cars	Diesel >2.0 l	Euro II	1997	2000	0	0	0	0	0	0	0	0	0
Passenger Cars	Diesel >2.0 l	Euro III	2001	2005	0	0	0	0	0	0	0	0	0
Passenger Cars	Diesel >2.0 l	Conventional	0	1990	30188	30188	30188	30188	30484	30874	30888	30400	29591

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	19010	17912	17078	16606	15707	16370	16830	16920	16820
Passenger Cars	2-Stroke	Conventional	0	9999	19010	17912	17078	16606	15707	16370	16830	16920	16820
Light Duty Vehicles	Gasoline <3.5t	Conventional	0	1994	19882	19445	19252	19597	19195	20255	20573	21208	21167
Light Duty Vehicles	Gasoline <3.5t	Euro I	1995	1998	0	0	0	0	0	0	0	0	0
Light Duty Vehicles	Gasoline <3.5t	Euro II	1999	2001	0	0	0	0	0	0	0	0	0
Light Duty Vehicles	Gasoline <3.5t	Euro III	2002	2006	0	0	0	0	0	0	0	0	0
Light Duty Vehicles	Diesel <3.5 t	Conventional	0	1994	35193	37676	36474	36501	38052	40234	40672	38721	37230
Light Duty Vehicles	Diesel <3.5 t	Euro I	1995	1998	0	0	0	0	0	0	0	0	0
Light Duty Vehicles	Diesel <3.5 t	Euro II	1999	2001	0	0	0	0	0	0	0	0	0
Light Duty Vehicles	Diesel <3.5 t	Euro III	2002	2006	0	0	0	0	0	0	0	0	0
Heavy Duty Vehicles	Gasoline >3.5 t	Conventional	0	9999	22460	21965	21747	22137	21683	24464	24848	25614	25565
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Conventional	0	1993	31160	33359	32294	32318	33691	41061	41509	39516	37996
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Euro I	1994	1996	0	0	0	0	0	0	0	0	0
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Euro II	1997	2001	0	0	0	0	0	0	0	0	0
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Euro III	2002	2006	0	0	0	0	0	0	0	0	0
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Conventional	0	1993	43415	46479	44996	45029	46942	49634	50175	47767	45929
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Euro I	1994	1996	0	0	0	0	0	0	0	0	0
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Euro II	1997	2001	0	0	0	0	0	0	0	0	0
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Euro III	2002	2006	0	0	0	0	0	0	0	0	0
Heavy Duty Vehicles	Diesel 16 - 32 t	Conventional	0	1993	60351	64610	62549	62594	65254	68996	69748	66402	63845
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro I	1994	1996	0	0	0	0	0	0	0	0	0
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro II	1997	2001	0	0	0	0	0	0	0	0	0
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro III	2002	2006	0	0	0	0	0	0	0	0	0
Heavy Duty Vehicles	Diesel >32t	Conventional	0	1993	60351	64610	62549	62594	65254	68996	69748	66402	63845
Heavy Duty Vehicles	Diesel >32t	Euro I	1994	1996	0	0	0	0	0	0	0	0	0
Heavy Duty Vehicles	Diesel >32t	Euro II	1997	2001	0	0	0	0	0	0	0	0	0
Heavy Duty Vehicles	Diesel >32t	Euro III	2002	2006	0	0	0	0	0	0	0	0	0

Sector	Subsector	Tech	FYear	LYear	1985	1986	1987	1988	1989	1990	1991	1992	1993
Buses	Urban Buses	Conventional	0	1993	91053	97478	94369	94437	98450	104096	107730	104029	103324
Buses	Urban Buses	Euro I	1994	1996	0	0	0	0	0	0	0	0	0
Buses	Urban Buses	Euro II	1997	2001	0	0	0	0	0	0	0	0	0
Buses	Urban Buses	Euro III	2002	2006	0	0	0	0	0	0	0	0	0
Buses	Coaches	Conventional	0	1993	81623	87383	84595	84656	88254	93315	98696	98846	98624
Buses	Coaches	Euro I	1994	1996	0	0	0	0	0	0	0	0	0
Buses	Coaches	Euro II	1997	2001	0	0	0	0	0	0	0	0	0
Buses	Coaches	Euro III	2002	2006	0	0	0	0	0	0	0	0	0
Mopeds	<50 cm ³	Conventional	0	1999	2018	1973	1954	1989	1948	2056	2137	2235	2304
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	5708	5582	5527	5626	5511	5815	6072	6372	6557
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	5708	5582	5527	5626	5511	5815	6072	6372	6557
Motorcycles	4-stroke <250 cm ³	97/24/EC	2000	2003	0	0	0	0	0	0	0	0	0
Motorcycles	4-stroke 250 - 750 cm ³	Conventional	0	1999	5708	5582	5527	5626	5511	5815	6072	6372	6557
Motorcycles	4-stroke 250 - 750 cm ³	97/24/EC	2000	2003	0	0	0	0	0	0	0	0	0
Motorcycles	4-stroke >750 cm ³	Conventional	0	1999	5708	5582	5527	5626	5511	5815	6072	6372	6557
Motorcycles	4-stroke >750 cm ³	97/24/EC	2000	2003	0	0	0	0	0	0	0	0	0

Sector	Subsector	Tech	FYear	LYear	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Passenger Cars	Gasoline <1.4 l	PRE ECE	0	1969	12679	12387	12152	11935	11988	11691	11507	11922	11743	11846
Passenger Cars	Gasoline <1.4 l	ECE 15/00-01	1970	1978	12679	12387	12152	11935	11988	11691	11507	11922	11743	11846
Passenger Cars	Gasoline <1.4 l	ECE 15/02	1979	1980	15513	13532	12152	11935	11988	11691	11507	11922	11743	11846
Passenger Cars	Gasoline <1.4 l	ECE 15/03	1981	1985	16701	15701	14867	14403	14225	13461	12591	11922	11743	11846
Passenger Cars	Gasoline <1.4 l	ECE 15/04	1986	1990	19947	18688	17564	16233	15648	14929	14356	12416	13780	13408
Passenger Cars	Gasoline <1.4 l	Euro I	1991	1996	25885	24768	23130	22344	21207	19843	18497	18409	17226	16508
Passenger Cars	Gasoline <1.4 l	Euro II	1997	2000	0	0	0	25981	25671	24357	24054	22954	21396	20639
Passenger Cars	Gasoline <1.4 l	Euro III	2001	2005	0	0	0	0	0	0	0	25954	25172	26178
Passenger Cars	Gasoline 1.4 - 2.0 l	PRE ECE	0	1969	12679	12387	12152	11935	11988	11691	11507	11922	11743	11846
Passenger Cars	Gasoline 1.4 - 2.0 l	ECE 15/00-01	1970	1978	12679	12387	12152	11935	11988	11691	11507	11922	11743	11846
Passenger Cars	Gasoline 1.4 - 2.0 l	ECE 15/02	1979	1980	15513	13532	12152	11935	11988	11691	11507	11922	11743	11846
Passenger Cars	Gasoline 1.4 - 2.0 l	ECE 15/03	1981	1985	16701	15701	14867	14403	14225	13461	12591	11922	11743	11846
Passenger Cars	Gasoline 1.4 - 2.0 l	ECE 15/04	1986	1990	19947	18688	17564	16233	15648	14929	14356	12416	13780	13408
Passenger Cars	Gasoline 1.4 - 2.0 l	Euro I	1991	1996	25885	24768	23130	22344	21207	19843	18497	18409	17226	16508
Passenger Cars	Gasoline 1.4 - 2.0 l	Euro II	1997	2000	0	0	0	25981	25671	24357	24054	22954	21396	20639
Passenger Cars	Gasoline 1.4 - 2.0 l	Euro III	2001	2005	0	0	0	0	0	0	0	25954	25172	26178
Passenger Cars	Gasoline >2.0 l	PRE ECE	0	1969	12679	12387	12152	11935	11988	11691	11507	11922	11743	11846
Passenger Cars	Gasoline >2.0 l	ECE 15/00-01	1970	1978	12679	12387	12152	11935	11988	11691	11507	11922	11743	11846
Passenger Cars	Gasoline >2.0 l	ECE 15/02	1979	1980	15513	13532	12152	11935	11988	11691	11507	11922	11743	11846
Passenger Cars	Gasoline >2.0 l	ECE 15/03	1981	1985	16701	15701	14867	14403	14225	13461	12591	11922	11743	11846
Passenger Cars	Gasoline >2.0 l	ECE 15/04	1986	1990	19947	18688	17564	16233	15648	14929	14356	12416	13780	13408
Passenger Cars	Gasoline >2.0 l	Euro I	1991	1996	25885	24768	23130	22344	21207	19843	18497	18409	17226	16508
Passenger Cars	Gasoline >2.0 l	Euro II	1997	2000	0	0	0	25981	25671	24357	24054	22954	21396	20639
Passenger Cars	Gasoline >2.0 l	Euro III	2001	2005	0	0	0	0	0	0	0	25954	25172	26178
Passenger Cars	Diesel <2.0 l	Euro I	1991	1996	44800	44746	43410	41641	39363	38090	35677	34320	33095	32058
Passenger Cars	Diesel <2.0 l	Euro II	1997	2000	0	0	0	47992	47256	46753	45221	42794	41107	40082
Passenger Cars	Diesel <2.0 l	Euro III	2001	2005	0	0	0	0	0	0	0	48385	48362	47987
Passenger Cars	Diesel <2.0 l	Conventional	0	1990	29501	29228	28169	27809	27304	27242	26288	22832	25212	25125
Passenger Cars	Diesel >2.0 l	Euro I	1991	1996	44800	44746	43410	41641	39363	38090	35677	34320	33095	32058
Passenger Cars	Diesel >2.0 l	Euro II	1997	2000	0	0	0	47992	47256	46753	45221	42794	41107	40082
Passenger Cars	Diesel >2.0 l	Euro III	2001	2005	0	0	0	0	0	0	0	48385	48362	47987
Passenger Cars	Diesel >2.0 l	Conventional	0	1990	29501	29228	28169	27809	27304	27242	26288	22832	25212	25125

Sector	Subsector	Tech	FYear	LYear	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
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	16701	15701	14867	12868	14225	13461	12591	11922	11743	11846
Passenger Cars	2-Stroke	Conventional	0	9999	16701	15701	14867	12868	14225	13461	12591	11922	11743	11846
Light Duty Vehicles	Gasoline <3.5t	Conventional	0	1994	21003	20157	20005	19559	18762	18082	18101	16619	18399	17511
Light Duty Vehicles	Gasoline <3.5t	Euro I	1995	1998	0	20157	20005	19559	18762	18082	18101	16619	18399	17511
Light Duty Vehicles	Gasoline <3.5t	Euro II	1999	2001	0	0	0	0	0	18082	18101	16619	18399	17511
Light Duty Vehicles	Gasoline <3.5t	Euro III	2002	2006	0	0	0	0	0	0	0	0	18399	17511
Light Duty Vehicles	Diesel <3.5 t	Conventional	0	1994	38732	36909	37282	37023	35010	34193	32789	32130	32060	32924
Light Duty Vehicles	Diesel <3.5 t	Euro I	1995	1998	0	36909	37282	37023	35010	34193	32789	32130	32060	32924
Light Duty Vehicles	Diesel <3.5 t	Euro II	1999	2001	0	0	0	0	0	34193	32789	32130	32060	32924
Light Duty Vehicles	Diesel <3.5 t	Euro III	2002	2006	0	0	0	0	0	0	0	0	32060	32924
Heavy Duty Vehicles	Gasoline >3.5 t	Conventional	0	9999	25367	24346	24162	21140	21559	21272	22009	23191	25362	25494
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Conventional	0	1993	39528	37666	38048	30803	31809	33583	34246	44099	43711	48920
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Euro I	1994	1996	39528	37666	38048	30803	31809	33583	34246	44099	43711	48920
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Euro II	1997	2001	0	0	0	30803	31809	33583	34246	44099	43711	48920
Heavy Duty Vehicles	Diesel 3.5 - 7.5 t	Euro III	2002	2006	0	0	0	0	0	0	0	0	43711	48920
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Conventional	0	1993	47781	45532	45991	43199	42348	39158	37550	20945	17878	19777
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Euro I	1994	1996	47781	45532	45991	43199	42348	39158	37550	20945	17878	19777
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Euro II	1997	2001	0	0	0	43199	42348	39158	37550	20945	17878	19777
Heavy Duty Vehicles	Diesel 7.5 - 16 t	Euro III	2002	2006	0	0	0	0	0	0	0	0	17878	19777
Heavy Duty Vehicles	Diesel 16 - 32 t	Conventional	0	1993	66422	63294	63934	64717	65653	66838	64092	68254	66841	71891
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro I	1994	1996	66422	63294	63934	64717	65653	66838	64092	68254	66841	71891
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro II	1997	2001	0	0	0	64717	65653	66838	64092	68254	66841	71891
Heavy Duty Vehicles	Diesel 16 - 32 t	Euro III	2002	2006	0	0	0	0	0	0	0	0	66841	71891
Heavy Duty Vehicles	Diesel >32t	Conventional	0	1993	66422	63294	63934	64717	65653	66838	64092	68254	66841	71891
Heavy Duty Vehicles	Diesel >32t	Euro I	1994	1996	66422	63294	63934	64717	65653	66838	64092	68254	66841	71891
Heavy Duty Vehicles	Diesel >32t	Euro II	1997	2001	0	0	0	64717	65653	66838	64092	68254	66841	71891
Heavy Duty Vehicles	Diesel >32t	Euro III	2002	2006	0	0	0	0	0	0	0	0	66841	71891

Sector	Subsector	Tech	FYear	LYear	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Buses	Urban Buses	Conventional	0	1993	108850	103224	103953	103313	102311	99871	95765	93590	93770	100911
Buses	Urban Buses	Euro I	1994	1996	108850	103224	103953	103313	102311	99871	95765	93590	93770	100911
Buses	Urban Buses	Euro II	1997	2001	0	0	0	103313	102311	99871	95765	93590	93770	100911
Buses	Urban Buses	Euro III	2002	2006	0	0	0	0	0	0	0	0	93770	100911
Buses	Coaches	Conventional	0	1993	108850	90022	85021	83545	82509	81021	77850	76121	76267	82075
Buses	Coaches	Euro I	1994	1996	108850	90022	85021	83545	82509	81021	77850	76121	76267	82075
Buses	Coaches	Euro II	1997	2001	0	0	0	83545	82509	81021	77850	76121	76267	82075
Buses	Coaches	Euro III	2002	2006	0	0	0	0	0	0	0	0	76267	82075
Mopeds	<50 cm ³	Conventional	0	1999	2315	2211	2188	2141	2151	1794	1614	1175	1306	1302
Mopeds	<50 cm ³	97/24/EC I	2000	2002	0	0	0	0	0	0	1614	1175	1306	1302
Mopeds	<50 cm ³	97/24/EC II	2003	9999	0	0	0	0	0	0	0	0	0	1302
Motorcycles	2-stroke >50 cm ³	Conventional	0	1999	6584	6279	6220	6106	6168	5971	6029	5563	6228	6212
Motorcycles	2-stroke >50 cm ³	97/24/EC	2000	2003	0	0	0	0	0	0	0	0	0	0
Motorcycles	4-stroke <250 cm ³	Conventional	0	1999	6584	6279	6220	6106	6168	5971	6029	5563	6228	6212
Motorcycles	4-stroke <250 cm ³	97/24/EC	2000	2003	0	0	0	0	0	0	6029	5563	6228	6212
Motorcycles	4-stroke 250 - 750 cm ³	Conventional	0	1999	6584	6279	6220	6106	6168	5971	6029	5563	6228	6212
Motorcycles	4-stroke 250 - 750 cm ³	97/24/EC	2000	2003	0	0	0	0	0	0	6029	5563	6228	6212
Motorcycles	4-stroke >750 cm ³	Conventional	0	1999	6584	6279	6220	6106	6168	5971	6029	5563	6228	6212
Motorcycles	4-stroke >750 cm ³	97/24/EC	2000	2003	0	0	0	0	0	0	6029	5563	6228	6212

Annex 3B-3: 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	CO _r	CO _h	NO _{xu}	NO _{xr}	NO _{xh}	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	CO _r	CO _h	NO _{xu}	NO _{xr}	NO _{xh}	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-4: 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	47	47	47	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	47	47	47	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	16	16	16	38	38	38
Light Duty Vehicles	Diesel <3.5 t	Euro IV - 98/69/EC Stage2005	35	35	35	32	32	32	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 cm ³	Conventional	0	0	0	0	0	0	0	0	0
Mopeds	<50 cm ³	97/24/EC Stage I	50	50	100	0	0	100	55	55	100
Mopeds	<50 cm ³	97/24/EC Stage II	90	90	100	67	67	100	78	78	100
Motorcycles	2-stroke >50 cm ³	97/24/EC	0	0	0	0	0	0	0	0	0
Motorcycles	2-stroke >50 cm ³	97/24/EC Stage II (proposal)	31	31	31	-200	-200	-200	70	70	70
Motorcycles	2-stroke >50 cm ³	97/24/EC Stage III (proposal)	75	75	75	-50	-50	-50	80	80	80
Motorcycles	4-stroke <250 cm ³	97/24/EC	0	0	0	0	0	0	0	0	0
Motorcycles	4-stroke <250 cm ³	97/24/EC Stage II (proposal)	58	58	58	0	0	0	67	67	67
Motorcycles	4-stroke <250 cm ³	97/24/EC Stage III (proposal)	85	85	85	50	50	50	90	90	90
Motorcycles	4-stroke 250 - 750 cm ³	97/24/EC	0	0	0	0	0	0	0	0	0
Motorcycles	4-stroke 250 - 750 cm ³	97/24/EC Stage II (proposal)	58	58	58	0	0	0	67	67	67
Motorcycles	4-stroke 250 - 750 cm ³	97/24/EC Stage III (proposal)	85	85	85	50	50	50	90	90	90
Motorcycles	4-stroke >750 cm ³	97/24/EC	0	0	0	0	0	0	0	0	0
Motorcycles	4-stroke >750 cm ³	97/24/EC Stage II (proposal)	58	58	58	0	0	0	67	67	67
Motorcycles	4-stroke >750 cm ³	97/24/EC Stage III (proposal)	85	85	85	50	50	50	90	90	90

Annex 3B-5: Fuel use factors (MJ/km) and emission factors (g/km)

Category	Year	FCu (MJ)	FCr (MJ)	FCh (MJ)	CO2u	CO2r	CO2h	CH4u	CH4r	CH4h	N2Ou	N2Or	N2Oh	SO2u	SO2r	SO2h	NOxu	NOxr	NOxh
Passenger Cars	1985	3.229	2.099	2.408	236	153	176	0.153	0.027	0.024	0.007	0.007	0.007	0.070	0.043	0.053	1.856	2.195	2.802
Passenger Cars	1986	3.197	2.090	2.390	234	153	175	0.151	0.027	0.024	0.007	0.007	0.007	0.045	0.028	0.034	1.850	2.195	2.812
Passenger Cars	1987	3.185	2.079	2.369	233	152	173	0.152	0.027	0.024	0.007	0.007	0.007	0.046	0.028	0.034	1.851	2.192	2.809
Passenger Cars	1988	3.116	2.068	2.345	228	151	171	0.144	0.027	0.024	0.007	0.007	0.007	0.045	0.028	0.034	1.832	2.187	2.808
Passenger Cars	1989	3.088	2.063	2.335	226	151	171	0.141	0.027	0.024	0.007	0.007	0.007	0.032	0.020	0.024	1.823	2.185	2.813
Passenger Cars	1990	3.082	2.054	2.318	225	150	169	0.143	0.027	0.024	0.008	0.007	0.008	0.031	0.020	0.023	1.791	2.142	2.763
Passenger Cars	1991	3.121	2.036	2.297	228	149	168	0.157	0.026	0.024	0.011	0.008	0.010	0.030	0.019	0.023	1.718	2.014	2.609
Passenger Cars	1992	3.133	2.020	2.276	229	148	166	0.165	0.025	0.023	0.014	0.009	0.011	0.021	0.014	0.016	1.649	1.901	2.475
Passenger Cars	1993	3.161	2.003	2.255	231	146	165	0.181	0.025	0.023	0.017	0.009	0.013	0.012	0.008	0.009	1.595	1.798	2.356
Passenger Cars	1994	3.162	1.981	2.226	231	145	163	0.189	0.024	0.022	0.021	0.010	0.016	0.012	0.008	0.009	1.488	1.624	2.149
Passenger Cars	1995	3.213	1.960	2.202	235	143	161	0.208	0.023	0.021	0.025	0.011	0.018	0.013	0.008	0.009	1.430	1.495	1.993
Passenger Cars	1996	3.275	1.945	2.182	239	142	159	0.234	0.022	0.021	0.028	0.012	0.020	0.013	0.008	0.009	1.393	1.395	1.875
Passenger Cars	1997	3.225	1.912	2.142	236	140	157	0.215	0.020	0.019	0.032	0.013	0.023	0.013	0.008	0.009	1.283	1.240	1.694
Passenger Cars	1998	3.201	1.901	2.128	234	139	156	0.198	0.018	0.017	0.034	0.013	0.024	0.013	0.008	0.009	1.197	1.129	1.549
Passenger Cars	1999	3.218	1.886	2.110	235	138	154	0.194	0.016	0.015	0.037	0.014	0.026	0.010	0.006	0.007	1.102	0.995	1.369
Passenger Cars	2000	3.207	1.875	2.097	234	137	153	0.187	0.014	0.014	0.038	0.015	0.027	0.007	0.004	0.005	1.027	0.893	1.232
Passenger Cars	2001	3.241	1.865	2.085	237	136	152	0.188	0.013	0.013	0.040	0.015	0.028	0.007	0.004	0.005	0.958	0.796	1.107
Passenger Cars	2002	3.205	1.860	2.079	234	136	152	0.167	0.012	0.012	0.041	0.016	0.029	0.007	0.004	0.005	0.907	0.749	1.041
Passenger Cars	2003	3.216	1.853	2.071	235	136	152	0.161	0.011	0.011	0.042	0.016	0.029	0.007	0.004	0.005	0.838	0.669	0.931
Light Duty Vehicles	1985	3.927	2.790	3.000	290	206	222	0.045	0.010	0.008	0.016	0.016	0.016	0.781	0.572	0.626	2.020	1.146	1.174
Light Duty Vehicles	1986	3.907	2.792	3.006	289	206	222	0.042	0.009	0.007	0.016	0.016	0.016	0.473	0.348	0.380	2.002	1.123	1.148
Light Duty Vehicles	1987	3.917	2.791	3.004	289	206	222	0.043	0.009	0.008	0.016	0.016	0.016	0.473	0.347	0.379	2.010	1.128	1.154
Light Duty Vehicles	1988	3.869	2.791	3.003	286	206	222	0.041	0.009	0.008	0.016	0.016	0.016	0.466	0.346	0.378	1.981	1.133	1.159
Light Duty Vehicles	1989	3.847	2.792	3.007	284	206	222	0.039	0.009	0.007	0.016	0.016	0.016	0.312	0.233	0.254	1.963	1.117	1.142
Light Duty Vehicles	1990	3.842	2.792	3.007	284	206	222	0.038	0.009	0.007	0.016	0.016	0.016	0.312	0.233	0.255	1.960	1.117	1.141
Light Duty Vehicles	1991	3.872	2.792	3.007	286	206	222	0.040	0.009	0.007	0.016	0.016	0.016	0.314	0.233	0.254	1.979	1.118	1.143
Light Duty Vehicles	1992	3.873	2.790	3.002	286	206	222	0.042	0.010	0.008	0.016	0.016	0.016	0.202	0.150	0.164	1.981	1.138	1.165
Light Duty Vehicles	1993	3.907	2.790	2.999	289	206	222	0.044	0.010	0.008	0.016	0.016	0.016	0.079	0.058	0.063	2.004	1.147	1.176
Light Duty Vehicles	1994	3.945	2.791	3.002	291	206	222	0.044	0.010	0.008	0.016	0.016	0.016	0.080	0.058	0.064	2.006	1.135	1.162
Light Duty Vehicles	1995	3.937	2.771	2.979	291	205	220	0.044	0.009	0.007	0.016	0.016	0.016	0.080	0.058	0.063	1.945	1.115	1.144
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	1.907	1.091	1.121
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	1.811	1.064	1.094
Light Duty Vehicles	1998	3.851	2.714	2.918	284	200	216	0.040	0.008	0.007	0.018	0.016	0.017	0.078	0.056	0.062	1.735	1.050	1.082
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	1.688	1.031	1.064

Light Duty Vehicles	2000	3.816	2.681	2.883	282	198	213	0.036	0.008	0.007	0.018	0.016	0.017	0.009	0.006	0.007	1.629	1.018	1.052
Light Duty Vehicles	2001	3.821	2.663	2.866	282	197	212	0.034	0.007	0.006	0.019	0.016	0.018	0.009	0.006	0.007	1.593	0.998	1.032
Light Duty Vehicles	2002	4.166	2.916	3.134	308	215	232	0.035	0.008	0.007	0.021	0.018	0.020	0.010	0.007	0.007	1.657	1.073	1.113
Category	Year	FCu (MJ)	FCr (MJ)	FCh (MJ)	CO2u	CO2r	CO2h	CH4u	CH4r	CH4h	N2Ou	N2Or	N2Oh	SO2u	SO2r	SO2h	NOxu	NOxr	NOxh
Light Duty Vehicles	2003	4.633	3.235	3.481	342	239	257	0.035	0.008	0.007	0.024	0.020	0.022	0.011	0.008	0.008	1.776	1.158	1.202
Heavy Duty Vehicles	1985	12.039	9.738	10.290	891	721	761	0.152	0.067	0.063	0.030	0.030	0.030	2.814	2.277	2.408	12.461	9.226	8.535
Heavy Duty Vehicles	1986	12.030	9.737	10.294	890	720	762	0.152	0.067	0.063	0.030	0.030	0.030	1.687	1.366	1.445	12.445	9.220	8.535
Heavy Duty Vehicles	1987	12.029	9.736	10.294	890	720	762	0.152	0.067	0.063	0.030	0.030	0.030	1.687	1.366	1.445	12.443	9.219	8.535
Heavy Duty Vehicles	1988	12.037	9.738	10.291	891	721	762	0.152	0.067	0.063	0.030	0.030	0.030	1.688	1.367	1.445	12.457	9.225	8.535
Heavy Duty Vehicles	1989	12.037	9.738	10.291	891	721	762	0.152	0.067	0.063	0.030	0.030	0.030	1.126	0.911	0.963	12.458	9.225	8.536
Heavy Duty Vehicles	1990	11.965	9.685	10.256	885	717	759	0.151	0.067	0.063	0.030	0.030	0.030	1.119	0.906	0.960	12.379	9.166	8.502
Heavy Duty Vehicles	1991	12.016	9.691	10.226	889	717	757	0.151	0.066	0.062	0.030	0.030	0.030	1.124	0.907	0.957	12.423	9.174	8.460
Heavy Duty Vehicles	1992	12.023	9.677	10.218	890	716	756	0.152	0.066	0.062	0.030	0.030	0.030	0.731	0.588	0.622	12.435	9.145	8.456
Heavy Duty Vehicles	1993	11.898	9.723	10.189	880	719	754	0.150	0.067	0.062	0.030	0.030	0.030	0.278	0.227	0.238	12.272	9.212	8.433
Heavy Duty Vehicles	1994	11.929	9.663	10.141	883	715	750	0.146	0.065	0.061	0.030	0.030	0.030	0.279	0.226	0.237	11.939	8.820	8.092
Heavy Duty Vehicles	1995	11.911	9.673	10.013	881	716	741	0.142	0.064	0.059	0.030	0.030	0.030	0.278	0.226	0.234	11.490	8.527	7.722
Heavy Duty Vehicles	1996	11.938	9.657	10.026	883	715	742	0.137	0.061	0.058	0.030	0.030	0.030	0.279	0.226	0.235	11.123	8.241	7.455
Heavy Duty Vehicles	1997	12.176	9.836	10.152	901	728	751	0.133	0.061	0.057	0.030	0.030	0.030	0.285	0.230	0.238	10.798	8.035	7.206
Heavy Duty Vehicles	1998	12.246	9.904	10.209	906	733	755	0.129	0.059	0.056	0.030	0.030	0.030	0.286	0.232	0.239	10.374	7.747	6.917
Heavy Duty Vehicles	1999	12.389	10.028	10.306	917	742	763	0.126	0.059	0.055	0.030	0.030	0.030	0.159	0.129	0.133	10.019	7.524	6.684
Heavy Duty Vehicles	2000	12.422	10.055	10.329	919	744	764	0.121	0.057	0.053	0.030	0.030	0.030	0.029	0.024	0.024	9.598	7.227	6.410
Heavy Duty Vehicles	2001	12.685	10.273	10.476	939	760	775	0.121	0.057	0.053	0.030	0.030	0.030	0.030	0.024	0.025	9.526	7.161	6.252
Heavy Duty Vehicles	2002	13.930	11.321	11.552	1031	838	855	0.124	0.060	0.056	0.033	0.033	0.033	0.033	0.027	0.027	9.669	7.332	6.400
Heavy Duty Vehicles	2003	15.372	12.568	12.875	1137	930	953	0.130	0.063	0.059	0.036	0.036	0.037	0.036	0.029	0.030	10.055	7.654	6.686
2-wheelers	1985	1.159	1.230	1.578	85	90	115	0.211	0.117	0.193	0.001	0.001	0.002	0.003	0.003	0.004	0.058	0.151	0.340
2-wheelers	1986	1.163	1.235	1.578	85	90	115	0.210	0.121	0.193	0.001	0.001	0.002	0.003	0.003	0.004	0.060	0.155	0.340
2-wheelers	1987	1.166	1.238	1.578	85	90	115	0.210	0.124	0.193	0.001	0.001	0.002	0.003	0.003	0.004	0.061	0.158	0.340
2-wheelers	1988	1.168	1.241	1.578	85	91	115	0.210	0.126	0.192	0.001	0.001	0.002	0.003	0.003	0.004	0.062	0.160	0.340
2-wheelers	1989	1.170	1.243	1.578	85	91	115	0.210	0.128	0.193	0.001	0.001	0.002	0.003	0.003	0.004	0.063	0.162	0.340
2-wheelers	1990	1.173	1.245	1.578	86	91	115	0.209	0.130	0.192	0.001	0.001	0.002	0.003	0.004	0.005	0.064	0.164	0.340
2-wheelers	1991	1.182	1.242	1.578	86	91	115	0.208	0.127	0.193	0.001	0.001	0.002	0.003	0.003	0.004	0.068	0.161	0.340
2-wheelers	1992	1.178	1.253	1.578	86	91	115	0.209	0.137	0.192	0.001	0.001	0.002	0.003	0.003	0.004	0.066	0.171	0.340
2-wheelers	1993	1.190	1.249	1.578	87	91	115	0.207	0.133	0.192	0.001	0.001	0.002	0.003	0.003	0.004	0.071	0.167	0.340
2-wheelers	1994	1.188	1.258	1.578	87	92	115	0.207	0.141	0.193	0.001	0.001	0.002	0.003	0.003	0.004	0.070	0.175	0.340
2-wheelers	1995	1.182	1.254	1.578	86	92	115	0.208	0.137	0.193	0.001	0.001	0.002	0.003	0.003	0.004	0.068	0.171	0.340
2-wheelers	1996	1.185	1.256	1.578	86	92	115	0.208	0.139	0.193	0.001	0.001	0.002	0.003	0.003	0.004	0.069	0.173	0.340
2-wheelers	1997	1.186	1.257	1.578	87	92	115	0.208	0.140	0.192	0.001	0.001	0.002	0.003	0.003	0.004	0.069	0.174	0.340
2-wheelers	1998	1.186	1.257	1.578	87	92	115	0.208	0.140	0.193	0.001	0.001	0.002	0.003	0.003	0.004	0.069	0.174	0.340

2-wheelers	1999	1.195	1.264	1.578	87	92	115	0.207	0.146	0.192	0.001	0.002	0.002	0.003	0.003	0.004	0.073	0.180	0.340
2-wheelers	2000	1.266	1.328	1.640	92	97	120	0.215	0.207	0.201	0.002	0.002	0.002	0.003	0.003	0.004	0.083	0.197	0.357
2-wheelers	2001	1.330	1.380	1.685	97	101	123	0.220	0.212	0.207	0.002	0.002	0.002	0.003	0.003	0.004	0.095	0.215	0.371
2-wheelers	2002	1.373	1.407	1.705	100	103	124	0.226	0.216	0.210	0.002	0.002	0.002	0.003	0.003	0.004	0.101	0.224	0.378
2-wheelers	2003	1.407	1.440	1.742	103	105	127	0.240	0.225	0.215	0.002	0.002	0.002	0.003	0.003	0.004	0.107	0.234	0.390

Category	Year	NMVOCu (exh)	NMVOCr (exh)	NMVOCh (exh)	NMVOCu (tot)	NMVOCr (tot)	NMVOCh (tot)	COu	COr	COh
Passenger Cars	1985	3.046	1.051	0.926	4.928	1.441	1.001	36.756	10.183	10.658
Passenger Cars	1986	2.947	1.029	0.901	4.837	1.421	0.977	34.663	9.688	10.036
Passenger Cars	1987	2.907	1.006	0.873	4.775	1.394	0.947	33.221	9.125	9.376
Passenger Cars	1988	2.686	0.976	0.835	4.625	1.378	0.913	29.040	8.378	8.477
Passenger Cars	1989	2.593	0.958	0.814	4.554	1.364	0.892	27.344	7.992	7.972
Passenger Cars	1990	2.527	0.929	0.787	4.440	1.325	0.863	26.382	7.625	7.554
Passenger Cars	1991	2.520	0.864	0.732	4.313	1.219	0.802	26.666	7.061	7.065
Passenger Cars	1992	2.416	0.804	0.681	4.195	1.139	0.738	25.631	6.538	6.663
Passenger Cars	1993	2.402	0.746	0.633	3.990	1.045	0.684	25.790	6.025	6.323
Passenger Cars	1994	2.200	0.654	0.555	3.671	0.919	0.601	23.663	5.243	5.741
Passenger Cars	1995	2.157	0.584	0.497	3.526	0.817	0.533	23.607	4.701	5.507
Passenger Cars	1996	2.176	0.526	0.449	3.393	0.731	0.477	24.352	4.267	5.365
Passenger Cars	1997	1.835	0.435	0.376	2.896	0.614	0.400	20.485	3.464	4.975
Passenger Cars	1998	1.619	0.382	0.329	2.552	0.539	0.350	18.258	3.057	4.674
Passenger Cars	1999	1.477	0.322	0.277	2.270	0.456	0.295	17.050	2.617	4.306
Passenger Cars	2000	1.335	0.277	0.238	1.868	0.367	0.250	15.805	2.309	4.104
Passenger Cars	2001	1.261	0.234	0.203	1.695	0.307	0.213	15.723	2.064	4.048
Passenger Cars	2002	1.119	0.213	0.185	1.524	0.282	0.194	14.127	1.911	3.885
Passenger Cars	2003	1.031	0.182	0.158	1.369	0.239	0.166	13.527	1.694	3.631
Light Duty Vehicles	1985	0.637	0.179	0.139	0.875	0.225	0.149	5.929	1.684	1.904
Light Duty Vehicles	1986	0.597	0.173	0.136	0.818	0.216	0.145	5.515	1.633	1.840
Light Duty Vehicles	1987	0.610	0.174	0.137	0.833	0.218	0.146	5.647	1.645	1.855
Light Duty Vehicles	1988	0.581	0.176	0.137	0.816	0.221	0.147	5.389	1.655	1.867
Light Duty Vehicles	1989	0.549	0.172	0.135	0.775	0.215	0.145	5.077	1.621	1.824
Light Duty Vehicles	1990	0.546	0.171	0.135	0.771	0.215	0.145	5.044	1.620	1.823
Light Duty Vehicles	1991	0.568	0.172	0.135	0.790	0.215	0.145	5.242	1.622	1.826
Light Duty Vehicles	1992	0.586	0.177	0.138	0.833	0.224	0.148	5.453	1.666	1.881
Light Duty Vehicles	1993	0.620	0.179	0.140	0.865	0.226	0.149	5.785	1.688	1.908
Light Duty Vehicles	1994	0.618	0.176	0.138	0.890	0.220	0.146	5.767	1.661	1.874

Light Duty Vehicles	1995	0.605	0.170	0.134	0.856	0.210	0.142	5.616	1.553	1.758
Light Duty Vehicles	1996	0.612	0.163	0.130	0.836	0.197	0.136	5.646	1.441	1.636
Light Duty Vehicles	1997	0.543	0.154	0.125	0.745	0.185	0.130	4.957	1.317	1.500
Light Duty Vehicles	1998	0.507	0.149	0.122	0.690	0.177	0.127	4.638	1.232	1.410
Light Duty Vehicles	1999	0.487	0.142	0.118	0.647	0.167	0.122	4.399	1.137	1.307
Light Duty Vehicles	2000	0.459	0.137	0.115	0.572	0.155	0.118	4.159	1.064	1.229
Light Duty Vehicles	2001	0.442	0.130	0.111	0.533	0.144	0.113	3.903	0.964	1.119
Light Duty Vehicles	2002	0.448	0.135	0.116	0.540	0.150	0.118	4.048	0.982	1.150
Light Duty Vehicles	2003	0.461	0.139	0.121	0.541	0.151	0.123	4.026	0.969	1.140

Category	Year	NMVOCu (exh)	NMVOCr (exh)	NMVOCh (exh)	NMVOCu (tot)	NMVOCr (tot)	NMVOCh (tot)	COu	COr	COh
Heavy Duty Vehicles	1985	1.528	1.007	0.792	1.528	1.007	0.792	3.717	2.417	1.861
Heavy Duty Vehicles	1986	1.529	1.007	0.791	1.529	1.007	0.791	3.698	2.405	1.855
Heavy Duty Vehicles	1987	1.529	1.008	0.791	1.529	1.008	0.791	3.701	2.408	1.856
Heavy Duty Vehicles	1988	1.528	1.007	0.791	1.528	1.007	0.791	3.708	2.411	1.857
Heavy Duty Vehicles	1989	1.527	1.006	0.791	1.527	1.006	0.791	3.699	2.404	1.853
Heavy Duty Vehicles	1990	1.527	1.007	0.792	1.527	1.007	0.792	3.707	2.411	1.857
Heavy Duty Vehicles	1991	1.532	1.007	0.792	1.532	1.007	0.792	3.687	2.414	1.862
Heavy Duty Vehicles	1992	1.532	1.011	0.792	1.532	1.011	0.792	3.700	2.413	1.866
Heavy Duty Vehicles	1993	1.538	1.008	0.792	1.538	1.008	0.792	3.707	2.420	1.872
Heavy Duty Vehicles	1994	1.475	0.986	0.775	1.475	0.986	0.775	3.588	2.323	1.814
Heavy Duty Vehicles	1995	1.439	0.964	0.761	1.439	0.964	0.761	3.411	2.225	1.757
Heavy Duty Vehicles	1996	1.396	0.938	0.745	1.396	0.938	0.745	3.260	2.156	1.704
Heavy Duty Vehicles	1997	1.331	0.903	0.721	1.331	0.903	0.721	3.070	2.044	1.632
Heavy Duty Vehicles	1998	1.283	0.876	0.700	1.283	0.876	0.700	2.941	1.970	1.586
Heavy Duty Vehicles	1999	1.234	0.849	0.680	1.234	0.849	0.680	2.795	1.885	1.535
Heavy Duty Vehicles	2000	1.193	0.826	0.663	1.193	0.826	0.663	2.686	1.824	1.500
Heavy Duty Vehicles	2001	1.148	0.803	0.645	1.148	0.803	0.645	2.625	1.770	1.467
Heavy Duty Vehicles	2002	1.171	0.830	0.671	1.171	0.830	0.671	2.685	1.832	1.537
Heavy Duty Vehicles	2003	1.222	0.874	0.710	1.222	0.874	0.710	2.789	1.917	1.625
2-wheelers	1985	6.932	4.753	2.011	7.427	5.023	2.040	16.514	19.368	27.917
2-wheelers	1986	6.808	4.598	2.011	7.322	4.870	2.040	16.616	19.528	27.917
2-wheelers	1987	6.729	4.504	2.011	7.242	4.770	2.040	16.680	19.624	27.917
2-wheelers	1988	6.666	4.431	2.011	7.210	4.709	2.041	16.732	19.700	27.917
2-wheelers	1989	6.606	4.364	2.011	7.171	4.649	2.042	16.781	19.769	27.917
2-wheelers	1990	6.532	4.283	2.011	7.095	4.562	2.041	16.842	19.852	27.917

2-wheelers	1991	6.249	4.379	2.011	6.770	4.669	2.047	17.073	19.753	27.917
2-wheelers	1992	6.372	4.042	2.011	6.937	4.303	2.045	16.972	20.099	27.917
2-wheelers	1993	6.033	4.187	2.011	6.538	4.462	2.048	17.250	19.950	27.917
2-wheelers	1994	6.097	3.880	2.011	6.663	4.139	2.047	17.197	20.267	27.917
2-wheelers	1995	6.271	4.023	2.011	6.850	4.295	2.038	17.055	20.119	27.917
2-wheelers	1996	6.184	3.960	2.011	6.726	4.212	2.046	17.126	20.184	27.917
2-wheelers	1997	6.153	3.931	2.011	6.729	4.198	2.048	17.152	20.214	27.917
2-wheelers	1998	6.145	3.924	2.011	6.720	4.189	2.047	17.158	20.221	27.917
2-wheelers	1999	5.895	3.704	2.011	6.509	3.974	2.048	17.363	20.448	27.917
2-wheelers	2000	5.868	3.574	2.066	6.412	3.801	2.096	18.167	21.197	28.604
2-wheelers	2001	5.542	3.318	2.077	6.165	3.558	2.109	18.904	21.824	28.956
2-wheelers	2002	5.505	3.238	2.044	6.158	3.482	2.075	19.434	22.206	29.326
2-wheelers	2003	5.375	3.151	2.034	6.050	3.397	2.066	19.655	22.492	29.740

Annex 3B-6: Fuel use (GJ) and emissions (tons) per vehicle category and as totals

Year	Sector	FC (GJ)	SO2	NOx	NMVOC	CH4	CO	CO2	N2O
1985	Passenger Cars	65998226	1413	53825	71922	2007	540484	4823200	179
1986	Passenger Cars	66376423	927	54512	71599	2007	517508	4850992	182
1987	Passenger Cars	66571313	943	54907	71062	2035	497147	4865325	184
1988	Passenger Cars	67036985	943	55829	70652	1997	449763	4899318	187
1989	Passenger Cars	66072647	677	55255	69046	1947	421127	4828973	187
1990	Passenger Cars	69608254	687	57332	71086	2079	427990	5087105	214
1991	Passenger Cars	73816548	709	57836	71423	2334	443231	5394444	280
1992	Passenger Cars	77348442	526	58614	70458	2467	434504	5652313	347
1993	Passenger Cars	79376296	307	57397	68127	2719	438753	5800343	407
1994	Passenger Cars	82258416	318	55069	63930	2876	410796	6010935	511
1995	Passenger Cars	83450719	329	52947	59334	3038	396227	6098344	587
1996	Passenger Cars	84286667	335	50991	55425	3288	394948	6159584	651
1997	Passenger Cars	86483699	344	48026	49139	3139	347652	6320175	761
1998	Passenger Cars	88522087	356	45484	44559	2975	320454	6469358	833
1999	Passenger Cars	89167631	292	41094	39478	2903	297453	6517606	896
2000	Passenger Cars	88595697	203	37329	32342	2769	274087	6476748	938
2001	Passenger Cars	88434195	203	33750	28703	2751	267408	6465693	981
2002	Passenger Cars	89468068	205	32435	26401	2503	247451	6542849	1013
2003	Passenger Cars	91187389	209	29907	23867	2443	238535	6669849	1063

1985 Light Duty Vehicles	16178208	3275	7434	2378	119	17016	1194974	77	
1986 Light Duty Vehicles	19029695	2343	8637	2641	131	18884	1405791	91	
1987 Light Duty Vehicles	19959842	2449	9088	2810	140	20160	1474454	95	
1988 Light Duty Vehicles	20694140	2535	9422	2897	141	20398	1528662	99	
1989 Light Duty Vehicles	21690131	1787	9790	2912	141	20435	1602386	105	
1990 Light Duty Vehicles	23115080	1906	10428	3091	149	21687	1707662	112	
1991 Light Duty Vehicles	23957024	1974	10830	3248	159	23002	1769846	115	
1992 Light Duty Vehicles	23479719	1248	10678	3305	160	23176	1734385	112	
1993 Light Duty Vehicles	23450531	481	10731	3389	167	24109	1732124	112	
1994 Light Duty Vehicles	24974574	516	11211	3480	167	24458	1844855	120	
1995 Light Duty Vehicles	24505598	504	10790	3295	164	23171	1810121	121	
1996 Light Duty Vehicles	25221292	519	10851	3235	170	23111	1862973	127	
1997 Light Duty Vehicles	25453281	526	10671	2991	159	21012	1880204	132	
1998 Light Duty Vehicles	24752576	509	10197	2750	151	19304	1828342	132	
1999 Light Duty Vehicles	25068712	287	10138	2630	146	18457	1851738	136	
2000 Light Duty Vehicles	25282013	59	10060	2401	141	17666	1867429	139	
2001 Light Duty Vehicles	25520318	60	9976	2271	135	16600	1885224	143	
2002 Light Duty Vehicles	26775092	62	10146	2227	134	16450	1977649	153	
2003 Light Duty Vehicles	28467267	66	10453	2145	129	15626	2102906	165	
Year	Sector	FC (GJ)	SO2	NOx	NM VOC	CH4	CO	CO2	N2O
1985 Heavy Duty Vehicles		29651116	6934	28239	3140	260	7555	2194138	84
1986 Heavy Duty Vehicles		32738906	4594	31157	3467	286	8301	2422634	93
1987 Heavy Duty Vehicles		31763074	4457	30226	3365	278	8061	2350423	90
1988 Heavy Duty Vehicles		31224098	4381	29732	3306	273	7936	2310539	88
1989 Heavy Duty Vehicles		32327613	3024	30782	3421	283	8196	2392200	91
1990 Heavy Duty Vehicles		33933165	3174	32300	3614	298	8675	2511006	96
1991 Heavy Duty Vehicles		34424256	3220	32781	3671	301	8792	2547345	98
1992 Heavy Duty Vehicles		33656314	2046	32044	3600	295	8622	2490515	96
1993 Heavy Duty Vehicles		33365322	780	31668	3560	292	8537	2468980	95
1994 Heavy Duty Vehicles		35732489	836	32553	3654	295	8705	2644149	103
1995 Heavy Duty Vehicles		36314627	849	31921	3638	293	8483	2687228	105
1996 Heavy Duty Vehicles		37071644	867	31494	3613	290	8346	2743246	107
1997 Heavy Duty Vehicles		37390997	875	30309	3433	282	7827	2766891	106
1998 Heavy Duty Vehicles		38573775	902	29875	3403	281	7719	2854414	109
1999 Heavy Duty Vehicles		39439479	508	29210	3320	277	7452	2918480	110
2000 Heavy Duty Vehicles		38127592	89	27017	3110	259	6950	2821398	106
2001 Heavy Duty Vehicles		38708387	91	26531	2991	257	6725	2864376	106

2002 Heavy Duty Vehicles	37849451	89	24060	2737	237	6175	2800810	103
2003 Heavy Duty Vehicles	40845625	96	24416	2799	243	6288	3022527	111
1985 2-wheelers	654306	1	56	3446	100	9813	47764	1
1986 2-wheelers	617565	2	55	3164	94	9300	45082	1
1987 2-wheelers	603008	1	55	3031	91	9104	44020	1
1988 2-wheelers	600711	2	55	2986	91	9088	43852	1
1989 2-wheelers	588020	1	55	2889	89	8912	42925	1
1990 2-wheelers	618260	2	59	2984	93	9392	45133	1
1991 2-wheelers	647664	2	59	3092	98	9806	47280	1
1992 2-wheelers	673027	2	65	3136	101	10261	49131	1
1993 2-wheelers	693419	2	65	3175	104	10540	50620	1
1994 2-wheelers	704846	2	70	3139	106	10790	51454	1
1995 2-wheelers	714032	2	73	3210	107	10957	52124	1
1996 2-wheelers	755112	2	74	3420	113	11533	55123	1
1997 2-wheelers	803775	2	79	3632	121	12287	58676	1
1998 2-wheelers	866101	2	86	3905	130	13242	63225	1
1999 2-wheelers	854128	2	88	3655	128	13144	62351	1
2000 2-wheelers	868068	2	95	3411	139	13205	63369	1
2001 2-wheelers	775393	2	91	2744	121	11713	56604	1
2002 2-wheelers	909105	2	110	3096	142	13707	66365	1
2003 2-wheelers	938799	2	116	3050	150	14011	68532	1

Year	Sector	FC (GJ)	SO2	NOx	NMVOC	CH4	CO	CO2	N2O
1985 Total		112481857	11624	89554	80886	2486	574867	8260076	340
1986 Total		118762589	7865	94361	80871	2518	553993	8724499	367
1987 Total		118897236	7850	94276	80268	2544	534472	8734221	370
1988 Total		119555934	7860	95038	79841	2503	487184	8782370	376
1989 Total		120678411	5490	95881	78269	2460	458670	8866485	384
1990 Total		127274759	5769	100118	80774	2620	467745	9350906	423
1991 Total		132845492	5905	101506	81436	2891	484830	9758915	494
1992 Total		135157502	3822	101402	80499	3024	476563	9926345	556
1993 Total		136885568	1571	99862	78250	3283	481940	10052066	615
1994 Total		143670326	1671	98904	74203	3444	454750	10551393	735
1995 Total		144984976	1684	95730	69476	3602	438837	10647817	813
1996 Total		147334715	1723	93410	65693	3862	437939	10820927	886
1997 Total		150131752	1746	89086	59195	3700	388778	11025946	1000
1998 Total		152714538	1769	85642	54617	3536	360719	11215339	1074
1999 Total		154529949	1089	80531	49083	3454	336505	11350175	1143
2000 Total		152873369	353	74501	41264	3308	311907	11228944	1185
2001 Total		153438293	355	70348	36708	3265	302446	11271897	1230
2002 Total		155001716	358	66750	34461	3016	283783	11387673	1270
2003 Total		161439080	373	64892	31861	2964	274460	11863815	1339

Annex 3B-7: COPERT III:DEA statistics fuel use ratios and mileage adjustment factors

Description	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
COPERT III:DEA Gasoline (sales)	0.89	0.88	0.87	0.88	0.86	0.91	0.95	0.99	1.02	1.03	0.98	0.97	0.95	0.95	0.92	0.92	0.84	0.94	0.93
COPERT III:DEA Diesel (sales)	0.67	0.63	0.65	0.65	0.63	0.60	0.58	0.60	0.60	0.57	0.60	0.60	0.60	0.61	0.63	0.65	0.67	0.68	0.64
COPERT III:DEA Gasoline (cons.)	1.12	1.14	1.15	1.13	1.16	1.10	1.06	1.01	0.98	0.97	1.02	1.03	1.05	1.05	1.09	1.09	1.19	1.07	1.07
COPERT III:DEA Diesel (cons.)	1.58	1.70	1.64	1.64	1.71	1.81	1.87	1.81	1.80	1.89	1.80	1.81	1.80	1.78	1.74	1.67	1.63	1.63	1.76
Gasoline mileage factor (sales)	1.07	1.07	1.05	1.01	1.00	0.99	1.01	1.00	0.99	1.00	1.02	1.02	1.04	1.04	1.06	1.07	1.15	1.04	1.05
Diesel mileage factor (sales)	0.67	0.65	0.67	0.67	0.65	0.61	0.60	0.61	0.61	0.59	0.62	0.62	0.62	0.63	0.64	0.66	0.72	0.73	0.71
Gasoline mileage factor (cons.)	0.93	0.94	0.95	0.99	1.00	1.01	0.99	1.00	1.01	1.00	0.98	0.98	0.96	0.96	0.95	0.94	0.87	0.96	0.95
Diesel mileage factor (cons.)	1.58	1.63	1.58	1.58	1.65	1.75	1.81	1.76	1.76	1.84	1.74	1.75	1.74	1.73	1.69	1.65	1.50	1.48	1.54

Annex 3B-8: Activity data, fuel use and emission factors for non-road working machinery and equipment

Diesel

SNAP	Type	No.	Size [kW]	LF	Hours [h]	Life time [years]	Stage I [year]	Stage II	NO _x (g/kWh)			NMVOC (g/kWh)			CH ₄ [g/kWh]
									Conv.	Stage I	Stage II	Conv.	Stage I	Stage II	
0808	Vibratory plates	3500	6	0.6	300	10			14.36	14.36	14.36	3.82	3.82	3.82	0.05
0808	Refrigerating units (distribution)	3000	8	0.5	1250	6			14.36	14.36	14.36	3.82	3.82	3.82	0.05
0808	Refrigerating units (long distance)	3500	15	0.5	200	7			14.36	14.36	14.36	3.82	3.82	3.82	0.05
0808	Tampers/Land rollers	2800	30	0.45	600	14		2000	14.36	14.36	8	2.91	2.91	1.5	0.05
0806	Tractors (agriculture)	5000	25	0.4	50	30		2002	14.36	14.36	8	2.91	2.91	1.5	0.05
0808	Forklifts 0-2 tons (diesel)	700	35	0.27	600	20		2000	14.36	14.36	8	2.91	2.91	1.5	0.05
0808	High pressure cleaners (diesel)	50	30	0.8	500	10		2000	14.36	14.36	8	2.91	2.91	1.5	0.05
0808	Sweepers (diesel)	200	30	0.4	300	10		2000	14.36	14.36	8	2.91	2.91	1.5	0.05
0808	Aerial lifts (diesel)	150	30	0.4	400	10		2000	14.36	14.36	8	2.91	2.91	1.5	0.05
0807	Chippers	100	35	0.5	250	10		2000	14.36	14.36	8	2.91	2.91	1.5	0.05
0806	Tractors (agriculture)	29000	32.5	0.4	100	30		2002	14.36	14.36	8	2.91	2.91	1.5	0.05
0808	Mini loaders	2800	30	0.5	700	14		2000	14.36	14.36	8	2.91	2.91	1.5	0.05
0808	Tractors (transport. industry)	3000	50	0.4	500	30	2002	2004	14.36	9.2	7	2.28	1.3	1.3	0.05
0808	Compressors (diesel)	5000	45	0.5	500	13	1999	2004	14.36	9.2	7	2.28	1.3	1.3	0.05
0806	Tractors (agriculture)	66600	50	0.5	300	30	2002	2004	14.36	9.2	7	2.28	1.3	1.3	0.05
0808	Generators (diesel)	5000	45	0.5	200	15	1999	2004	14.36	9.2	7	2.28	1.3	1.3	0.05
0808	Forklifts 3-5 tons (diesel)	3900	50	0.27	600	20	1999	2004	14.36	9.2	7	2.28	1.3	1.3	0.05
0808	Forklifts 2-3 tons (diesel)	2900	45	0.27	600	20	1999	2004	14.36	9.2	7	2.28	1.3	1.3	0.05
0808	Excavators/Loaders	4200	50	0.45	700	14	1999	2004	14.36	9.2	7	2.28	1.3	1.3	0.05
0806	Self-propelled vehicles	1100	60	0.75	150	15	1999	2004	14.36	9.2	7	2.28	1.3	1.3	0.05
0806	Tractors (agriculture)	32000	70	0.5	500	30	2002	2004	14.36	9.2	7	2.28	1.3	1.3	0.05
0806	Tractors (machine pool)	5500	70	0.6	800	30	2002	2004	14.36	9.2	7	2.28	1.3	1.3	0.05
0808	Excavators (track type)	2000	110	0.6	1100	10	1999	2003	14.36	9.2	6	1.67	1.3	1	0.05
0806	Combines (agriculture)	33700	85	0.75	100	15	1999	2003	14.36	9.2	6	1.67	1.3	1	0.05
0806	Combines (machine pool)	2000	120	0.75	150	15	1999	2003	14.36	9.2	6	1.67	1.3	1	0.05
0808	Airport ground activities (medium duty)	350	125	0.5	300	10	1999	2003	14.36	9.2	6	1.67	1.3	1	0.05
0808	Forklifts >10 tons (diesel)	200	120	0.27	600	20	1999	2003	14.36	9.2	6	1.67	1.3	1	0.05
0808	Loaders (track type)	100	100	0.5	1100	10	1999	2003	14.36	9.2	6	1.67	1.3	1	0.05
0808	Motor graders	100	100	0.4	700	10	1999	2003	14.36	9.2	6	1.67	1.3	1	0.05

0808	Excavators (wheel type)	1000	100	0.6	1200	10	1999	2003	14.36	9.2	6	1.67	1.3	1	0.05
0808	Airport ground activities (light duty)	500	100	0.5	400	10	1999	2003	14.36	9.2	6	1.67	1.3	1	0.05
0808	Asphalt pavers	300	80	0.35	700	10	1999	2003	14.36	9.2	6	1.67	1.3	1	0.05
0808	Pumps (diesel)	1000	75	0.5	5	15	1999	2003	14.36	9.2	6	1.67	1.3	1	0.05
0808	Forklifts 5-10 tons (diesel)	900	75	0.27	600	20	1999	2003	14.36	9.2	6	1.67	1.3	1	0.05
0808	Wheel loaders	2500	120	0.5	1200	10	1999	2003	14.36	9.2	6	1.67	1.3	1	0.05
0808	Dozers (track type)	250	140	0.5	1100	10	1999	2002	14.36	9.2	6	1.3	1.3	1	0.05
0808	Dump trucks	500	180	0.4	1200	10	1999	2002	14.36	9.2	6	1.3	1.3	1	0.05
0808	Refuse compressors	100	160	0.25	1300	10	1999	2002	14.36	9.2	6	1.3	1.3	1	0.05
0808	Airport ground activities (Heavy duty)	650	175	0.5	200	10	1999	2002	14.36	9.2	6	1.3	1.3	1	0.05

SNAP	Type	N ₂ O	CO (g/kWh)		
		[g/kWh]	Conv.	Stage I	Stage II
0808	Vibratory plates	0.035	8.38	8.38	8.38
0808	Refrigerating units (distribution)	0.035	8.38	8.38	8.38
0808	Refrigerating units (long distance)	0.035	8.38	8.38	8.38
0808	Tampers/Land rollers	0.035	6.43	6.43	5.5
0806	Tractors (agriculture)	0.035	6.43	6.43	5.5
0808	Forklifts 0-2 tons (diesel)	0.035	6.43	6.43	5.5
0808	High pressure cleaners (diesel)	0.035	6.43	6.43	5.5
0808	Sweepers (diesel)	0.035	6.43	6.43	5.5
0808	Aerial lifts (diesel)	0.035	6.43	6.43	5.5
0807	Chippers	0.035	6.43	6.43	5.5
0806	Tractors (agriculture)	0.035	6.43	6.43	5.5
0808	Mini loaders	0.035	6.43	6.43	5.5
0808	Tractors (transport. industry)	0.035	5.06	5.06	5
0808	Compressors (diesel)	0.035	5.06	5.06	5
0806	Tractors (agriculture)	0.035	5.06	5.06	5
0808	Generators (diesel)	0.035	5.06	5.06	5
0808	Forklifts 3-5 tons (diesel)	0.035	5.06	5.06	5
0808	Forklifts 2-3 tons (diesel)	0.035	5.06	5.06	5
0808	Excavators/Loaders	0.035	5.06	5.06	5
0806	Self-propelled vehicles	0.035	5.06	5.06	5
0806	Tractors (agriculture)	0.035	5.06	5.06	5
0806	Tractors (machine pool)	0.035	5.06	5.06	5
0808	Excavators (track type)	0.035	3.76	3.76	3.76
0806	Combines (agriculture)	0.035	3.76	3.76	3.76
0806	Combines (machine pool)	0.035	3.76	3.76	3.76
0808	Airport ground activities (medium duty)	0.035	3.76	3.76	3.76
0808	Forklifts >10 tons (diesel)	0.035	3.76	3.76	3.76
0808	Loaders (track type)	0.035	3.76	3.76	3.76
0808	Motor graders	0.035	3.76	3.76	3.76
0808	Excavators (wheel type)	0.035	3.76	3.76	3.76
0808	Airport ground activities (light duty)	0.035	3.76	3.76	3.76
0808	Asphalt pavers	0.035	3.76	3.76	3.76
0808	Pumps (diesel)	0.035	3.76	3.76	3.76

0808	Forklifts 5-10 tons (diesel)	0.035	3.76	3.76	3.76
0808	Wheel loaders	0.035	3.76	3.76	3.76
0808	Dozers (track type)	0.035	3	3	3
0808	Dump trucks	0.035	3	3	3
0808	Refuse compressors	0.035	3	3	3
0808	Airport ground activities (Heavy duty)	0.035	3	3	3

Gasoline

SNAP	Type	No.	Size [kW]	LF	Hours [h]	Life time [years]	NO _x [g/kWh]	VOC [g/kWh]	CH ₄ [g/kWh]	NMVOC [g/kWh]	CO [g/kWh]	CO ₂ [kg/kWh]	N ₂ O [g/kWh]	FC [g/kWh]	FC [MJ/kWh]
0806	Other (gasoline)	100	5	0.4	50	10	4.0	38	1.8	35.9	700	1.288	0.03	403	17.6
0806	Fodder trucks	11000	8	0.4	200	10	4.0	28	1.4	27.0	550	1.264	0.03	395	17.3
0806	Sweepers	2500	3	0.3	50	10	4.0	52	2.5	49.9	967	1.315	0.03	411	18.0
0806	Scrapers	750	3	0.3	50	10	4.0	52	2.5	49.9	967	1.315	0.03	411	18.0
0806	Bedding machines	1100	3	0.3	50	10	4.0	52	2.5	49.9	967	1.315	0.03	411	18.0
0806	Tractors (agriculture)	20000	30	0.4	50	37	4.1	14	0.7	13.8	367	1.200	0.03	375	16.4
0806	Tractors (agriculture)	10000	30	0.4	100	37	4.1	14	0.7	13.8	367	1.200	0.03	375	16.4
0807	Chain saws (forestry use)	2000	3	0.6	800	2	1.0	383	3.8	379.3	700	1.530	0.01	479	21.0
0808	Other (gasoline)	1000	5	0.5	40	10	4.0	38	1.8	35.9	700	1.288	0.03	403	17.6
0808	Sweepers (gasoline)	500	10	0.4	150	10	4.0	25	1.2	23.8	500	1.253	0.03	392	17.2
0808	Generators (gasoline)	11000	2.5	0.4	80	10	4.0	59	2.8	56.3	1100	1.325	0.03	414	18.1
0808	High pressure cleaners (gasoline)	500	5	0.6	200	10	4.0	38	1.8	35.9	700	1.288	0.03	403	17.6
0808	Cutters	800	4	0.5	50	10	4.0	43	2.1	41.4	800	1.300	0.03	407	17.8
0808	Compressors (gasoline)	500	4	0.35	15	8	4.0	43	2.1	41.4	800	1.300	0.03	407	17.8
0808	Drills	100	3	0.4	10	10	1.0	383	3.8	379.3	700	1.530	0.01	479	21.0
0808	Aerial lifts (gasoline)	50	20	0.4	400	10	4.1	17	0.8	16.6	400	1.219	0.03	381	16.7
0808	Pumps (gasoline)	10000	4	0.4	300	5	4.0	43	2.1	41.4	800	1.300	0.03	407	17.8
0808	Slicers	100	10	0.7	150	10	1.1	251	2.5	248.9	420	1.460	0.01	457	20.0
0808	Rammers	3000	2.5	0.4	80	10	1.0	416	4.1	411.5	780	1.541	0.01	482	21.1
0808	Vibratory plates(gasoline)	2500	4	0.5	200	10	4.0	43	2.1	41.4	800	1.300	0.03	407	17.8
0809	Other (gasoline)	200	2	0.5	20	10	1.0	462	4.6	457.3	900	1.555	0.01	486	21.3
0809	Wood cutters	100	4	0.5	15	10	4.0	43	2.1	41.4	800	1.300	0.03	407	17.8
0809	Shrub clearers	50000	0.8	0.6	15	10	1.0	759	7.5	751.1	1800	1.613	0.01	504	22.1
0809	Chippers	200	10	0.7	100	10	1.1	251	2.5	248.9	420	1.460	0.01	457	20.0
0809	Cultivators	150000	4	0.6	25	10	4.0	43	2.1	41.4	800	1.300	0.03	407	17.8
0809	Hedge cutters	15000	0.6	0.5	10	10	1.0	902	8.9	893.4	2300	1.632	0.01	510	22.4
0809	Garden shredders	500	3	0.7	20	10	1.0	383	3.8	379.3	700	1.530	0.01	479	21.0
0809	Chain saws (public use)	10000	2.5	0.4	150	10	1.0	416	4.1	411.5	780	1.541	0.01	482	21.1
0809	Chain saws (private use)	250000	2	0.3	12	20	1.0	462	4.6	457.3	900	1.555	0.01	486	21.3
0809	Mini tractors	40000	8	0.5	150	10	4.0	28	1.4	27.0	550	1.264	0.03	395	17.3
0809	Lawn movers (small)	800000	2.5	0.4	20	10	4.0	59	2.8	56.3	1100	1.325	0.03	414	18.1
0809	Lawn movers (riders)	35000	6	0.5	125	10	4.0	34	1.6	32.1	633.33	1.279	0.03	400	17.5
0809	Suction machines	300	4	0.5	80	10	1.0	340	3.4	336.8	600	1.513	0.01	473	20.7

0809	Trimmers	60000	0.8	0.5	15	10	1.0	759	7.5	751.1	1800	1.613	0.01	504	22.1

LPG

SNAP	Type	No.	Size [kW]	LF	Hours [h]	NO _x [g/kWh]	VOC [g/kWh]	CH ₄ [g/kWh]	NMVOC [g/kWh]	CO [g/kWh]	CO ₂ [kg/kWh]	N ₂ O [g/kWh]	FC [g/kWh]	FC [MJ/kWh]
0808	Forklifts 0-2 tons (LPG)	5300	33	0.27	600	10	14.5	1	13.5	15	1.047	0.05	350	16.1
0808	Forklifts 2-3 tons (LPG)	4800	40	0.27	600	10	14.5	1	13.5	15	1.047	0.05	350	16.1
0808	Forklifts 3-5 tons (LPG)	2100	50	0.27	600	10	14.5	1	13.5	15	1.047	0.05	350	16.1
0808	Forklifts 5-10 tons (LPG)	100	78	0.27	600	10	14.5	1	13.5	15	1.047	0.05	350	16.1

Annex 3B-9: Emission factors and total emissions for 1990 and 2003 in CollectER format

Year	SNAP ID	Category	Fuel type	Mode	Fuel [GJ]	SO2 [g/GJ]	NOx [g/GJ]	NMVOC [g/GJ]	CH4 [g/GJ]	CO [g/GJ]	CO2 [kg/GJ]	N2O [g/GJ]
1990	70101	Passenger cars	Diesel	Highway driving	716028	93.68	253.78	24.51	4.30	179.70	74	0.47
1990	70101	Passenger cars	Gasoline 2-stroke	Highway driving	28730	2.97	288.90	2357.34	10.03	3490.86	73	0.80
1990	70101	Passenger cars	Gasoline conventional	Highway driving	7394952	2.25	1311.04	369.53	11.10	3612.94	73	0.85
1990	70101	Passenger cars	Gasoline catalyst	Highway driving	183522	1.95	190.36	35.59	7.47	943.80	73	47.89
1990	70101	Passenger cars	LPG	Highway driving	1512	0.00	1151.70	187.09	10.06	3914.25	65	0.00
1990	70102	Passenger cars	Diesel	Rural driving	2039148	93.68	253.33	46.16	2.75	268.08	74	0.57
1990	70102	Passenger cars	Gasoline 2-stroke	Rural driving	115355	2.97	352.84	2476.82	13.84	2594.44	73	0.69
1990	70102	Passenger cars	Gasoline conventional	Rural driving	22799974	2.24	1139.51	488.47	13.94	4110.62	73	0.96
1990	70102	Passenger cars	Gasoline catalyst	Rural driving	570376	1.95	143.35	42.55	9.25	370.07	73	53.34
1990	70102	Passenger cars	LPG	Rural driving	4361	0.00	1248.46	305.18	16.91	1146.38	65	0.00
1990	70103	Passenger cars	Diesel	Urban driving	3046172	93.68	208.31	85.82	2.37	310.69	74	0.36
1990	70103	Passenger cars	Gasoline 2-stroke	Urban driving	181888	2.97	61.43	3122.63	30.71	4238.59	73	0.41
1990	70103	Passenger cars	Gasoline conventional	Urban driving	31532452	2.25	633.42	894.14	50.15	9534.02	73	0.65
1990	70103	Passenger cars	Gasoline catalyst	Urban driving	987315	1.95	163.59	299.31	68.50	3772.36	73	20.13
1990	70103	Passenger cars	LPG	Urban driving	6471	0.00	642.80	421.67	33.67	1249.98	65	0.00
1990	70201	Light duty vehicles	Diesel	Highway driving	2313348	93.68	270.67	31.16	1.62	344.14	74	0.32
1990	70201	Light duty vehicles	Gasoline conventional	Highway driving	254498	2.97	1369.26	170.29	10.11	2987.40	73	0.81
1990	70201	Light duty vehicles	Gasoline catalyst	Highway driving	0	0.00	0.00	0.00	0.00	0.00	73	0.00
1990	70202	Light duty vehicles	Diesel	Rural driving	8280955	93.68	299.25	35.71	1.78	358.42	74	0.36
1990	70202	Light duty vehicles	Gasoline conventional	Rural driving	1057020	2.97	1188.86	262.59	15.25	2316.18	73	0.76
1990	70202	Light duty vehicles	Gasoline catalyst	Rural driving	0	0.00	0.00	0.00	0.00	0.00	73	0.00

1990	70203 Light duty vehicles	Diesel	Urban driving	9666704	93.68	489.77	57.53	2.29	403.83	74	0.27
1990	70203 Light duty vehicles	Gasoline conventional	Urban driving	1542555	2.97	638.11	671.68	58.35	7008.46	73	0.46
1990	70203 Light duty vehicles	Gasoline catalyst	Urban driving	0	0.00	0.00	0.00	0.00	0.00	73	0.00
1990	70301 Heavy duty vehicles	Diesel	Highway driving	7558528	93.68	828.80	76.83	6.11	174.57	74	0.28
1990	70301 Heavy duty vehicles	Gasoline	Highway driving	6630	2.97	1037.77	474.61	9.69	7610.35	73	0.28
1990	70302 Heavy duty vehicles	Diesel	Rural driving	14175012	93.68	946.10	102.99	6.86	237.86	74	0.27
1990	70302 Heavy duty vehicles	Gasoline	Rural driving	19287	2.97	1141.55	820.40	16.74	8371.39	73	0.30
1990	70303 Heavy duty vehicles	Diesel	Urban driving	12151405	93.68	1035.68	126.62	12.65	297.36	74	0.25
1990	70303 Heavy duty vehicles	Gasoline	Urban driving	22301	2.97	456.62	696.09	14.21	7102.99	73	0.20
1990	704 Mopeds	Gasoline		270104	2.97	27.40	8057.18	162.00	13698.63	73	0.74
1990	70501 Motorcycles	Gasoline	Highway driving	68816	2.97	215.21	1274.28	121.98	17689.89	73	1.27
1990	70502 Motorcycles	Gasoline	Rural driving	128454	2.97	173.17	1528.62	146.07	16834.36	73	1.52
1990	70503 Motorcycles	Gasoline	Urban driving	150886	2.97	93.28	2018.58	147.26	15322.43	73	1.53

Year	SNAPID	Category	Fuel type	Mode	Fuel [GJ]	SO2 [g/GJ]	NOx [g/GJ]	NMVOC [g/GJ]	CH4 [g/GJ]	CO [g/GJ]	CO2 [kg/GJ]	N2O [g/GJ]
1990	801	Military	Diesel		146162	93.68	778.10	83.81	6.66	250.19	74	0.28
1990	801	Military	Jet fuel	< 3000 ft	986	4.60	250.57	24.94	2.65	229.89	72	
1990	801	Military	Jet fuel	> 3000 ft	4913	4.60	250.57	24.94	2.65	229.89	72	
1990	801	Military	Gasoline		149678	2.28	871.06	1129.29	33.78	6687.29	73	1.63
1990	801	Military	Aviation gasoline		1347105	4.57	859.00	1242.60	21.90	6972.00	73	1.60
1990	802	Railways	Diesel		4010007	93.68	1225.13	79.94	3.07	223.21	74	0.20
1990	802	Railways	Kerosene		70	5.00	50.00	3.00	7.00	20.00	72	
1990	802	Railways	Gasoline		0	2.28	871.06	1129.29	33.78	6687.29	73	1.63
1990	803	Inland waterways	Diesel		544970	93.68	1249.33	270.13	4.35	595.20	74	0.17
1990	803	Inland waterways	Gasoline		371237	2.28	64.34	10809.58	108.10	18485.08	73	0.10
1990	80402	National sea traffic	Residual oil		3559806	1466.99	1393.64	56.92	1.76	180.93	78	
1990	80402	National sea traffic	Diesel		2782388	93.68	1334.89	54.52	1.69	173.30	74	
1990	80402	National sea traffic	Kerosene		452	4.60	50.00	3.00	7.00	20.00	72	
1990	80402	National sea traffic	LPG		1794		1249.00	384.90	20.30	443.00	65	
1990	80403	Fishing	Residual oil		285426	1466.99	1393.64	56.92	1.76	180.93	78	
1990	80403	Fishing	Diesel		10051143	93.68	1334.89	54.52	1.69	173.30	74	
1990	80403	Fishing	Kerosene		25787	4.60	50.00	3.00	7.00	20.00	72	
1990	80403	Fishing	Gasoline		9001	2.28	64.34	10809.58	108.10	18485.08	73	0.10
1990	80403	Fishing	LPG		42320		1249.00	384.90	20.30	443.00	65	
1990	80404	International sea traffic	Residual oil		28543368	1711.49	2127.14	56.92	1.76	180.93	78	
1990	80404	International sea traffic	Diesel		11632674	468.38	2037.47	54.52	1.69	173.30	74	
1990	80501	Air traffic. other airports	Jet fuel	Dom. < 3000 ft	378795	2.30	310.41	16.54	1.76	100.94	72	
1990	80501	Air traffic. other airports	Aviation gasoline		104947	4.57	859.00	1242.60	21.90	6972.00	73	1.60
1990	80502	Air traffic. other airports	Jet fuel	Int. < 3000 ft	136077	2.30	306.48	18.38	1.95	177.11	72	

1990	80502 Air traffic. other airports	Aviation gasoline		30660	4.57	859.00	1242.60	21.90	6972.00	73	1.60
1990	80503 Air traffic. other airports	Jet fuel	Dom. > 3000 ft	910427	2.30	330.34	9.28	0.99	93.07	72	
1990	80504 Air traffic. other airports	Jet fuel	Int. > 3000 ft	1612988	2.30	242.81	6.20	0.66	54.25	72	
1990	806 Agriculture	Diesel		17292498	93.68	1273.14	190.59	4.43	424.13	74	0.18
1990	806 Agriculture	Gasoline		520115	2.28	244.33	1022.05	51.10	24741.09	73	0.12
1990	807 Forestry	Diesel		5001	93.68	1255.79	238.29	4.37	526.70	74	0.17
1990	807 Forestry	Gasoline		60375	2.28	48.66	18095.47	180.95	33391.26	73	0.10
1990	808 Industry	Diesel		9277501	93.68	1286.85	174.83	4.48	390.74	74	0.18
1990	808 Industry	Gasoline		142938	2.28	216.67	3096.74	119.76	44820.30	73	0.11
1990	808 Industry	LPG		1251154	0.00	621.12	838.51	62.11	931.68	65	0.19
1990	809 Household and gardening	Gasoline		1187573	2.28	213.71	3726.00	116.17	42616.59	73	0.11
1990	80501 Air traffic. Copenhagen airport	Jet fuel	Dom. < 3000 ft	441215	2.30	280.41	23.40	2.49	144.24	72	
1990	80501 Air traffic. Copenhagen airport	Aviation gasoline		8642	4.57	859.00	1242.60	21.90	6972.00	73	1.60
1990	80502 Air traffic. Copenhagen airport	Jet fuel	Int. < 3000 ft	2037255	2.30	326.94	34.43	3.66	159.73	72	
1990	80502 Air traffic. Copenhagen airport	Aviation gasoline		5612	4.57	859.00	1242.60	21.90	6972.00	73	1.60
1990	80503 Air traffic. Copenhagen airport	Jet fuel	Dom. > 3000 ft	1160709	2.30	315.28	8.51	0.90	79.30	72	
1990	80504 Air traffic. Copenhagen airport	Jet fuel	Int. > 3000 ft	20653862	2.30	291.18	8.79	0.93	36.07	72	

Year	SNAP ID	Category	Fuel type	Mode	Fuel [GJ]	SO2 [g/GJ]	NOx [g/GJ]	NMVOC [g/GJ]	CH4 [g/GJ]	CO [g/GJ]	CO2 [kg/GJ]	N2O [g/GJ]
2003	70101	Passenger cars	Diesel	Highway driving	2367693	2.34	281.99	12.33	4.36	99.51	74	0.49
2003	70101	Passenger cars	Gasoline 2-stroke	Highway driving	561	2.28	288.90	2357.34	10.03	3490.86	73	0.80
2003	70101	Passenger cars	Gasoline conventional	Highway driving	2431463	2.28	1366.59	331.26	11.46	2554.21	73	0.88
2003	70101	Passenger cars	Gasoline catalyst	Highway driving	10334218	2.28	271.78	31.14	4.12	1943.10	73	49.11
2003	70101	Passenger cars	LPG	Highway driving	84	0.00	1151.70	187.09	10.06	3914.25	65	0.00
2003	70102	Passenger cars	Diesel	Rural driving	5033891	2.34	255.16	20.34	2.61	96.44	74	0.56
2003	70102	Passenger cars	Gasoline 2-stroke	Rural driving	1575	2.28	352.84	2476.82	13.84	2594.44	73	0.69
2003	70102	Passenger cars	Gasoline conventional	Rural driving	5327550	2.28	1163.83	450.22	14.17	3088.30	73	0.97
2003	70102	Passenger cars	Gasoline catalyst	Rural driving	22410273	2.28	193.62	32.10	4.59	580.67	73	54.83
2003	70102	Passenger cars	LPG	Rural driving	169	0.00	1248.46	305.18	16.91	1146.38	65	0.00
2003	70103	Passenger cars	Diesel	Urban driving	5771890	2.34	261.28	59.28	2.73	249.89	74	0.37
2003	70103	Passenger cars	Gasoline 2-stroke	Urban driving	2025	2.28	61.43	3122.63	30.71	4238.59	73	0.41
2003	70103	Passenger cars	Gasoline conventional	Urban driving	6225773	2.28	632.26	888.22	54.58	8327.42	73	0.63
2003	70103	Passenger cars	Gasoline catalyst	Urban driving	31280011	2.28	186.65	255.83	58.01	4116.20	73	20.92
2003	70103	Passenger cars	LPG	Urban driving	213	0.00	613.83	439.70	35.11	1362.11	65	0.00
2003	70201	Light duty vehicles	Diesel	Highway driving	3535198	2.34	327.68	31.43	1.64	217.92	74	0.35
2003	70201	Light duty vehicles	Gasoline conventional	Highway driving	122385	2.28	1369.26	170.29	10.11	2987.40	73	0.81

2003	70201 Light duty vehicles	Gasoline catalyst	Highway driving	294122	2.28	131.37	16.76	2.72	538.34	73	34.36
2003	70202 Light duty vehicles	Diesel	Rural driving	10770334	2.34	348.00	36.01	1.79	208.60	74	0.39
2003	70202 Light duty vehicles	Gasoline conventional	Rural driving	432603	2.28	1188.86	262.59	15.25	2316.18	73	0.76
2003	70202 Light duty vehicles	Gasoline catalyst	Rural driving	1038501	2.28	115.58	22.73	3.11	403.03	73	32.44
2003	70203 Light duty vehicles	Diesel	Urban driving	10489916	2.34	402.05	64.22	2.56	248.60	74	0.28
2003	70203 Light duty vehicles	Gasoline conventional	Urban driving	525646	2.28	622.43	711.11	61.78	7581.33	73	0.44
2003	70203 Light duty vehicles	Gasoline catalyst	Urban driving	1258564	2.28	127.82	137.87	26.13	3235.16	73	13.11
2003	70301 Heavy duty vehicles	Diesel	Highway driving	11307971	2.34	518.85	54.80	4.59	119.87	74	0.27
2003	70301 Heavy duty vehicles	Gasoline	Highway driving	9557	2.28	1037.78	474.61	9.69	7610.35	73	0.28
2003	70302 Heavy duty vehicles	Diesel	Rural driving	17202121	2.34	608.42	68.67	5.01	143.23	74	0.26
2003	70302 Heavy duty vehicles	Gasoline	Rural driving	19445	2.28	1141.55	820.40	16.74	8371.38	73	0.30
2003	70303 Heavy duty vehicles	Diesel	Urban driving	12286671	2.34	654.46	78.48	8.46	170.27	74	0.23
2003	70303 Heavy duty vehicles	Gasoline	Urban driving	19858	2.28	456.62	696.09	14.21	7102.99	73	0.20
2003	704 Mopeds	Gasoline		211381	2.28	30.24	7571.80	210.99	13069.31	73	1.04
2003	70501 Motorcycles	Gasoline	Highway driving	119293	2.28	224.08	1167.69	123.67	17073.88	73	1.28
2003	70502 Motorcycles	Gasoline	Rural driving	277434	2.28	181.40	1408.90	148.13	15988.31	73	1.53
2003	70503 Motorcycles	Gasoline	Urban driving	330690	2.28	99.81	1879.37	149.77	14442.06	73	1.55

Year	SNAP ID	Category	Fuel type	Mode	Fuel [GJ]	SO2 [g/GJ]	NOx [g/GJ]	NMVOC [g/GJ]	CH4 [g/GJ]	CO [g/GJ]	CO2 [kg/GJ]	N2O [g/GJ]
2003	801 Military		Diesel		585796	2.34	470.25	56.07	4.23	173.84	74	0.31
2003	801 Military		Jet fuel	< 3000 ft	66524	4.60	250.57	24.94	2.65	229.89	72	0.00
2003	801 Military		Jet fuel	> 3000 ft	598713	4.60	250.57	24.94	2.65	229.89	72	0.00
2003	801 Military		Gasoline		3975	2.28	332.39	327.17	31.72	3136.82	73	29.99
2003	801 Military		Aviation gasoline		6095	4.57	859.00	1242.60	21.90	6972.00	73	1.60
2003	802 Railways		Diesel		2950035	2.34	1199.93	75.60	2.90	207.09	74	0.20
2003	803 Inland waterways		Diesel		902453	23.42	1249.33	270.13	4.35	595.20	74	0.17
2003	803 Inland waterways		Gasoline		1001571	2.28	64.34	10809.58	108.10	18485.08	73	0.10
2003	80402 National sea traffic		Residual oil		1822827	810.26	1393.60	56.90	1.76	180.90	78	
2003	80402 National sea traffic		Diesel		3827869	93.68	1334.90	54.50	1.69	173.30	74	0.00
2003	80402 National sea traffic		Kerosene		1079	4.60	50.00	3.00	7.00	20.00	72	2.00
2003	80402 National sea traffic		LPG		230	0.00	1249.00	384.90	20.30	443.00	65	0.00
2003	80403 Fishing		Residual oil		84024	810.26	1393.60	56.90	1.76	180.90	78	
2003	80403 Fishing		Diesel		8428083	93.68	1334.90	54.50	1.69	173.30	74	0.00

2003	80403 Fishing	Kerosene		731	4.60	50.00	3.00	7.00	20.00	72	
2003	80403 Fishing	Gasoline		0	2.28	64.34	10809.60	108.10	18485.10	73	0.10
2003	80403 Fishing	LPG		20332	0.00	1249.00	384.90	20.30	443.00	65	0.00
2003	80404 International sea traffic	Residual oil		20461869	1681.38	2127.10	56.90	1.76	180.90	78	
2003	80404 International sea traffic	Diesel		20729767	468.38	2037.50	54.50	1.69	173.30	74	
2003	80501 Air traffic. other airports	Jet fuel	Dom. < 3000 ft	184147	2.30	286.15	18.05	1.92	136.71	72	
2003	80501 Air traffic. other airports	Aviation gasoline		75380	4.57	859.00	1242.60	21.90	6972.00	73	1.60
2003	80502 Air traffic. other airports	Jet fuel	Int. < 3000 ft	239381	2.30	299.62	15.06	1.60	162.52	72	
2003	80502 Air traffic. other airports	Aviation gasoline		5565	4.57	859.00	1242.60	21.90	6972.00	73	1.60
2003	80503 Air traffic. other airports	Jet fuel	Dom. > 3000 ft	531959	2.30	276.36	12.96	1.38	120.46	72	
2003	80504 Air traffic. other airports	Jet fuel	Int. > 3000 ft	2378029	2.30	242.75	6.19	0.66	52.29	72	
2003	806 Agriculture	Diesel		15994341	23.42	1219.65	183.26	4.43	423.43	74	0.18
2003	806 Agriculture	Gasoline		489194	2.28	244.33	1022.05	51.10	24741.09	73	0.12
2003	807 Forestry	Diesel		4625	23.42	1033.31	195.44	4.37	508.41	74	0.17
2003	807 Forestry	Gasoline		56786	2.28	48.66	18095.47	180.95	33391.26	73	0.10
2003	808 Industry	Diesel		8581034	23.42	1131.35	155.37	4.48	391.04	74	0.18
2003	808 Industry	Gasoline		134440	2.28	48.66	3096.74	119.76	44820.30	73	0.11
2003	808 Industry	LPG		1498955	0.00	621.12	838.51	62.11	931.68	65	0.19
2003	809 Household and gardening	Gasoline		1116970	2.28	213.71	3726.00	116.17	42616.59	73	0.11
2003	80501 Air traffic. Copenhagen airport	Jet fuel	Dom. < 3000 ft	229615	2.30	280.58	24.21	2.57	179.28	72	
2003	80501 Air traffic. Copenhagen airport	Aviation gasoline		611	4.57	859.00	1242.60	21.90	6972.00	73	1.60
2003	80502 Air traffic. Copenhagen airport	Jet fuel	Int. < 3000 ft	2587577	2.30	330.71	36.63	3.89	209.94	72	0.00
2003	80502 Air traffic. Copenhagen airport	Aviation gasoline		885	4.57	859.00	1242.60	21.90	6972.00	73	1.60
2003	80503 Air traffic. Copenhagen airport	Jet fuel	Dom. > 3000 ft	890213	2.30	286.82	14.32	1.52	64.93	72	0.00
2003	80504 Air traffic. Copenhagen airport	Jet fuel	Int. > 3000 ft	25170690	2.30	308.99	11.26	1.20	37.06	72	0.00

Year	Category	Mode	SNAP ID	SO2 [tons]	NOx [tons]	NMVOC [tons]	CH4 [tons]	CO [tons]	CO2 [ktons]	N2O [tons]
1990	Passenger cars	Highway driving	70101	84	9922	2825	87	27126	608	15
1990	Passenger cars	Rural driving	70102	244	26625	11543	330	94784	1866	54
1990	Passenger cars	Urban driving	70103	359	20785	29322	1662	306081	2613	41
1990	Light duty vehicles	Highway driving	70201	217	975	115	6	1556	190	1
1990	Light duty vehicles	Rural driving	70202	779	3735	573	31	5416	690	4
1990	Light duty vehicles	Urban driving	70203	910	5719	1592	112	14715	828	3
1990	Heavy duty vehicles	Highway driving	70301	708	6271	584	46	1370	560	2
1990	Heavy duty vehicles	Rural driving	70302	1328	13433	1476	98	3533	1050	4
1990	Heavy duty vehicles	Urban driving	70303	1138	12595	1554	154	3772	901	3
1990	Mopeds		704	1	7	2176	44	3700	20	0
1990	Motorcycles	Highway driving	70501	0	15	88	8	1217	5	0
1990	Motorcycles	Rural driving	70502	0	22	196	19	2162	9	0
1990	Motorcycles	Urban driving	70503	0	14	305	22	2312	11	0
1990	Evaporation		706	0	0	28425	0	0	0	0
1990	Military		801	21	494	57	5	422	119	0
1990	Railways		802	376	4913	321	12	895	297	1
1990	Inland waterways		803	52	705	4160	43	7187	67	0
1990	National sea traffic		80402	5483	8678	355	11	1127	484	0
1990	Fishing		80403	1360	13870	678	19	1979	771	0
1990	International sea traffic		80404	54300	84417	2259	70	7180	3087	0
1990	Air traffic. Dom. < 3000 ft.		80501	2	339	158	4	894	67	0
1990	Air traffic. Int. < 3000 ft.		80502	5	739	118	9	602	159	0
1990	Air traffic. Dom. > 3000 ft.		80503	5	667	18	2	177	149	0
1990	Air traffic. Int. > 3000 ft.		80504	51	6406	192	20	832	1603	0
1990	Agriculture		806	1621	22143	3827	103	20203	1318	3
1990	Forestry		807	1	9	1094	11	2019	5	0
1990	Industry		808	869	12747	3114	136	11197	778	2
1990	Household and gardening		809	3	254	4425	138	50610	87	0

Year	Category	Mode		SO2 [tons]	NOx [tons]	NMVOC [tons]	CH4 [tons]	CO [tons]	CO2 [ktons]	N2O [tons]
2003	Passenger cars	Highway driving	70101	35	6799	1158	81	26529	1107	511
2003	Passenger cars	Rural driving	70102	75	11825	3224	192	29956	2398	1237
2003	Passenger cars	Urban driving	70103	99	11283	13881	2170	182050	3165	661
2003	Light duty vehicles	Highway driving	70201	9	1365	137	8	1294	292	11
2003	Light duty vehicles	Rural driving	70202	29	4382	525	29	3667	904	38
2003	Light duty vehicles	Urban driving	70203	29	4706	1221	92	10665	907	20
2003	Heavy duty vehicles	Highway driving	70301	27	5877	624	52	1428	837	3
2003	Heavy duty vehicles	Rural driving	70302	40	10488	1197	86	2627	1274	4
2003	Heavy duty vehicles	Urban driving	70303	29	8050	978	104	2233	911	3
2003	Mopeds		704	0	6	1601	45	2763	15	0
2003	Motorcycles	Highway driving	70501	0	27	139	15	2037	9	0
2003	Motorcycles	Rural driving	70502	1	50	391	41	4436	20	0
2003	Motorcycles	Urban driving	70503	1	33	621	50	4776	24	1
2003	Evaporation		706	0	0	6164	0	0	0	0
2003	Military		801	4	449	58	5	310	92	0
2003	Railways		802	7	3540	223	9	611	218	1
2003	Inland waterways		803	23	1192	11070	112	19051	140	0
2003	National sea traffic		80402	1836	7650	312	10	993	426	0
2003	Fishing		80403	858	11393	472	15	1485	632	0
2003	International sea traffic		80404	44114	85761	2294	71	7294	3130	0
2003	Air traffic. Dom. < 3000 ft.		80501	1	182	103	3	596	35	0
2003	Air traffic. Int. < 3000 ft.		80502	7	933	106	11	627	204	0
2003	Air traffic. Dom. > 3000 ft.		80503	3	402	20	2	122	102	0
2003	Air traffic. Int. > 3000 ft.		80504	63	8355	298	32	1057	1984	0
2003	Agriculture		806	376	19627	3431	96	18876	1219	3
2003	Forestry		807	0	8	1028	10	1899	4	0
2003	Industry		808	201	10646	3006	148	10778	742	2
2003	Household and gardening		809	3	239	4162	130	47601	82	0

Annex 3B-10: Fuel use and emissions in IPCC sectors

Fuel

IPCC ID		Unit	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Fuel	Other (1A5)	[PJ]	5.5	4.3	5.0	2.7	2.3	1.6	3.9	1.9	3.3	3.5	3.4	2.4	2.3	2.8	2.5	1.5	1.3	1.2	1.3
Fuel	Railways (1A3c)	[PJ]	4.9	4.9	4.4	4.6	4.2	4.0	4.1	4.3	4.5	4.1	4.1	4.1	4.0	3.3	3.1	3.1	2.9	2.8	3.0
Fuel	Navigation (1A3d)	[PJ]	6.5	7.4	7.8	6.9	7.6	7.3	8.6	8.0	8.9	8.5	9.0	9.4	8.5	7.2	6.7	6.8	6.7	7.7	7.6
Fuel	Ag./for./fish. (1A4c)	[PJ]	26.7	27.8	26.0	27.1	27.9	28.3	28.3	28.2	25.9	25.5	24.8	25.3	25.1	25.2	25.0	24.9	24.5	25.5	25.1
Fuel	Civil Aviation (1A3a)	[PJ]	3.6	3.3	3.7	3.8	3.6	3.4	2.8	2.7	2.6	2.7	2.8	2.8	2.9	2.7	2.4	2.1	2.2	1.9	1.9
Fuel	Industry-Other (1A2f)	[PJ]	10.7	10.7	10.7	10.7	10.7	10.7	10.6	10.6	10.5	10.5	10.4	10.4	10.4	10.3	10.3	10.2	10.2	10.2	10.2
Fuel	Residential (1A4b)	[PJ]	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Fuel	Road (1A3b)	[PJ]	112.5	118.8	118.9	119.6	120.7	127.3	132.8	135.2	136.9	143.7	145.0	147.3	150.1	152.7	154.5	152.9	153.4	155.0	161.4
Fuel	Navigation int.(1A3d)	[PJ]	17.3	20.1	29.4	37.3	38.2	40.2	36.1	37.9	56.1	63.1	66.3	63.0	57.8	58.2	54.6	56.0	47.3	39.1	41.2
Fuel	Civil Aviation int. (1A3a)	[PJ]	19.3	20.9	22.4	24.0	25.1	24.1	22.7	23.5	23.0	25.2	25.9	27.4	27.9	30.0	31.8	32.6	33.1	28.6	30.4

Pollutant	CRF ID	Unit	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
SO2	Military (1A5)	[tons]	337	211	113	31	38	21	164	65	32	31	50	25	35	41	20	6	4	5	4
SO2	Railways (1A3c)	[tons]	1152	695	618	641	393	376	382	263	105	95	96	95	93	78	40	7	7	7	7
SO2	Navigation (1A3d)	[tons]	4248	5521	6137	4381	6137	5535	6698	3393	3666	3274	2782	2093	1852	1683	1723	1653	1390	2050	1859
SO2	Ag./for./fish. (1A4c)	[tons]	5326	3827	3679	3386	2895	2982	2747	2772	2534	2349	2299	1410	1478	1187	1161	1158	1117	1212	1234
SO2	Civil Aviation (1A3a)	[tons]	8	8	9	9	9	8	7	6	6	7	7	7	7	6	6	5	5	5	5
SO2	Industry-Other (1A2f)	[tons]	2173	1304	1304	1304	869	869	863	856	850	843	837	208	206	205	203	201	201	201	201
SO2	Residential (1A4b)	[tons]	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
SO2	Road (1A3b)	[tons]	11624	7865	7850	7860	5490	5769	5905	3822	1571	1671	1684	1723	1746	1769	1089	353	355	358	373
SO2	Navigation int. (1A3d)	[tons]	20684	24627	39745	51685	52277	54300	46066	37478	65384	69311	76281	71536	65585	59858	60339	65168	54366	39610	44114
SO2	Civil Aviation int. (1A3a)	[tons]	44	48	52	55	58	56	52	54	53	58	60	63	64	69	73	75	76	66	70
NOx	Military (1A5)	[tons]	2302	1986	1608	977	868	494	1864	1010	1296	1263	1716	937	1139	1296	955	509	607	416	449
NOx	Railways (1A3c)	[tons]	6025	6063	5391	5589	5145	4913	4995	5284	5485	4971	5015	4977	4846	4089	3730	3727	3396	3396	3540
NOx	Navigation (1A3d)	[tons]	8316	9536	10108	8817	9813	9382	11195	10240	11202	10622	11218	11644	10247	8456	7694	7790	7626	9115	8842
NOx	Ag./for./fish. (1A4c)	[tons]	33912	35344	33015	34467	35469	36021	36035	36023	32929	32431	31502	32186	31951	31957	31735	31490	30832	31863	31028
NOx	Civil Aviation (1A3a)	[tons]	1203	1132	1237	1252	1208	1123	920	902	900	940	958	971	998	911	815	723	747	636	585
NOx	Industry-Other (1A2f)	[tons]	12747	12747	12747	12747	12747	12747	12673	12598	12524	12449	12375	12300	12226	12151	11766	11362	11029	10668	10646
NOx	Residential (1A4b)	[tons]	254	254	254	254	254	254	252	251	249	248	246	245	243	242	240	239	239	239	239
NOx	Road (1A3b)	[tons]	89554	94361	94276	95038	95881	100118	101506	101402	99862	98904	95730	93410	89086	85642	80531	74501	70348	66750	64892
NOx	Navigation int. (1A3d)	[tons]	36143	42057	61836	78416	80275	84417	75576	79058	117623	132160	138528	131504	120575	120988	113827	117148	98722	81292	85761
NOx	Civil Aviation int. (1A3a)	[tons]	5663	6129	6569	7035	7313	7016	6586	6846	6702	7317	7517	7904	8058	8662	9204	9446	9611	8738	9288
NM VOC	Military (1A5)	[tons]	615	488	187	482	315	57	204	113	146	130	191	107	133	149	128	64	75	55	58
NM VOC	Railways (1A3c)	[tons]	393	396	352	365	336	321	326	345	358	324	327	325	316	267	276	253	248	243	223
NM VOC	Navigation (1A3d)	[tons]	4472	4521	4545	4491	4533	4515	5278	5929	6661	7322	8035	8742	9374	9990	10647	11340	11333	11394	11383
NM VOC	Ag./for./fish. (1A4c)	[tons]	5401	5460	5376	5433	5482	5502	5472	5442	5282	5236	5170	5177	5130	5101	5064	5020	4990	5001	4931
NM VOC	Civil Aviation (1A3a)	[tons]	216	213	190	198	193	186	168	164	161	191	206	194	186	169	162	156	155	151	123
NM VOC	Industry-Other (1A2f)	[tons]	3114	3114	3114	3114	3114	3114	3120	3126	3132	3138	3144	3150	3155	3162	3142	3117	3086	3052	3006
NM VOC	Residential (1A4b)	[tons]	4425	4425	4425	4425	4425	4425	4399	4372	4346	4320	4293	4267	4241	4214	4188	4162	4162	4162	4162
NM VOC	Road (1A3b)	[tons]	80886	80871	80268	79841	78269	80774	81436	80499	78250	74203	69476	65693	59195	54617	49083	41264	36708	34461	31861
NM VOC	Navigation int. (1A3d)	[tons]	967	1126	1655	2098	2148	2259	2022	2116	3149	3536	3707	3519	3226	3237	3045	3134	2641	2174	2294
NM VOC	Civil Aviation int. (1A3a)	[tons]	261	288	313	342	361	331	309	316	309	308	343	360	365	386	395	407	406	391	405

Pollutant	CRF ID	Unit	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
CH4	Military (1A5)	[tons]	31	25	16	19	14	5	17	9	12	12	16	9	11	12	10	5	6	4	5
CH4	Railways (1A3c)	[tons]	15	15	14	14	13	12	13	13	14	12	13	12	12	10	11	10	10	9	9
CH4	Navigation (1A3d)	[tons]	52	54	54	53	54	53	63	68	77	83	90	98	103	108	114	121	120	122	122
CH4	Ag./for./fish. (1A4c)	[tons]	129	131	129	130	132	133	132	131	126	125	123	124	123	122	121	121	120	122	121
CH4	Civil Aviation (1A3a)	[tons]	8	8	8	8	8	7	6	6	6	7	7	7	7	7	6	5	5	5	5
CH4	Industry-Other (1A2f)	[tons]	136	136	136	136	136	136	138	139	140	141	142	143	144	145	147	148	148	148	148
CH4	Residential (1A4b)	[tons]	138	138	138	138	138	138	137	136	135	135	134	133	132	131	131	130	130	130	130
CH4	Road (1A3b)	[tons]	2486	2518	2544	2503	2460	2620	2891	3024	3283	3444	3602	3862	3700	3536	3454	3308	3265	3016	2964
CH4	Navigation int. (1A3d)	[tons]	30	35	51	65	66	70	63	65	97	109	115	109	100	100	94	97	82	67	71
CH4	Civil Aviation int. (1A3a)	[tons]	25	27	30	32	33	31	29	30	29	31	35	37	38	40	41	42	42	41	42
CO	Military (1A5)	[tons]	4147	3071	1303	3129	1947	422	985	500	835	806	847	604	575	654	719	396	302	317	310
CO	Railways (1A3c)	[tons]	1098	1105	982	1018	937	895	910	963	999	906	914	907	883	745	717	694	637	627	611
CO	Navigation (1A3d)	[tons]	8176	8334	8408	8240	8370	8314	9729	10786	12094	13195	14453	15688	16687	17635	18715	19908	19887	20080	20045
CO	Ag./for./fish. (1A4c)	[tons]	23748	23934	23641	23828	23964	24034	23911	23786	23258	23073	22829	22802	22641	22518	22377	22228	22150	22323	22259
CO	Civil Aviation (1A3a)	[tons]	1256	1241	1118	1167	1140	1098	989	955	930	1098	1180	1117	1085	973	932	895	888	860	718
CO	Industry-Other (1A2f)	[tons]	11197	11197	11197	11197	11197	11197	11155	11113	11071	11028	10986	10944	10902	10860	10820	10778	10778	10778	10778
CO	Residential (1A4b)	[tons]	50610	50610	50610	50610	50610	50610	50309	50009	49708	49407	49106	48805	48504	48203	47902	47601	47601	47601	47601
CO	Road (1A3b)	[tons]	574867	553993	534472	487184	458670	467744	484830	476563	481940	454750	438837	437939	388778	360719	336505	311907	302446	283783	274460
CO	Navigation int. (1A3d)	[tons]	3074	3578	5260	6670	6828	7180	6428	6725	10007	11241	11783	11185	10256	10291	9681	9963	8396	6914	7294
CO	Civil Aviation int. (1A3a)	[tons]	1103	1207	1289	1416	1564	1442	1357	1399	1388	1342	1421	1502	1564	1662	1743	1790	1796	1610	1684
CO2	Military (1A5)	[ktons]	402	316	361	196	165	119	287	141	237	252	252	176	171	204	182	111	97	89	92
CO2	Railways (1A3c)	[ktons]	364	366	326	338	311	297	302	319	331	300	303	301	293	247	232	228	211	210	218
CO2	Navigation (1A3d)	[ktons]	492	560	592	519	575	551	657	608	665	637	674	702	629	535	497	507	498	581	565
CO2	Ag./for./fish. (1A4c)	[ktons]	1975	2054	1925	2005	2061	2093	2092	2090	1918	1890	1838	1875	1861	1861	1852	1844	1810	1883	1855
CO2	Civil Aviation (1A3a)	[ktons]	256	241	268	271	262	243	199	193	190	196	199	205	212	194	174	154	161	140	138
CO2	Industry-Other (1A2f)	[ktons]	778	778	778	778	778	778	775	771	767	764	760	757	753	749	746	742	742	742	742
CO2	Residential (1A4b)	[ktons]	87	87	87	87	87	87	86	86	85	85	84	84	83	83	82	82	82	82	82
CO2	Road (1A3b)	[ktons]	8260	8724	8734	8782	8866	9351	9759	9926	10052	10551	10648	10821	11026	11215	11350	11229	11272	11388	11864
CO2	Navigation int. (1A3d)	[ktons]	1320	1537	2261	2869	2936	3087	2762	2887	4300	4829	5061	4803	4403	4414	4155	4279	3605	2966	3130
CO2	Civil Aviation int. (1A3a)	[ktons]	1391	1503	1613	1725	1809	1736	1632	1693	1659	1818	1867	1971	2010	2159	2290	2350	2385	2059	2188

Pollutant	CRF ID	Unit	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
N2O	Military (1A5)	[tons]	15	12	13	6	6	4	12	6	9	9	11	7	8	9	8	4	5	4	5
N2O	Railways (1A3c)	[tons]	10	10	9	9	9	8	8	9	9	8	8	8	8	7	6	6	6	6	6
N2O	Navigation (1A3d)	[tons]	29	33	35	30	34	32	39	35	39	37	39	40	35	29	26	26	26	31	30
N2O	Ag./for./fish. (1A4c)	[tons]	96	101	93	98	101	103	103	104	93	91	88	91	90	90	90	90	88	92	91
N2O	Civil Aviation (1A3a)	[tons]	10	10	11	11	11	10	9	9	9	9	10	11	11	9	9	8	8	8	8
N2O	Industry-Other (1A2f)	[tons]	33	33	33	33	33	33	33	33	33	33	33	32	32	32	32	32	32	32	32
N2O	Residential (1A4b)	[tons]	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
N2O	Road (1A3b)	[tons]	340	367	370	376	384	423	494	556	615	735	813	886	1000	1074	1143	1185	1230	1270	1339
N2O	Navigation int. (1A3d)	[tons]	83	97	142	180	185	194	174	182	270	304	318	302	277	278	262	270	228	187	198
N2O	Civil Aviation int. (1A3a)	[tons]	47	50	54	58	61	59	56	58	57	63	64	69	70	75	80	82	82	72	76

Annex 3B-11: Uncertainty estimates

Uncertainty estimation, CO₂

		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 Gg	Input data Gg	Input data %	Input data %	%	%	%	%	%	%	%
Road transport	CO2		9351	11864	2	5	5.385	4.107	0.08105	0.8776	0.4052	2.4822	2.5151
Military	CO2		119	92	2	5	5.385	0.032	-0.003326	0.0068	-0.0166	0.0192	0.0254
Railways	CO2		297	218	2	5	5.385	0.076	-0.00911	0.0161	-0.0456	0.0457	0.0645
Navigation (small boats)	CO2		67	140	56	5	56.223	0.506	0.004609	0.0103	0.0230	0.8196	0.8199
Navigation (large vessels)	CO2		484	426	2	5	5.385	0.147	-0.009693	0.0315	-0.0485	0.0890	0.1014
Fisheries	CO2		771	632	2	5	5.385	0.219	-0.018869	0.0467	-0.0943	0.1321	0.1624
Agriculture	CO2		1318	1219	26	5	26.476	2.075	-0.021945	0.0902	-0.1097	3.3164	3.3182
Forestry	CO2		5	4	26	5	26.476	0.008	-7.48E-05	0.0003	-0.0004	0.0122	0.0122
Industry (mobile)	CO2		778	742	40	5	40.311	1.923	-0.011339	0.0549	-0.0567	3.1059	3.1064
Residential	CO2		87	82	51	5	51.245	0.269	-0.001348	0.0060	-0.0067	0.4350	0.4351
Civil aviation	CO2		243	138	10	5	11.180	0.099	-0.010468	0.0102	-0.0523	0.1441	0.1533
			13519	15556				25.286					27.9127
Total uncertainties					Overall uncertainty in the year (%):			5.029		Trend uncertainty (%):			5.283

Uncertainty estimation, CH₄

								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
	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	%	%	%	%	%
Road transport	CH4	2620	256	2	40	40.050	33.883	0.00254181	0.9521	0.1017	2.6930	2.6949
Military	CH4	5	5	2	100	100.020	0.129	-0.000392	0.0014	-0.0392	0.0041	0.0394
Railways	CH4	12	9	2	100	100.020	0.245	-0.0017054	0.0028	-0.1705	0.0078	0.1707
Navigation (small boats)	CH4	43	112	56	100	114.612	3.680	0.02072659	0.0361	2.0727	2.8617	3.5335
Navigation (large vessels)	CH4	11	10	2	100	100.020	0.277	-0.0008662	0.0031	-0.0866	0.0088	0.0871
Fisheries	CH4	18	15	2	100	100.020	0.424	-0.001932	0.0048	-0.1932	0.0135	0.1937
Agriculture	CH4	103	96	26	100	103.325	2.836	-0.0065322	0.0309	-0.6532	1.1357	1.3102
Forestry	CH4	11	10	26	100	103.325	0.305	-0.0006516	0.0033	-0.0652	0.1220	0.1383
Industry (mobile)	CH4	136	148	40	100	107.703	4.551	-0.0018855	0.0476	-0.1885	2.6902	2.6968
Residential	CH4	138	130	51	100	112.254	4.169	-0.0082102	0.0418	-0.8210	3.0144	3.1242
Civil aviation	CH4	7	5	10	100	100.499	0.135	-0.0011105	0.0015	-0.1111	0.0214	0.1131
		3105	3494				1208.150					38.6053
Total uncertainties				Overall uncertainty in the year (%):			34.758		Trend uncertainty (%):			6.213

Uncertainty estimation, N₂O

		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 Mg	Input data Mg	Input data %	Input data %	%	%	%	%	%	%	%
Road transport	N2O		423	1341	2	50	50.040	44.319	0.485873	2.1762	24.2937	6.1551	25.0613
Military	N2O		4	5	2	1000	1000.002	3.077	-0.008545	0.0076	-8.5447	0.0214	8.5448
Railways	N2O		8	6	2	1000	1000.002	3.975	-0.02284	0.0098	-22.8405	0.0276	22.8405
Navigation (small boats)	N2O		2	3	56	1000	1001.567	2.163	-0.00207	0.0053	-2.0697	0.4202	2.1119
Navigation (large vessels)	N2O		30	27	2	1000	1000.002	17.783	-0.077622	0.0437	-77.6220	0.1236	77.6221
Fisheries	N2O		49	40	2	1000	1000.002	26.460	-0.128677	0.0650	-128.6770	0.1839	128.6772
Agriculture	N2O		55	51	26	1000	1000.338	33.365	-0.1356	0.0820	-135.5996	3.0134	135.6331
Forestry	N2O		0	0	26	1000	1000.338	0.026	-9.46E-05	0.0001	-0.0946	0.0024	0.0946
Industry (mobile)	N2O		33	32	40	1000	1000.800	21.009	-0.080814	0.0516	-80.8144	2.9178	80.8670
Residential	N2O		2	2	51	1000	1001.300	1.184	-0.00471	0.0029	-4.7101	0.2095	4.7148
Civil aviation	N2O		10	8	10	1000	1000.050	5.329	-0.027925	0.0131	-27.9246	0.1852	27.9252
			616	1514				4594.788					49548.104
													1
Total uncertainties					Overall uncertainty in the year (%):			67.785		Trend uncertainty (%):			222.594

Uncertainty estimation, N₂O

Uncertainty summary table													
Uncertainty introduced into the trend in total national emissions	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty i trend in national emissions introduced by emission factor uncertainty	Type B sensitivity	Type A sensitivity	Combined uncertainty as % of total national emissions in year t		Combined uncertainty	Emission factor uncertainty	Activity data uncertainty	Year t emission	Base year emission	Gas	IPCC Source category

Annex 3C

Industrial Processes. CRF sector 2

Lime production

CRF source category 2.A Mineral Products, 2. Lime Production.

SNAP source category 040614. Lime (decarbonizing).

Source category description

This source includes CO₂ emissions from production of lime/hydrated lime and bricks and represents as such a combined activity in the CRF tables. This Annex serves to explain the source.

The source is not a key source neither for the trend nor for the level key source analyses in this report.

The production of lime has a slightly falling trend in the time-series 1990-2003, while the production of bricks is slightly increasing until 2000. As a result the CO₂ emission for the combined activity in year 2003 is lower than in 1990, refer to the table below.

Methodology

The CO₂ emission from production of Lime is calculated according to the IPCC guidelines, Reference Manual p 2.8, with the emission factor of 0.79 kg CO₂ / kg Lime. The CO₂ emission factor for production of Hydrated Lime - 0.541 kg CO₂/Hydrated Lime - is calculated from the above mentioned emission factor and information on water content obtained from the company. These emission factors are multiplied by activity data from production statistics published by Statistics Denmark, refer the Table below.

The emission factor from production of yellow bricks is calculated the following way. When limestone (CaCO₃) is heated it decomposes into lime (CaO) and CO₂. Using the molecular weights, implies that 44 kg of CO₂ is emitted for every 100 kg CaCO₃ decomposed. Since clay used to produce yellow bricks contains 18% of limestone, the emission factor is 0.18*0.44=0.079 kg CO₂ / kg yellow bricks. This emission factor is multiplied by activity data from production statistics published by Statistics Denmark. This Statistics accounts for the number of bricks produced, the average weight of a brick is estimated to 2 kg. Refer to the Table below for the data and the emissions calculated.

The activity data and the resulting emissions from production of lime and bricks are aggregated in the CRF, in Table 2(I).A-G sheet 1. The underlying data and the resulting aggregated data are given in the table below.

Table. Production of Lime/Hydrated Lime and Bricks, CO₂ emission factors and CO₂ emissions.

Year	Lime		Production of hydrated lime		Yellow Bricks		Lime and Bricks		
	Production of burned lime	CO ₂ emission	Production of hydrated lime	CO ₂ emission	Production	CO ₂ emission	Production	CO ₂ emission	Combined emission factor
	(1) (t)	(2) (Mg)	(1) (t)	(3) (Mg)	(4) (t)	(5) (Mg)	(6) (kt)	(6) (Gg)	(6) (t/t)
1990	126706	99555	27686	14978	291348	23016	445,74	137,55	0,31
1991	86226	67749	27561	14911	291497	23028	405,28	105,69	0,26
1992	104526	82128	23821	12887	303629	23987	431,98	119,00	0,28
1993	106587	83747	18482	9999	278534	22004	403,60	115,75	0,29
1994	112480	88377	14781	7996	389803	30794	517,06	127,17	0,25
1995	100929	79301	15865	8583	365149	28847	481,94	116,73	0,24
1996	95028	74665	13600	7358	397206	31379	505,83	113,40	0,22
1997	102587	80604	12542	6785	419431	33135	534,56	120,52	0,23
1998	88922	69867	8445	4569	417301	32967	514,67	107,40	0,21
1999	95137	74751	7654	4141	405241	32014	508,03	110,91	0,22
2000	92002	72287	8159	4414	412082	32554	512,24	109,26	0,21
2001	96486	75810	9012	4875	351955	27804	457,45	108,49	0,24
2002	122641	96361	12006	6495	346633	27384	481,28	130,24	0,27
2003	87549	68789	11721	6341	341981	27016	441,25	102,15	0,23

Notes:

- (1) Statistics Denmark: Sales Statistics for manufacturing industries.
- (2) Emission factor 0,786 kg CO₂/kg; 1996 IPCC guidelines; reference manual p. 2.8
- (3) Emission factor 0,5410 kg CO₂/kg; according to producer (Faxø Kalk)
- (4) Statistics Denmark: Sales Statistics for manufacturing industries, assuming that of the bricks produced and sold, 50% is yellow bricks each with an average weight of 2 kg.
- (5) Emission factor 0,079 kg CO₂/kg, further information in the text.
- (6) Corresponding to the values in the CRF Table 2(I).A-Gs1, A.2. in this report for the respective years (apart from roundings).

Source specific planned improvements

The review team in their report on the April 15 2004 submission made a note on the implied emission factor in the CRF tables on this activity. We have considered reporting the two activities separately in the CRF. However, we find the activities so much related both being a decarbonizing process that we find a combination of the activities justified with the explanations given in this Annex.

Annex 3D

Background data for CRF, table 4.A

Enteric Fermentation

Table 1 Detailed information related to the feed intake 1990 - 2003

IPCC livestock category	Subcategory	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
		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	297.9	299.7	299.5
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	100.0	99.7
Sheep	Covers mother sheep incl. lamb	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. kid	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		145.8	145.8	145.8	145.8	145.8	145.8	145.8	145.8	145.8	145.8	145.8	145.8	145.8	145.8
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	27.2	27.5	27.3
Poultry	Laying hens, broilers, ducks, turkeys, geese	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

Table 2 Cattle and swine subcategories 2003

IPCC livestock category	Subcategory	2003
		Feed intake MJ/head/day
Dairy Cattle	Average	299.5
	Large breed	305.8
	Jersey	255.7
Non-dairy cattle	Average	99.7
	Calves, bull < ½ year	61.4
	Calves, heifer <½ year	42.5
	Bull >½ year	115.8
	Heifer >½ year	106.7

	Suckling cattle	170.2
Swine	Average	27.3
	Sows	64.2
	Piglets and slaughter pigs	23.7

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
	Percent of feeding in stable													
Dairy cattle	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	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
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
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
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
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

^aIn 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
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
Kg milk/cow/year	6231	6187	6288	6560	6533	6628	6872	7001	7118	7252	7308	7416	7525	7911

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

Background data for CRF, table 4.B(a)
CH₄ Emissions from Manure Management

Table 6

IPCC livestock category	Acs content	Typical animal mass	VS daily excretion	Comments
	1990-2003	1990-2003	1990-2003	
		Average	Average VS	
		kg	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 2003

Livestock category	Stable type	Manure type	Methane convention factor - MCF	Distribution of stable type 2003	Vs daily excretion kg VS/prod. head/yr 2003	Distribution of stable type 1990	Vs daily excretion kg VS/prod. head/yr 1990
Dairy cattle	Tied-up with liquid and solid manure	Solid manure	1	0.08	1317	0.35	1317
		+ Liquid	10	0.08	225	0.35	225
	Tied-up with slurry	Slurry	10	0.18	1473	0.44	1473
	Loose-holding with beds, slatted floor	Slurry	10	0.42	1473	0.13	1473
	Loose-holding with beds, slatted floor, scrapes	Slurry	10	0.05	1473	0.01	1473
	Loose-holding with beds, solid floor	Slurry	10	0.16	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				1619		1539

Table 8 VS daily excretion for heifer > ½ year 1990 and 2003

Livestock category	Stable type	Manure type	Methane conversion factor - MCF	Distribution of stable type 2003	Vs daily excretion kg VS/prod. head/yr 2003	Distribution of stable type 1990	Vs daily excretion kg VS/prod. head/yr 1990
Heifer							
> ½ year*	Tied-up with liquid and solid manure	Solid manure	1	0.07	216	0.19	255
		+ Liquid	10	0.07	29	0.19	35
	Tied-up with slurry	Slurry	10	0.07	235	0.19	279
		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				294		310

* is the largest subcategory

Table 9 VS daily excretion for swine 19990 and 2003

Livestock category	Stable type	Manure type	Methane conversion factor - MCF	Distribution of stable type 2003	Vs daily excretion kg VS/prod. head/yr 2003	Distribution of stable type 1990	Vs daily excretion kg VS/prod. head/yr 1990
Slaughter pigs	Full slatted floor	Slurry	10	0.55	22	0.51	22
	Partly slatted floor	Slurry	10	0.35	24	0.23	24
	Solid floor	Solid manure	1	0.04	16	0.22	16
		+ Liquid	10	0.04	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					22	23

Table 10 Changes in stable type 1990 – 2003

Livestock categories	Stable type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
		pct													
Horses		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
	Deep litter, solid floor	0	0	0	0	0	0	0	0	0	0	0	9	14	18
Bull, 6 mth.-440 kg (jersey = 328 kg)	Tied-up with liquid and solid manure	20	19	17	16	15	14	13	12	11	11	10	9	8	8
	Tied-up with slurry	20	19	17	16	15	14	13	12	11	11	10	9	8	8
	Slatted floor-boxes	41	40	40	39	38	37	37	36	35	34	33	32	31	30
	Deep litter (all)	3	3	2	2	2	1	1	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
	Deep litter, slatted floor	4	5	6	7	8	8	9	10	11	10	9	8	7	5
	Deep litter, slatted floor, scrapes	1	1	1	1	1	2	2	2	2	2	2	2	2	1
	Deep litter, solid floor, scrapes	1	2	2	2	2	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
	Deep litter, solid floor	0	0	0	0	0	0	0	0	0	0	0	11	16	17
Heifer, 6 mth.-calving	Tied-up with liquid and solid manure	19	18	17	16	15	13	12	11	10	10	9	8	7	7
	Tied-up with slurry	19	18	17	16	15	13	12	11	10	10	9	8	7	7
	Slatted floor-boxes	40	39	38	37	36	35	34	33	33	32	32	31	30	30
	Loose-holding with beds, slatted floor	4	4	5	6	7	7	8	10	12	13	14	17	20	21
	Deep litter (all)	3	3	2	2	2	1	1	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
	Deep litter, slatted floor	4	4	5	6	7	7	7	7	6	6	6	5	5	5
	Deep litter, slatted floor, scrapes	1	1	1	1	1	1	1	1	2	2	2	2	2	1
	Deep litter, solid floor, scrapes	1	1	2	2	2	2	3	3	3	3	3	3	3	3
Dairy cows	Tied-up with liquid and solid manure	35	35	34	33	32	31	30	30	30	30	18	15	12	8
	Tied-up with slurry	44	43	43	43	43	42	42	36	30	30	28	25	23	18
	Loose-holding with beds, slatted floor	13	14	15	16	16	17	18	21	24	24	34	36	39	42
	Loose-holding with beds, slatted floor, scrapes	1	1	1	1	1	1	1	2	3	3	3	4	4	5
	Loose-holding with beds, solid floor	4	3	3	3	3	3	3	3	3	3	6	9	11	16
	Deep litter (all)	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
	Deep litter, slatted floor, scrapes	0	0	0	0	0	0	0	0	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

Livestock categories	Stable type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
pct															
Suckling cattle	Tied-up with liquid and solid manure	10	10	10	10	10	10	10	10	10	10	9	8	7	4
	Deep litter (all)	73	69	66	62	59	55	52	48	45	45	45	44	43	44
	Deep litter, solid floor	17	21	24	28	31	35	38	42	45	45	46	48	50	52
Sheep and goats		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sheep	Deep litter (all)	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
Swine		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sows	Full slatted floor	9	10	10	11	12	12	13	13	14	14	14	13	13	12
(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
	Solid floor	30	27	25	22	20	17	15	12	10	7	7	6	6	6
	Deep litter	5	5	5	6	6	7	7	8	9	9	10	10	10	10
	Deep litter + slatted floor	0	0	1	1	2	2	3	3	4	4	6	7	8	9
	Deep litter + solid floor	0	0	1	1	2	2	3	3	4	4	5	6	7	8
	Outdoor sows	0	0	1	1	1	2	2	2	3	3	3	3	2	2
Piglets, 7.5-30 kg	Full slatted floor	54	57	60	57	54	51	49	46	43	40	38	36	35	33
	Partly slatted floor	20	20	20	24	27	31	34	38	41	45	47	49	50	52
	Solid floor	21	18	15	14	12	11	9	8	6	5	5	5	5	5
	Deep litter (to-clima stables)	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
Slaughtering pigs, 30-98.3 kg	Full slatted floor	51	56	60	60	60	60	60	60	60	60	58	57	56	55
(75 kg slaughtering weight)	Partly slatted floor	23	21	20	21	23	24	25	26	28	29	31	33	34	35
	Solid floor	22	19	15	14	12	11	9	8	6	5	5	4	4	4
	Deep litter	4	4	5	4	4	3	3	2	2	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
Poultry		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Outdoor hens (100 pcs.)		0	1	2	4	5	6	7	8	9	9	9	9	7	8
Ecological hens (100 pcs.)		0	1	2	4	5	6	7	10	12	14	15	15	15	16
Scrub hens (100 pcs.)		11	11	12	12	13	13	13	15	17	18	18	17	19	18
Battery hens, manure house (100 pcs.)		54	52	49	47	44	41	39	36	32	29	26	26	23	23
Battery hens, manure tank (100 pcs.)		12	11	11	10	9	8	7	6	6	5	5	5	4	5
Battery hens, manure cellar (100 pcs.)		23	23	24	24	25	25	26	25	25	24	27	27	32	30
HPR-hens (egg for hatching) (100 pcs.)		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

Pullet, consumption, floor (100 pcs.)		57	58	60	61	62	63	64	65	66	67	69	67	69	68
Pullet, egg for hatching (100 pcs.)		26	26	26	26	26	26	26	26	26	26	23	25	25	25
Livestock categories	Stable type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
pct															
Broilers, conv. 39 days) (1000 pcs.)		100	100	100	100	100	100	100	100	100	100	100	100	100	100
Broilers, scrabe(81 days) (1000 pcs.)		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
Turkey, male (100 pcs.)		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
Ducks (100 pcs.)		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
Fur farming		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mink	Slurry system	18	20	20	22	23	25	26	28	29	30	42	50	55	60
	Solid manure and black liquid	82	80	80	78	77	75	74	73	71	70	58	50	45	40
Foxes	Slurry system	0	0	0	0	0	0	0	0	0	0	2	5	10	15
	Solid manure and black liquid	100	100	100	100	100	100	100	100	100	100	98	95	90	85

Livestock Category	Stable type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
pct.															
<u>Cattle</u>															
	Tied-up stables	7909	7791	7673	7555	7436	7318	7200	6600	6000	6000	4600	4000	3500	2600
	Loose-holdings with beds	5673	5727	5782	5836	5891	5945	6000	5700	5400	5400	6200	6100	6200	6000
	Deep litter	1409	1491	1573	1655	1736	1818	1900	2300	2700	2700	3700	4000	4300	4700
<u>Swine</u>															
	Full slatted floor	5114	5557	6000	6000	6000	6000	6000	6000	6000	6000	5800	5700	5600	5500
	Partly slatted floor	2286	2143	2000	2129	2257	2386	2514	2643	2771	2900	3100	3300	3400	3500
	Solid floor	2214	1857	1500	1357	1214	1071	929	786	643	500	500	400	400	400
	Deep litter	386	443	500	443	386	329	271	214	157	100	100	100	100	100

Reference: The Danish Agricultural Advisory Centre

Table 11 Background data for estimation of N₂O emission from crop residue 2003

Crop type	Stubble	Husks	Top	Leafs	Frequency of ploughing	Nitrogen content in crop residue	
	<u>kg N/ha</u>	<u>kg N/ha</u>	<u>kg N/ha</u>	<u>kg N/ha</u>	No. of year before ploughing	<u>kg N/ha/yr</u>	<u>M kg N/yr</u>
Winter wheat	6.3	10.7	-	-	1	17.0	11.07
Spring wheat	6.3	7.4	-	-	1	13.7	0.17
Winter rye	6.3	10.7	-	-	1	17.0	0.56
Triticale	6.3	10.7	-	-	1	17.0	0.62
Winter barley	6.3	5.9	-	-	1	11.3	1.58
Spring barley	6.3	4.1	-	-	1	10.4	5.99
Oats	6.3	4.1	-	-	1	10.4	0.51
Winter rape	4.4	-	-	-	1	4.4	0.45
Spring rape	4.4	-	-	-	1	4.4	0.02
Potatoes (top), non-harvest	-	-	48.7	-	1	48.7	1.76
Beet (top), non-harvest	-	-	54.4 ^a	-	1	54.4	3.14
Straw, non-harvest	-	-	-	-	1	7.6 ^a	8.97
Pulse	11.3	-	-	-	1	11.3	0.35
Lucerne	32.3	-	-	-	3	10.8	0.04
Maize – for green fodder	6.3	-	-	-	1	6.3	0.75
Cereal – for green fodder	6.3	-	-	-	1	6.3	0.69
Pulses, fodder cabbage and other green fodder	6.3	-	-	-	1	6.3	0.00
Peas for canning	11.3	-	-	-	1	11.3	0.04
Vegetable	11.3	-	-	-	1	11.3	0.07
Grass- and clover field in rotation	32.3		-	10.0	2	26.2	5.54
Grass- and clover field out of rotation	38.8		-	20.0	-	20.0	3.55
Aftermath	6.3	-	-	-	1	6.3	1.20
Seeds of grass crops	6.3	10.7	-	-	2	13.9	1.14
Set-a-side	38.8	-	-	15.0	10	18.9	4.30
Total N from crop residue - 2003							52.51

^a express the yield for 2003 - varies from year to year. Based on yield data from Statistics Denmark and N-content from the feeding plan.
Reference: Djurhuus and Hansen 2003

Annex 3E

Solid Waste Disposal on Land

The starting year for the FOD model used is 1960 using historic data for waste amounts. The record of ISAG registration of waste amounts does not go back in time that far, but for the time-series 1990-2003 reported here this does not play a bigger role as regards time-series consistency.

Table 3E.1 shows the results from the calculations by the model for selected years 1970-1979 to illustrate how the model performs: The two left columns represent the time-series of potential emissions. The actual emissions are in the next column as total. The “from year” columns present the contribution of emissions from individual previous years to the actual years emission (the total). So, the contribution from the deposited waste in 1970 with its potential emission in 1970 (=39.2) to the actual emissions in 1970 was 2.63. In 1971 the contribution from the 1970 deposited waste was 2.45. In 1972 it was 2.29 and so on. Summing the 1970 column for the ten years period shown in the table the result is - as shown in the table - 19.6 corresponding to that the half-life time is 10 years and half of the potential emission of 39.2 is then emitted after 10 years. The reason for choosing the period from 1970 to 1979 for this illustration of the models performance is that the number of columns “from years” are limited to a number where illustration in a simple table is possible.

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 years” columns is the total actual emission 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 the Danish household is connected to a municipal sewer system. The WWTPs have been upgraded significantly since 1987 when the first Water Environment Action Plan was launched by the Danish parliament. The plan included more strict emission standards for nutrients and organic matter for WWTPs with a capacity above 5000 PE and thus rendered technological upgrading of the majority of Danish WWTPs necessary.

In 2002 there were 1267 Danish WWTPs bigger 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 the wastewater. The capacities of WWTPs are calculated based on the amount of organic matter in the influent wastewater and converted to the 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 per cent 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
>2000 PE	441	98
>5000 PE	274	93
>15000 PE	130	83
>50000 PE	63	68
>100000 PE	30	48

In 1989 only 10% of the wastewater treatment processes included reduction of N, P and BOD. In 1996 the number was 76%. Today 85% of the 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 about 40% from 1999 onwards. The fraction of industrial sources discharges to city sewers contributing to the influent wastewater load in the national WWTPs is given in per cent based on PEs (1 PE = 60g BOD/day) in Table 3E.3.

Table 3E.3. The fraction 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
% industrial load	0-5	5	-	48	41	42	38	38	37

* 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 biggest 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. 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 hygienization, dewatering and stabilisation of the sludge, the sludge may be mineralised, composted, dried or combusted. Composting and sanitation is attributed by a storage time of 3 to 6 months. For plants with mineralization of sludge the storage time is about 10 years.

At this point 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 are 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
BOD	93	87	92	79	94	94	95	96	96	96
N	64	56	68	66	74	74	77	79	77	81
P	76	80	85	91	90	90	91	92	91	93

1.1.1 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 is needed in the unit of tonnes BOD /year, which is obtained by using total influent amount of water per year 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).

Table 3E.5 Total degradable organic waste (TOW) calculated by use of country-specific data.

	Year	1993	1999	2000	2001	2002	2003
BOD (mg/L)		129.6*	160	175	203	189	300
Influent water (million m ³ / year)		-	825	825	720	809	611
TOW _{BOD} (tonnes BOD/year)		129600	132000	144375	167475	155513	247500
TOW _{COD} (tonnes BOD/year)**			148500	138600	163350	163020	216810

*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.

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 18250 kg/BOD/1000 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 per cent contribution from the industry 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
Population- Estimates (1000)	5140	5153	5170	5188	5208	5228	5248	5268	5287	5305	5322	5338	5351	5383
TOW (tonnes BOD/year), default BOD IPCC	93805	94042	94353	94681	95046	95411	95776	96141	96488	96816	97127	97419	97656	98247
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	40.3	42.0
TOW (tonnes BOD/year), default BOD IPCC corrected for industrial contribution	96150	96393	96711	99415	10977 8	11821 4	12671 2	13527 0	14280 2	13651 1	13792 0	13443 8	13704 4	13951 1

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 underestimates the TOW. This underestimation becomes less by increasing the TOW data according to the industrial contribution to the TOW. The increase in the country-specific TOW data registered by the DEPA from 2002 to 2003 (Table 3E.5) is about 30-35%, which is much higher than expected from the slight increase in the industrial influent load, which increases only 1.7 %. The default methodology, including corrections for industrial contribution to TOW, does not agree with the country-specific TOW data based on measurement of dissolved organic matter in the influent wastewater. The national TOW data seems to include some uncertainties too in addition to the data gaps.

Based on mean values and standard deviation of TOW from Table 3E.5 and last row of Table 3E.6, an estimate of the maximum uncertainty on TOW is 28 %.

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 anaerobic, 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 anaerobic 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 MCF. By doing so it is assumed that all of the sludge treated anaerobic is treated 100 % anaerobic and no weighted MCF is calculated. The per cent sludge that is treated anaerobic, aerobic and by additional different stabilisation methods is 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, 2001 and 2003 a.

Year **	Units	Biological		Chemical		EF (IPCC 1996) [kg CH ₄ / kg BOD]*
		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 per cent amount of sludge treated anaerobic 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 1997 to 2002. It seems reasonable to assume a constant emission factor of 0.26 kg CH₄/kg BOD based on the dry weight fraction of sludge treated anaerobic and an emission factor of 0.15 kg CH₄/kg BOD based on the wet weight fraction of sludge treated anaerobic. The emission factor based on wet weight is used for calculating the gross CH₄ emission since it seems the most appropriate to use when combined with BOD data in the emission calculation procedure.

The uncertainty in the fraction of wastewater treated anaerobic is judged by the average and spread of average of data given above. Both anaerobic fraction data based on wet and dry weight are included. The uncertainty is estimated to be 28%.

1.2 Data Gap filling - Methane

Gross CH₄ emission

Due to uncertainty in the country-specific TOW data and for the purpose of extrapolation of data needed outside the scope of the NIR, it was decided to develop a regression concept based on a consistent methodology through all the years. For this purpose a comparison between country-specific and default IPCC methodology time trends was performed taking into

account a correction for the contribution from the industry.

Table 3E.8 The gross-emission data based on raw (original) TOW data

year	Contribution from industrial inlet BOD %	Population- Estimates (1000)	Gross CH ₄ emission (Gg), country-specific data (based on BOD data)*	Gross CH ₄ emission (Gg), country-specific data (based on COD data)*	Gross CH ₄ emission (Gg), country-specific data (based on BOD data)*, household only	Gross CH ₄ emission (Gg), country-specific data (based on COD data)*, household only	Gross CH ₄ emission (Gg), National default TOW data
1990	2.5	5140					14.07
1991	2.5	5153					14.11
1992	2.5	5170					14.15
1993	5	5188	19.44		18.47		14.20
1994	15.5	5208					14.26
1995	23.9	5228					14.31
1996	32.3	5248					14.37
1997	40.7	5268					14.42
1998	48	5287					14.47
1999	41	5305	19.80	22.28	11.68	13.14	14.52
2000	42	5322	21.66	20.79	12.56	12.06	14.57
2001	38	5338	25.12	21.38	15.58	13.26	14.61
2002	40.3	5351	28.59	23.98	17.06	14.31	14.65
2003	42	5383	37.13	32.52	21.58	18.91	14.74

*When based on measured COD data, BOD=COD/2.5

The uncertainty on BOD data are estimated to be higher than for COD data due to differences in methodologies of measurements from year to year caused by reporting of varying BOD data measured as modified, unmodified and sometimes reported as the average of the two measurement methods. Therefore, it has been decided to use the regression line based on COD derived gross emission data as shown in Figure 3.E.1 below.

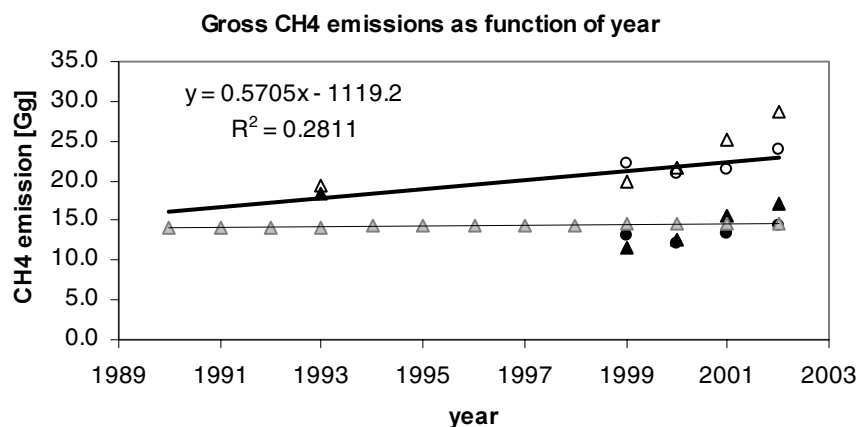


Figure 3.E.1. The open triangles and circles represent the country-specific gross emission derived from measured BOD and COD values, respectively. The grey triangles represent the gross emission based on the IPCC GL default value for Europe of 18250 kg BOD/1000 persons/yr. The black triangles and circles represent the country-specific gross emission derived from measured BOD and COD values, respectively, where the industrial contribution to the influent TOW has been subtracted. The data point from 1993 indicated that the industrial contribution to the TOW at the WWTPs might have been underestimated.

For data gap filling backward it is assumed reasonable to use the interpolated linear regression equation. For future trend analyses it may be considered to use a correction for non-linearity depending on the national statistics on TOW. At this stage, the gross emission estimates of methane are based on an average of the above regression equation and the default IPCC methodology using a constant contribution from the industry of 0.417; an average of the contribution from 1997 and forward where the industrial contribution seems to have stabilised. The results of the regression approach and the adjusted default IPCC approach are given

in Table 3E.9.

Table 3E.9 Gross emissions of methane (Gg) by the adjusted IPCC method, the country-specific method and average of the two methods.

Gross emission [Gg]	Population (1000)	Corrected default IPCC methodology derived	Regression based on country-specific Gross emissions	Average
1990	5140	20.0	16.1	18.0
1991	5153	20.0	16.7	18.3
1992	5170	20.1	17.2	18.7
1993	5188	20.2	17.8	19.0
1994	5208	20.2	18.4	19.3
1995	5228	20.3	18.9	19.6
1996	5248	20.4	19.5	20.0
1997	5268	20.5	20.1	20.3
1998	5287	20.5	20.7	20.6
1999	5305	20.6	21.2	20.9
2000	5322	20.7	21.8	21.2
2001	5338	20.7	22.4	21.6
2002	5351	20.8	22.9	21.9
2003	5383	20.9	23.5	22.4

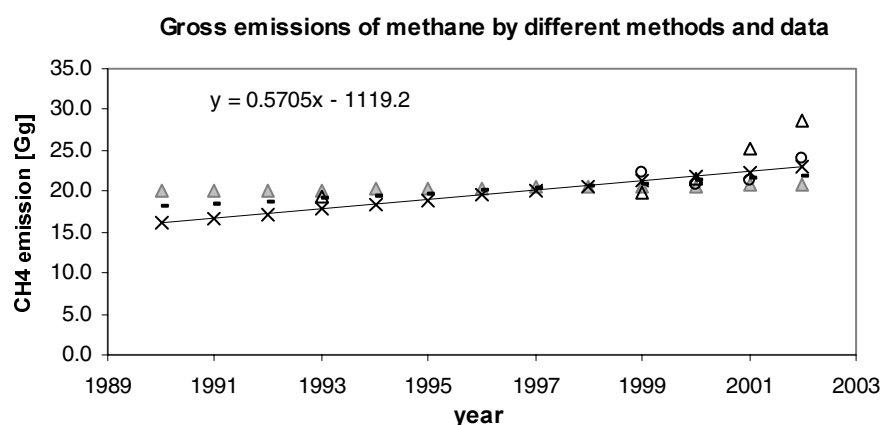


Figure 3.E.2. The open triangles and circles represent the country-specific gross emission derived from measured BOD and COD values, respectively. The grey triangles represent the default derived gross emission based on the IPCC GL default value for Europe of 18250 kg BOD/1000 persons/yr corrected by increasing the degradable organic component 41.7% due to industry. The crosses represent the country-specific gross emission regression equation derived from the measured COD values. The average reported values are presented by the dots.

At this point it is not possible to quantify a non-linear trend curve for the gross emission, and therefore it seems most reasonable to use the average value of the two methods.

The open triangles representing gross emissions derived from measured BOD data are not considered for interpolation or extrapolation purposes as these measurements for some years are based on a technique that includes oxygen used by nitrification, and for some year they are not and again sometimes the measurements are reported as an average of modified and unmodified BOD. This makes the data useless for interpolation purposes.

The average value is the reported gross CH₄ emission.

Recovered and combusted methane potentials

The calculated theoretical CH₄ not emitted is given in Table 3E.10 below.

Table 3E.10. Theoretical CH₄ 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 sand-blasting 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 sand-blasting 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				

*The biogas production is assumed zero in 1987.

Due to missing data linear regression was performed based on the above given country-specific CH₄ potentials not emitted from 1990 to 2002.

The variation in time trends is high as illustrated in Figure 3.E.E. Based on the per cent 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 about 25%, while the uncertainty for external combustion, combustion for production of sandblasting product and biogas is about 70%. The variations/uncertainties originates from the activity data given in Table 4.16 in the main report.

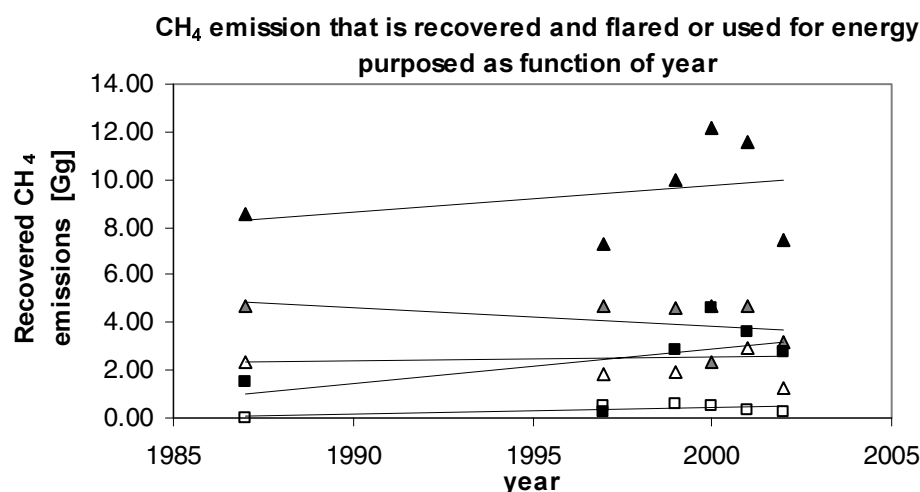


Figure 3.E.3. From top to bottom based on 1987 data points: The upper regression line represents the total methane potential not emitted. The grey triangles and decreasing regression line represent the trend in internal combusting. The open triangles and regression line of insignificant slope represent external combustion. The black quadrants and increasing regression line represent the methane potential internal combusted and reused for production of sandblasting products (corresponds to the category "Other" in Table 4.16 in the main document). Lastly the open quadrants and regression line with no or slightly positive slope represent the methane potential used for biogas production.

Average emission data is based on regression estimates and country-specific data is reported where available. Regression estimates are used where no country-specific data is available (cf. Table 4.12 in the main report).

1.2.1 Quality Check and verification - Nitrous oxide

EF used for calculating the direct emission of N₂O

A German estimate of the emission factor for direct emission of N₂O from wastewater treatment processes, not including industrial influents, is 7 g N₂O/ person per year (Schön et al, 1993). In an investigation for the Netherlands, the emission factor is suggested to be 3.2 g N₂O/person per year (Czepiel, Crill and Harries, 1995). Similar to 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. The decentralised WWTPs are assumed to have no influent wastewater load from the industry, and the centralised WWTPs receives most of the industrial wastewater, the difference in average influent loads may be used to derive an estimate of the fraction of industrial nitrogen influent load. The estimated fraction of industrial influent nitrogen load is used in combination with the Netherlands emission factor to arrive at an EF corrected for industrial influent nitrogen load. In the United States a correction factor of 1.25 was obtained resulting in an emission factor of (1.25*3.2) 4 g N₂O/person per year (Scheehle and Doorn, 1997) including the contribution from industrial nitrogen influent load. An analogue approach has been used for calculating the Danish direct emission of N₂O upon wastewater treatment.

Key data on nitrogen influent load distribution according to small, medium and large WWTPs is available from the [Danish Water and Wastewater Association](#) (Danva, 2001). The data is based on 20-25 WWTPs located in five big city areas in Denmark and it is 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.11. Correction factors (CF) to adjust the emission factor (EF) to include influent loads of N to WWTPs from industry.

<i>year</i>	<i>WWTP-large</i> [tonnes N / year]	<i>WWTP-medium</i> [tonnes N/year]	<i>CF</i>	<i>EF</i> [N ₂ O /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 N₂O/person per year. The average resulting emission factor for direct emission of N₂O is (3.52*3.2) 11.3 g N₂O/person per year. However, the contribution to the Danish WWTPs from the industry has changed from close to zero in 1984 up to an average of 42 % since 1998. Therefore, the per cent 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, was 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.

$$\text{Eq. 1: } EF_{N_2O, WWTP, direct} = 0.1887 * I + 3.2816$$

where *I* is the per cent 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 performed by the National Environmental Technology Centre, June 2000, and covers the following sectors

Total emission
Energy Production
Comm+ Residn Combustn.
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-trimethylcyclopentane
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-butyrolactone
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-phenol
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 unspeciatiated alcohols
- 640 unspeciatiated aliphatic hydrocarbons
- 641 unspeciatiated alkanes
- 642 unspeciatiated alkenes
- 643 unspeciatiated amines
- 644 unspeciatiated aromatic hydrocarbons
- 645 unspeciatiated carboxylic acids
- 646 unspeciatiated cycloalkanes
- 647 unspeciatiated hydrocarbons
- 648 unspeciatiated ketones
- 649 urea
- 650 vinyl acetate
- (1) BVOC- biogenic VOCs, such as alpha-pinene and other terpenes

Annex 4 CO₂ 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 1990-2003 and due for submission 15 April 2005 include all sources identified by the Revised IPPC Guidelines except the following, further refer Table A5.1, which is a copy of the Completeness table (Table 9) of the Danish CRF -submission:

Industrial processes: CO₂ emission from use of lime and limestone for flue gas cleaning, sugar production etc. and production of expanded clay will be included in the next submission. CO₂ emissions from use of coke in iron foundries will be included in the next submission. These sources are expected to contribute with about 4% of the total industrial sector GHG emissions in 2003.

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 to the total emission from enteric fermentation.

Table A5.1

TABLE 9 COMPLETENESS
(Sheet 1 of 2)Denmark
2003
2005, Mar15

Sources and sinks not reported (NE) ⁽¹⁾				
GHG	Sector ⁽²⁾	Source/sink category ⁽²⁾	Explanation	
CO ₂	2. Industry	A.3-4. Limestone, dolomite and soda ash use	Emissions are presently included in glass production. It will be investigated to establish a detailed inventory.	
	2. Industry	A.5. Asphalt roofing and road paving	Emission estimates are under development	
	5. LULUCF	D. Cultivation of Mineral Soils	In an on-going survey estimates are calculated and discussed.	
	6. Waste	A.1. Managed Waste Disposal onLand	Emissions are considered to be of negligible importance	
CH ₄	4. Agriculture	A. Enteric Fermentation. Poultry and fur farming.	Emission considered of minor importance. No default values for the methane emission factor are recommended in IPCC-GPG (table A-4)	
	4. Agriculture	D. Agricultural Soils	Direct and Indirect Soil Emissions are considered of minor importance for CH ₄ . No methodology is recommended in	
N ₂ O	4. Agriculture	D. Agricultural Soils	Frac-NCRBF and Frac-NCRO are not yet estimated	
HFCs				
PFCs				
SF ₆				
Sources and sinks reported elsewhere (IE) ⁽³⁾				
GHG	Source/sink category	Allocation as per IPCC Guidelines	Allocation used by the Party	Explanation
CO ₂	1B2a Oil, i+iii	1B2a Oil, i+iii	1B2a Oil, ii	Due to limitation in the structure of the national emission inventory databases
	1B2a Oil, iv	1B2a Oil, iv	1B2a Oil, vi	Due to limitation in the structure of the national emission inventory databases
	1B2b Oil i	1B2b Oil i	1B2a Natural gas, ii	Due to limitation in the structure of the national emission inventory databases
	1B2b Natural gas, iii Other leakage	1B2b Natural gas, iii Other leakage	1B2b Natural gas, ii Transmission	
	1B2c Venting, ii Gas	1B2c Venting, ii Gas	1B2b Natural gas, ii Transmission	
	6C Waste Incineration non biogenic	6.C	1.A1a	Waste Incineration plants are used for energy and heat production and are included in energy statistics
CH ₄	1A1a Other fuel, 1A2f Other fuel, 1A4a Other fuel	1A1a Other fuel, 1A2f Other fuel, 1A4a Other fuel	1A1a Biomass, 1A2f Biomass, 1A4a Biomass	Municipal waste consists of a biomass part and a plastic (fossil fuel) part. The CO ₂ emission from combustion of the plastic part of waste is reported in the fuel category Other fuel and thus included in the national total. The CO ₂ emission from the biomass part of municipal waste is included in the fuel category Biomass. The fuel consumption, CH ₄ emission and N ₂ O emission from combustion municipal waste (biomass part AND plastic part of waste) is reported in the fuel category Biomass.
	1B2b Natural gas, iii Other leakage	1B2b Natural gas, iii Other leakage	1B2b Natural gas, ii Transmission	
	1B2c Venting, ii Gas	1B2c Venting, ii Gas	1B2b Natural gas, ii Transmission	
	4D2 Agricultural Soils - Animal Production	4D2	4B	CH ₄ emission from animal on pasture is included in the emission given in CRF table 4s1, 4B
	6B Wastewater Handling-Industrial WW	6B1	6B2	The methodology used estimates emissions from Industrial and Domestic and Commercial WW together
	6C Waste Incineration non biogenic	6C	1.A1a	Waste Incineration plants are used for energy and heat production and are included in energy statistics
N ₂ O	1A1a Other fuel, 1A2f Other fuel, 1A4a Other fuel	1A1a Other fuel, 1A2f Other fuel, 1A4a Other fuel	1A1a Biomass, 1A2f Biomass, 1A4a Biomass	Explanation as above for CH ₄ for the same category
	6B Wastewater Handling-Industrial WW	6B1	6B2	The methodology used estimates emissions from Industrial and Domestic and Commercial WW together
	6C Waste Incineration non biogenic	6C	1.A1a	Waste Incineration plants are used for energy and heat production and are included in energy statistics
HFCs				
PFCs				
SF ₆				

⁽¹⁾ Please, clearly indicate sources and sinks which are considered in the IPCC Guidelines but are not considered in the submitted inventory. Explain the reason for excluding these sources and sinks, in order to avoid arbitrary interpretations. An entry should be made for each source/sink category for which the indicator "NE" is entered in the sectoral tables.

⁽²⁾ Indicate omitted source/sink following the IPCC source/sink category structure (e.g. sector: Waste, source category: Wastewater Handling).

⁽³⁾ Please clearly indicate sources and sinks in the submitted inventory that are allocated to a sector other than that indicated by the IPCC Guidelines. Show the sector indicated in the IPCC Guidelines and the sector to which the source or sink is allocated in the submitted inventory. Explain the reason for reporting these sources and sinks in a different sector. An entry should be made for each source/sink for which the indicator "IE" is used in the sectoral tables.

Annex 6.1

Annex 6.1. Additional information to be considered as part of the NIR submission (where relevant) or other useful reference information

Annual emission inventories 1990-2003 CRF Table 10 for the Kingdom of Denmark

In previous NIRs we included the full CRF tables in the NIR itself as well as we submitted the CRF as spreadsheet files. In this NIR we only include the trend tables 1990-2003 (CRF Table 10 sheet 1-5) as they appear in the CRF 2003 spreadsheet file, Tables A6.1.1-6.1.5. The full CRF tables 1990-2003 as spreadsheets are submitted separately.

The Tables enclosed in this Annex, Tables A6.1.1-6.1.5 are for the Kingdom of Denmark, i.e. Denmark, Faroe Islands and Greenland.

Table A6.1.1

TABLE 10 EMISSIONS TRENDS (CO₂)

(Sheet 1 of 5)

Kingdom DK

2003

2005, Apr15

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year ⁽¹⁾	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	(Gg)														
1. Energy	0.00	51 502.17	62 014.65	56 106.89	58 411.05	62 026.09	58 991.95	72 323.71	62 649.65	58 595.28	55 792.36	51 289.87	52 879.10	52 535.29	57 634.90
A. Fuel Combustion (Sectoral Approach)	0.00	51 238.74	61 496.64	55 572.68	57 942.72	61 558.48	58 626.70	71 923.33	62 084.64	58 173.01	54 894.54	50 695.65	52 245.82	51 999.92	57 085.08
1. Energy Industries		26 173.20	35 113.22	30 082.25	31 627.29	35 351.77	31 934.17	44 320.89	35 084.13	31 380.85	28 231.12	25 113.91	26 399.69	26 552.92	31 401.90
2. Manufacturing Industries and Construction		5 376.37	5 799.92	5 501.77	5 438.07	5 697.16	5 889.61	6 012.34	6 018.67	5 970.25	6 019.81	5 786.23	5 803.79	5 558.56	5 404.21
3. Transport		10 441.37	10 916.69	11 046.38	11 237.36	11 684.89	11 823.43	12 028.40	12 159.47	12 190.50	12 253.10	12 117.62	12 142.32	12 318.77	12 785.27
4. Other Sectors		9 128.79	9 380.12	8 801.50	9 402.87	8 573.14	8 727.61	9 385.78	8 651.54	8 427.38	8 208.16	7 567.36	7 803.15	7 480.90	7 401.72
5. Other		119.01	286.69	140.79	237.13	251.52	251.89	175.92	170.83	204.03	182.35	110.53	96.87	88.78	91.98
B. Fugitive Emissions from Fuels	0.00	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
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
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
2. Industrial Processes	0.00	1 067.54	1 239.30	1 356.00	1 368.66	1 369.49	1 374.87	1 446.33	1 612.43	1 618.46	1 538.93	1 574.17	1 605.87	1 601.40	1 488.18
A. Mineral Products		1 037.36	1 209.11	1 325.81	1 335.95	1 334.25	1 334.57	1 409.40	1 575.56	1 574.85	1 494.14	1 530.77	1 556.10	1 598.28	1 485.51
B. Chemical Industry		1.74	1.74	1.74	1.74	1.74	1.74	1.74	1.87	1.42	1.76	2.68	3.10	3.12	2.67
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	0.00	0.00
D. Other Production		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
E. Production of Halocarbons and SF ₆															
F. Consumption of Halocarbons and SF ₆															
G. Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Solvent and Other Product Use		316.89	304.61	292.32	280.03	267.74	242.45	265.35	262.28	195.33	192.07	212.20	130.08	151.24	205.59
4. Agriculture	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
A. Enteric Fermentation															
B. Manure Management															
C. Rice Cultivation															
D. Agricultural Soils ⁽²⁾		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
E. Prescribed Burning of Savannas															
F. Field Burning of Agricultural Residues															
G. Other															
5. Land-Use Change and Forestry ⁽³⁾	0.00	158.29	-112.75	-252.39	-466.23	-330.26	-234.45	-422.45	-442.87	-819.06	-870.19	1 781.54	-1 157.93	-1 475.74	-1 204.28
A. Changes in Forest and Other Woody Biomass Stocks		-2 832.00	-3 013.00	-3 000.00	-3 215.00	-3 100.00	-2 992.00	-3 064.00	-3 153.00	-3 313.00	-3 311.00	-653.00	-3 539.00	-3 813.00	-3 533.00
B. Forest and Grassland Conversion		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
C. Abandonment of Managed Lands		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
D. CO ₂ Emissions and Removals from Soil		2 990.29	2 900.25	2 747.61	2 748.77	2 769.74	2 757.55	2 641.55	2 710.13	2 493.94	2 440.81	2 434.54	2 381.07	2 337.26	2 328.72
E. Other		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6. Waste	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
A. Solid Waste Disposal on Land															
B. Waste-water Handling															
C. Waste Incineration															
D. Other															
7. Other (please specify)	0.00	1 333.00	1 291.00	1 244.00	536.00	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
Greenland and Faroe Islands total		1 333.00	1 291.00	1 244.00	536.00	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
Total Emissions/Removals with LUCF ⁽⁴⁾	0.00	54 377.90	64 736.80	58 746.81	60 129.50	64 371.06	61 438.82	74 754.93	65 215.48	60 756.00	57 883.17	56 215.79	54 865.12	54 180.19	59 549.39
Total Emissions without LUCF ⁽⁴⁾	0.00	54 219.61	64 849.56	58 999.21	60 595.74	64 701.32	61 673.27	75 177.38	65 658.35	61 575.06	58 753.36	54 434.25	56 023.05	55 655.93	60 753.67
Memo Items:															
International Bunkers	0.00	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	5 317.55
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	2 187.52
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
Multilateral Operations		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
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	7 637.26	8 383.05	9 107.71

Table A6.1.2

TABLE 10 EMISSIONS TRENDS (CH₄)
(Sheet 2 of 5)

Kingdom DK

2003

2005, Apr15

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year ¹	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
		(Gg)													
Total Emissions	0.00	271.51	276.38	277.95	286.30	286.99	291.75	297.38	291.38	288.61	284.41	283.87	288.06	284.50	280.65
1. Energy	0.00	14.15	16.15	16.71	20.20	24.43	31.52	36.42	36.65	34.83	35.06	34.38	36.07	35.52	36.71
A. Fuel Combustion (Sectoral Approach)	0.00	8.88	9.96	10.70	13.08	16.39	22.34	27.30	27.04	28.29	28.17	27.58	29.00	28.68	28.30
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
2. Manufacturing Industries and Construction		0.78	0.82	0.79	0.81	0.83	0.93	1.35	1.36	1.44	1.45	1.64	1.69	1.65	1.62
3. Transport		2.69	2.97	3.11	3.38	3.55	3.71	3.98	3.82	3.66	3.58	3.44	3.40	3.15	3.10
4. Other Sectors		4.29	4.62	4.95	5.49	5.64	6.18	6.99	7.34	7.48	7.50	7.65	7.84	7.87	7.87
5. Other		0.01	0.02	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
B. Fugitive Emissions from Fuels	0.00	5.27	6.19	6.02	7.12	8.04	9.18	9.13	9.61	6.54	6.89	6.80	7.06	6.85	8.41
1. Solid Fuels		3.45	3.97	3.91	4.79	5.61	6.30	6.36	6.53	3.47	3.37	3.04	3.28	2.97	4.43
2. Oil and Natural Gas		1.83	2.22	2.11	2.33	2.43	2.88	2.76	3.08	3.07	3.51	3.76	3.78	3.88	3.98
2. Industrial Processes	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
A. Mineral Products		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
B. Chemical Industry		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
C. Metal Production		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
D. Other Production															
E. Production of Halocarbons and SF ₆															
F. Consumption of Halocarbons and SF ₆															
G. Other		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Solvent and Other Product Use															
A. Agriculture	0.00	183.46	184.97	185.37	189.39	187.71	187.54	188.59	184.29	186.33	180.58	181.40	183.53	179.73	176.45
A. Enteric Fermentation		148.09	147.90	145.82	147.30	146.69	146.61	147.06	142.24	142.58	137.40	136.78	138.00	133.71	130.17
B. Manure Management		35.37	37.08	39.55	42.09	41.03	40.93	41.53	42.05	43.75	43.18	44.62	45.53	46.02	46.28
C. Rice Cultivation		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
D. Agricultural Soils		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
E. Prescribed Burning of Savannas		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
F. Field Burning of Agricultural Residues		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
G. Other		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5. 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
A. Changes in Forest and Other Woody Biomass Stocks															
B. Forest and Grassland Conversion		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
C. Abandonment of Managed Lands															
D. CO ₂ Emissions and Removals from Soil															
E. Other		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6. Waste	0.00	73.05	74.37	74.99	75.83	73.94	71.79	71.47	69.50	66.53	67.86	67.13	67.49	68.27	66.51
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	55.06	54.90
B. Waste-water Handling		9.52	9.72	9.93	10.14	10.35	10.57	10.78	11.99	11.21	11.16	10.36	10.92	13.21	11.62
C. Waste Incineration		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
D. Other		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7. Other (please specify)	0.00	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
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
Memo Items:															
International Bunkers	0.00	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
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
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
Multilateral Operations		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
CO ₂ Emissions from Biomass															

Table A6.1.3

TABLE 10 EMISSIONS TRENDS (N₂O)

(Sheet 3 of 5)

Kingdom DK

2003

2005, Apr15

GREENHOUSE GAS SOURCE AND SINK CATEGORIE	Base year ¹	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
		(Gg)													
Total Emissions	0.00	34.63	34.22	32.74	32.09	31.62	31.23	30.34	29.92	29.60	28.61	27.89	27.13	26.02	26.10
1. Energy	0.00	1.90	2.29	2.17	2.29	2.48	2.46	2.93	2.74	2.65	2.63	2.55	2.65	2.71	2.94
A. Fuel Combustion (Sectoral Approach)	0.00	1.90	2.28	2.16	2.28	2.48	2.45	2.93	2.73	2.64	2.62	2.54	2.64	2.70	2.93
1. Energy Industries		0.89	1.17	1.01	1.06	1.17	1.05	1.44	1.14	1.01	0.92	0.82	0.87	0.89	1.06
2. Manufacturing Industries and Construction		0.18	0.19	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.19	0.18	0.18	0.19	0.18
3. Transport		0.47	0.55	0.61	0.67	0.79	0.87	0.94	1.05	1.12	1.18	1.23	1.27	1.32	1.38
4. Other Sectors		0.36	0.37	0.35	0.36	0.34	0.34	0.35	0.34	0.32	0.32	0.30	0.31	0.31	0.31
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
B. Fugitive Emissions from Fuels	0.00	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
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
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
2. Industrial Processes	0.00	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
A. Mineral Products		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
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
C. Metal Production		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
D. Other Production															
E. Production of Halocarbons and SF ₆															
F. Consumption of Halocarbons and SF ₆															
G. Other		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Solvent and Other Product Use	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
4. Agriculture	0.00	29.01	28.50	27.53	26.87	26.16	25.51	24.41	24.15	24.05	22.62	21.79	21.34	20.53	19.98
A. Enteric Fermentation															
B. Manure Management		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	1.81
C. Rice Cultivation															
D. Agricultural Soils		26.80	26.31	25.33	24.67	24.02	23.44	22.33	22.08	21.95	20.59	19.85	19.39	18.63	18.17
E. Prescribed Burning of Savannas		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
F. Field Burning of Agricultural Residues		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
G. Other		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5. 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
A. Changes in Forest and Other Woody Biomass Stocks															
B. Forest and Grassland Conversion		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
C. Abandonment of Managed Lands															
D. CO ₂ Emissions and Removals from Soil															
E. Other		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6. Waste	0.00	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	0.20
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	0.20
C. Waste Incineration		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
D. Other		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7. Other (please specify)	0.00	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
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
Memo Items:															
International Bunkers	0.00	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
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	0.08
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
Multilateral Operations		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
CO₂ Emissions from Biomass															

Table A6.1.4

TABLE 10 EMISSION TRENDS (HFCs, PFCs and SF₆)
(Sheet 4 of 5)

Kingdom DK

2003

2005, Apr15

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year ⁽¹⁾	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	(Gg)														
Emissions of HFCs ⁽⁵⁾ - CO ₂ equivalent (Gg)	0,00	0,00	0,00	3,44	93,93	134,53	217,73	329,30	323,75	411,20	502,98	604,64	647,32	672,06	695,48
HFC-23		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
HFC-32		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,01	0,01	0,01
HFC-41		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
HFC-43-10mee		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
HFC-125		0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,02	0,02	0,03	0,04	0,05	0,05	0,05
HFC-134		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
HFC-134a		0,00	0,00	0,00	0,07	0,10	0,15	0,20	0,17	0,21	0,23	0,25	0,27	0,28	0,27
HFC-152a		0,00	0,00	0,00	0,03	0,05	0,04	0,03	0,02	0,01	0,04	0,02	0,01	0,01	0,00
HFC-143		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
HFC-143a		0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,01	0,02	0,03	0,04	0,04	0,04	0,05
HFC-227ea		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
HFC-236fa		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
HFC-245ca		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
Emissions of PFCs ⁽⁵⁾ - CO ₂ equivalent (Gg)	0,00	0,00	0,00	0,00	0,00	0,05	0,50	1,66	4,12	9,10	12,48	17,89	22,13	22,17	19,34
CF ₄		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
C ₂ F ₆		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
C ₃ F ₈		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
C ₄ F ₁₀		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
c-C ₄ F ₈		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
C ₅ F ₁₂		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
C ₆ F ₁₄		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
Emissions of SF ₆ ⁽⁵⁾ - CO ₂ equivalent (Gg)	0,00	44,45	63,50	89,15	101,17	122,06	107,36	60,99	73,09	59,46	65,39	59,25	30,43	25,01	31,37
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

Table A6.1.5

TABLE 10 EMISSION TRENDS (SUMMARY)
(Sheet 5 of 5)Kingdom DK
2003
2005, Apr15

GREENHOUSE GAS EMISSIONS	Base year ⁽¹⁾	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	CO ₂ equivalent (Gg)														
Net CO ₂ emissions/removals		54.377,90	64.736,80	58.746,81	60.129,50	64.371,06	61.438,82	74.754,93	65.215,48	60.756,00	57.883,17	56.215,79	54.865,12	54.180,19	59.549,39
CO ₂ emissions (without LUCF) ⁽⁶⁾		54.219,61	64.849,56	58.999,21	60.595,74	64.701,32	61.673,27	75.177,38	65.658,35	61.575,06	58.753,36	54.434,25	56.023,05	55.655,93	60.753,67
CH ₄		5.701,78	5.803,95	5.837,04	6.012,25	6.026,84	6.126,82	6.244,94	6.118,88	6.060,72	5.972,60	5.961,22	6.049,36	5.974,55	5.893,69
N ₂ O		10.735,92	10.608,63	10.149,21	9.946,99	9.802,85	9.682,50	9.404,43	9.275,02	9.174,61	8.869,54	8.644,74	8.411,47	8.066,38	8.091,00
HFCs		0,00	0,00	3,44	93,93	134,53	217,73	329,30	323,75	411,20	502,98	604,64	647,32	672,06	695,48
PFCs		0,00	0,00	0,00	0,00	0,05	0,50	1,66	4,12	9,10	12,48	17,89	22,13	22,17	19,34
SF ₆		44,45	63,50	89,15	101,17	122,06	107,36	60,99	73,09	59,46	65,39	59,25	30,43	25,01	31,37
Total (with net CO ₂ emissions/removals)		70.860,06	81.212,88	74.825,65	76.283,85	80.457,40	77.573,74	90.796,25	81.010,34	76.471,10	73.306,16	71.503,52	70.025,83	68.940,36	74.280,27
Total (without CO ₂ from LUCF) ⁽⁶⁾		70.701,76	81.325,64	75.078,04	76.750,08	80.787,65	77.808,19	91.218,70	81.453,22	77.290,16	74.176,36	69.721,98	71.183,76	70.416,09	75.484,55

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year ⁽¹⁾	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	CO ₂ equivalent (Gg)														
1. Energy		52.389,52	63.064,65	57.130,09	59.544,52	63.309,19	60.415,19	73.998,29	64.267,45	60.147,70	57.345,33	52.801,86	54.458,28	54.120,86	59.317,73
2. Industrial Processes		2.154,90	2.257,63	2.292,17	2.358,68	2.432,65	2.604,31	2.672,60	2.861,61	2.904,73	3.069,99	3.259,45	3.191,05	3.094,71	3.129,04
3. Solvent and Other Product Use		316,89	304,61	292,32	280,03	267,74	242,45	265,35	262,28	195,33	192,07	212,20	130,08	151,24	205,59
4. Agriculture		12.845,26	12.719,76	12.428,68	12.306,59	12.051,60	11.845,36	11.526,18	11.356,92	11.368,47	10.805,70	10.565,13	10.470,01	10.137,69	9.898,00
5. Land-Use Change and Forestry ⁽⁷⁾		158,29	-112,75	-252,39	-466,23	-330,26	-234,45	-422,45	-442,87	-819,06	-870,19	1.781,54	-1.157,93	-1.475,74	-1.204,28
6. Waste		1.621,65	1.645,23	1.648,10	1.683,25	1.644,96	1.592,67	1.570,18	1.524,66	1.463,14	1.486,98	1.475,12	1.474,59	1.491,86	1.457,46
7. Other		1.373,54	1.333,77	1.286,68	577,01	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

Annex 6.2 Additional information to be considered as part of the NIR submission (where relevant) or other useful reference information – Greenland/Faroe islands

CO₂ emissions in Greenland and the Faroe Islands

In the Faroe Islands a major work was made 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 CO₂, CH₄ and N₂O for the years 1990-2001.

An update of this work has recently been made (Heilsufrøðiliga Starvsstovan, 2005). The results reported in the latter work is however incomplete as regards the emission sources included, and thus the current 2002 estimate is used also for 2003.

For Greenland only totals for CO₂ emissions from fossil fuels are reported. However, fossil fuels are expected to be the most important sources of greenhouse gases in this region. Figures for CO₂ emissions from 1990 to 2003 are given in the table below.

The significant increase in CO₂ emissions from 1998 to 2001 is mainly due to more fuel use in the fishery, public electricity and manufacturing industry sectors, while the CH₄ and N₂O emission increases (the Faroe Islands) are due to rising activity in the agricultural sector.

The possibilities for corresponding improvement in statistics and greenhouse gas inventories in both Greenland and the Faroe Islands will be investigated.

Table 1 Estimation of greenhouse gas emissions in Greenland and the Faroe Islands 1990 –2003.

	2	Green	Faroe Islands		
		land			
			Gg CO₂	Mg CH₄	Mg N₂O
1990			624	709	853
1991			609	682	885
1992			594	650	881
1993			0	536	875
1994			494	544	906
1995			523	541	909
1996			564	578	904
1997			575	559	935
1998			550	616	908
1999			585	645	920
2000			659	699	959
2001			617	791	973
2002			577	791	973
2003			634	791	973

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 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 Gg CO2 eq	Input data Gg CO2 eq	Input data %	Input data %	%	%	%	%	%	%	%
Stationary Combustion, Coal	CO2	24077	22609	1	5	5,099	1,562	-0,044	0,326	-0,218	0,461	0,510
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	108	3	5	5,831	0,008	-0,001	0,002	-0,003	0,007	0,007
Stationary Combustion, Petroleum coke	CO2	410	779	3	5	5,831	0,062	0,005	0,011	0,025	0,048	0,054
Stationary Combustion, Plastic waste	CO2	349	649	5	5	7,071	0,062	0,004	0,009	0,020	0,066	0,069
Stationary Combustion, Residual oil	CO2	2505	2120	2	2	2,828	0,081	-0,008	0,031	-0,016	0,087	0,088
Stationary Combustion, Gas oil	CO2	4564	2918	4	5	6,403	0,253	-0,028	0,042	-0,140	0,238	0,276
Stationary Combustion, Kerosene	CO2	366	24	4	5	6,403	0,002	-0,005	0,000	-0,026	0,002	0,026
Stationary Combustion, Orimulsion	CO2	0	154	1	2	2,236	0,005	0,002	0,002	0,004	0,003	0,005
Stationary Combustion, Natural gas	CO2	4330	11152	3	1	3,162	0,478	0,094	0,161	0,094	0,683	0,689
Stationary Combustion, LPG	CO2	164	74	4	5	6,403	0,006	-0,001	0,001	-0,007	0,006	0,009
Stationary Combustion, Refinery gas	CO2	806	942	3	5	5,831	0,074	0,001	0,014	0,006	0,058	0,058
Stationary combustion plants, gas engines	CH4	6	391	2,2	40	40,060	0,212	0,006	0,006	0,222	0,018	0,222
Stationary combustion plants, other	CH4	115	130	2,2	100	100,024	0,177	0,000	0,002	0,012	0,006	0,013
Stationary combustion plants	N2O	398	440	2,2	1000	1000,002	5,964	0,000	0,006	0,239	0,020	0,240
Transport, Road transport	CO2	9351	11864	2	5	5,385	0,866	0,027	0,171	0,137	0,484	0,503
Transport, Military	CO2	119	92	2	5	5,385	0,007	-0,001	0,001	-0,003	0,004	0,005
Transport, Railways	CO2	297	218	2	5	5,385	0,016	-0,001	0,003	-0,007	0,009	0,011
Transport, Navigation (small boats)	CO2	67	140	56	5	56,223	0,107	0,001	0,002	0,005	0,160	0,160
Transport, Navigation (large vessels)	CO2	484	426	2	5	5,385	0,031	-0,001	0,006	-0,006	0,017	0,019
Transport, Fisheries	CO2	771	632	2	5	5,385	0,046	-0,003	0,009	-0,014	0,026	0,029
Transport, Agriculture	CO2	1318	1219	26	5	26,476	0,437	-0,003	0,018	-0,013	0,647	0,647
Transport, Forestry	CO2	5	4	26	5	26,476	0,002	0,000	0,000	0,000	0,002	0,002
Transport, Industry (mobile)	CO2	778	742	40	5	40,311	0,405	-0,001	0,011	-0,006	0,606	0,606
Transport, Residential	CO2	87	82	51	5	51,245	0,057	0,000	0,001	-0,001	0,085	0,085
Transport, Civil aviation	CO2	243	138	10	5	11,180	0,021	-0,002	0,002	-0,009	0,028	0,029
Transport, Road transport	CH4	55	62	2	40	40,050	0,034	0,000	0,001	0,002	0,003	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	1	2	56	100	114,612	0,004	0,000	0,000	0,002	0,003	0,003
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	2	26	100	103,325	0,003	0,000	0,000	0,000	0,001	0,001
Transport, Forestry	CH4	0	0	26	100	103,325	0,000	0,000	0,000	0,000	0,000	0,000

Transport, Industry (mobile)	CH4	3	3	40	100	107,703	0,005	0,000	0,000	0,000	0,003	0,003
Transport, Residential	CH4	3	3	51	100	112,254	0,004	0,000	0,000	-0,001	0,003	0,003
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	131	416	2	50	50,040	0,282	0,004	0,006	0,199	0,017	0,200
Transport, Military	N2O	1	1	2	1000	1000,002	0,020	0,000	0,000	0,002	0,000	0,002
Transport, Railways	N2O	3	2	2	1000	1000,002	0,025	0,000	0,000	-0,012	0,000	0,012
Transport, Navigation (small boats)	N2O	1	1	56	1000	1001,567	0,014	0,000	0,000	0,006	0,001	0,006
Transport, Navigation (large vessels)	N2O	9	8	2	1000	1000,002	0,113	0,000	0,000	-0,025	0,000	0,025
Transport, Fisheries	N2O	15	12	2	1000	1000,002	0,168	0,000	0,000	-0,052	0,001	0,052
Transport, Agriculture	N2O	17	16	26	1000	1000,338	0,212	0,000	0,000	-0,034	0,008	0,035
Transport, Forestry	N2O	0	0	26	1000	1000,338	0,000	0,000	0,000	0,000	0,000	0,000
Transport, Industry (mobile)	N2O	10	10	40	1000	1000,800	0,134	0,000	0,000	-0,016	0,008	0,018
Transport, Residential	N2O	1	1	51	1000	1001,300	0,008	0,000	0,000	-0,001	0,001	0,001
Transport, Civil aviation	N2O	3	3	10	1000	1000,050	0,034	0,000	0,000	-0,013	0,001	0,013
Energy, fugitive emissions, oil and natural gas	CO2	263	550	15	5	15,811	0,118	0,004	0,008	0,019	0,168	0,169
Energy, fugitive emissions, solid fuels	CH4	72	93	2	200	200,010	0,252	0,000	0,001	0,046	0,004	0,046
Energy, fugitive emissions, oil and natural gas	CH4	38	84	15	50	52,202	0,059	0,001	0,001	0,031	0,026	0,040
Energy, fugitive emissions, oil and natural gas	N2O	1	3	15	50	52,202	0,002	0,000	0,000	0,001	0,001	0,001
6 A. Solid Waste Disposal on Land	CH4	1334	1153	10	40,8	42,008	0,656	-0,004	0,017	-0,158	0,235	0,283
6 B. Wastewater Handling	CH4	200	244	20	35	40,311	0,133	0,000	0,004	0,016	0,100	0,101
6 B. Wastewater Handling	N2O	88	61	10	30	31,623	0,026	0,000	0,001	-0,014	0,012	0,019
2A1 Cement production	CO2	882	1370	1	2	2,236	0,042	0,006	0,020	0,012	0,028	0,031
2A2 Lime production	CO2	138	102	5	5	7,071	0,010	-0,001	0,001	-0,003	0,010	0,011
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	2	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	895	2	25	25,080	0,304	-0,003	0,013	-0,078	0,037	0,086
2F Consumption of HFC	HFC	218	695	10	50	50,990	0,481	0,007	0,010	0,334	0,142	0,363
2F Consumption of PFC	PFC	1	19	10	50	50,990	0,013	0,000	0,000	0,014	0,004	0,014
2F Consumption of SF6	SF6	107	31	10	50	50,990	0,022	-0,001	0,000	-0,060	0,006	0,060
4A Enteric Fermentation	CH4	3110	2734	10	8	12,806	0,474	-0,008	0,039	-0,067	0,558	0,562
4B Manure Management	CH4	743	972	10	100	100,499	1,323	0,003	0,014	0,261	0,198	0,328
4B Manure Management	N2O	685	560	10	100	100,499	0,763	-0,002	0,008	-0,244	0,114	0,270
4D Agricultural Soils	N2O	8308	5632	7,6	19,6	21,022	1,604	-0,046	0,081	-0,909	0,874	1,260
Total		69293	73803				45,699					4,411
Total uncertainties				Overall uncertainty i the year (%):		6,760	Trend uncertainty (%):			2,100		

Annex 8 Other annexes – (Any other relevant information)

2.1.1 Quality Control

The QC has 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 *Point for Measuring (PM)* is identified as building blocks for a solid QC. The levels refer to the data structure outlined in Figure 2. This part of the development for QC is still under discussion and may thus be adjusted during 2005.

Level 1

Transparency

The reasoning behind any specific value of external data has to be perceptible.

PM 1.1: One to one references for any external data source has to be available for any single number in any data set.

The data at level 1 has to be perceptible in relation to inventory work at higher levels, where questions regarding the output of the emission inventory can be assessed by tracking back to the base set.

PM 1.2: The data Id at level 1 has to be linked directly to the Ids used in higher level data sets.

Consistency

The consistency has to be kept as much as possible at level 1

PM 1.3: The origin of external data has to be preserved when it is possible without damaging other PM's

Comparability

Not relevant PM at this level

Completeness

The collection of external data needs to be complete in order not to miss important and potential available information

PM 1.4: Documentation showing that all possible national data sources are included by setting up the reasoning for the selection of

Accuracy

The best available external data sources have to be applied.

PM 1.6: Quantification of the uncertainty level of every single data value including the reasoning for the specific values.

The data value uncertainty has to be quantified

PM 1.5: Documentation for external expertise in order to secure the delivery of highest possible accuracy of data

Control of values in order to trace for possible miscalculation and errors

PM 1.7:

- Check of time series of the CRF and SNAP source categories as they are found in the Corinair databases. Considerable trends and changes are checked and explained.

- Comparison to inventory of the previous year on the level of the categories of the CRF as well as on SNAP source categories. Any major changes are checked, verified, etc.

- Total emissions when aggregated to CRF source categories are compared to totals based on SNAP source categories (control of data transfer).

Robustness

The gathering of external data shall not be dependent on specific personal relations between employees.

PM 1.8: Explicit agreements between the external institution of data delivery and NERI about the condition of delivery

Correctness

The data in external data sources has to be represented correctly in local databases.

PM 1.9: At least two employees shall have a detailed insight into the gathering of every external data set.

PM 1.10: Show a one to one correctness between external data sources and the databases in house, which are linked to higher levels in the

Level 2

Transparency

The theoretical and logical reasoning for any calculation has to be perceptible.

PM 2.1: All calculations need to be clearly described in a document, in which the following factors are addressed:

1. The calculation principle and equations used
2. The theoretical reasoning for mathematical methods
3. Explicit listing of assumptions behind the methods
4. Clear reference to data set at level 1

Consistency

The calculations shall secure the conditions for consistency at higher level activities

PM 2.2: An explicit description in order to keep consistency at higher level activities needs to accompany any change in the calculation procedure at level 2.

PM 2.3: Identify parameters (e.g. activity data, constants) that are common to multiple source categories and confirm that there is consistency in the values used for these parameters in the emission calculations

Comparability

No relevant PM at this level

Completeness

The applied mathematical procedures shall be so complete as possible in the description.

PM 2.4: Assessment of the ignorance in the data sources (most important missing external information for data sources):

- Missing knowledge about the relationship needs to interpret existing data sources
- Missing accessibility to critical data sources

Accuracy

The known uncertainty of data values at level 1 has to be included in the calculations at level 2.

PM 2.5: Uncertainty assessment for every data sources as input to level 4 in relation to type of variability (Distribution as: normal, log normal or other type of variability)

PM 2.6: Uncertainty assessment for every data sources as input to level 4 in relation to scale of variability (size of variation intervals)

Robustness

The work of calculation shall not be uniquely dependent on a single person in the inventory working group.

PM 2.7: Any calculation at level 2 shall be anchored to two responsible persons that can replace each other in the technical issue of performing the calculations

Correctness

The data processing and modelling for emission inventory has to be done correctly

PM 2.8: Show at least once by hand calculation the correctness of every data manipulation

Level 3**Transparency**

The structure of the data set shall support an easy inspection in order to facilitate understanding for the cause of important factors in the inventory results

PM 3.1: The time trend for every single parameter shall be graphically available and easy to map.

The background of every single data value has to be perceptible from the level 1 data set.

PM 3.2: A clear Id shall be given in the data set having reference to level 1

Any value change needs to be traceable

PM 3.3: A manual log table in the emission databases to collect information about recalculations

Consistency

Not relevant PM at this level.

Comparability

Not relevant PM at this level.

Completeness

Not relevant PM at this level.

Accuracy

Not relevant PM at this level.

Robustness

The handling of data and understanding of data structure shall be possible for all persons in the inventory work.

PM 3.4: All persons in the inventory work shall be able to handle and understand all data at level 3.

Correctness

The data at level 3 has to be linked correctly to the data at level 1

PM 3.5: Document a correct connection between all data type at level 3 to data at level 1

Level 4**Transparency**

The background for the uncertainty analysis needs to be transparent.

PM 4.1: The reasoning for the choice of methodology for uncertainty analysis needs to be written explicitly.

The technical implementation of the calculation procedure has to be transparent

PM 4.2: In the calculation sheets there has to be clear link to level 3 data

Consistency

Not relevant PM at this level.

Comparability

The calculations shall be in agreement with international demands of comparability.

PM 4.3: The inventory calculation has to follow the international guidelines suggested by UNFCCC and IPCC.

Completeness

Not relevant PM at this level.

Accuracy

PM 4.4: Documentation of the methodological approach for the uncertainty analysis.

PM 4.5: Quantification of uncertainty

Robustness

The work of calculation shall not be uniquely dependent on a single person in the inventory working group.

PM 4.6: Any calculation at level 4 shall be anchored to two responsible persons that can replace each other in the technical issue of performing the calculations

Correctness

The data processing and modelling for emission inventory has to be done correctly

PM 4.7: Show at least once by hand calculation the correctness of every data manipulation

Level 5

Transparency

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

PM 5.1: The following items from level 2 shall be summarised in the report (from PM 2.1):

1. The calculation principle and equations used
2. The theoretical reasoning for mathematical methods
3. Explicit listing of assumptions behind the methods
4. Clear reference to data set at level 1

Consistency

All international obligations needs to be fulfilled

PM 5.2: The inventory reporting has to follow the international guidelines suggested by UNFCCC and IPCC.

Comparability

PM 5.3: Description of Similarities and differences in relation to other country inventories for the methodological approach.

Completeness

PM 5.4: National and international verification including explanation of the discrepancies.

Accuracy

Robustness

Not relevant PM at this level

Correctness

The data at level 3 has to be linked correctly to the data at level 1

PM 5.6: Document a correct connection between all data type at level 5 to data at level 3

Level 6

Transparency

The background for the results of the inventory needs to be understandable for a broader audience of users.

PM 6.1: External review for evaluation of the communication per-

Consistency

Not relevant PM at this level

Comparability

Not relevant PM at this level

Completeness

External review of the inventory

PM 6.2: Questionnaire to external experts:

1. Can one or more *PMs* be better fulfilled than done?
2. Are the set of *PMs* complete in relation to the quality objectives?

PM 6.3: Description and reasoning for the time schedule of reviewing including the time interval between them (1, 2 or more years)

Accuracy

Not relevant PM at this level.

Robustness

Not relevant PM at this level

Correctness

Not relevant PM at this level

Annex 9 Annual emission inventories 1990-2003 CRF

Table 10 for Denmark

In previous NIRs we included the full CRF tables in the NIR itself as well as we submitted the CRF as spreadsheet files. In this NIR we only include the trend tables 1990-2003 (CRF Table 10 sheet 1-5) as they appear in the CRF 2003 spreadsheet file, Tables 9.1-9.5. The full CRF tables 1990-2003 as spreadsheets are submitted separately.

Table A9.1

TABLE 10 EMISSIONS TRENDS (CO₂)

(Sheet 1 of 5)

Denmark

2003

2005, Mar15

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year ⁽¹⁾	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
		(Gg)													
1. Energy	0.00	51,502.17	62,014.65	56,106.89	58,411.05	62,026.09	58,991.95	72,323.71	62,649.65	58,595.28	55,792.36	51,289.87	52,879.10	52,535.29	57,634.90
A. Fuel Combustion (Sectoral Approach)	0.00	51,238.74	61,496.64	55,572.68	57,942.72	61,558.48	58,626.70	71,923.33	62,084.64	58,173.01	54,894.54	50,695.65	52,245.82	51,999.92	57,085.08
1. Energy Industries		26,173.20	35,113.22	30,082.25	31,627.29	35,351.77	31,934.17	44,320.89	35,084.13	31,380.85	28,231.12	25,113.91	26,399.69	26,552.92	31,401.90
2. Manufacturing Industries and Construction		5,376.37	5,799.92	5,501.77	5,438.07	5,697.16	5,889.61	6,012.34	6,018.67	5,970.25	6,019.81	5,786.23	5,803.79	5,558.56	5,404.21
3. Transport		10,441.37	10,916.69	11,046.38	11,237.36	11,684.89	11,823.43	12,028.40	12,159.47	12,190.50	12,253.10	12,117.62	12,142.32	12,318.77	12,785.27
4. Other Sectors		9,128.79	9,380.12	8,801.50	9,402.87	8,573.14	8,727.61	9,385.78	8,651.54	8,427.38	8,208.16	7,567.36	7,803.15	7,480.90	7,401.72
5. Other		119.01	286.69	140.79	237.13	251.52	251.89	175.92	170.83	204.03	182.35	110.53	96.87	88.78	91.98
B. Fugitive Emissions from Fuels	0.00	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
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
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
2. Industrial Processes	0.00	1,067.54	1,239.30	1,356.00	1,368.66	1,369.49	1,374.87	1,446.33	1,612.43	1,618.46	1,538.93	1,574.17	1,605.87	1,601.40	1,488.18
A. Mineral Products		1,037.36	1,209.11	1,325.81	1,335.95	1,334.25	1,334.57	1,409.40	1,575.56	1,574.85	1,494.14	1,530.77	1,556.10	1,598.28	1,485.51
B. Chemical Industry		1.74	1.74	1.74	1.74	1.74	1.74	1.74	1.87	1.42	1.76	2.68	3.10	3.12	2.67
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	0.00	0.00
D. Other Production		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
E. Production of Halocarbons and SF ₆															
F. Consumption of Halocarbons and SF ₆															
G. Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Solvent and Other Product Use		316.89	304.61	292.32	280.03	267.74	242.45	265.35	262.28	195.33	192.07	212.20	130.08	151.24	205.59
4. Agriculture	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
A. Enteric Fermentation															
B. Manure Management															
C. Rice Cultivation															
D. Agricultural Soils ⁽²⁾		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
E. Prescribed Burning of Savannas															
F. Field Burning of Agricultural Residues															
G. Other															
5. Land-Use Change and Forestry ⁽³⁾	0.00	158.29	-112.75	-252.39	-466.23	-330.26	-234.45	-422.45	-442.87	-819.06	-870.19	1,781.54	-1,157.93	-1,475.74	-1,204.28
A. Changes in Forest and Other Woody Biomass Stocks		-2,832.00	-3,013.00	-3,000.00	-3,215.00	-3,100.00	-2,992.00	-3,064.00	-3,153.00	-3,313.00	-3,311.00	-653.00	-3,539.00	-3,813.00	-3,533.00
B. Forest and Grassland Conversion		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
C. Abandonment of Managed Lands		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
D. CO ₂ Emissions and Removals from Soil		2,990.29	2,900.25	2,747.61	2,748.77	2,769.74	2,757.55	2,641.55	2,710.13	2,493.94	2,440.81	2,434.54	2,381.07	2,337.26	2,328.72
E. Other		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6. Waste	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
A. Solid Waste Disposal on Land															
B. Waste-water Handling															
C. Waste Incineration															
D. Other															
7. Other (please specify)	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
Total Emissions/Removals with LUCF ⁽⁴⁾	0.00	53,044.90	63,445.80	57,502.81	59,593.50	63,333.06	60,374.82	73,612.93	64,081.48	59,590.00	56,653.17	54,857.79	53,457.12	52,812.19	58,124.39
Total Emissions without LUCF ⁽⁴⁾	0.00	52,886.61	63,558.56	57,755.21	60,059.74	63,663.32	60,609.27	74,035.38	64,524.35	60,409.06	57,523.36	53,076.25	54,615.05	54,287.93	59,328.67
Mem o Items:															
International Bunkers	0.00	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	5,317.55
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	2,187.52
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
Multilateral Operations		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
CO₂ 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	7,637.26	8,383.05	9,107.71

Table A9.2

TABLE 10 EMISSIONS TRENDS (CH₄)

(Sheet 2 of 5)

Denmark

2003

2005, Mar15

GREENHOUSE GAS SOURCE AND SINK CATEGORY	Base year ⁽¹⁾	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
(Gg)															
Total Emissions	0.00	270.66	275.49	277.07	285.42	286.09	290.84	296.47	290.44	287.70	283.49	282.91	287.09	283.53	279.68
1. Energy	0.00	14.15	16.15	16.71	20.20	24.43	31.52	36.42	36.65	34.83	35.06	34.38	36.07	35.52	36.71
A. Fuel Combustion (Sectoral Approach)	0.00	8.88	9.96	10.70	13.08	16.39	22.34	27.30	27.04	28.29	28.17	27.58	29.00	28.68	28.30
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
2. Manufacturing Industries and Construction		0.78	0.82	0.79	0.81	0.83	0.93	1.35	1.36	1.44	1.45	1.64	1.69	1.65	1.62
3. Transport		2.69	2.97	3.11	3.38	3.55	3.71	3.98	3.82	3.66	3.58	3.44	3.40	3.15	3.10
4. Other Sectors		4.29	4.62	4.95	5.49	5.64	6.18	6.99	7.34	7.48	7.50	7.65	7.84	7.87	7.87
5. Other		0.01	0.02	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
B. Fugitive Emissions from Fuels	0.00	5.27	6.19	6.02	7.12	8.04	9.18	9.13	9.61	6.54	6.89	6.80	7.06	6.85	8.41
1. Solid Fuels		3.45	3.97	3.91	4.79	5.61	6.30	6.36	6.53	3.47	3.37	3.04	3.28	2.97	4.43
2. Oil and Natural Gas		1.83	2.22	2.11	2.33	2.43	2.88	2.76	3.08	3.07	3.51	3.76	3.78	3.88	3.98
2. Industrial Processes	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
A. Mineral Products		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
B. Chemical Industry		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
C. Metal Production		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
D. Other Production															
E. Production of Halocarbons and SF ₆															
F. Consumption of Halocarbons and SF ₆															
G. Other		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Solvent and Other Product Use															
4. Agriculture	0.00	183.46	184.97	185.37	189.39	187.71	187.54	188.59	184.29	186.33	180.58	181.40	183.53	179.73	176.45
A. Enteric Fermentation		148.09	147.90	145.82	147.30	146.69	146.61	147.06	142.24	142.58	137.40	136.78	138.00	133.71	130.17
B. Manure Management		35.37	37.08	39.55	42.09	41.03	40.93	41.53	42.05	43.75	43.18	44.62	45.53	46.02	46.28
C. Rice Cultivation		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
D. Agricultural Soils		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
E. Prescribed Burning of Savannas		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
F. Field Burning of Agricultural Residues		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
G. Other		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5. 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
A. Changes in Forest and Other Woody Biomass Stocks															
B. Forest and Grassland Conversion		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
C. Abandonment of Managed Lands															
D. CO ₂ Emissions and Removals from Soil															
E. Other		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6. Waste	0.00	73.05	74.37	74.99	75.83	73.94	71.79	71.47	69.50	66.53	67.86	67.13	67.49	68.27	66.51
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	55.06	54.90
B. Waste-water Handling		9.52	9.72	9.93	10.14	10.35	10.57	10.78	11.99	11.21	11.16	10.36	10.92	13.21	11.62
C. Waste Incineration		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
D. Other		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7. Other (please specify)	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
Memo Items:															
International Bunkers	0.00	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
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
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
Multilateral Operations		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
CO₂ Emissions from Biomass															

Table A9.3

TABLE 10 EMISSIONS TRENDS (N₂O)

(Sheet 3 of 5)

Denmark

2003

2005, Mar15

GREENHOUSE GAS SOURCE AND SINK CATEGORY	Base year ⁽¹⁾	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
		(Gg)													
Total Emissions	0.00	34.56	34.14	32.66	32.01	31.54	31.15	30.26	29.83	29.51	28.52	27.79	27.03	25.92	26.00
1. Energy	0.00	1.90	2.29	2.17	2.29	2.48	2.46	2.93	2.74	2.65	2.63	2.55	2.65	2.71	2.94
A. Fuel Combustion (Sectoral Approach)	0.00	1.90	2.28	2.16	2.28	2.48	2.45	2.93	2.73	2.64	2.62	2.54	2.64	2.70	2.93
1. Energy Industries		0.89	1.17	1.01	1.06	1.17	1.05	1.44	1.14	1.01	0.92	0.82	0.87	0.89	1.06
2. Manufacturing Industries and Construction		0.18	0.19	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.19	0.18	0.18	0.19	0.18
3. Transport		0.47	0.55	0.61	0.67	0.79	0.87	0.94	1.05	1.12	1.18	1.23	1.27	1.32	1.38
4. Other Sectors		0.36	0.37	0.35	0.36	0.34	0.34	0.35	0.34	0.32	0.32	0.30	0.31	0.31	0.31
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
B. Fugitive Emissions from Fuels	0.00	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
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
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
2. Industrial Processes	0.00	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
A. Mineral Products		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
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
C. Metal Production		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
D. Other Production															
E. Production of Halocarbons and SF ₆															
F. Consumption of Halocarbons and SF ₆															
G. Other		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Solvent and Other Product Use	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
4. Agriculture	0.00	29.01	28.50	27.53	26.87	26.16	25.51	24.41	24.15	24.05	22.62	21.79	21.34	20.53	19.98
A. Enteric Fermentation															
B. Manure Management		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	1.81
C. Rice Cultivation															
D. Agricultural Soils		26.80	26.31	25.33	24.67	24.02	23.44	22.33	22.08	21.95	20.59	19.85	19.39	18.63	18.17
E. Prescribed Burning of Savannas		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
F. Field Burning of Agricultural Residues		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
G. Other		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5. 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
A. Changes in Forest and Other Woody Biomass Stocks															
B. Forest and Grassland Conversion		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
C. Abandonment of Managed Lands															
D. CO ₂ Emissions and Removals from Soil															
E. Other		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6. Waste	0.00	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	0.20
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	0.20
C. Waste Incineration		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
D. Other		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7. Other (please specify)	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
Memo Items:															
International Bunkers	0.00	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
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	0.08
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
Multilateral Operations	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
CO₂ Emissions from Biomass															

Table A9.4

TABLE 10 EMISSION TRENDS (HFCs, PFCs and SF₆)

(Sheet 4 of 5)

Denmark

2003

2005, Mar15

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year ⁽¹⁾	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	(Gg)														
Emissions of HFCs ⁽⁵⁾ - CO ₂ equivalent (Gg)	0,00	0,00	0,00	3,44	93,93	134,53	217,73	329,30	323,75	411,20	502,98	604,64	647,32	672,06	695,48
HFC-23		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
HFC-32		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,01	0,01	0,01
HFC-41		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
HFC-43-10mee		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
HFC-125		0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,02	0,02	0,03	0,04	0,05	0,05	0,05
HFC-134		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
HFC-134a		0,00	0,00	0,00	0,07	0,10	0,15	0,20	0,17	0,21	0,23	0,25	0,27	0,28	0,27
HFC-152a		0,00	0,00	0,00	0,03	0,05	0,04	0,03	0,02	0,01	0,04	0,02	0,01	0,01	0,00
HFC-143		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
HFC-143a		0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,01	0,02	0,03	0,04	0,04	0,04	0,05
HFC-227ea		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
HFC-236fa		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
HFC-245ca		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
Emissions of PFCs ⁽⁵⁾ - CO ₂ equivalent (Gg)	0,00	0,00	0,00	0,00	0,00	0,05	0,50	1,66	4,12	9,10	12,48	17,89	22,13	22,17	19,34
CF ₄		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
C ₂ F ₆		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
C ₃ F ₈		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
C ₄ F ₁₀		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
c-C ₄ F ₈		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
C ₃ F ₁₂		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
C ₆ F ₁₄		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
Emissions of SF ₆ ⁽⁵⁾ - CO ₂ equivalent (Gg)	0,00	44,45	63,50	89,15	101,17	122,06	107,36	60,99	73,09	59,46	65,39	59,25	30,43	25,01	31,37
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

Table A9.5

TABLE 10 EMISSION TRENDS (SUMMARY)

(Sheet 5 of 5)

Denmark

2003

2005, Mar15

GREENHOUSE GAS EMISSIONS	Base year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	CO ₂ equivalent (Gg)														
Net CO ₂ emissions/removals		53.044,90	63.445,80	57.502,81	59.593,50	63.333,06	60.374,82	73.612,93	64.081,48	59.590,00	56.653,17	54.857,79	53.457,12	52.812,19	58.124,39
CO ₂ emissions (without LUCF) ⁽⁶⁾		52.886,61	63.558,56	57.755,21	60.059,74	63.663,32	60.609,27	74.035,38	64.524,35	60.409,06	57.523,36	53.076,25	54.615,05	54.287,93	59.328,67
CH ₄		5.683,87	5.785,37	5.818,54	5.993,88	6.007,81	6.107,73	6.225,96	6.099,25	6.041,65	5.953,28	5.941,08	6.028,93	5.954,11	5.873,26
N ₂ O		10.713,29	10.584,45	10.125,03	9.924,36	9.778,36	9.657,39	9.379,32	9.248,36	9.148,88	8.842,57	8.614,67	8.380,16	8.035,07	8.059,69
HFCs		0,00	0,00	3,44	93,93	134,53	217,73	329,30	323,75	411,20	502,98	604,64	647,32	672,06	695,48
PFCs		0,00	0,00	0,00	0,00	0,05	0,50	1,66	4,12	9,10	12,48	17,89	22,13	22,17	19,34
SF ₆		44,45	63,50	89,15	101,17	122,06	107,36	60,99	73,09	59,46	65,39	59,25	30,43	25,01	31,37
Total (with net CO ₂ emissions/removals)		69.486,51	79.879,12	73.538,97	75.706,85	79.375,88	76.465,54	89.610,16	79.830,05	75.260,30	72.029,87	70.095,31	68.566,08	67.520,61	72.803,53
Total (without CO ₂ from LUCF) ⁽⁶⁾		69.328,22	79.991,87	73.791,36	76.173,08	79.706,14	76.699,99	90.032,61	80.272,92	76.079,36	72.900,07	68.313,78	69.724,02	68.996,35	74.007,81

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	CO ₂ equivalent (Gg)														
1. Energy		52.389,52	63.064,65	57.130,09	59.544,52	63.309,19	60.415,19	73.998,29	64.267,45	60.147,70	57.345,33	52.801,86	54.458,28	54.120,86	59.317,73
2. Industrial Processes		2.154,90	2.257,63	2.292,17	2.358,68	2.432,65	2.604,31	2.672,60	2.861,61	2.904,73	3.069,99	3.259,45	3.191,05	3.094,71	3.129,04
3. Solvent and Other Product Use		316,89	304,61	292,32	280,03	267,74	242,45	265,35	262,28	195,33	192,07	212,20	130,08	151,24	205,59
4. Agriculture		12.845,26	12.719,76	12.428,68	12.306,59	12.051,60	11.845,36	11.526,18	11.356,92	11.368,47	10.805,70	10.565,13	10.470,01	10.137,69	9.898,00
5. Land-Use Change and Forestry ⁽⁷⁾		158,29	-112,75	-252,39	-466,23	-330,26	-234,45	-422,45	-442,87	-819,06	-870,19	1.781,54	-1.157,93	-1.475,74	-1.204,28
6. Waste		1.621,65	1.645,23	1.648,10	1.683,25	1.644,96	1.592,67	1.570,18	1.524,66	1.463,14	1.486,98	1.475,12	1.474,59	1.491,86	1.457,46
7. Other		0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00