DANISH EMISSION INVENTORIES FOR STATIONARY COMBUSTION PLANTS

Inventories until 2015

Scientific Report from DCE – Danish Centre for Environment and Energy No. 279 2018

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Data sheet

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Abstract: Emission inventories for stationary combustion plants are presented and the methodologies and assumptions used for the inventories are described. The pollutants considered are SO_2, NO_x, NMVOC, CH_4, CO, CO_2, N_2O, NH_3, particulate matter, black carbon, heavy metals, PCDD/F, HCB, PCBs and PAH. The CO_2 emission from stationary combustion was 51.2 % lower in 2015 than in 1990 and the total greenhouse gas emission was 50.5 % lower than in 1990. However, fluctuations in the emission level for CO_2 are large as a result of electricity import/export. A considerable decrease of the SO_2, NO_x and heavy metal emissions is mainly a result of decreased emissions from large power plants and waste incineration plants. The combustion of wood in residential plants has increased considerably in 1990-2007 resulting in increased emission of PAH, particulate matter and black carbon. The emissions have decreased after 2007 due to installation of modern stoves and boilers. The PCDD/F emission decreased since 1990 due to flue gas cleaning on waste incineration plants.

Keywords: Emission, combustion, emission inventory, stationary combustion, power plants, district heating, CHP, co-generation, boiler, engine, incineration, MSW, residential combustion, SO_2, NO_x, NMVOC, CH_4, CO, CO_2, N_2O, particulate matter, black carbon, NH_3, heavy metals, PCDD/F, PAH, HCB, PCB, greenhouse gas

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Contents

List of abbreviations

As	Arsenic
BAT	Best Available Techniques
BC	Black Carbon
BKB	Brown Coal Briquettes
BREF	BAT Reference Document
Cd	Cadmium
CH_4	Methane
CHP	Combined Heat and Power
CLRTAP	Convention on Long-Range Transboundary Air Pollution
CO	Carbon monoxide
CO_2	Carbon dioxide
CORINAIR	CORe INventory on AIR emissions
Cr	Chromium
CRF	Common Reporting Format applied for greenhouse gas emission reporting
Cu	Copper
DEA	Danish Energy Agency
DEPA	Danish Environmental Protection Agency
dl-PCB	Dioxin-like PCB
EEA	European Environment Agency
EMEP	European Monitoring and Evaluation Programme
EU ETS	EU Emission Trading Scheme
GHG	GreenHouse Gas
HCB	HexaChloroBenzene
Hg	Mercury
HM	Heavy Metals
I-Teq	International Toxic Equivalents for dioxins and furans
IEF	Implied Emission Factor
IIR	Informative Inventory Report (2017 update: Nielsen et al., 2017b)
IPCC	Intergovernmental Panel on Climate Change
KCA	Key Category Analysis
LPG	Liquefied Petroleum Gas
LRTAP	Long-Range Transboundary Air Pollution
LULUCF	Land Use, Land-Use Change and Forestry
MSW	Municipal Solid Waste
N_2O	Nitrous oxide
NCV	Net Calorific Value
NECD	European Commissions National Emissions Ceiling Directive
NFR	Nomenclature for Reporting applied for emission reporting for the LRTAP Convention
NH_3	Ammonia
Ni	Nickel
NIR	National Inventory Report (2017 update: Nielsen et al., 2017a)
NMVOC	Non-Methane Volatile Organic Compounds

NO_x	Nitrogen Oxides
PAH	Polycyclic Aromatic Hydrocarbons
Pb	Lead
PCB	PolyChlorinated Biphenyl
PCDD/-F	Poly Chlorinated Dibenzo Dioxins and Furans
PM	Point for Measuring (QA/QC chapter)
PM	Particulate Matter
PM_{10}	Particulate Matter < 2.5 µm
$PM_{2.5}$	Particulate Matter < 10 µm
POP	Persistent Organic Pollutant
Se	Selenium
SNAP	Selected Nomenclature for Air Pollution
SO_2	Sulphur dioxide
TSP	Total Suspended Particulates
UHC	Unburned hydrocarbons
UNECE	United Nations Economic Commission for Europe
Zn	Zinc

Preface

On behalf of the Ministry of the Environment and the Ministry of Climate, Energy and Building, the Danish Centre for Environment and Energy (DCE), Aarhus University, is responsible for the calculation and reporting of the Danish national emission inventory. The inventories are reported to EU and the UNFCCC (United Nations Framework Convention on Climate Change) and to the UNECE CLRTAP (Convention on Long Range Transboundary Air Pollution) conventions.

This report forms part of the documentation for the emission inventories for stationary combustion plants. The report includes both methodology and emission data. The results of inventories up to 2015 are included. The report updates the six reports published in 2004, 2006, 2007, 2009, 2010 and 2014.

The emission factors that refer to the EEA Guidelines have been updated according to the latest update (EEA, 2016).

In addition to the data for stationary combustion, this report also includes two other greenhouse gas (GHG) data sets that are reported to EU:

- Total EU ETS data compared to CRF data
- Emission inventories based on Eurostat data and comparison to national approach

The sector reports are reviewed by external national experts. The external national reviews forms a vital part of the QA activities for the emission inventories for stationary combustion required in IPCC Guidelines (IPCC, 2006). This year, energy statistics experts from the Danish Energy Agency have reviewed chapters related to the use of energy statistics in the emission inventory.

The 2004, 2006, 2009 and 2014 updates of this report were reviewed by Jan Erik Johnsson from the Technical University of Denmark, Bo Sander from Elsam Engineering, Annemette Geertinger from FORCE Technology and Vibeke Vestergaard Nielsen, DCE - Danish Centre for Environment and Energy, Aarhus University.

Summary

Danish emission inventories are prepared on an annual basis and are reported to the United Nations Framework Convention on Climate Change (UNFCCC or Climate Convention) and to the Kyoto Protocol. Furthermore, a greenhouse gas emission inventory is reported to the European Union (EU) due to the EU – as well as the individual member states – being party to the Climate Convention and the Kyoto Protocol.

Danish emission inventories for non-GHGs are prepared on an annual basis and are reported to the UNECE-Convention on Long-Range Transboundary Air Pollution (LRTAP) and EU Directive 2016/2284 on the reduction of national emissions of certain atmospheric pollutants.

Five pollutants (sulphur dioxide, nitrogen oxides, non-methane volatile organic compounds, ammonia and particulate matter with an aerodynamic diameter below 2.5 µm) are estimated for reporting to the European Commission's National Emissions Ceiling Directive (NECD).

The inventories include the following pollutants relevant to stationary combustion: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur dioxide (SO_2), nitrogen oxides (NO_x), non-volatile organic compounds (NMVOC), carbon monoxide (CO), particulate matter (PM), black carbon (BC), ammonia (NH_3), heavy metals (HMs), polyclorinated dibenzodioxins and –furans (PCDD/F), polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB) and hexachlorobenzene (HCB).

The inventories for stationary combustion are based on the Danish energy statistics and on a set of emission factors for various source categories, technologies and fuels. Plant specific emissions for large combustion sources are incorporated into the inventories. This report provides detailed background information on the methodology and references for the input data in the inventory - energy statistics and emission factors.

The emission factors are based either on national references or on international guidebooks (EEA, 2016; IPCC, 2006). The majority of the country-specific emission factors are determined from Danish legislation, Danish research reports, or calculations based on plant-specific emission data from a considerable number of large point sources. The plant-specific emission factors are provided by plant operators, e.g. in PRTR data, other annual environmental reports or in the EU Emission Trading Scheme (ETS).

In the inventory for the year 2015, 76 stationary combustion plants are specified as large point sources. The point sources include large power plants, waste incineration plants, industrial combustion plants and petroleum refining plants. The fuel consumption of these large point sources corresponds to 50 % of the overall fuel consumption of stationary combustion.

The fuel consumption for stationary combustion plants has decreased since 1990. However, the fuel consumption fluctuates due to variation in the import/export of electricity from year to year. In 2015, the total fuel consumption was 23 % lower than in 1990 and the fossil fuel consumption was 45 %

lower than in 1990. The use of coal and oil has decreased whereas the use of natural gas, waste and biomass has increased.

In 2015, stationary combustion accounted for 37 % of the national emission of GHGs (including Land Use, Land-Use Change and Forestry, LULUCF) and 48 % of the CO_2 emission.

Stationary combustion plants account for more than 50 % of the national emission (2015) for the following pollutants: SO_2, PM_{10}, $PM_{2.5}$, BC, the heavy metals As, Cd, Cr, Hg and Se, HCB, PCDD/F and PAH. Furthermore, the emission from stationary combustion plants accounts for more than 10 % of the national emission for the following pollutants: NO_x, NMVOC, CO, TSP and the heavy metals Ni, Pb and Zn. Stationary combustion plants account for less than 10 % of the national emission of CH_4, N_2O, NH_3, the heavy metal Cu, and PCB.

Public electricity and heat production is the most important stationary combustion emission source for CO_2, N_2O, and NO_x.

Residential wood combustion and lean-burn gas engines installed in decentralised combined heating and power (CHP) plants are the two largest emission sources for CH_4.

Residential plants is the most important stationary combustion emission source for CO, NMVOC, PM, BC, PAH and PCDD/F. Wood combustion in residential plants is the predominant emission source.

The main emission sources for SO_2 are industrial plants and public electricity and heat production plants.

Industrial plants, public electricity and heat production plants and residential plants are the main emission sources for the different heavy metals.

CO_2 is the most important greenhouse gas accounting for 97.8 % of the greenhouse gas emission (CO_2 eq.) from stationary combustion. The greenhouse gas (GHG) emission trend follows the CO_2 emission trend closely. Both the CO_2 and the total GHG emission were lower in 2015 than in 1990: CO_2 by 51.2 % and GHG by 50.5 %. However, fluctuations in the GHG emission level are large. The fluctuations in the time series are mainly a result of electricity import/export but also of outdoor temperature variations from year to year that results in fluctuations in the fuel consumption for space heating.

The CH_4 emission from stationary combustion was 43 % higher in 2015 than in 1990. The emission increased until 1996 and decreased after 2004. This time series is related to the considerable number of lean-burn gas engines installed in CHP plants in Denmark during the 1990s. The decline in later years is due to structural changes in the Danish electricity market, which means that the fuel consumption in gas engines has been decreasing. The CH_4 emission from residential plants has increased since 1990 due to increased combustion of wood in residential plants.

The emission of N_2O was 1 % higher in 2015 than in 1990. The fluctuations follow the fluctuations of the fuel consumption, which is a result of import/export of electricity.

SO_2 emission from stationary combustion plants has decreased by 95 % since 1990. The considerable emission decrease is mainly a result of the reduced emission from electricity and heat production plants due to installation of desulphurisation technology and the use of fuels with lower sulphur content. These improvements are a result of sulphur tax laws, legislation concerning sulphur content of fuels, emission ceilings for large power plants and lower emission limit values for several plant categories.

The NO_x emission from stationary combustion plants has decreased by 77 % since 1990. The reduced emission is largely a result of the reduced emission from electricity and heat production due to installation of low NO_x burners, selective catalytic reduction (SCR) units and selective non-catalytic reduction (SNCR) units. The installation of the technical improvements was launched by legislation including emission ceilings for large power plants, lower emission limits for several plant categories and NO_x tax laws. The fluctuations in the emission time series follow fluctuations in electricity import / export.

In 2015, the wood consumption in residential plants was 4.2 times the 1990 level. The consumption of wood in residential plants increased between 1990 and 2007. The increased residential wood consumption until 2007 has caused considerable changes in the emission of NMVOC, CO, PM, BC and PAH from stationary combustion due to the fact that residential wood combustion is a major emission source for these pollutants. However, a change of technology (installation of modern stoves) has caused decreasing emission factors.

The CO emission from stationary combustion has decreased 20 % since 1990. The decreased emission in 2007-2015 is a result of implementation of improved residential wood combustion technologies and the fact that the rapid increase of wood consumption until 2007 have stopped. Furthermore, the emission from straw-fired farmhouse boilers has decreased considerably.

The NMVOC emission from stationary combustion plants has decreased by 3 % from 1990. The emission increased until 2007 and decreased between 2007 and 2014. The increased emission is mainly a result of the increasing wood consumption in residential plants and of the increased use of lean-burn gas engines in CHP plants. The decrease in 2007-2014 is a result of lower emission from residential wood combustion and the low number of operation hours for the lean burn gas engines.

The emission of TSP, PM_{10} and $PM_{2.5}$ has increased by 20-24 % since 1990 due to the increase of wood combustion in residential plants until 2007. After 2007, the emission has decreased due to installation of modern stoves and boilers with lower emission factors. The time series for BC follows the time series for PM.

The emission of PAHs has increased until 2007 and decreased after 2007. This is also a result of the time series for combustion of wood in residential plants.

All the heavy metal emissions have decreased considerably since 1990 – between 41 % and 91 %. This is a result of the installation and improved performance of gas cleaning devices in waste incineration plants and large power plants.

The PCDD/F emission has decreased 67 % since 1990 mainly due to installation of dioxin filters in waste incineration plants. The emission from residential plants has increased due to increased wood consumption. However, the emission factor for residential wood combustion has decreased due to installation of modern stoves and boilers.

The HCB emission has decreased 80 % since 1990 mainly due to improved flue gas cleaning in waste incineration plants. The emission from residential plants has increased in recent years due to increased wood consumption.

The dioxin like PCB emission has decreased 67 % since 1990. The decrease is mainly a result of the flue gas cleaning devices that have been installed in waste incineration plants for dioxin reduction.

The uncertainty level of the Danish greenhouse gas (GHG) emission from stationary combustion is estimated to be within a range of ±2.2 % and the trend in greenhouse gas emission is -50.5 % ± 1.0 %-age points.

An emission inventory including fuel consumption and CO_2 emissions have been estimated based on Eurostat data. The results based on Eurostat data are presented and compared to the Danish emission inventory. The largest differences between the two approaches have been explained. The fuel consumption for transport between mainland Denmark and Greenland and the Faroe Islands is not included in the reporting to Eurostat whereas it is considered domestic in the Danish emission inventory. This causes a difference for liquid fuels used for aviation and navigation. Some calorific values (LCV) applied in the Eurostat data are inaccurate and not in agreement with the Danish energy statistics. This cause differences for several fuels including a considerable difference for coal.

The verified emission data reported under EU ETS Directive 2003/87/EC have been compared to the Danish emission inventory for GHGs. The verified CO_2 emissions add up to 45 % of the total CO_2 emission reported in the Danish emission inventory.

Sammendrag

Opgørelser over de samlede danske luftemissioner rapporteres årligt til klimakonventionen (United Nation Framework Convention on Climate Change, UNFCCC) og Kyotoprotokollen samt til UNECE konventionen om langtransporteret grænseoverskridende luftforurening (UNECE Convention on Long-Range Transboundary Air Pollution, der forkortes LRTAP Convention). Endvidere rapporteres drivhusgasemissionen til EU, fordi EU – såvel som de enkelte medlemslande – har ratificeret klimakonventionen og Kyotoprotokollen. Der udarbejdes også opgørelser til rapportering til Europakommissionens NEC (National Emissions Ceiling) direktiv.

De danske emissioner opgøres og rapporteres af DCE – Nationalt Center for Miljø og Energi ved Aarhus Universitet (AU). Emissionsopgørelserne omfatter følgende stoffer af relevans for stationær forbrænding: CO_2, CH_4, N_2O, SO_2, NO_x, NMVOC, CO, partikler (PM), black carbon (BC), NH_3, tungmetaller (HM), dioxin (PCDD/F), PAH, PCB og HCB.

Emissionsopgørelserne for stationære forbrændingsanlæg (ikke mobile kilder) er baseret på den danske energistatistik og på et sæt emissionsfaktorer for forskellige sektorer, teknologier og brændsler. Anlægsspecifikke emissionsdata for store anlæg, som fx kraftværker, indarbejdes i opgørelserne. Denne rapport giver detaljeret baggrundsinformation om den anvendte metode samt referencer for de data, der ligger til grund for opgørelsen – energistatistikken og emissionsfaktorerne.

Emissionsfaktorerne stammer enten fra danske referencer eller fra internationale guidebøger (EEA, 2016 og IPCC, 2006) udarbejdet til brug for denne type emissionsopgørelser. De danske referencer omfatter miljølovgivning, danske rapporter samt middelværdier baseret på anlægsspecifikke emissionsdata fra et betydeligt antal større værker. Anlægsspecifikke emissionsfaktorer oplyses af anlægsejere, bl.a. i PRTR data, grønne regnskaber og CO_2-kvoteindberetninger.

I emissionsopgørelsen for 2015 er 76 stationære forbrændingsanlæg defineret som punktkilder. Punktkilderne omfatter: kraftværker, decentrale kraftvarmeværker, affaldsforbrændingsanlæg, industrielle forbrændingsanlæg samt raffinaderier. Brændselsforbruget for disse anlæg udgør 50 % af det samlede brændselsforbrug for stationære forbrændingsanlæg.

Brændselsforbruget til stationære forbrændingsanlæg har været faldende siden 1990. Variationen i årlig import/eksport af el medvirker til at brændselsforbruget til stationære forbrændingsanlæg varierer meget fra år til år. I 2015 var det samlede brændselsforbrug 23 % lavere end i 1990, mens det fossile brændselsforbrug var 45 % lavere end i 1990. Forbruget af kul og olie er faldet, mens forbruget af naturgas, affald og biobrændsler er steget.

I 2015 stammede 37 % af den samlede danske emission af drivhusgasser fra stationær forbrænding. For CO_2 var andelen fra stationær forbrænding 48 %.

For følgende stoffer udgør emissionen fra stationær forbrænding over 50 % af den nationale emission: SO_2, PM_{10}, $PM_{2.5}$, BC, tungmetallerne As, Cd, Cr, Hg og Se, HCB, dioxin og PAH. Endvidere udgør emissionen over 10 % for NO_x,

NMVOC, CO, TSP, Ni, Pb og Zn. Stationær forbrænding bidrager med mindre end 10 % af den nationale emission af CH_4, N_2O, NH_3, Cu og PCB.

For stationær forbrænding er kraftværker og decentrale kraftvarmeværker den betydeligste emissionskilde for CO_2, N_2O og NO_x.

Gasmotorer installeret på decentrale kraftvarmeværker samt forbrænding af biomasse i forbindelse med beboelse er de største emissionskilder for CH_4.

Emissioner fra kedler, brændeovne mv. i forbindelse med beboelse er den betydeligste emissionskilde for CO, NMVOC, partikler, BC, dioxin og PAH. Det er især forbrænding af træ, som bidrager til disse emissioner.

De største emissionskilder for SO_2 er industrielle anlæg samt kraft- og kraftvarmeværker.

Både industrianlæg, kraftværker / kraftvarmeværker og villakedler / -brændeovne er væsentlige emissionskilder for de forskellige tungmetaller.

CO_2 udgjorde i 2015 97.8 % af den samlede drivhusgasudledning fra stationær forbrænding. Tidsserien for drivhusgasemissionen følger tidsserien for CO_2-emissionen ganske tæt. Både CO_2-emissionen og den samlede drivhusgasemission fra stationær forbrænding var lavere i 2015 end i 1990. CO_2 emissionen var 51.2 % lavere og drivhusgasemissionen var 50.5 % lavere. Emissionerne fluktuerer dog betydeligt, primært pga. variationerne i import / eksport af el men også som resultat af varierende udetemperatur og deraf følgende variationer i brændselsforbruget til rumopvarmning.

CH_4-emissionen fra stationær forbrænding var 43% højere i 2015 end i 1990. Emissionen steg frem til 1996 og faldt igen fra 2004. Stigningen skyldes primært, at der i 1990'erne blev installeret et betydeligt antal gasmotorer på decentrale kraftvarmeværker. De senere år er emissionen dog faldet, som følge af de ændrede afregningsregler i henhold til det frie elmarked, som har resulteret i færre driftstimer for gasmotorerne. Emissionen fra beboelse er steget væsentligt de senere år på grund af det øgede forbrug af træ i brændeovne og kedler.

Emissionen af N_2O var 1 % højere i 2015 end i 1990. Emissionen af N_2O fluktuerer som følge af variationerne i brændselsforbruget for stationær forbrænding, der er en følge af den varierende import / eksport af el.

SO_2-emissionen fra stationær forbrænding er faldet med 95 % siden 1990. Den store reduktion er primært et resultat af installering af afsvovlingsanlæg fra el- og fjernvarmeproducerende anlæg samt brug af brændsler med lavere svovlindhold. Dette er sket på baggrund af en indført svovlafgift, grænseværdier for svovlindhold i brændsler, SO_2-kvoter for centrale kraftværker samt lavere emissionsgrænseværdier.

NO_x-emissionen fra stationær forbrænding er faldet med 77 % siden 1990. Reduktionen er primært et resultat af, at emissionen fra el- og fjernvarmeproducerende anlæg er faldet som følge af, at der benyttes lav-NO_x-brændere på flere anlæg og at der er idriftsat NO_x-røggasrensning på flere store kraftværker. Baggrunden herfor er emissionsloft for de centrale kraftværker, lavere emissionsgrænseværdier for flere anlægstyper og NO_x-afgift. NO_x-emissionen fluktuerer som følge af variationen i import / eksport af el.

Mængden af træ forbrændt i villakedler og brændeovne var i 2015 4,2 gange så højt som i 1990. Den store stigning skete frem til år 2007 hvorefter forbruget er stabiliseret. Dette har stor betydning for tidsserierne for en række emissionskomponenter for hvilke netop træ, anvendt i villakedler / brændeovne, er en væsentlig emissionskilde: NMVOC, CO, partikler, BC og PAH. Emissionen fra nyere brændeovne / -kedler er lavere end for de ældre, idet forbrændingsteknologien er forbedret, og stigningen i emissioner er således lavere end stigningen i brændselsforbruget.

CO-emissionen fra stationær forbrænding er faldet 20 % siden 1990. Faldet i CO emission fra 2007 til 2015 er et resultat af lovmæssige krav til udledninger fra brændeovne og deraf følgende implementering af bedre teknologi samt at brændeforbruget er stabiliseret fra 2007 og frem. Endvidere er emissionen fra halmfyrede gårdanlæg faldet.

Emissionen af NMVOC fra stationær forbrænding er faldet 3 % siden 1990. Emissionen steg indtil 2007 og faldt derefter frem til 2014. Stigningen skyldes primært øget brændeforbrug i brændeovne og øget anvendelse af gasmotorer. Faldet i emission fra 2007-2014 er et resultat af forbedret forbrændingsteknologi i brændeovnene samt færre driftstimer for gasmotorerne.

Emissionen af TSP, PM_{10} og $PM_{2.5}$ er steget 20-24 % siden år 1990 - igen på grund af den øgede brug af træ i brændeovne og små villakedler frem til 2007. Efter 2007 er emissionen faldet igen som følge af installering af flere nyere brændeovne og -kedler. Emissionsgrænseværdier i Brændeovnsbekendtgørelsen og grænseværdier for Svanemærkede brændeovne er sat ned flere gange.

Emissionen af de forskellige PAH'er er på grund af udviklingen for brændeovne ligeledes steget frem til 2007 og faldet efterfølgende.

Tungmetalemissionerne er faldet betydeligt siden 1990. Emissionen af de enkelte tungmetaller er reduceret mellem 41 % og 91 %. Reduktionen er et resultat af den forbedrede røggasrensning på affaldsforbrændingsanlæg og på kraftværker.

Emissionen af dioxin var 67 % lavere i 2015 end i 1990. Dette fald skyldes primært installering af dioxinrensningsanlæg på affaldsforbrændingsanlæg, som alle affaldsforbrændingsanlæg iht. Affaldsforbrændingsbekendtgørelsen[1] skulle idriftsætte senest i 2005. Emissionen fra brændeovne er dog samtidig steget.

HCB-emissionen er faldet 80 % siden 1990, primært på grund af forbedret røggasrensning på affaldsforbrændingsanlæg. Emissionen fra brændeovne er dog steget.

PCB-emissionen (dioxinlignende PCB) er faldet 67 % siden 1990. Faldet er et resultat af forbedret dioxinrensning på affaldsforbrændingsanlæggene.

Emissionen af drivhusgasser er bestemt med en usikkerhed på ±2,2 %. Drivhusgasemissionen er siden 1990 faldet 50,5 % ± 1,0 %-point.

[1] Bekendtgørelse om anlæg der forbrænder affald, Bekendtgørelse 162 af 11. marts 2003.

Der er udarbejdet en emissionsopgørelse for CO_2 baseret på Eurostat-data. Resultatet af denne opgørelse er efterfølgende sammenholdt med Danmarks officielle emissionsopgørelse og der er redegjort for forskellene mellem de to opgørelser. Brændselsforbruget til transport mellem Danmark og henholdsvis Færøerne og Grønland er ikke inkluderet i rapporteringerne til Eurostat. Dette brændselsforbrug er imidlertid inkluderet under indenrigs luftfart / søfart i de danske emissionsopgørelser. Endvidere er brændværdierne anvendt i Eurostat ikke i overensstemmelse med den danske energistatistik for alle brændsler. Denne afvigelse i brændværdi giver en væsentlig afvigelse imellem de to opgørelsesmetoder for blandt andet kul.

Summen af de rapporterede CO_2 kvotedata er blevet sammenholdt med de danske emissionsopgørelser for CO_2 på sektorniveau. Samlet set udgør kvotedata 45 % af den samlede danske CO_2-emission.

1. Introduction

1.1 National emission

An overview of the total emissions for Denmark for 2015 including all emission source categories is shown in Table 1-4[2]. The emission inventories reported to the LRTAP Convention and to the Climate Convention are organised in six main source categories and a number of subcategories. The emission source *Energy* includes combustion in stationary and mobile sources as well as fugitive emissions from the energy source category. Emissions from incineration of waste in power plants or district heating plants are included in the source category *Energy*, rather than in the source category *Waste*.

Links to the latest emission inventories can be found at the AU home page: http://envs.au.dk/videnudveksling/luft/emissioner/emissioninventory/. Updated emission factors are also available on the AU homepage.

Note that according to convention decisions emissions from certain specific sources are not included in the inventory totals. These emissions are reported as memo items and are thus estimated, but not included in the totals. The data for the national emission included in this report does not include memo items.

CO_2 emission from combustion of biomass is not included in national totals, but reported as a memo item. Likewise, emissions from international bunkers and from international aviation are not included in national totals.

Further emission data for stationary combustion plants are provided in Chapter 3, 4 and 5.

Table 1 National greenhouse gas emission for the year 2015 (Nielsen et al., 2017a).

Pollutant	CO_2	CH_4	N_2O	HFCs, PFCs & SF6
Unit		Gg CO2 equivalent		
1. Energy	33722	365	389	-
2. Industrial processes and product use	1226	4	20	741.96
3. Agriculture	177	5524	4597	-
4. Land use, land-use change and forestry	4059	60	34	-
5. Waste	21	955	176	-
6. Other	-	-	-	-
Total CO_2 equivalent emissions without land use, land-use change and forestry		47919		
Total CO_2 equivalent emissions with land use, land-use change and forestry		52072		

[2] Emissions from Greenland and the Faroe Islands are not included.

Table 2 National emissions for the year 2015 reported to the LRTAP Convention (Nielsen et al., 2017b).

Pollutant	NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1. Energy	97	42	9	3	18	19	21	4	318
2. Industrial processes and product use	0	30	1	1	1	3	5	0	5
3. Agriculture	15	38	0	69	1	8	62	0	3
4. Land use, land-use change and forestry	-	-	-	-	-	-	-	-	-
5. Waste	0	0	1	1	0	0	0	0	1
6. Other	-	-	-	-	-	-	-	-	-
National emission	112	109	11	73	20	30	89	4	327

Table 3 National heavy metal (HM) emissions for the year 2015 reported to the LRTAP Convention (Nielsen et al., 2017b).

Pollutant	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
	Mg	Mg	Mg	Mg	Mg	Mg	Mg	Mg	Mg
1. Energy	8.43	0.62	0.29	0.26	1.36	40.77	3.35	0.78	49.76
2. Industrial processes and product use	1.27	0.03	0.00	0.05	0.20	2.62	0.31	0.52	2.68
3. Agriculture	0.04	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00
4. Land use, land-use change and forestry	-	-	-	-	-	-	-	-	-
5. Waste	1.94	0.00	0.00	0.00	0.01	0.07	0.01	0.00	7.57
6. Other	-	-	-	-	-	-	-	-	-
National emission	11.67	0.66	0.30	0.31	1.59	43.46	3.67	1.31	60.00

Table 4 National emissions of PAH, dioxins/furans (PCDD/F), hexachlorobenzene (HCB) and polychlorinated biphenyls (PCB) for the year 2015 reported to the LRTAP Convention (Nielsen et al., 2017b).

Pollutant	Benzo(a)-pyrene	Benzo(b)-fluoran-thene	Benzo(k)-fluoran-thene	Indeno (1,2,3-c,d) pyrene	PCDD/F	HCB	PCB
	Mg	Mg	Mg	Mg	g I-Teq	kg	kg
1. Energy	2.09	2.33	0.88	1.27	15.89	2.03	41.51
2. Industrial processes and product use	0.04	0.04	0.02	0.03	0.50	0.15	0.09
3. Agriculture	0.12	0.12	0.05	0.05	0.03	0.14	0.00
4. Land use, land-use change and forestry	-	-	-	-	-	-	-
5. Waste	0.05	0.06	0.05	0.07	7.68	0.01	0.02
6. Other	-	-	-	-	-	-	-
National emission	2.31	2.55	1.00	1.42	24.09	2.33	41.63

1.2 Definition of stationary combustion and subsectors

Stationary combustion plants are included in the emission source subcategories:

- 1A1 Energy, Fuel combustion, Energy Industries
  - 1A1a Public electricity and heat production
  - 1A1b Petroleum refining
  - 1A1c Oil and gas extraction
- 1A2 Energy, Fuel combustion, Manufacturing Industries and Construction
  - 1A2a Iron and steel
  - 1A2b Non-ferrous metals
  - 1A2c Chemicals
  - 1A2d Pulp, Paper and Print
  - 1A2e Food processing, beverages and tobacco
  - 1A2f Non-metallic minerals
  - 1A2 g viii Other manufacturing industry
- 1A4 Energy, Fuel combustion, Other Sectors
  - 1A4a i Commercial/institutional plants.
  - 1A4b i Residential plants.

- o 1A1c i Agriculture / forestry.

The emission and fuel consumption data included in tables and figures in this report only include emissions originating from stationary combustion plants of a given CRF sector.

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 source categories. Danish Centre for Environment and Energy, Aarhus University (DCE) has modified the SNAP categorisation to enable direct reporting of the disaggregated data for manufacturing industries and construction. Aggregation to the IPCC source category codes is based on a correspondence list enclosed in Annex 1. Stationary combustion is defined as combustion activities in the SNAP sectors 01 – 03, not including SNAP 0303.

The CO_2 emission from calcinations is not part of the source category *Energy*. This emission is included in the source category *Industrial Processes*.

1.3 Emission share from stationary combustion

Table 5 gives an overview of the emission share from stationary combustion compared to national total. Main emission sources are discussed in Chapter 3 and 4.

Table 5 Emission share from stationary combustion compared to national total for the year 2015.

Pollutant	Emission share, %
GHG	37
CO_2	48
CH_4	3.5
N_2O	3.4
SO_2	66
NO_x	23
NMVOC	21
CO	36
NH_3	2.2
TSP	18
PM_{10}	50
$PM_{2.5}$	73
BC	55
As	69
Cd	86
Cr	71
Cu	1.3
Hg	85
Ni	44
Pb	18
Se	52
Zn	35
HCB	50
PCDD/F	65
Benzo(a)pyrene	88
Benzo(b)fluoranthene	87
Benzo(k)fluoranthene	79
Indeno(123cd)pyrene	84
PCB	0.92

1.4 Key Categories for GHGs

For greenhouse gases, a key category analysis is reported each year. Key category analysis points out main emission sources for which higher tier methodologies are required (IPCC, 2006).

Key Category Analysis (KCA) approach 1 and approach 2 for the years 1990 and 2015 and for the trend 1990-2015 for Denmark has been carried out in accordance with the IPCC Guidelines (IPCC, 2006). Table 6 shows the 24 stationary combustion key categories. The table is based on the analysis including LULUCF. Detailed key category analysis is shown in NIR Chapter 1.5 (Nielsen et al., 2017a).

The CO_2 emissions from stationary combustion are key categories for all the major fuels. In addition, CH_4 from residential wood combustion and from straw combustion in agriculture / residential plants are key categories in the approach 2 analysis. Finally, due to the relatively high uncertainty for N_2O emission factors, the N_2O emission from a number of emission sources are also key categories in the approach 2 analysis.

Table 6 Key categories[3], stationary combustion.

			Approach 1			Approach 2		
			1990	2015	1990-2015	1990	2015	1990-2015
Energy	1A Stationary combustion, Coal, ETS data	CO_2		Level	Trend			Trend
Energy	1A Stationary combustion, Coal, no ETS data	CO_2	Level	Level	Trend	Level		Trend
Energy	1A Stationary combustion, BKB	CO_2						
Energy	1A Stationary combustion, Coke oven coke	CO_2						
Energy	1A Stationary combustion, Fossil waste, ETS data	CO_2		Level	Trend		Level	Trend
Energy	1A Stationary combustion, Fossil waste, no ETS data	CO_2	Level	Level	Trend		Level	
Energy	1A Stationary combustion, Petroleum coke, ETS data	CO_2		Level	Trend			
Energy	1A Stationary combustion, Petroleum coke, no ETS data	CO_2	Level		Trend			
Energy	1A Stationary combustion, Residual oil, ETS data	CO_2		Level	Trend			
Energy	1A Stationary combustion, Residual oil, no ETS data	CO_2	Level		Trend			Trend
Energy	1A Stationary combustion, Gas oil	CO_2	Level	Level	Trend	Level		Trend
Energy	1A Stationary combustion, Kerosene	CO_2	Level		Trend			
Energy	1A Stationary combustion, LPG	CO_2						
Energy	1A1b Stationary combustion, Petroleum refining, Refinery gas	CO_2	Level	Level	Trend			
Energy	1A Stationary combustion, Natural gas, onshore	CO_2	Level	Level	Trend		Level	Trend
Energy	1A1c_ii Stationary combustion, Oil and gas extraction, Offshore gas turbines, Natural gas	CO_2	Level	Level	Trend			
Energy	1A1 Stationary combustion, Solid fuels	CH_4						
Energy	1A1 Stationary combustion, Liquid fuels	CH_4						
Energy	1A1 Stationary combustion, not engines, gaseous fuels	CH_4						
Energy	1A1 Stationary combustion, Waste	CH_4						
Energy	1A1 Stationary combustion, not engines, Biomass	CH_4						
Energy	1A2 Stationary combustion, solid fuels	CH_4						
Energy	1A2 Stationary combustion, Liquid fuels	CH_4						
Energy	1A2 Stationary combustion, not engines, gaseous fuels	CH_4						
Energy	1A2 Stationary combustion, Waste	CH_4						
Energy	1A2 Stationary combustion, not engines, Biomass	CH_4						
Energy	1A4 Stationary combustion, Solid fuels	CH_4						
Energy	1A4 Stationary combustion, Liquid fuels	CH_4						
Energy	1A4 Stationary combustion, not engines, gaseous fuels	CH_4						
Energy	1A4 Stationary combustion, Waste	CH_4						
Energy	1A4 Stationary combustion, not engines, not residential wood and not residential/agricultural straw, Biomass	CH_4						
Energy	1A4b_i Stationary combustion, Residential wood combustion	CH_4				Level	Level	Trend
Energy	1A4b_i/1A4c_i Stationary combustion, Residential and agricultural straw combustion	CH_4				Level		
Energy	1A Stationary combustion, Natural gas fuelled engines, gaseous fuels	CH_4						
Energy	1A Stationary combustion, Biogas fuelled engines, Biomass	CH_4						
Energy	1A1 Stationary combustion, Solid fuels	N_2O				Level	Level	Trend
Energy	1A1 Stationary combustion, Liquid fuels	N_2O						
Energy	1A1 Stationary combustion, Gaseous fuels	N_2O				Level	Level	Trend
Energy	1A1 Stationary combustion, Waste	N_2O						Trend
Energy	1A1 Stationary combustion, Biomass	N_2O					Level	Trend
Energy	1A2 Stationary combustion, Solid fuels	N_2O						
Energy	1A2 Stationary combustion, Liquid fuels	N_2O				Level	Level	Trend
Energy	1A2 Stationary combustion, Gaseous fuels	N_2O					Level	Trend
Energy	1A2 Stationary combustion, Waste	N_2O						
Energy	1A2 Stationary combustion, Biomass	N_2O						
Energy	1A4 Stationary combustion, Solid fuels	N_2O						
Energy	1A4 Stationary combustion, Liquid fuels	N_2O				Level		Trend
Energy	1A4 Stationary combustion, Gaseous fuels	N_2O					Level	Trend
Energy	1A4 Stationary combustion, Waste	N_2O						
Energy	1A4 Stationary combustion, not residential wood and not residential/agricultural straw, Biomass	N_2O						
Energy	1A4b_i Stationary combustion, Residential wood combustion	N_2O					Level	Trend
Energy	1A4b_i/1A4c_i Stationary combustion, Residential and agricultural straw combustion	N_2O						

[3] For Denmark, not including Greenland and Faroe Island. Based on the KCA including LULUCF.

2. Fuel consumption data

In 2015, the total fuel consumption for stationary combustion plants was 387 PJ of which 253 PJ was fossil fuels and 134 PJ was biomass.

Fuel consumption distributed according to the Stationary combustion subcategories is shown in Figure 1 and Figure 2. The majority - 52 % - of all fuels is combusted in the source category Public electricity and heat production. Other source categories with high fuel consumption are Residential and Industry.

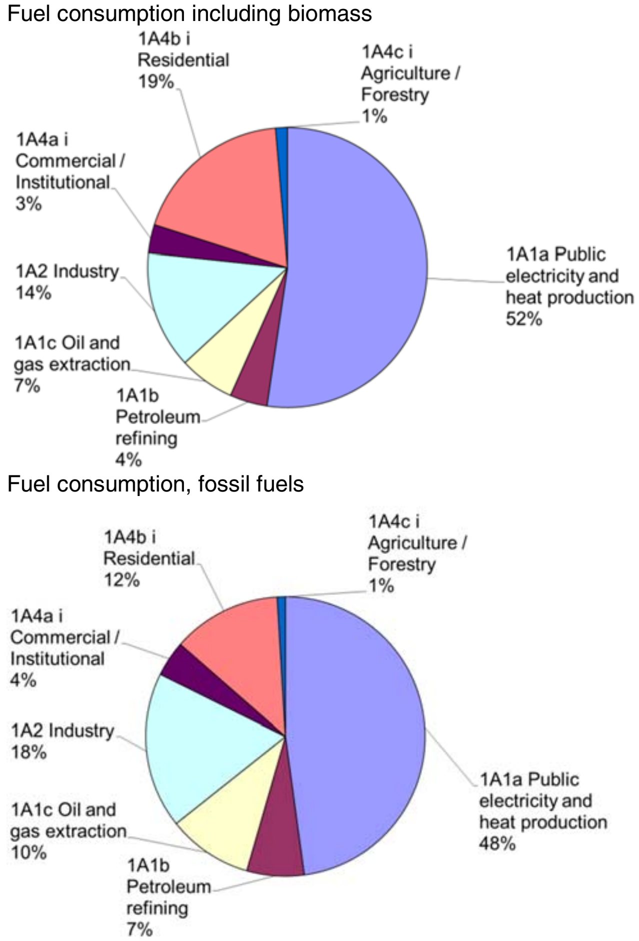


Figure 1 Fuel consumption of stationary combustion source categories in 2015. Based on DEA (2016a).

Coal, natural gas and wood are the most utilised fuels for stationary combustion plants. Coal is mainly used in power plants. Natural gas is used in power plants and decentralised combined heating and power plants (CHP), as well as in industry, residential plants and offshore gas turbines (see Figure 2). Wood is mainly applied for public electricity and heat production and in residential plants.

Detailed fuel consumption rates are shown in Annex 2.

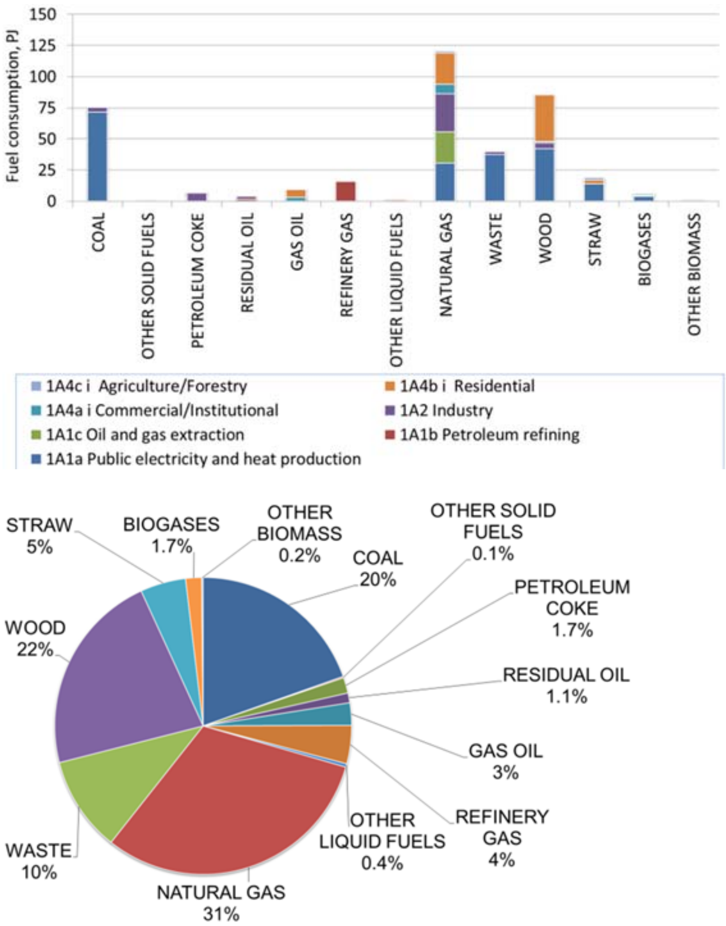


Figure 2 Fuel consumption of stationary combustion 2015, disaggregated to fuel type. Based on DEA (2016a).

The time series for fuel consumption in stationary combustion plants are presented in Figure 3. The fuel consumption for stationary combustion was 23 % lower in 2015 than in 1990, while the fossil fuel consumption was 45 % lower. The biomass fuel consumption was 3.3 times the consumption in 1990.

The consumption of natural gas, waste and biomass has increased since 1990 whereas the consumption of coal and oil has decreased.

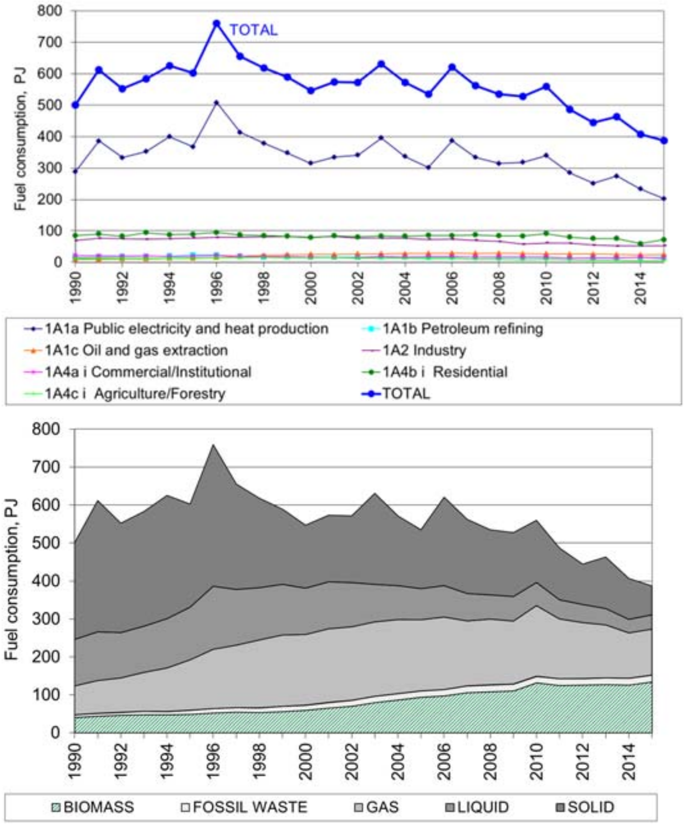


Figure 3 Fuel consumption time series, stationary combustion. Based on DEA (2016a).

The fluctuations in the time series for fuel consumption are mainly a result of electricity import / export, but also of outdoor temperature variations from year to year. This, in turn, leads to fluctuations in emission levels. The fluctuations in electricity trade, fuel consumption, CO_2 and NO_x emission are illustrated and compared in Figure 4. In 1990, the Danish net electricity import was large causing relatively low fuel consumption, whereas the fuel consumption was high in 1996 and 2003 due to a large net electricity export. In 2015, the net electricity import was 21 PJ, whereas there was a 10 PJ net electricity import in 2014. The large net electricity export that occurs some years 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 trend, the Danish Energy Agency (DEA) produces a correction of the observed fuel consumption and CO_2 emission without random variations in electricity import / export and in ambient temperature. This fuel consumption trend is also illustrated in Figure 4. The estimates are based on DEA (2016d). The corrections are included here to explain the fluctuations in the time series for fuel rates and emissions.

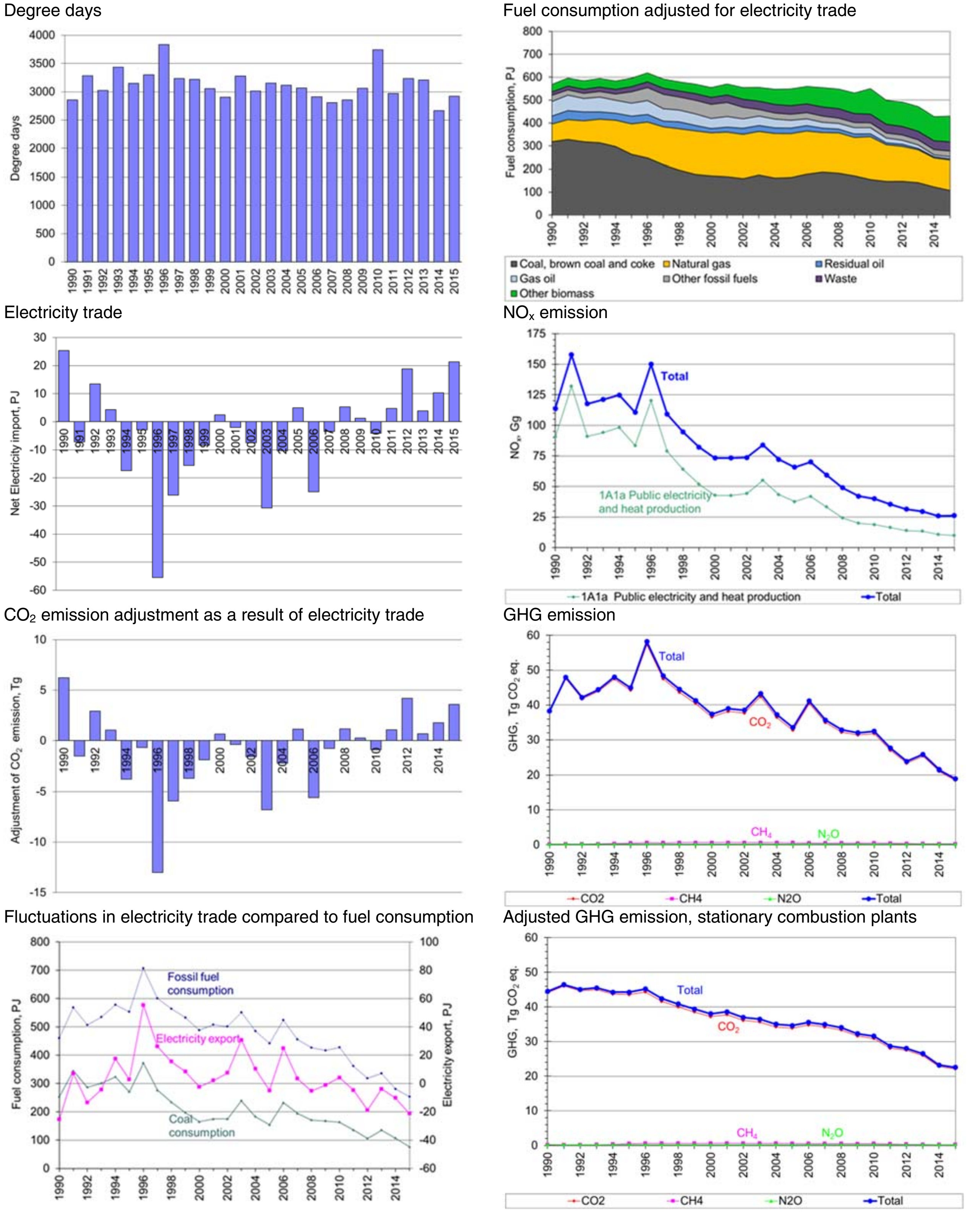


Figure 4 Comparison of time series fluctuations for electricity trade, fuel consumption, CO_2 emission and NO_x emission. Based on DEA (2016a).

Fuel consumption time series for the subcategories to stationary combustion are shown in Figure 5, 6 and 7.

Fuel consumption for *Energy Industries* fluctuates due to electricity trade as discussed above. The fuel consumption in 2015 was 12 % lower than in 1990 and the fossil fuel consumption was 45 % lower. The fluctuation in electricity production is based on fossil fuel consumption in the subcategory *Public electricity and heat production*. The energy consumption in *Oil and gas extraction* is mainly natural gas used in gas turbines in the offshore industry. The biomass fuel consumption in *Energy Industries* in 2015 added up to 82 PJ, which is 5.0 times the level in 1990 and almost the same as in 2014.

The fuel consumption in *Industry* was 24 % lower in 2015 than in 1990 (Figure 6). The fuel consumption in industrial plants decreased considerably after 2006 as a result of the financial crisis. The biomass fuel consumption in *Industry* in 2015 added up to 7 PJ, which is a 13 % increase since 1990.

The fuel consumption in *Other Sectors* decreased 24 % since 1990 (Figure 7) and increased 11 % since 2014. The biomass fuel consumption in *Other sectors* in 2015 added up to 46 PJ, which is 2.5 times the consumption in 1990, and a 15 % decrease since 2014. Wood consumption in residential plants in 2015 was 4.2 times the consumption in 1990.

Time series for subcategories are shown in Chapter 5.

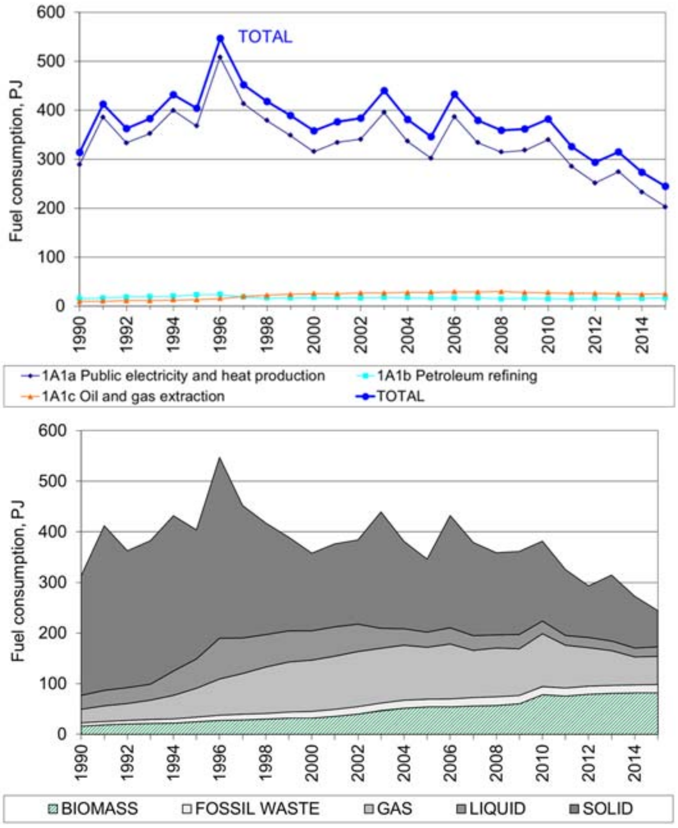


Figure 5 Fuel consumption time series for subcategories - 1A1 Energy Industries.

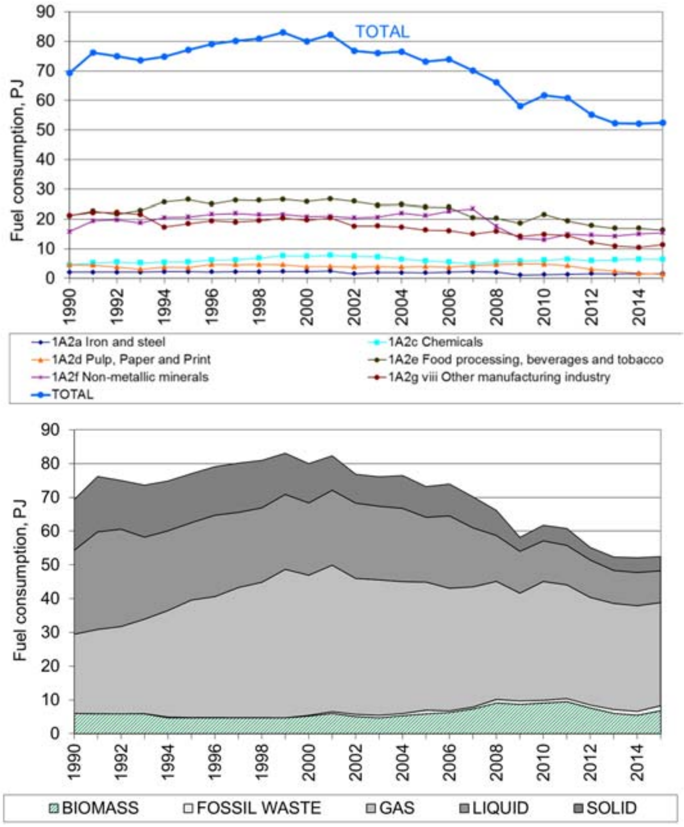


Figure 6 Fuel consumption time series for subcategories - 1A2 Industry.

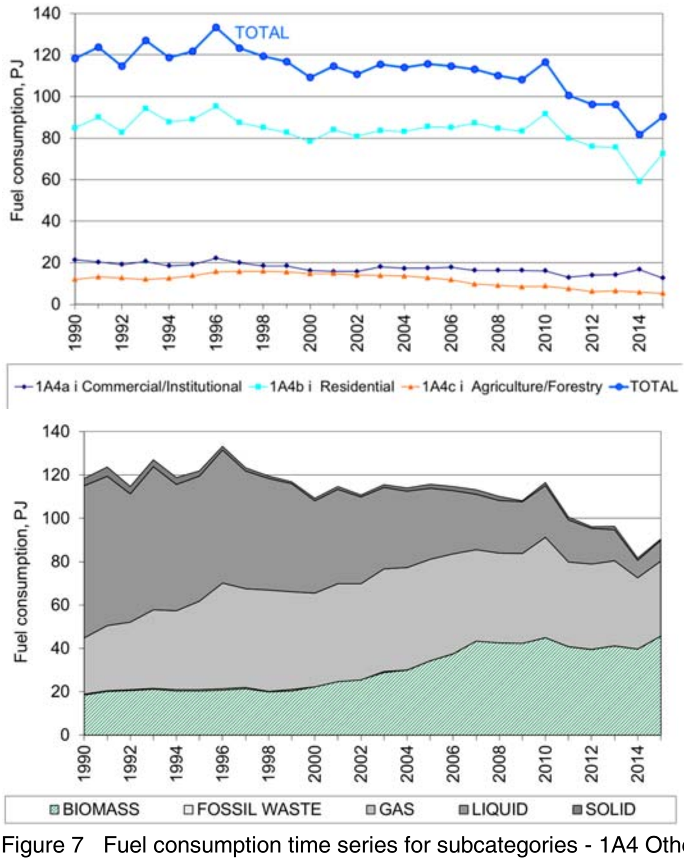


Figure 7 Fuel consumption time series for subcategories - 1A4 Other Sectors.

3. Emissions of greenhouse gases

The greenhouse gas (GHG) emissions from stationary combustion are listed in Table 7. The emission data shown below are the emission data reported in 2017. The emission from stationary combustion accounted for 37 % of the national greenhouse gas emission (including LULUCF) in 2015.

The CO_2 emission from stationary combustion plants accounted for 48 % of the national CO_2 emission (including LULUCF). The CH_4 emission accounted for 3.5 % of the national CH_4 emission and the N_2O emission for 3.4 % of the national N_2O emission.

Table 7 Greenhouse gas emission, 2015 [1)].

	CO_2	CH_4	N_2O
	Gg CO_2 equivalent		
1A1 Fuel Combustion, Energy industries	12668	85	82
1A2 Fuel Combustion, Manufacturing Industries and Construction[1)]	3113	12	34
1A4 Fuel Combustion, Other sectors [1)]	2725	146	65
Emission from stationary combustion plants	18505	244	181
Emission share for stationary combustion (LULUCF included)	48%	3.5%	3.4%

[1)] Only emissions from stationary combustion plants in the categories are included.

CO_2 is the most important greenhouse gas accounting for 97.8 % of the greenhouse gas emission (CO_2 eq.) from stationary combustion. CH_4 accounts for 1.3 % and N_2O for 1.0 % of the greenhouse gas emission (CO_2 eq.) from stationary combustion (Figure 8).

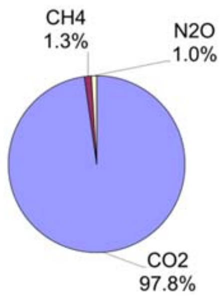


Figure 8 Greenhouse gas emission from stationary combustion (CO_2 equivalent), contribution from each pollutant.

Figure 9 shows the time series of greenhouse gas emissions (CO_2 eq.) from stationary combustion. The greenhouse gas emission trend follows the CO_2 emission development very closely. Both the CO_2 and the total greenhouse gas emission are lower in 2015 than in 1990, CO_2 by 51.2 % and greenhouse gas by 50.5 %. However, fluctuations in the GHG emission level are large.

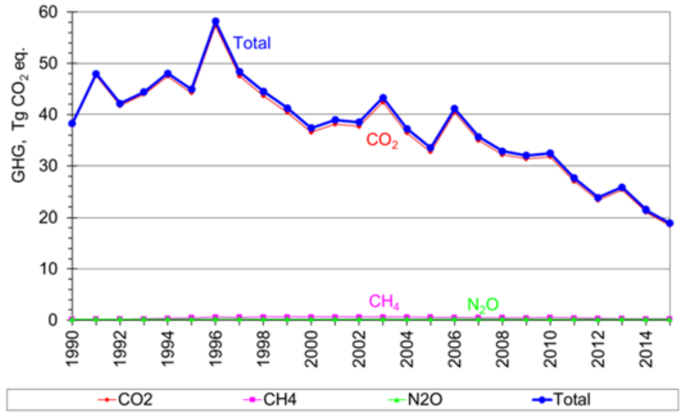


Figure 9 GHG emission time series for stationary combustion.

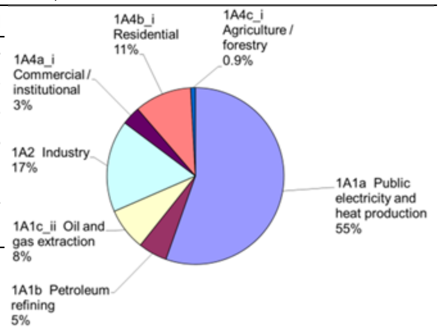
The fluctuations in the time series are largely a result of electricity import / export, but also of outdoor temperature variations from year to year. The fluctuations follow the fluctuations in fuel consumption discussed in Chapter 2. As mentioned in Chapter 2, the Danish Energy Agency estimates a correction of the observed CO_2 emission without random variations in electricity imports / exports and in ambient temperature. The greenhouse gas emission corrected for electricity import / export and ambient temperature has decreased by 49.4 % since 1990, and the CO_2 emission by 49.9 %. These data are included here to explain the fluctuations in the emission time series.

3.1 Carbon dioxide (CO_2)

The carbon dioxide (CO_2) emission from stationary combustion plants is one of the most important sources of greenhouse gas emissions. Thus, the CO_2 emission from stationary combustion plants accounts for 48 % of the national CO_2 emission (LULUCF included). Table 8 shows the CO_2 emission inventory for stationary combustion plants for 2015. *Public electricity and heat production* accounts for 55 % of the CO_2 emission from stationary combustion. This share is somewhat higher than the fossil fuel consumption share for this category, which is 48 % (Figure 1). This is due to a large share of coal in this category. Other large CO_2 emission sources are *Industry*, *Residential plants* and *Oil and gas extraction*. These are the source categories, which also account for a considerable share of fuel consumption.

Table 8 CO_2 emission from stationary combustion plants, 2015[1)].

	CO_2 Gg
1A1a Public electricity and heat production	10254
1A1b Petroleum refining	978
1A1c Oil and gas extraction	1436
1A2 Industry	3113
1A4a Commercial/Institutional	632
1A4b Residential	1934
1A4c Agriculture/Forestry	159
Total	18505

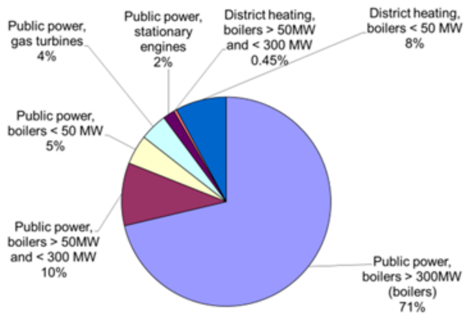


[1)] Only emissions from stationary combustion plants in the categories are included.

In the Danish inventory, the source category *Public electricity and heat production* is further disaggregated. The CO_2 emission from each of the subcategories is shown in Table 9. The largest subcategory is power plant boilers >300MW.

Table 9 CO_2 emission from subcategories to 1A1a Public electricity and heat production.

SNAP	SNAP name	CO_2, Gg
0101	Public power	
010101	Combustion plants ≥ 300MW (boilers)	7311
010102	Combustion plants ≥ 50MW and < 300 MW (boilers)	997
010103	Combustion plants <50 MW (boilers)	468
010104	Gas turbines	435
010105	Stationary engines	188
0102	District heating plants	
010202	Combustion plants ≥ 50MW and < 300 MW (boilers)	46
010203	Combustion plants <50 MW (boilers)	810



CO_2 emission from combustion of biomass fuels is not included in the total CO_2 emission data, because biomass fuels are considered CO_2 neutral. The CO_2 emission from biomass combustion is reported as a memo item in the Climate Convention reporting. In 2015, the CO_2 emission from biomass combustion was 15 031 Gg.

In Figure 10, the fuel consumption share (fossil fuels) is compared to the CO_2 emission share disaggregated to fuel origin. Due to the higher CO_2 emission factor for coal than oil and gas, the CO_2 emission share from coal combustion is higher than the fuel consumption share. Coal accounts for 30 % of the fossil fuel consumption and for 39 % of the CO_2 emission. Natural gas accounts for 48 % of the fossil fuel consumption but only 37 % of the CO_2 emission.

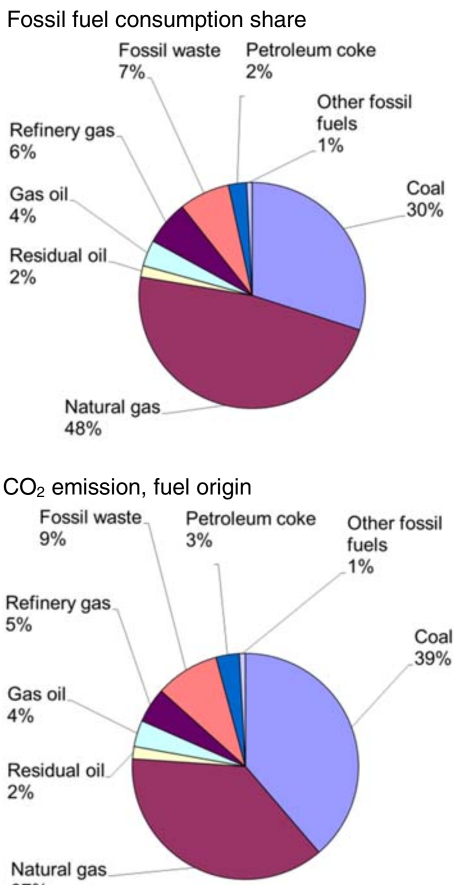


Figure 10 CO_2 emission, fuel origin.

The time series for CO_2 emission is provided in Figure 11. Despite a decrease in fuel consumption of 23 %[4] since 1990, the CO_2 emission from stationary combustion has decreased by 51 % because of the change of fuel type used.

The fluctuations in total CO_2 emission follow the fluctuations in CO_2 emission from *Public electricity and heat production* (Figure 11) and in coal consumption (Figure 4). The fluctuations are a result of electricity import / export as discussed in Chapter 2.

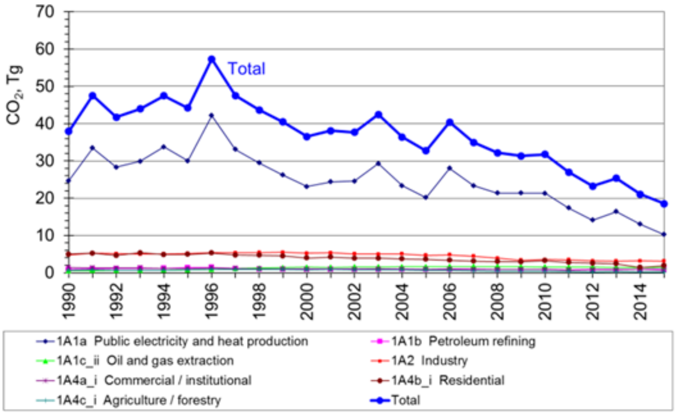


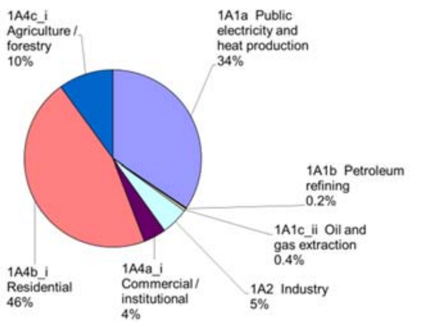
Figure 11 CO_2 emission time series for stationary combustion plants.

3.2 Methane (CH_4)

The methane (CH_4) emission from stationary combustion plants accounts for 3.5 % of the national CH_4 emission. Table 10 shows the CH_4 emission inventory for stationary combustion plants in 2015. *Public electricity and heat production* accounts for 34 % of the CH_4 emission from stationary combustion. The emission from residential plants adds up to 46 % of the emission.

Table 10 CH_4 emission from stationary combustion plants, 2015[1)].

	CH_4, Mg
1A1a Public electricity and heat production	3352
1A1b Petroleum refining	19
1A1c Oil and gas extraction	42
1A2 Industry	494
1A4a Commercial/Institutional	401
1A4b Residential	4463
1A4c Agriculture/Forestry	976
Total	9747



1) Only emissions from stationary combustion plants in the source categories are included.

The CH_4 emission factor for reciprocating gas engines is much higher than for other combustion plants due to the continuous ignition / burn-out of the gas. Lean-burn gas engines have an especially high emission factor. A considerable number of lean-burn gas engines are in operation in Denmark and in 2015, these plants accounted for 40 % of the CH_4 emission from stationary combustion plants (Figure 12). Most engines are installed in CHP plants and the fuel used is either natural gas or biogas. Residential wood combustion is also a large emission source accounting for 36 % of the emission in 2015.

[4] The consumption of fossil fuels has decreased 45 %.

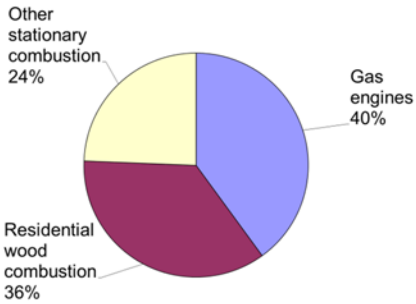


Figure 12 CH_4 emission share for gas engines and residential wood combustion, 2015.

Figure 13 shows the time series for CH_4 emission. The CH_4 emission from stationary combustion was 43 % higher in 2015 than in 1990. The emission increased until 1996 and decreased after 2004. This time series is related to the considerable number of lean-burn gas engines installed in CHP plants in Denmark during the 1990s. Figure 14 provides time series for the fuel consumption rate in gas engines and the corresponding increase of CH_4 emission. The decline in later years is due to structural changes in the Danish electricity market, which means that the fuel consumption in gas engines has been decreasing.

The CH_4 emission from residential plants has increased since 1990 due to increased combustion of biomass in residential plants. Combustion of wood accounted for 78 % of the CH_4 emission from residential plants in 2015.

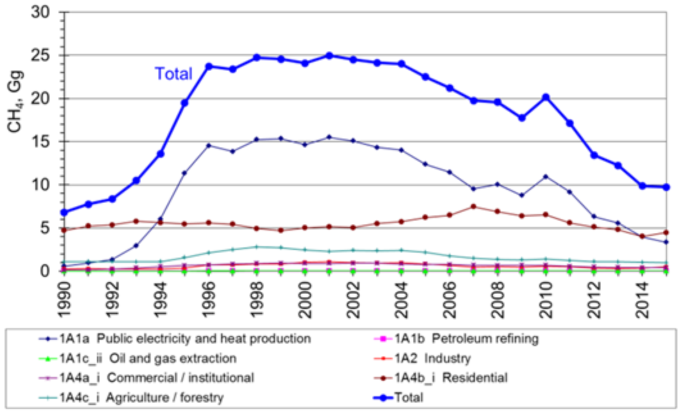


Figure 13 CH_4 emission time series for stationary combustion plants.

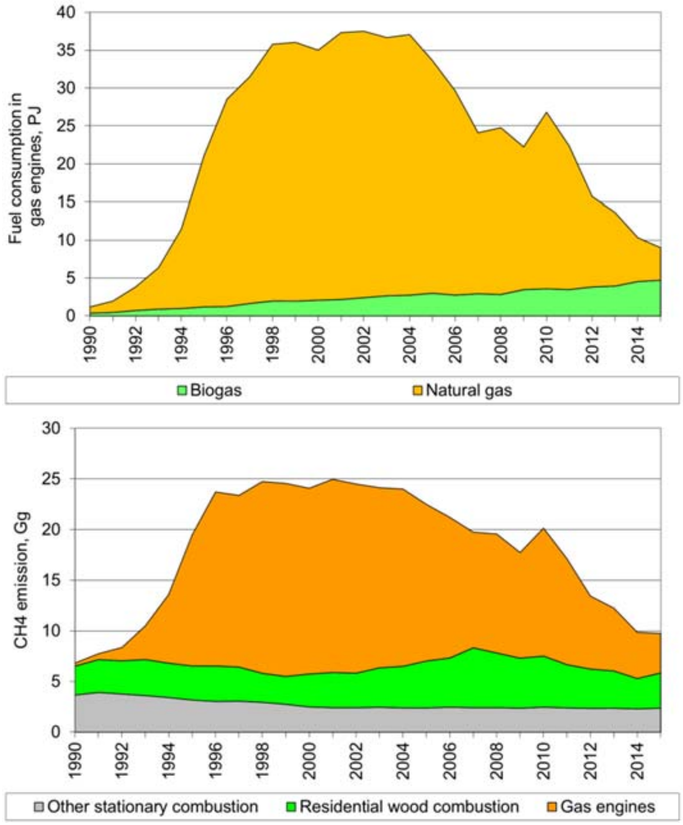


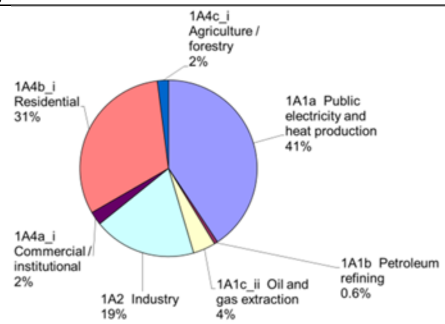
Figure 14 Time series for a) fuel consumption in gas engines and b) CH_4 emission from gas engines, residential wood combustion and other plants.

3.3 Nitrous oxide (N_2O)

The nitrous oxide (N_2O) emission from stationary combustion plants accounts for 3.4 % of the national N_2O emission. Table 11 shows the N_2O emission inventory for stationary combustion plants in the year 2015. *Public electricity and heat production* accounted for 41 % of the N_2O emission from stationary combustion.

Table 11 N_2O emission from stationary combustion plants, 2015[1)].

	N_2O, Mg
1A1a Public electricity and heat production	247
1A1b Petroleum refining	4
1A1c Oil and gas extraction	25
1A2 Industry	114
1A4a Commercial/Institutional	15
1A4b Residential	190
1A4c Agriculture/Forestry	12
Total	606



[1)] Only emissions from stationary combustion plants in the source categories are included.

Figure 15 shows the time series for N_2O emission. The N_2O emission from stationary combustion has increased by 1 % from 1990 to 2015, but again fluctuations in emission level due to electricity import / export are considerable.

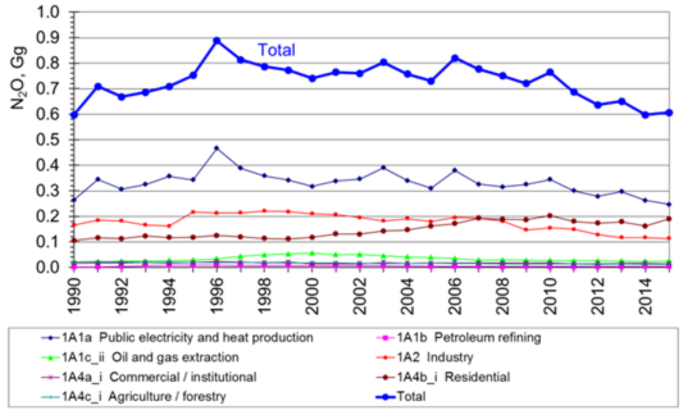


Figure 15 N_2O emission time series for stationary combustion plants.

4. Emissions of other pollutants

Emission data for non-GHGs reported in 2017 are shown in this chapter.

4.1 Sulphur dioxide (SO_2)

Stationary combustion is the most important emission source for SO_2 accounting for 66 % of the national emission. Table 12 presents the SO_2 emission inventory for the stationary combustion subcategories.

The largest emission sources are *Public electricity and heat production* and *Manufacturing industries and construction* accounting for 32 % and 42 % of the emission from stationary combustion.

For *Public electricity and heat production*, the SO_2 emission share is however lower than the fuel consumption share for this source category, which is 52 %. This is a result of effective flue gas desulphurisation equipment installed in power plants combusting coal. In the Danish inventory, the source category *Public electricity and heat production* is further disaggregated. Figure 16 shows the SO_2 emission from *Public electricity and heat production* on a disaggregated level. District heating boilers < 50 MW and power plants >300MW_{th} are the main emission sources, accounting for 45 % and 28 % of the emission.

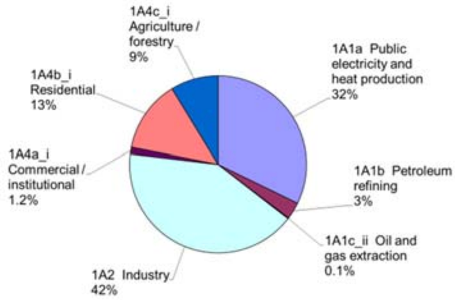
The SO_2 emission from industrial plants adds up to 42 % of the emission from stationary combustion, a remarkably high emission share compared with fuel consumption. The main emission sources in the industrial category are combustion of coal and emissions from the cement industry, mineral wool industry and sugar production plants. Until year 2000, the SO_2 emission from the industrial category only accounted for a small part of the emission from stationary combustion, but as a result of reduced emissions from power plants, the share has now increased.

The time series for SO_2 emission from stationary combustion is shown in Figure 17. Time series from 1980 are shown in Annex 11. The SO_2 emission from stationary combustion plants has decreased by 95 % since 1990. The large emission decrease is mainly a result of the reduced emission from *Public 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 public electricity and heat production plants, these still account for 32 % of the emission from stationary combustion, as mentioned above. The emission from other source categories also decreased considerably since 1990. Time series for subcategories are shown in Chapter 5.

The emission of SO_2 has decreased since 2005, but the emission level has steadied since 2009.

Table 12 SO_2 emission from stationary combustion plants, 2015[1)].

		SO_2, Mg
1A1a	Public electricity and heat production	2317
1A1b	Petroleum refining	225
1A1c	Oil and gas extraction	11
1A2	Industry	2979
1A4a	Commercial/Institutional	88
1A4b	Residential	947
1A4c	Agriculture/Forestry	627
Total		7194



[1)] Only emissions from stationary combustion plants in the source categories are included.

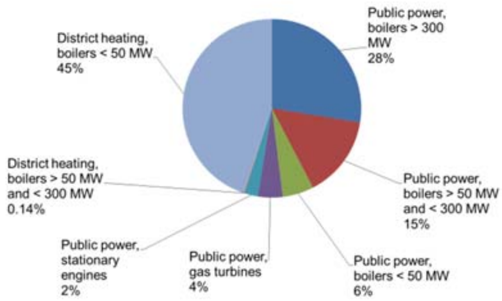


Figure 16 Disaggregated SO_2 emissions from 1A1a Public electricity and heat production.

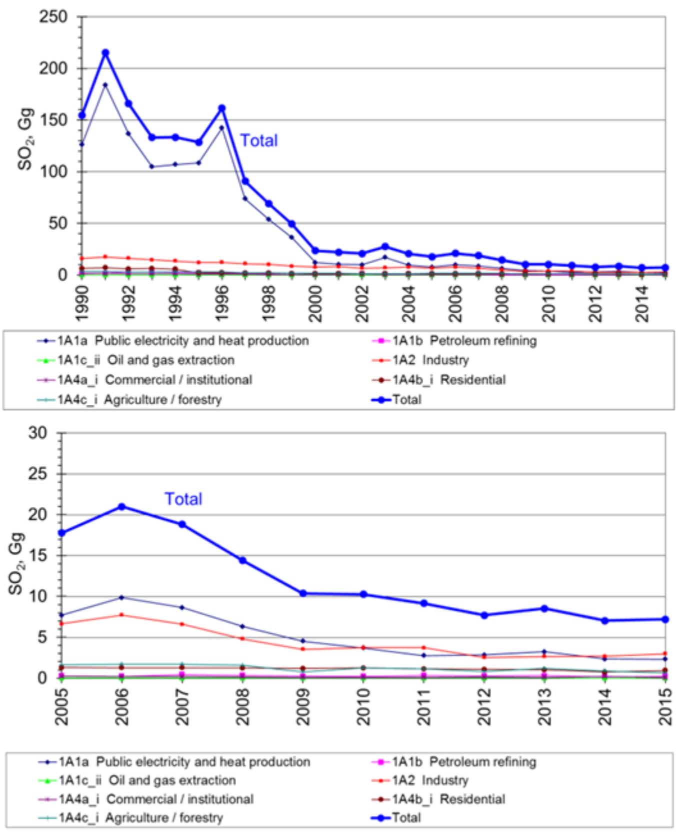


Figure 17 SO_2 emission time series for stationary combustion.

4.2 Nitrogen oxides (NO_x)

Stationary combustion accounts for 23% of the national NO_x emission. Table 13 shows the NO_x emission inventory for stationary combustion subcategories.

Public electricity and heat production is the largest emission source accounting for 38 % of the emission from stationary combustion plants. The emission from public power boilers > 300 MW_{th} accounts for 21 % of the emission in this subcategory.

Industrial combustion plants are also an important emission source accounting for 18 % of the emission. The main industrial emission source is cement production, which accounts for 38 % of the emission.

Residential plants account for 16 % of the NO_x emission. The fuel origin of this emission is mainly wood accounting for 70 % of the residential plant emission.

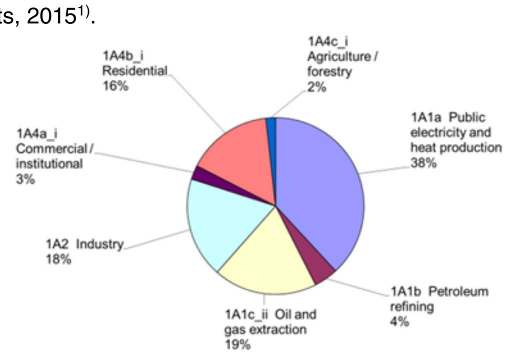
Oil and gas extraction, which is mainly offshore gas turbines accounts for 19 % of the NO_x emission.

Time series for NO_x emission from stationary combustion are shown in Figure 18. Time series from 1985 are shown in Annex 11. NO_x emission from stationary combustion plants has decreased by 77 % since 1990. The reduced emission is largely a result of the reduced emission from public electricity and heat production due to installation of low NO_x burners, selective catalytic reduction (SCR) units and selective non-catalytic reduction (SNCR) units. The fluctuations in the time series follow the fluctuations in public electricity and heat production, which, in turn, result from electricity trade fluctuations.

The emission has also decreased considerably since 2005; see Figure 18.

Table 13 NO_x emission from stationary combustion plants, 2015[1].

		NO_x, Mg
1A1a	Public electricity and heat production	9974
1A1b	Petroleum refining	1153
1A1c	Oil and gas extraction	4964
1A2	Industry	4824
1A4a	Commercial/Institutional	672
1A4b	Residential	4114
1A4c	Agriculture/Forestry	461
Total		26163



[1] Only emissions from stationary combustion plants in the source categories are included.

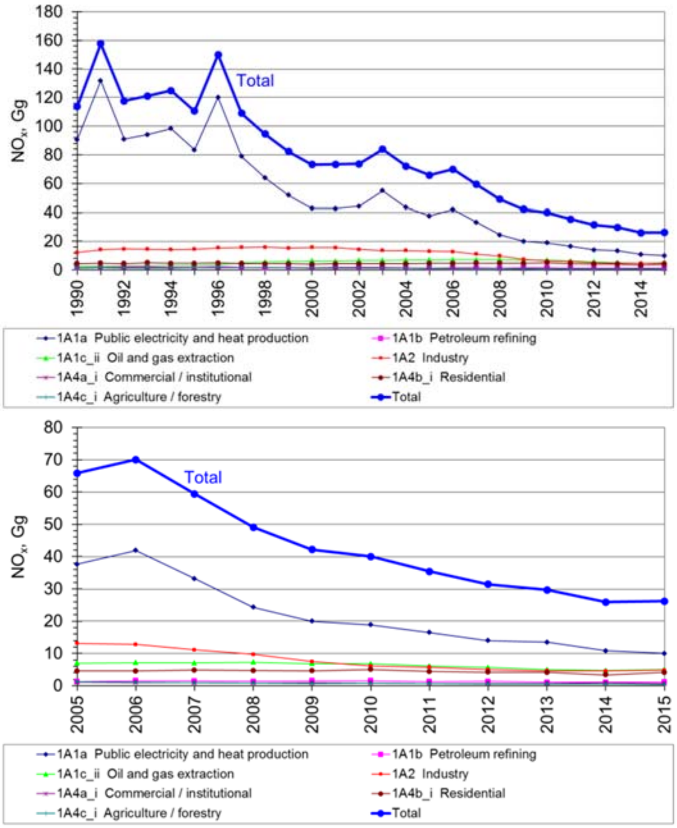


Figure 18 NO_x emission time series for stationary combustion.

4.3 Non methane volatile organic compounds (NMVOC)

Stationary combustion plants account for 21 % of the national NMVOC emission. Table 14 presents the NMVOC emission inventory for the stationary combustion subcategories.

Residential plants are the largest emission source accounting for 83 % of the emission from stationary combustion plants. For residential plants NMVOC is mainly emitted from wood and straw combustion, see Figure 19.

Public electricity and heat production is also a considerable emission source, accounting for 5 % of the emission. Lean-burn gas engines have a relatively high NMVOC emission factor and are the most important emission source in this subcategory (see Figure 19). The gas engines are either natural gas or biogas fuelled.

Agricultural plants accounted for 8 % of the emission in 2015. Combustion of straw was the main emission source in this category.

The time series for NMVOC emission from stationary combustion is shown in Figure 20. Time series from 1985 are shown in Annex 11. The emission has decreased by 3 % from 1990. The emission increased until 2007 and decreased between 2007 and 2014. The increased emission is mainly a result of the increasing wood consumption in residential plants and of the increased use of lean-burn gas engines in CHP plants. The decrease in 2007-2014 is a result of lower emission from residential wood combustion and the low number of operation hours for the lean burn gas engines. The increase from 2014 to 2015 is a result of increased consumption of wood in residential plants.

The emission from residential plants has increased 9 % since 1990.

The emission from straw combustion in farmhouse boilers has decreased (42 %) over this period due to both a decreasing emission factor and decrease in straw consumption in this source category. The emission from most other fuels has also decreased.

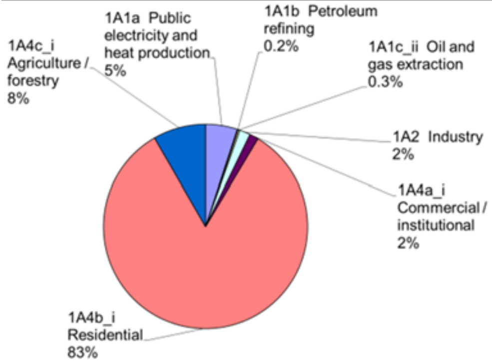
However, the NMVOC emission from residential wood combustion was 50 % higher in 2015 than in 1990 due to increased wood consumption. The emission factor has decreased since 1990 due to installation of modern stoves and boilers with improved combustion technology.

The use of wood in residential boilers and stoves was relatively low in 1998-99 resulting in a lower emission level.

The consumption of wood in residential plants increased until 2007. The improved technology that has been implemented in residential wood combustion has led to lower emission factors and thus decreasing NMVOC emission since 2007. The increased NMVOC emission from 2014 to 2015 reflects an increase of residential wood consumption.

Table 14 NMVOC emission from stationary combustion plants, 2015[1)].

		NMVOC, Mg
1A1a	Public electricity and heat production	786
1A1b	Petroleum refining	24
1A1c	Oil and gas extraction	40
1A2	Industry	266
1A4a	Commercial/Institutional	220
1A4b	Residential	12921
1A4c	Agriculture/Forestry	1297
Total		15555



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

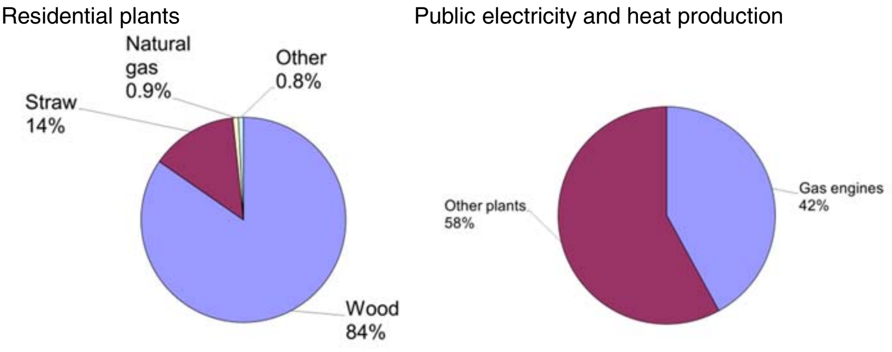


Figure 19 NMVOC emission from residential plants and from public electricity and heat production, 2015.

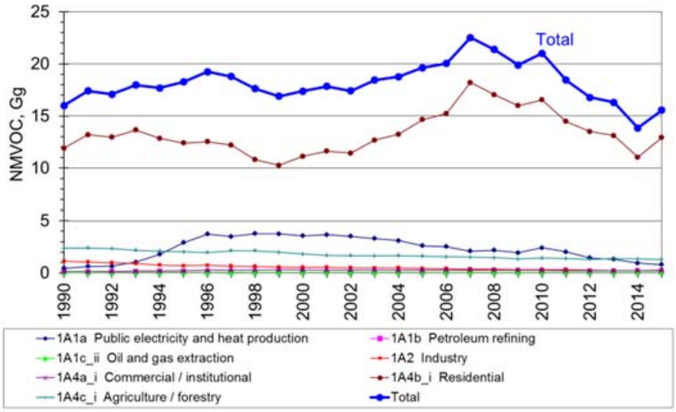


Figure 20 NMVOC emission time series for stationary combustion.

4.4 Carbon monoxide (CO)

Stationary combustion accounts for 36 % of the national CO emission. Table 15 presents the CO emission inventory for stationary combustion subcategories.

Residential plants are the largest emission source, accounting for 79 % of the emission. Wood combustion accounts for 86 % of the emission from residential plants, see Figure 21. This is in spite of the fact that the fuel consumption share is only 51 %. Combustion of straw is also a considerable emission source whereas the emission from other fuels used in residential plants is almost negligible.

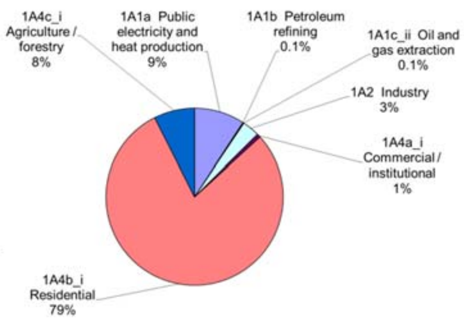
The time series for CO emission from stationary combustion is shown in Figure 22. Time series from 1985 are shown in Annex 11. The emission has decreased by 20 % from 1990. The time series for CO from stationary combustion plants follow the time series for CO emission from residential plants.

The increase of wood consumption in residential plants in 1999-2007 is reflected in the time series for CO emission. The consumption of wood in residential plants in 2015 was 4.2 times the 1990 level. The decreased emission in 2007-2015 is a result of implementation of improved residential wood combustion technologies and the fact that the rapid increase of wood consumption until 2007 have stopped. The increased CO emission in 2015 is a result of increased wood consumption in residential plants in 2015.

Both consumption and CO emission factor have decreased for residential straw combustion plants since 1990.

Table 15 CO emission from stationary combustion plants, 2015[1)].

	CO, Mg
1A1a Public electricity and heat production	10780
1A1b Petroleum refining	119
1A1c Oil and gas extraction	120
1A2 Industry	3705
1A4a Commercial/Institutional	796
1A4b Residential	93048
1A4c Agriculture/Forestry	8728
Total	117296



[1)] Only emissions from stationary combustion plants in the source categories are included.

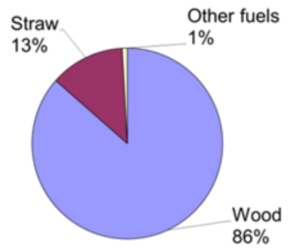


Figure 21 CO emission sources, residential plants, 2015.

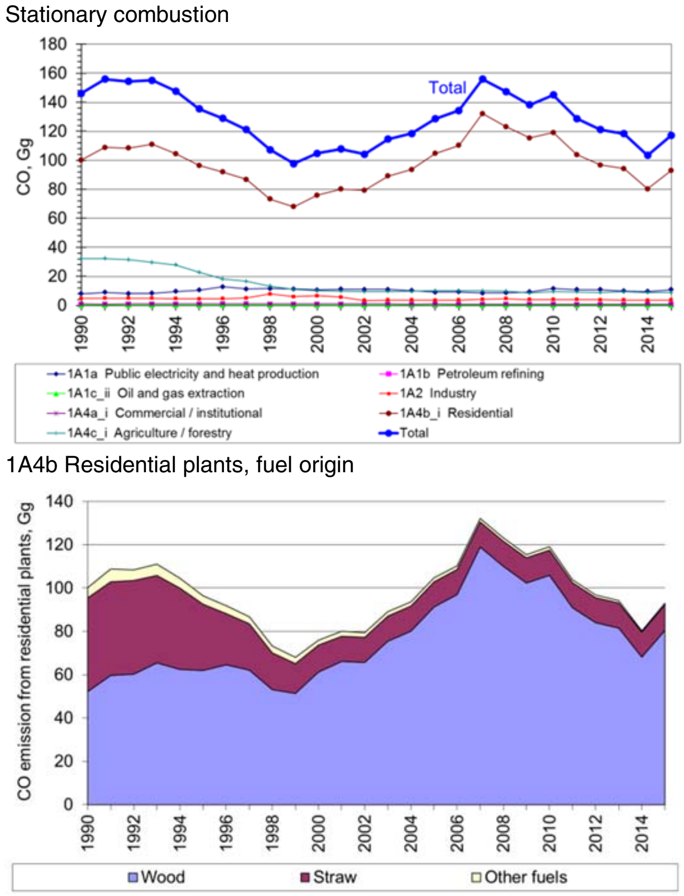


Figure 22 CO emission time series for stationary combustion.

4.5 Ammonia (NH_3)

Stationary combustion plants accounted for only 2.2 % of the national NH_3 emission in 2015.

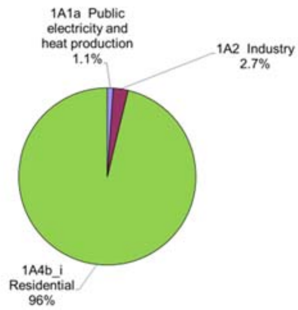
Table 16 shows the NH_3 emission inventory for the stationary combustion subcategories. Residential plants accounted for 96 % of the emission. Wood combustion accounted for 99 % of the emission from residential plants.

The time series for the NH_3 emission is presented in Figure 23. The NH_3 emission has increased to 2.3 times the 1990 level.

The NH_3 emission from non-residential plants is neglectable and default emission factors are not available in EEA Guidelines (EEA, 2016). However, based on national references the NH_3 emission from waste incineration has been included in the Danish inventory.

Table 16 NH_3 emission from stationary combustion plants, 2015[1)].

	NH_3, Mg
1A1a Public electricity and heat production	15
1A1b Petroleum refining	-
1A1c Oil and gas extraction	-
1A2 Industry	40
1A4a Commercial/Institutional	-
1A4b Residential	1407
1A4c Agriculture/Forestry	-
Total	1463



1) Only emissions from stationary combustion plants in the source categories are included.

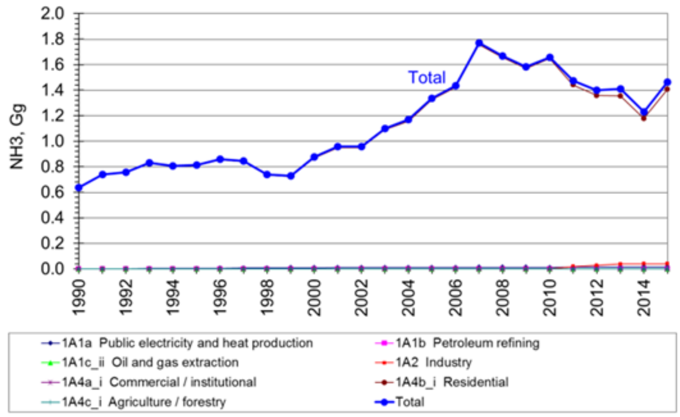


Figure 23 NH_3 emission time series for stationary combustion plants.

4.6 Particulate matter (PM)

TSP from stationary combustion accounted for 18 % of the national emission in 2015. The emission shares for PM_{10} and $PM_{2.5}$ were 50 % and 73 %, respectively.

Table 17 and Figure 24 show the PM emission inventory for the stationary combustion subcategories. Residential plants are the largest emission source accounting for 92 % of the $PM_{2.5}$ emission from stationary combustion plants.

The primary sources of PM emissions are:

- Residential boilers, stoves and fireplaces combusting wood
- Farmhouse / residential boilers combusting straw
- Power plants primarily combusting coal
- Wood combusted in non-residential plants

The PM emission from wood combusted in residential plants is the predominant source. Thus, 87 % of the $PM_{2.5}$ emission from stationary combustion is emitted from residential wood combustion. This corresponds to 64 % of the national emission. A literature review (Nielsen et al., 2003) and a Nordic project (Sternhufvud et al., 2004) has demonstrated that the emission factor uncertainty for residential combustion of wood in stoves and boilers is notably high.

Figure 25 shows the fuel consumption and the $PM_{2.5}$ emission of residential plants. Wood combustion accounts for 95 % of the $PM_{2.5}$ emission from residential plants in spite of a wood consumption share of 51 %.

Emission inventories for PM are now reported for the years 1990-2015. The time series for PM emission from stationary combustion is shown in Figure 26. The emission of TSP, PM_{10} and $PM_{2.5}$ was 20 %, 21% and 24 % higher in 2015 than in 1990. The PM emissions increased until 2007 and decreased after 2007. However, the emission increased in 2015. The increase until 2007 was caused by the increased wood combustion in residential plants. However, the PM emission factors have decreased for this emission source category due to installation of modern stoves and boilers. The stabilisation of wood consumption in residential plants in 2007-2014 has resulted in a decrease of PM emission from stationary combustion in recent years. However, due to increased wood consumption in 2015 the emission was higher in 2015 than in 2014.

The time series for PM emission from stationary combustion plants follows the time series for PM emission from residential plants.

Table 17 PM emission from stationary combustion plants, 2015[1)].

		TSP, Mg	PM_{10}, Mg	$PM_{2.5}$, Mg
1A1a	Public electricity and heat production	595	439	340
1A1b	Petroleum refining	112	106	103
1A1c	Oil and gas extraction	2	2	1
1A2	Industry	258	187	119
1A4a	Commercial/Institutional	181	179	169
1A4b	Residential	14401	13676	13329
1A4c	Agriculture/Forestry	502	474	447
Total		16052	15062	14509

1) Only emissions from stationary combustion plants in the source categories are included.

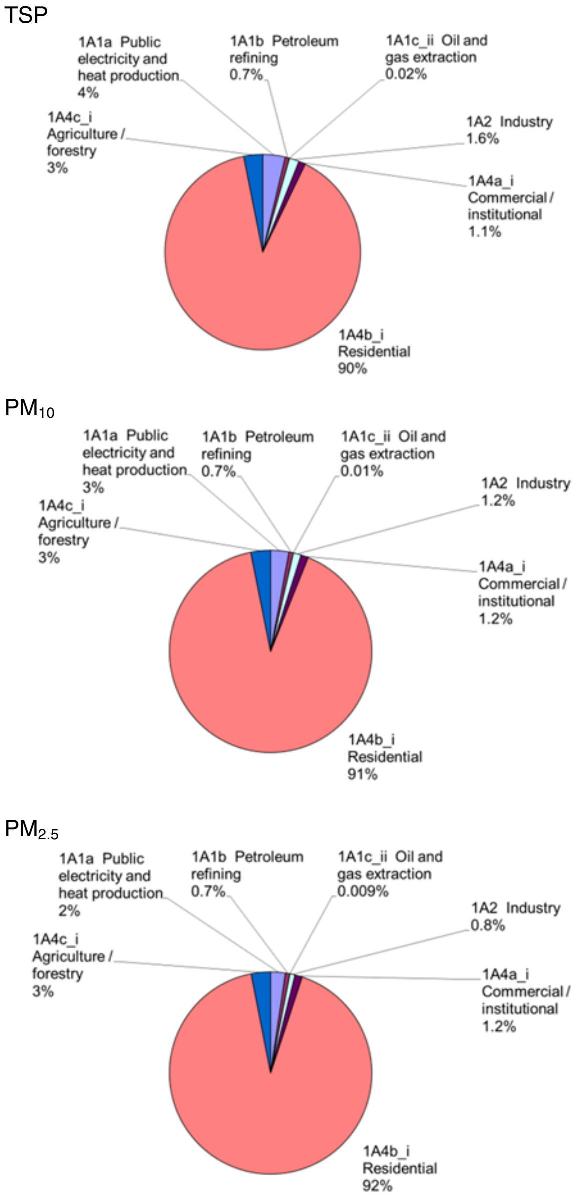


Figure 24 PM emission sources from stationary combustion plants, 2015.

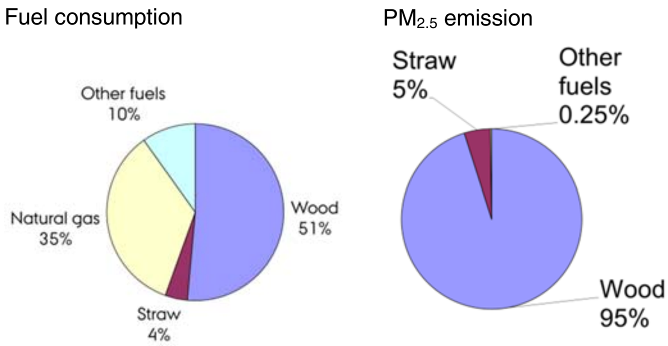


Figure 25 Fuel consumption and $PM_{2.5}$ emission from residential plants.

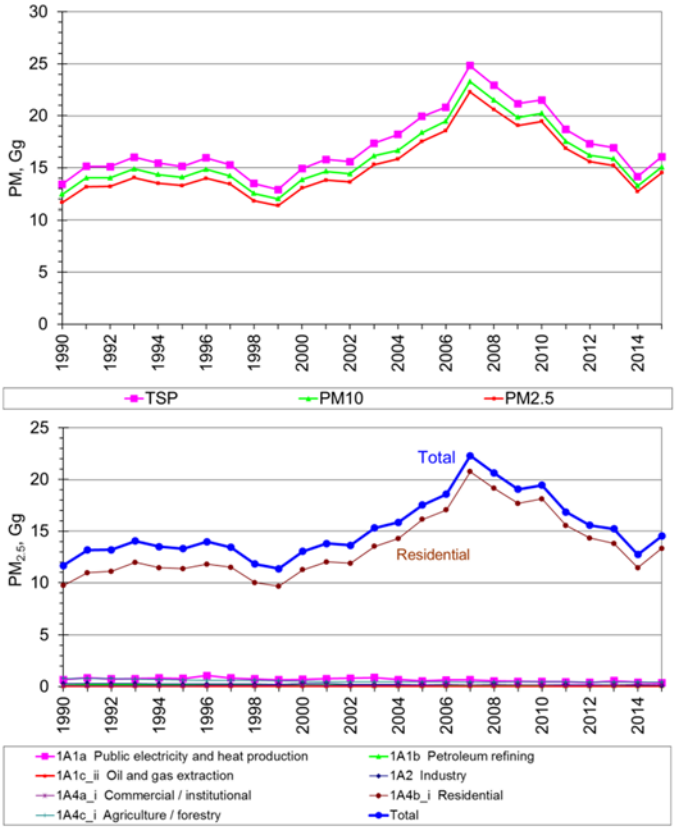


Figure 26 PM emission time series for stationary combustion.

4.7 Black carbon (BC)

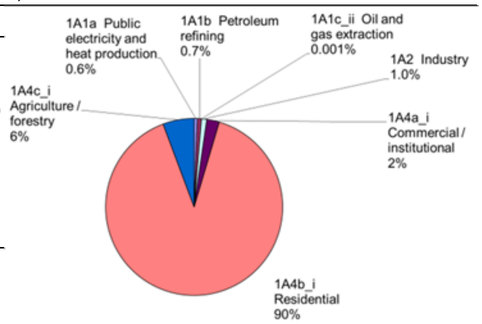
Black carbon (BC) from stationary combustion accounted for 55 % of the national emission in 2015. Residential combustion is the main emission source accounting for 90 % of the emission from stationary combustion. Residential wood combustion is the main emission source accounting for 97 % of the emission from residential plants.

Table 18 shows the BC emission inventory for the stationary combustion subcategories.

BC emissions are reported for year 1990 onwards. Figure 27 shows time series for BC emission. The emission increased until 2007 and decreased in 2007-2014. The emission increased in 2015. The time series for BC emission follow the time series for $PM_{2.5}$ emission.

Table 18 BC emission from stationary combustion plants, 2015[1)].

		BC, Mg
1A1a	Public electricity and heat production	13
1A1b	Petroleum refining	16
1A1c	Oil and gas extraction	0
1A2	Industry	21
1A4a	Commercial/Institutional	50
1A4b	Residential	1955
1A4c	Agriculture/Forestry	124
Total		2179



[1)] Only emissions from stationary combustion plants in the source categories are included.

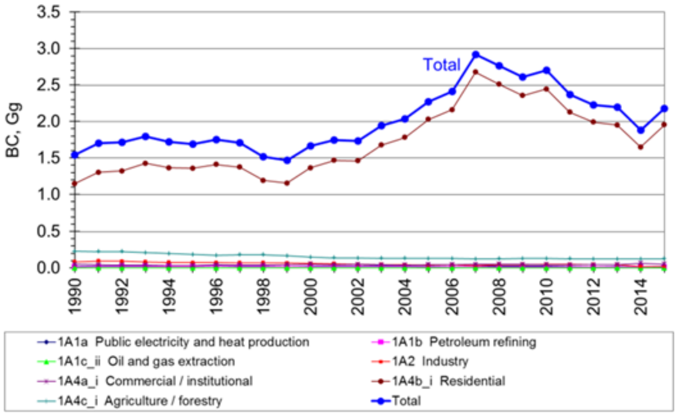


Figure 27 BC emission time series for stationary combustion.

4.8 Heavy metals

Stationary combustion is one of the largest emission source categories for heavy metals. The emission share for stationary combustion compared to national total is shown for each metal in Table 19.

Table 19 and Figure 28 present the heavy metal emission inventory for the stationary combustion subcategories. The source categories *Public electricity and heat production*, *Residential* and *Industry* are the main emission sources. The emission share for waste incineration plants has decreased considerably since the year 2000 due to installation of new improved flue gas cleaning technology that was initiated based on lower emission limit values in Danish legislation (DEPA, 2011).

Table 19 Heavy metal emission from stationary combustion plants, 2015[1)].

	As, kg	Cd, kg	Cr, kg	Cu, kg	Hg, kg	Ni, kg	Pb, kg	Se, kg	Zn, kg
1A1a Public electricity and heat production	88	27	144	135	133	219	330	451	368
1A1b Petroleum refining	32	23	24	47	23	248	69	111	88
1A1c Oil and gas extraction	3	0	0	0	2	0	0	0	0
1A2 Industry	70	23	78	100	60	1041	453	85	958
1A4a Commercial/Institutional	3	1	4	4	2	5	5	1	9
1A4b Residential	13	489	867	250	26	89	1125	20	19476
1A4c Agriculture/Forestry	5	4	15	29	6	18	162	17	385
Total	213	567	1133	564	252	1620	2144	686	21284
Emission share from stationary combustion	69%	86%	71%	1%	85%	44%	18%	52%	35%

[1)] Only emissions from stationary combustion plants in the source categories are included.

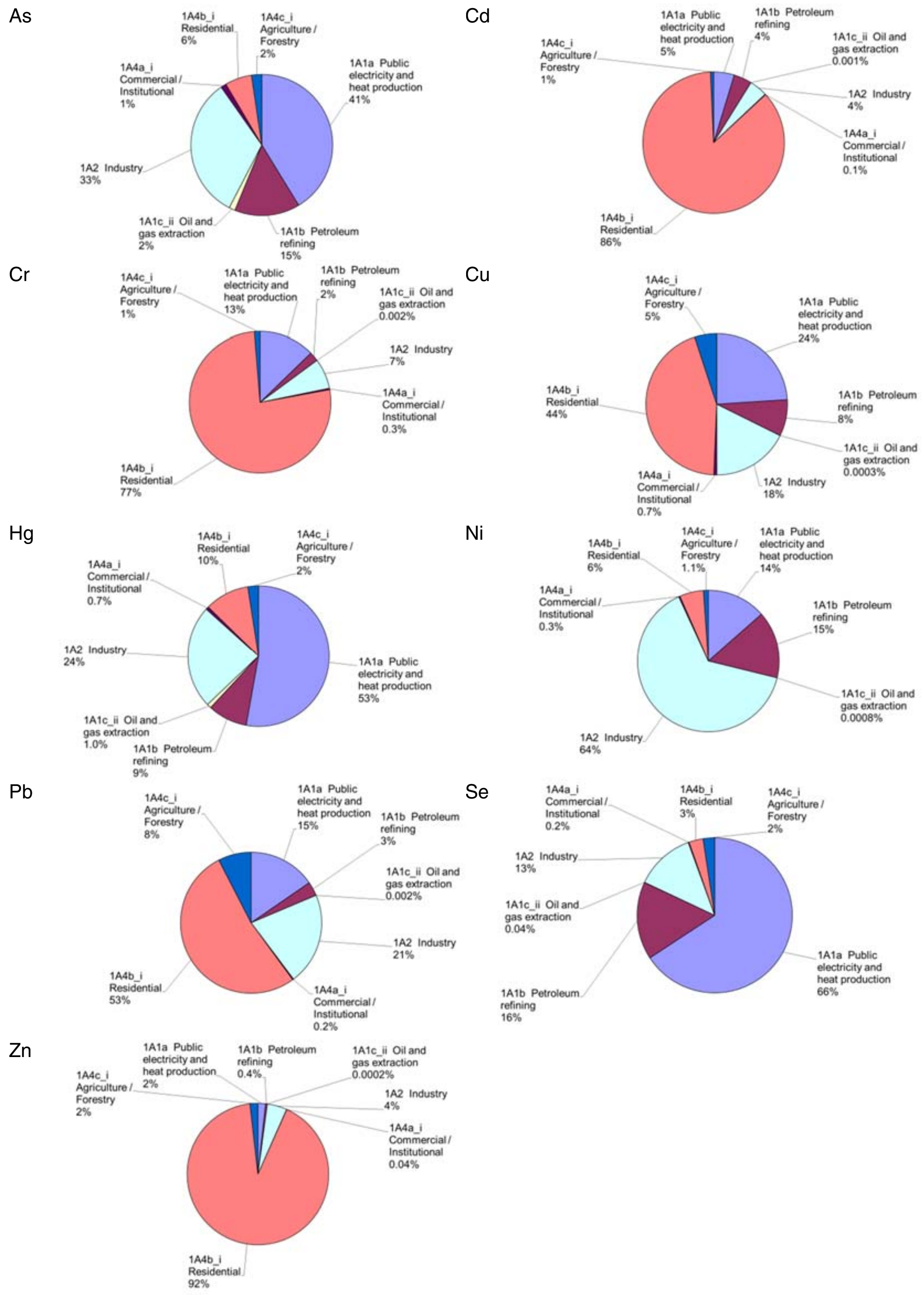


Figure 28 Heavy metal emission sources from stationary combustion plants, 2015.

The time series for heavy metal emissions are provided in Figure 29. Emissions of all heavy metals have decreased considerably (23 % - 91 %) since 1990, see Table 20. Emissions have decreased despite increased incineration of waste. This has been possible due to installation and improved performance of gas cleaning devices in waste incineration plants and also in large power plants, the latter being a further important emission source.

For Cd, Cr, Pb and Zn the main emission source in recent years was residential plants, mainly from residential wood combustion. Thus, in recent years the time series for Cd, Cr, Pb and Zn follow the time series for residential wood combustion.

Table 20 Decrease in heavy metal emission 1990-2015.

Pollutant	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
Decrease since 1990, %	82	41	79	84	91	90	86	83	23

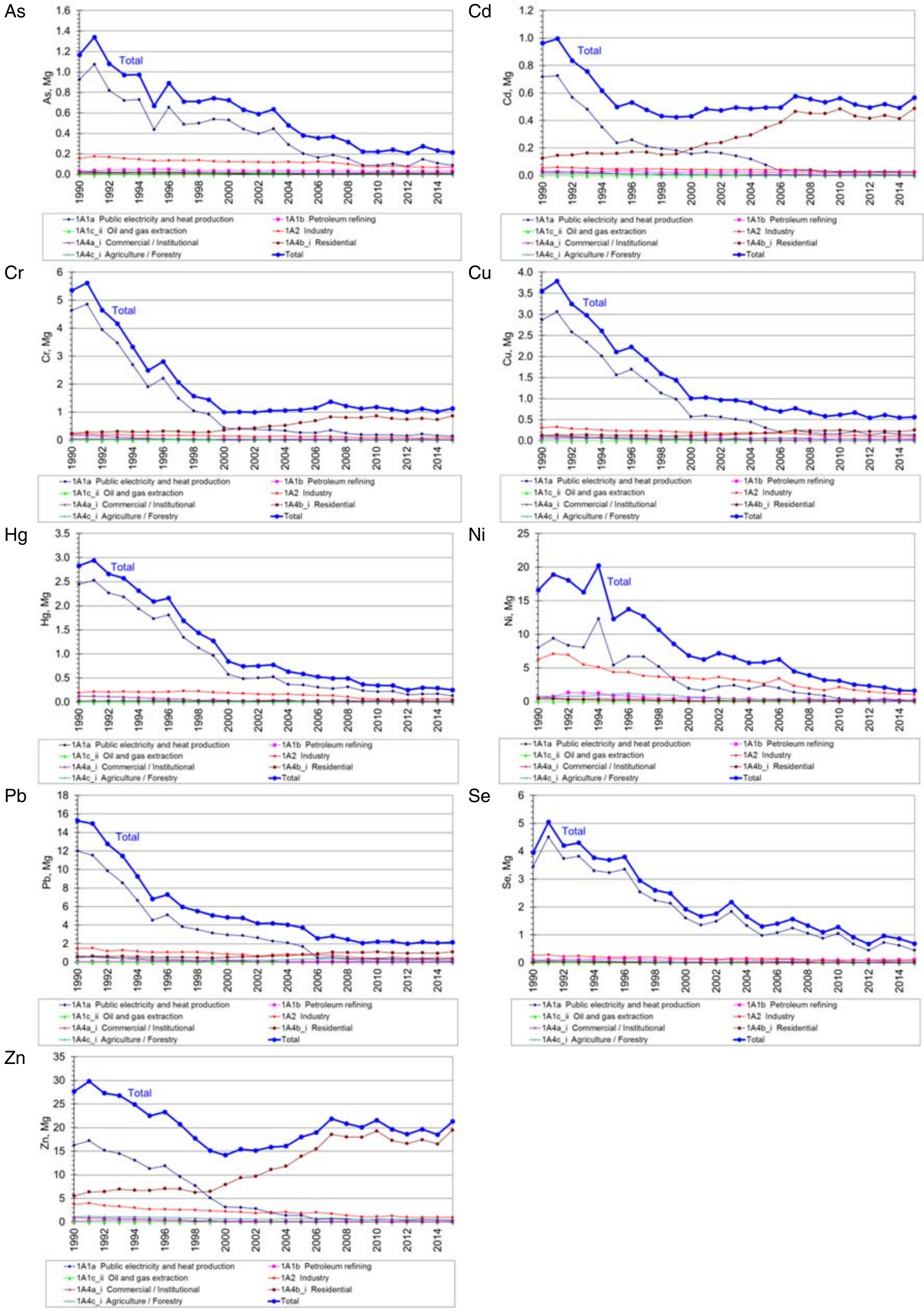


Figure 29 Heavy metal emission time series for stationary combustion plants.

4.9 Polycyclic aromatic hydrocarbons (PAH)

Stationary combustion plants accounted for more than 79 % of the PAH emission in 2015.

Table 21 and Figure 30 present the PAH emission inventories for the stationary combustion subcategories. Residential combustion is the largest emission source accounting for more than 78 % of the emission. Combustion of wood is the predominant source, accounting for more than 96 % of the PAH emission from residential plants, see Figure 31.

The time series for PAH emissions are presented in Figure 32. The increase of PAHs until 2007 is a result of the increased combustion of wood in residential plants. The time series for wood combustion in residential plants is also provided in Figure 32. The stabilisation of the consumption of wood in residential plants in 2007-2014 is reflected in the PAH emission time series. The decrease in these years is related to installation of improved residential wood combustion units. The increase in 2015 reflects an increased wood consumption in residential plants.

Table 21 PAH emissions from stationary combustion plants, 2015[1)].

	Benzo(a)-pyrene, kg	Benzo(b)-fluoranthene, kg	Benzo(k)-fluoran-thene, kg	Indeno (1,2,3-c,d)-pyrene, kg
1A1a Public electricity and heat production	10	39	25	7
1A1b Petroleum refining	0	0	0	0
1A1c Oil and gas extraction	0	0	0	0
1A2 Industry	21	73	10	3
1A4a Commercial/Institutional	195	256	85	138
1A4b Residential	1697	1738	636	937
1A4c Agriculture/Forestry	96	109	30	106
Total	2019	2216	787	1192
Emission share from stationary combustion	88%	87%	79%	84%

1) Only emissions from stationary combustion plants in the source categories are included.

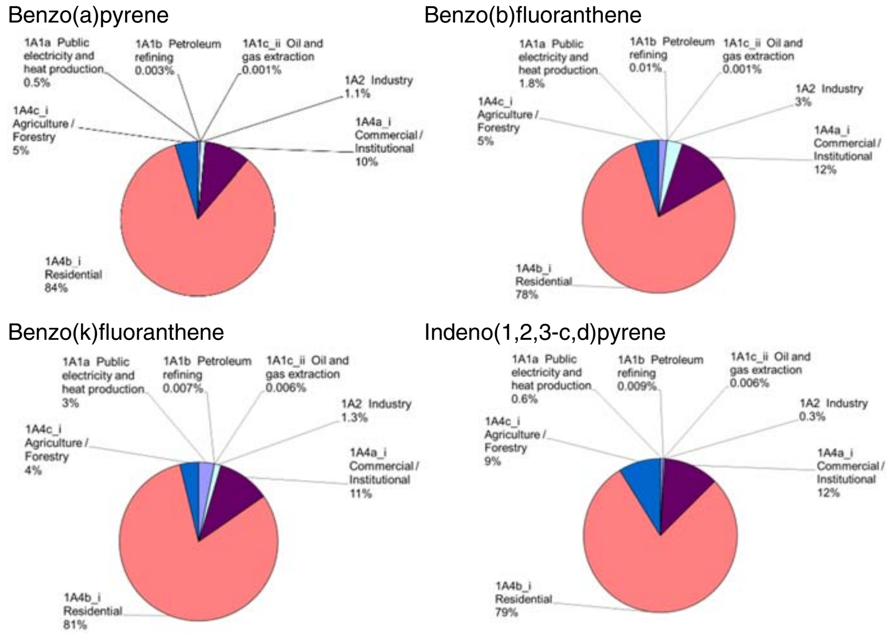


Figure 30 PAH emission sources from stationary combustion plants, 2015.

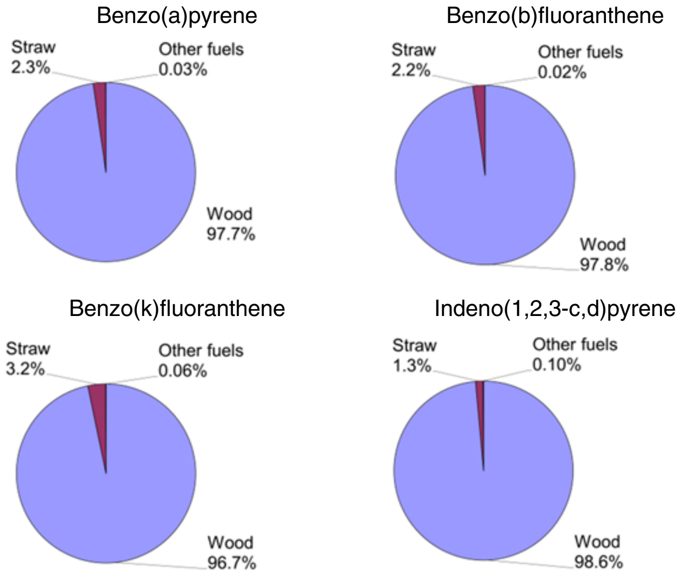


Figure 31 PAH emissions from residential combustion plants (stationary), fuel origin.

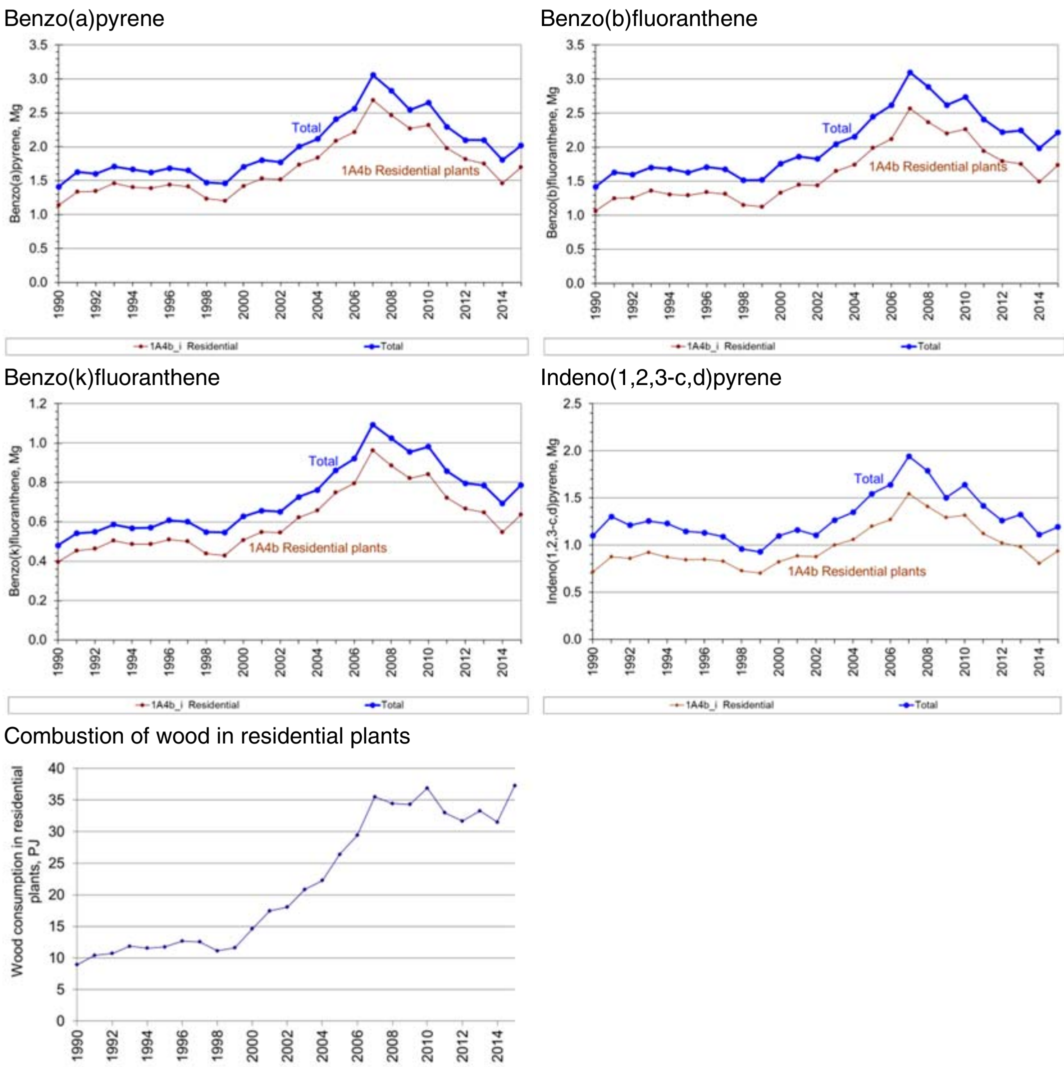


Figure 32 PAH emission time series for stationary combustion plants. Comparison with wood consumption in residential plants.

4.10 Polychlorinated dibenzodioxins and -furans (PCDD/F)

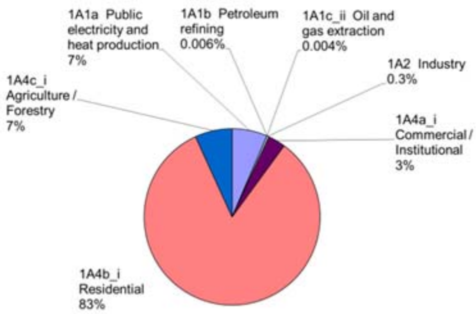
Stationary combustion plants accounted for 65 % of the national emission of polyclorinated dibenzodioxins and –furans (PCDD/F) in 2015.

Table 22 presents the PCDD/F emission inventories for the stationary combustion subcategories. In 2015, the emission from residential plants accounted for 83 % of the emission. Combustion of wood is the predominant source accounting for 88 % of the emission from residential plants (Figure 33).

The time series for PCDD/F emission is presented in Figure 34. The PCDD/F emission has decreased 67 % since 1990 mainly due to installation of dioxin filters in waste incineration plants. The emission from residential plants has increased due to increased wood consumption in this source category. However, the emission factor for residential wood combustion has decreased due to installation of modern stoves and boilers.

Table 22 PCDD/F emissions from stationary combustion plants, 2015[1)].

	PCDD/F, g I-teq
1A1a Public electricity and heat production	1.01
1A1b Petroleum refining	0.00
1A1c Oil and gas extraction	0.00
1A2 Industry	0.05
1A4a Commercial/Institutional	0.50
1A4b Residential	12.94
1A4c Agriculture/Forestry	1.06
Total	15.57



[1)] Only emissions from stationary combustion plants in the source categories are included.

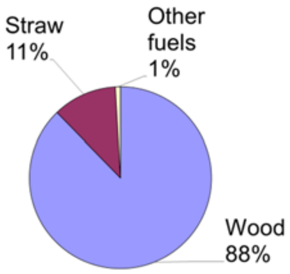


Figure 33 PCDD/F emission from residential plants, fuel origin.

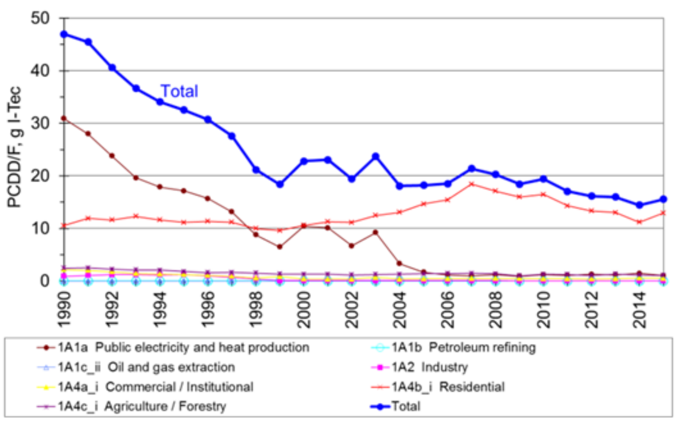


Figure 34 PCDD/F emission time series for stationary combustion plants.

4.11 Hexachlorobenzene (HCB)

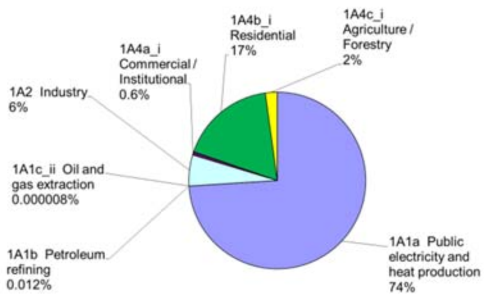
Stationary plants accounted for 50 % of the estimated national emission of hexachlorobenzene (HCB) in 2015.

Table 23 shows the HCB emission inventory for the stationary combustion subcategories. *Public electricity and heat production* account for 74 % of the emission. Residential plants account for 17 % of the emission.

The time series for HCB emission is presented in Figure 35. The HCB emission has decreased 80 % since 1990 mainly due to improved flue gas cleaning in waste incineration plants. The high emission from residential plants in 1990-1995 is related to combustion of coal in residential plants.

Table 23 HCB emissions from stationary combustion plants, 2015[1)].

	HCB, kg
1A1a Public electricity and heat production	0.855
1A1b Petroleum refining	0.0001
1A1c Oil and gas extraction	0.00000009
1A2 Industry	0.066
1A4a Commercial/Institutional	0.007
1A4b Residential	0.203
1A4c Agriculture/Forestry	0.025
Total	1.156



[1)] Only the emissions from stationary combustion plants in the source categories are included.

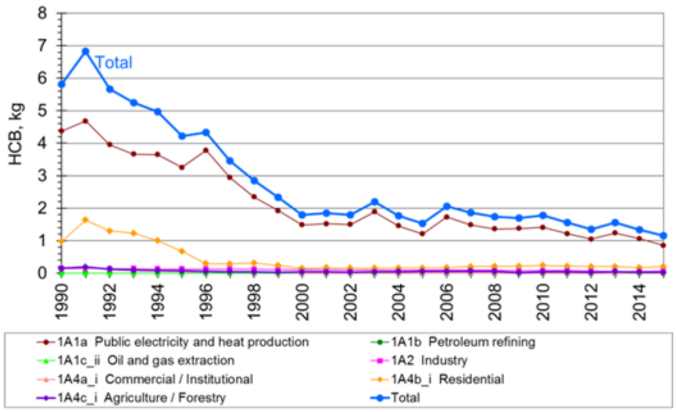


Figure 35 HCB emission time series for stationary combustion plants.

4.12 Polychlorinated biphenyls (PCBs)

Polychlorinated biphenyls (PCBs) can be emitted in any chemical process involving chloride and organic carbon or emitted due to incomplete combustion of PCBs in fuel (waste incineration). In Denmark, waste with high levels of PCBs is only incinerated in plants with permission to incinerate this waste fraction, as it requires a high combustion temperature.

Different references for PCBs emissions are not directly comparable because some PCBs emission data are reported for individual PCB congeners, some as a sum of a specified list of PCB congeners and some PCBs emission data are reported as toxic equivalence (teq) based on toxicity equivalence factors (TEF) for 12 dioxin-like PCB congeners. The emission measurements reported by

Thistlethwaite (2001a and 2001b) show that the emission of non-dioxin-like PCBs is high compared to the emission of dioxin-like PCBs.

Furthermore, teq values based on TEF are reported as WHO_{2005}-teq or WHO_{1998}-teq. This difference is however typically less than 50%[5].

For stationary combustion, the emission inventory is a sum of dioxin-like PCBs (dl-PCBs) emission, no teq values applied.

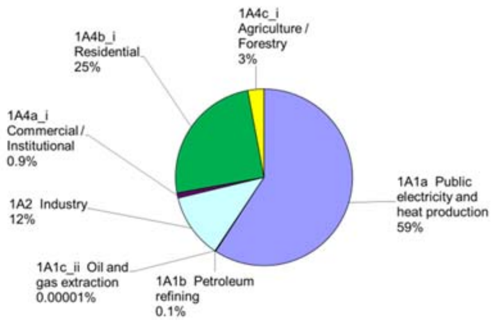
Stationary plants accounted for 0.9 % of the estimated national PCB emission in 2015.

Table 24 shows the dioxin-like PCBs emission inventory for the stationary combustion subcategories. *Public electricity and heat production* accounted for 59 % of the emission in 2015. Residential plants accounted for 25 % of the emission.

The time series for dioxin-like PCBs emission is presented in Figure 36. The dioxin-like PCBs emission has decreased 67 % since 1990. The decrease is mainly a result of the flue gas cleaning devices that have been installed in waste incineration plants for dioxin reduction.

Table 24 Dioxin-like PCBs emissions from stationary combustion plants, 2015[1)].

	PCB, kg
1A1a Public electricity and heat production	0.228
1A1b Petroleum refining	0.001
1A1c Oil and gas extraction	0.000
1A2 Industry	0.046
1A4a Commercial/Institutional	0.004
1A4b Residential	0.096
1A4c Agriculture/Forestry	0.011
Total	0.385



[1)] Only the emissions from stationary combustion plants in the source categories are included.

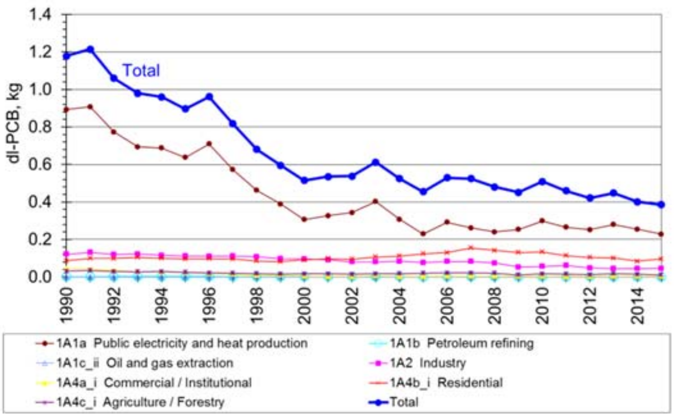


Figure 36 PCBs emission time series for stationary combustion plants.

[5] Data have been compared for a few datasets in which each dioxin-like PCB congener was specified.

5. Trend for subsectors

In addition to the data for stationary combustion, this chapter presents and discusses data for each of the subcategories in which stationary combustion is included. Time series are presented for fuel consumption and emissions.

5.1 1A1 Energy industries

The emission source category *1A1 Energy Industries* consists of the subcategories:

- 1A1a Public electricity and heat production
- 1A1b Petroleum refining
- 1A1c Oil and gas extraction

Figure 37-42 present time series for the *Energy Industries. Public electricity and heat production* is the largest subcategory accounting for the main part of all emissions. Time series are discussed below for each subcategory.

The high emission of two PAHs in 1994 is an error that will be corrected in the 2018 inventory.

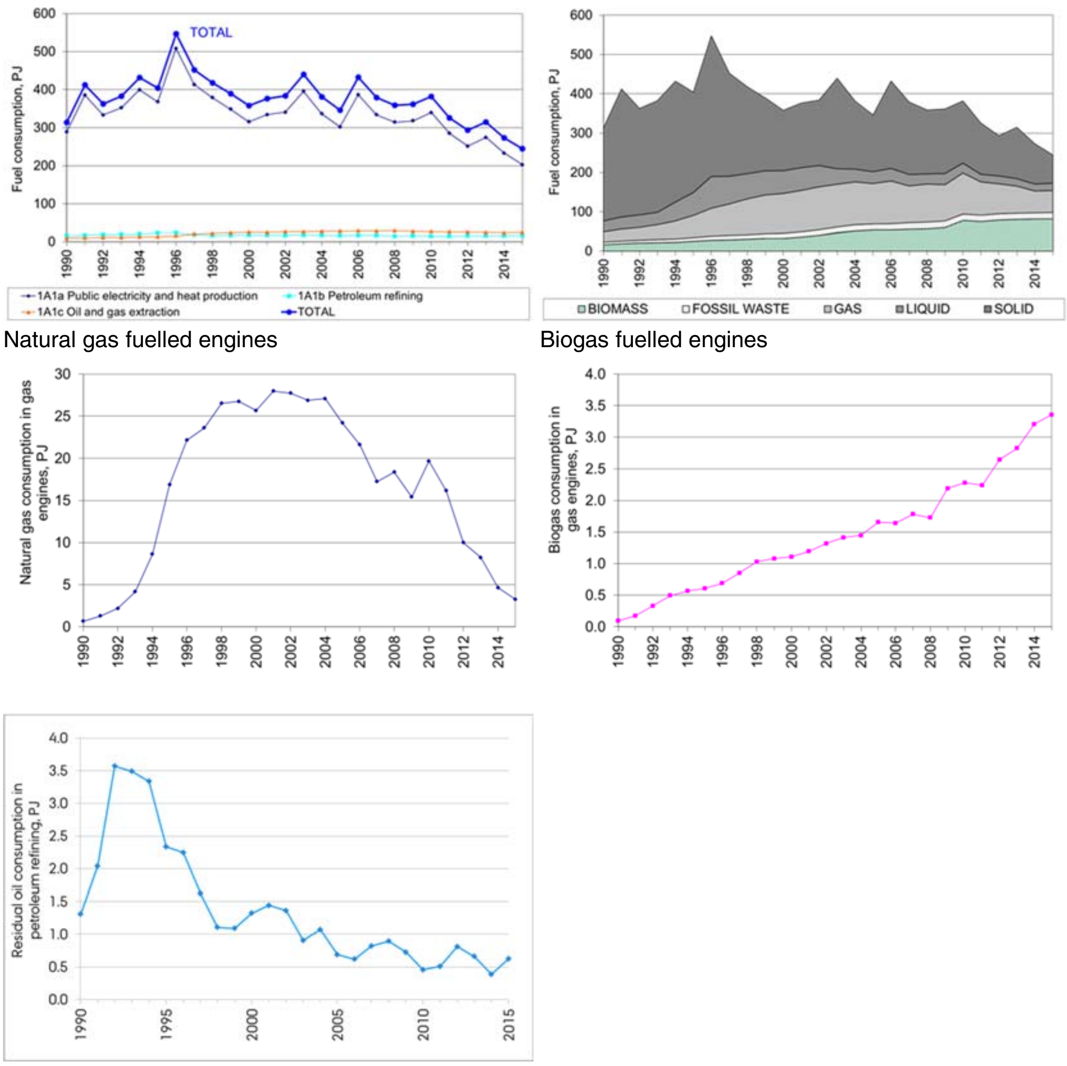


Figure 37 Time series for fuel consumption in source category 1A1 Energy industries.

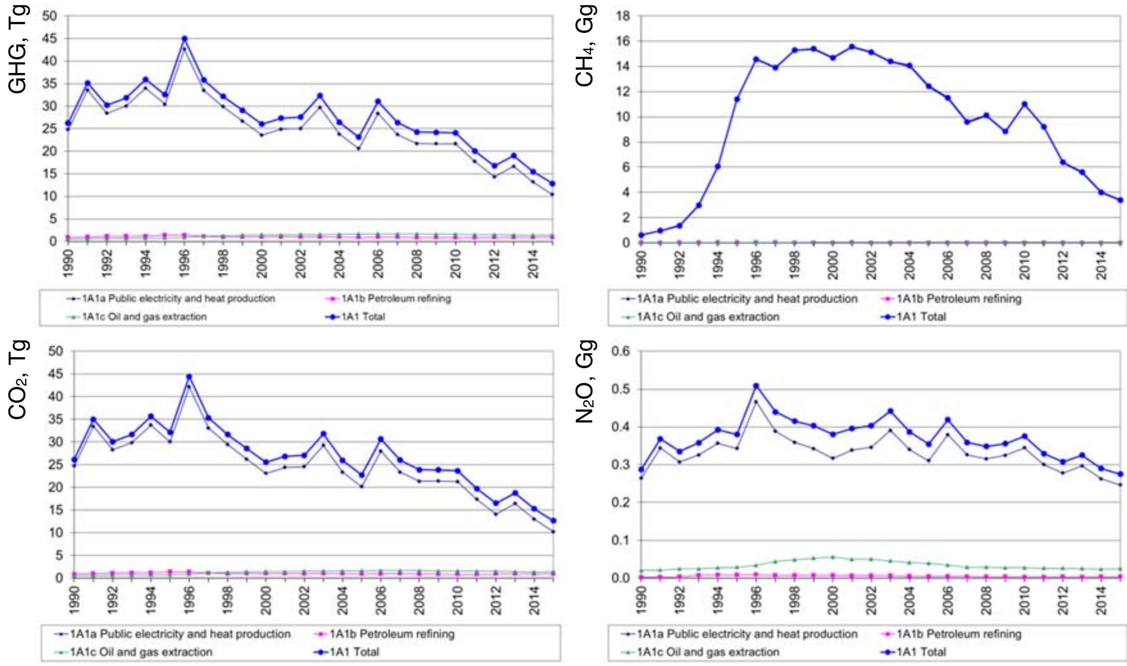


Figure 38 Time series for greenhouse gas emissions in source category 1A1 Energy industries.

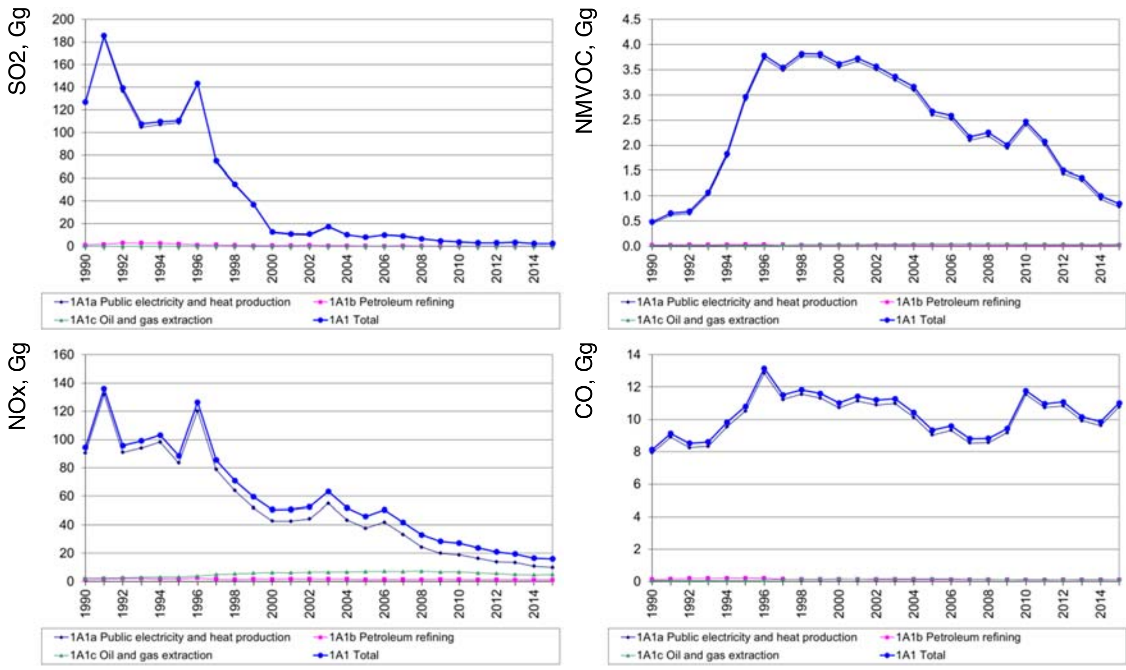


Figure 39 Time series for SO_2, NO_x, NMVOC and CO emission, 1A1 Energy industries.

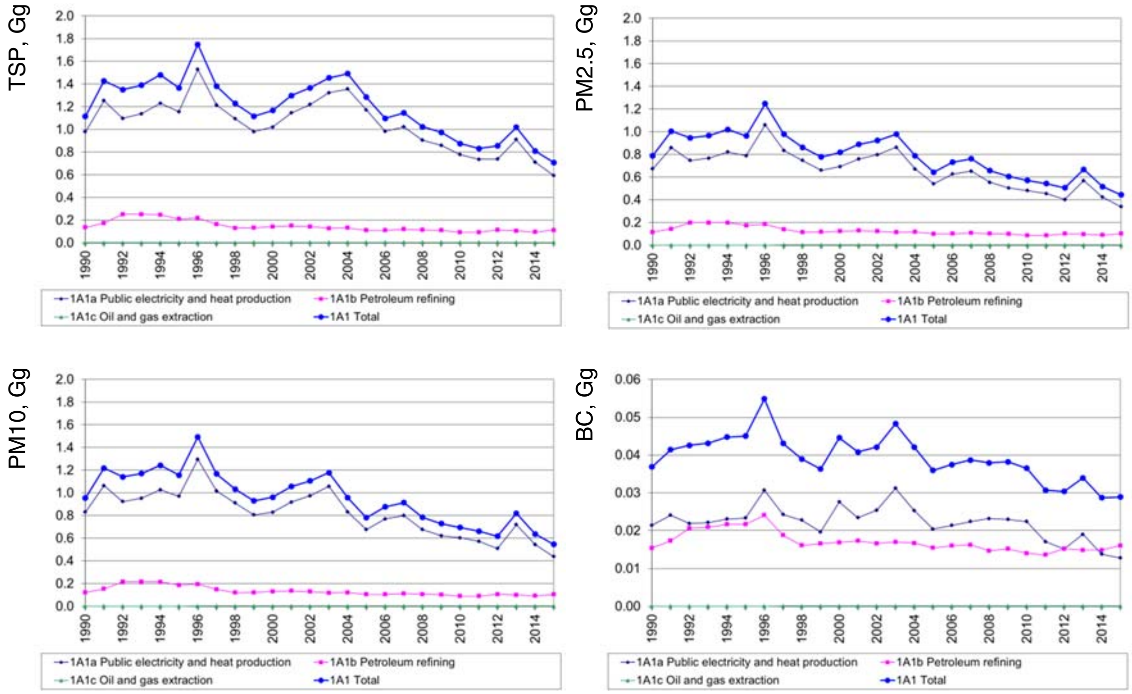


Figure 40   Time series for PM and BC emission in source caterory 1A1 Energy industries.

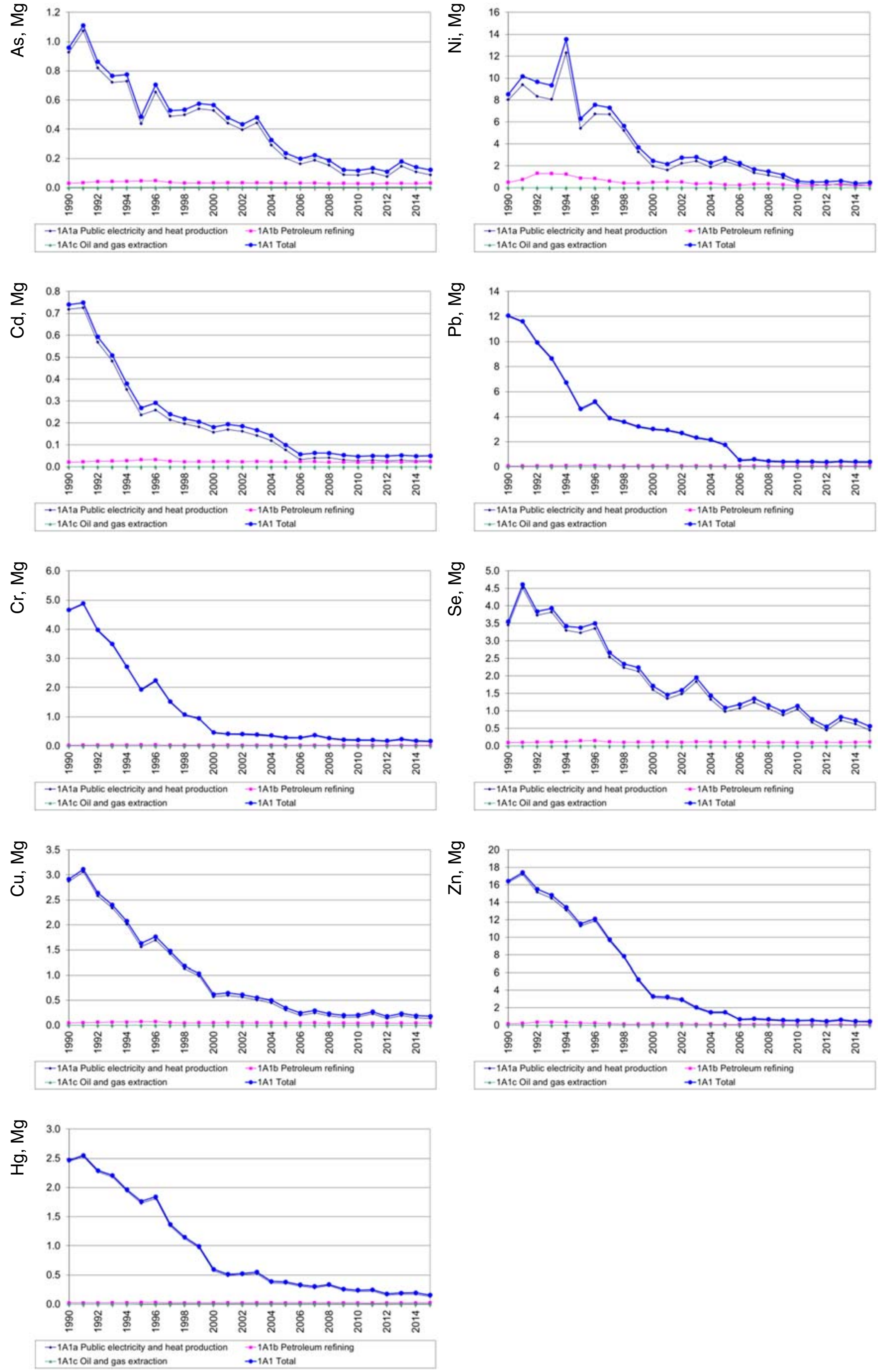


Figure 41 Time series for HM emission in source category 1A1 Energy industries.

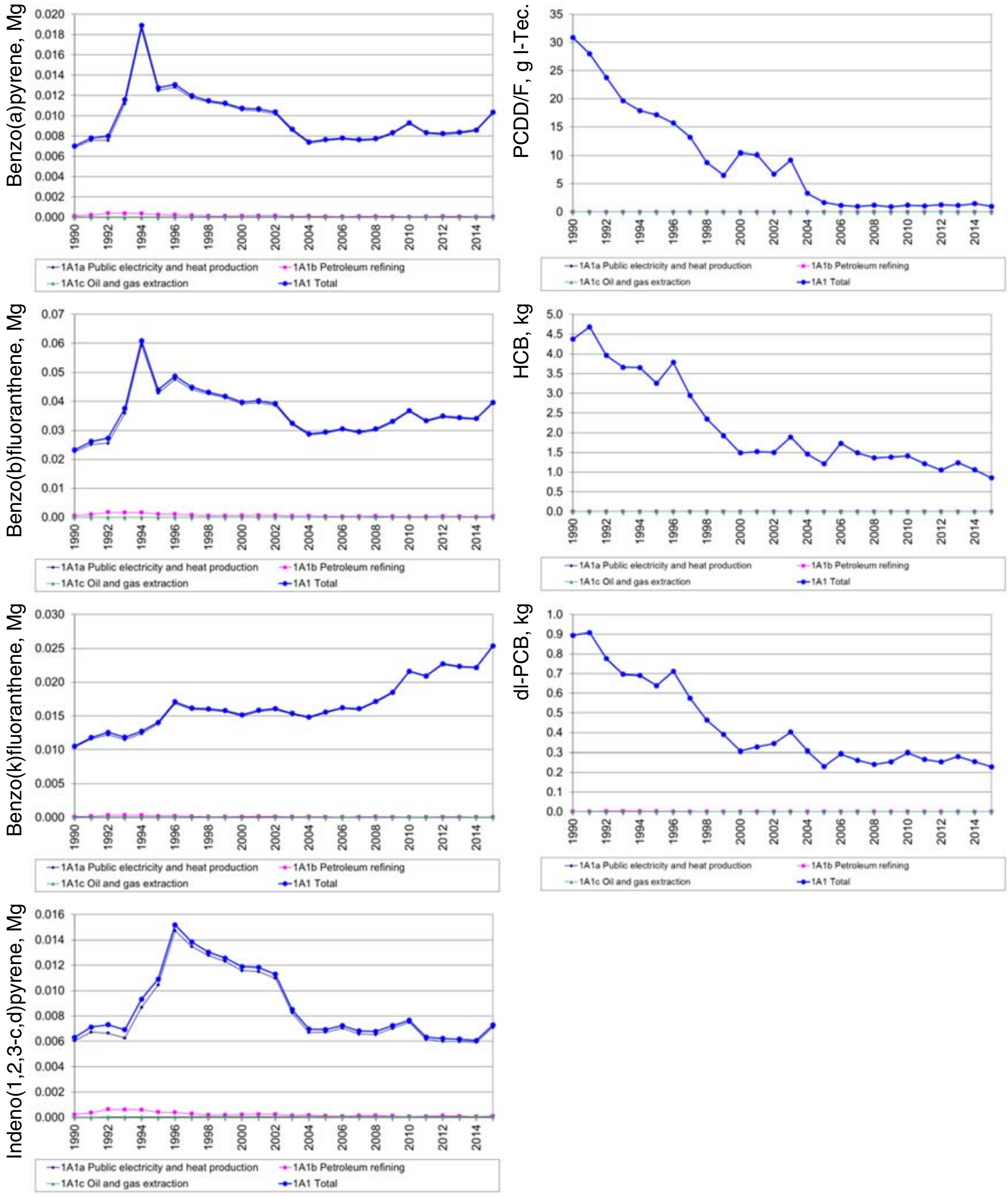


Figure 42 Time series for PAH, PCDD/F, HCB and dl-PCB emission in source category 1A1 Energy industries.

5.1.1 1A1a Electricity and heat production

Public electricity and heat production is the largest source category regarding both fuel consumption and greenhouse gas emissions for stationary combustion. Figure 43 shows the time series for fuel consumption and emissions.

The fuel consumption in public electricity and heat production was 30 % lower in 2015 than in 1990. The fossil fuel consumption was 56% lower than in 1990 whereas the biomass consumption was 5 times the 1990-level. In addition to the fuel type changes, the total fuel consumption is also influenced by the fact that the Danish wind power production has increased.

As discussed in Chapter 2 the fuel consumption fluctuates mainly because of electricity trade. Coal is the fuel that is affected the most by the fluctuating electricity trade.

Coal is the main fuel in the source category even in years with electricity import. The coal consumption in 2015 was 70 % lower than in 1990. Natural gas is also an important fuel and the consumption of natural gas increased in 1990-2000 but has decreased since 2010. A considerable part of the natural gas is combusted in gas engines (Figure 37). The consumption of waste and biomass has increased.

The CO_2 emission was 58 % lower in 2015 than in 1990. This decrease – in spite of only a 30 % decrease in fuel consumption - is a result of the change of fuel types used as discussed above.

The CH_4 emission has increase until the mid-nineties as a result of the considerable number of lean-burn gas engines installed in CHP plants in Denmark in this period. The decline after 2004 is due to structural changes in the Danish electricity market, which means that the fuel consumption in gas engines has been decreasing (Figure 37). The emission in 2015 was 5.6 times the 1990 emission level.

The N_2O emission in 2015 was 7 % lower than the 1990 emission level. The emission fluctuates similar to the fuel consumption.

The SO_2 emission has decreased 98 % from 1990 to 2015. This decrease is a result of both lower sulphur content in fuels and installation and improved performance of desulphurisation plants. The emission was 1 % lower in 2015 than in 2014.

The NO_x emission has decreased 89 % since 1990 due to installation of low NO_x burners, selective catalytic reduction (SCR) units and selective non-catalytic reduction (SNCR) units. The fluctuations in time series follow the fluctuations in fuel consumption and electricity trade. The NO_x emission was 8 % lower in 2015 than in 2014.

The emission of NMVOC was 74 % higher in 2015 than in 1990. The emission increased until 1996 and decreased after 2002. This is a result of the large number of gas engines installed in Danish CHP plants. The decreasing emission in 2004-2015 is results of the time series for natural gas consumption in gas engines (Figure 37). In addition, the emission of NMVOC from engines decreased in 1995-2007 as a result of the introduction of an emission limits for unburned hydrocarbon[6] (DEPA, 2005).

The CO emission was 36 % higher in 2015 than in 1990. The fluctuations follow the fluctuations of the fuel consumption. In addition, the emission from gas engines is considerable.

[6] Including methane.

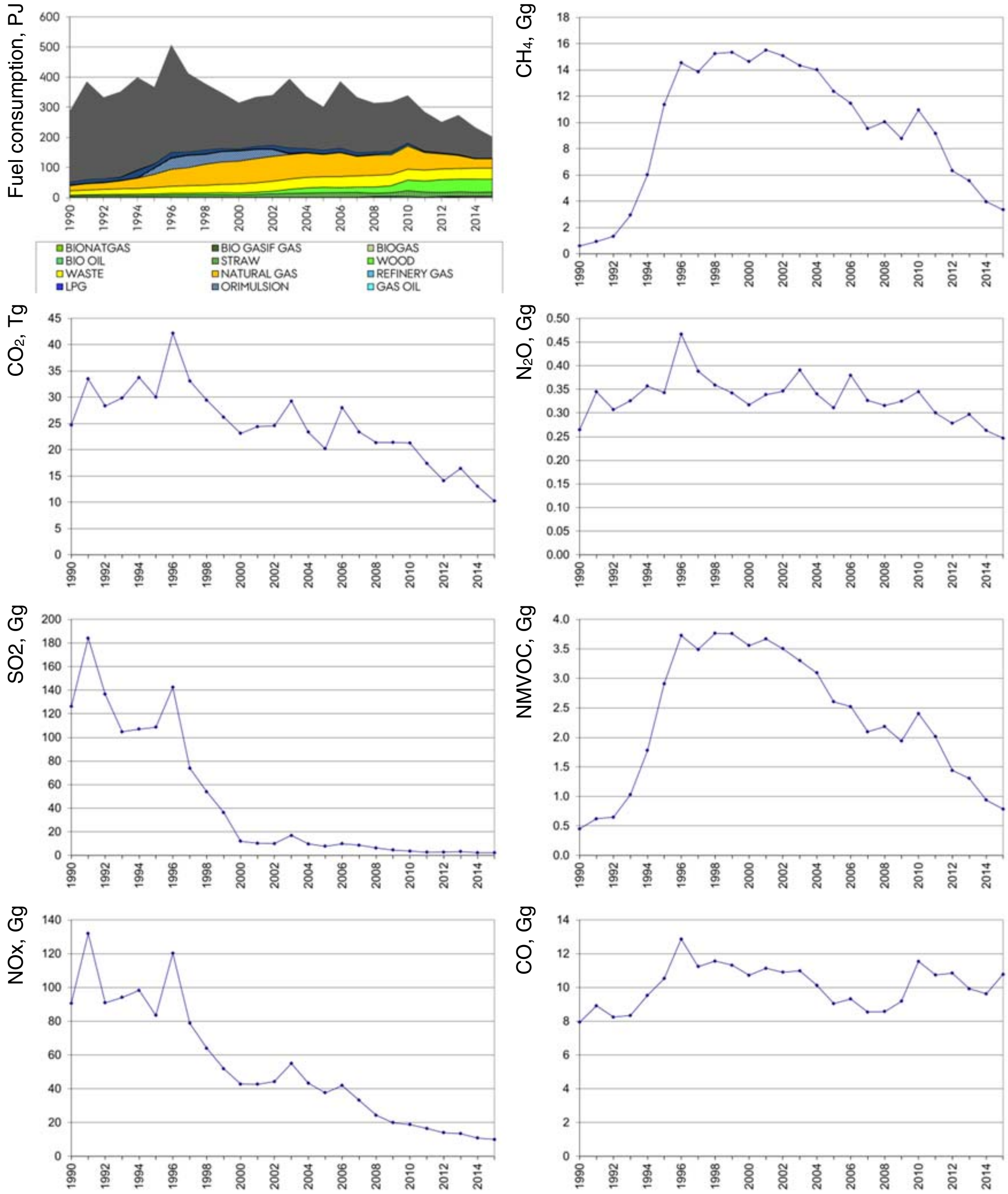


Figure 43 Time series for subcategory 1A1a Public electricity and heat production.

5.1.2 1A1b Petroleum refining

Petroleum refining is a small source category regarding both fuel consumption and emissions for stationary combustion. There are presently only two refineries operating in Denmark. Figure 44 shows the time series for fuel consumption and emissions.

The significant decrease in both fuel consumption and emissions in 1996 is a result of the closure of a third refinery.

The fuel consumption has increased 10 % since 1990 and the CO_2 emission has increased 8 %.

The CH_4 emission has increased 9 % since 1990 and increased 8 % since 2014. The reduction in CH_4 emission from 1995 to 1996 is caused by the closure of a refinery.

The N_2O emission was 75 % higher in 2015 than in 1990. The emission increased in 1993 as a result of the installation of a gas turbine in one of the refineries (DEA, 2016b).

The N_2O emission factor for the refinery gas fuelled gas turbine has been assumed equal to the emission factor for natural gas fuelled turbines and thus the emission factor have been decreasing since 2001. The time series for the emission factor cause the decreasing N_2O emission since 2001.

The emission of SO_2 has shown a pronounced decrease (79 %) since 1990, mainly because decreased consumption of residual oil (52 %) also shown in Figure 44. The increase in SO_2 emission in 1990-1992 also follows the residual oil consumption. The NO_x emission in 2015 was 21 % lower than in 1990. Since 2005, data for both SO_2 and NO_x are plant specific data stated by the refineries.

The NMVOC emission time series follows the time series for fuel consumption.

Emissions from refineries are further discussed in Nielsen et al. (2017a), Nielsen et al. (2017b), and Plejdrup et al., (2015).

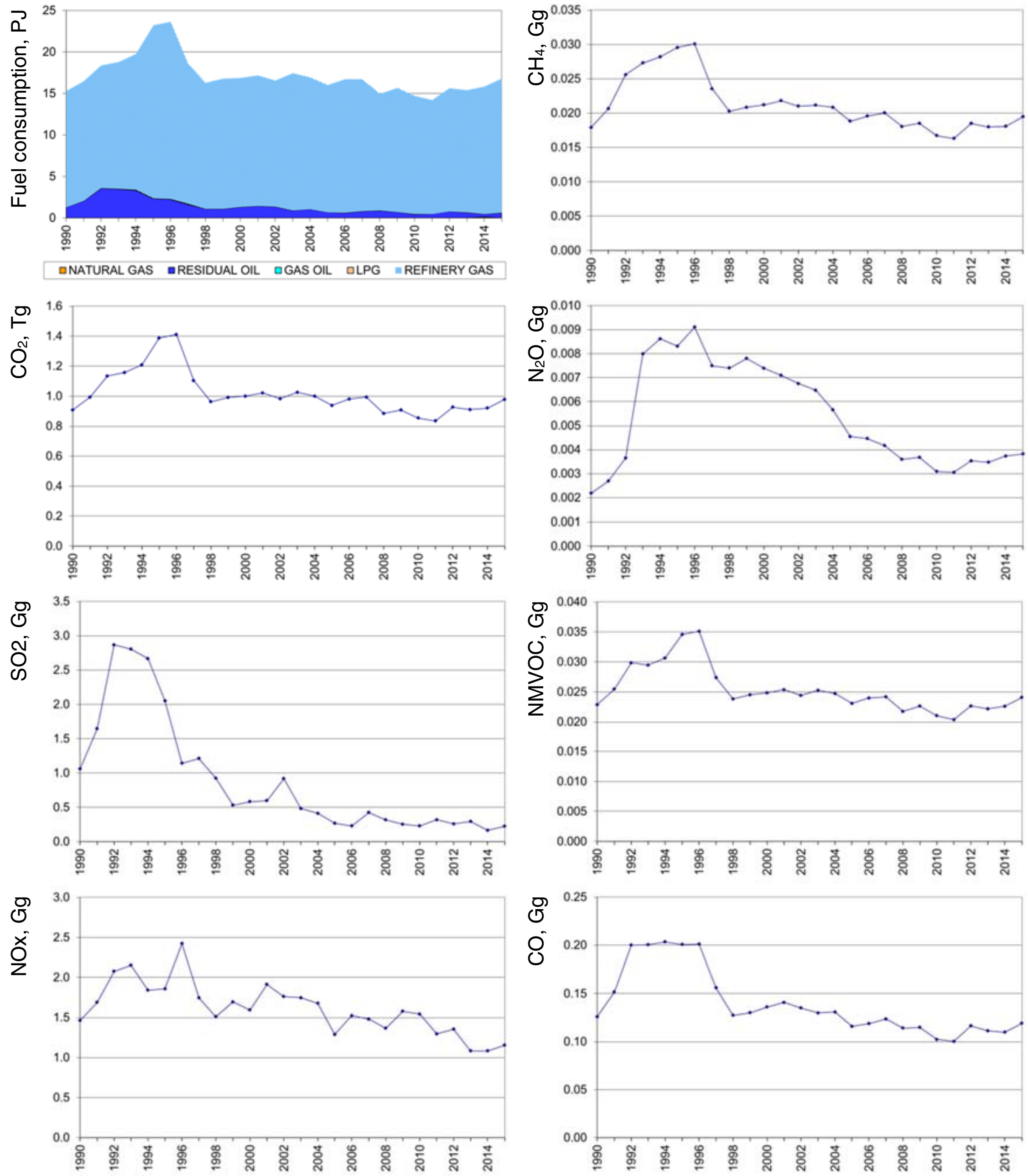


Figure 44 Time series for subcategory 1A1b Petroleum refining.

5.1.3 1A1c Oil and gas extraction

The source category *Oil and gas extraction* comprises natural gas consumption in the offshore industry and in addition a small consumption in the Danish gas treatment plant[7]. Gas turbines are the main plant type. Figure 45 shows the time series for fuel consumption and emissions.

The fuel consumption in 2015 was 2.6 times the consumption in 1990. The fuel consumption has decreased since 2008, but increased between 2014 and 2015. The CO_2 emission follows the fuel consumption and the emission in 2015 was 2.6 times the emission in 1990.

The emission factor time series for N_2O follow the decreasing emission factor time series for gas turbines applied in CHP plants.

The emissions of SO_2, NO_x, NMVOC and CO follow the increased fuel consumption.

The decrease of CO emission in 2005 – 2007 is a result of a lower emission factor. This decrease of the emission factor is valid for gas turbines in CHP plants, but might not be valid for offshore gas turbines. However, the same emission factors have been assumed for CO emission due to the lack of data from offshore gas turbines.

[7] Nybro.

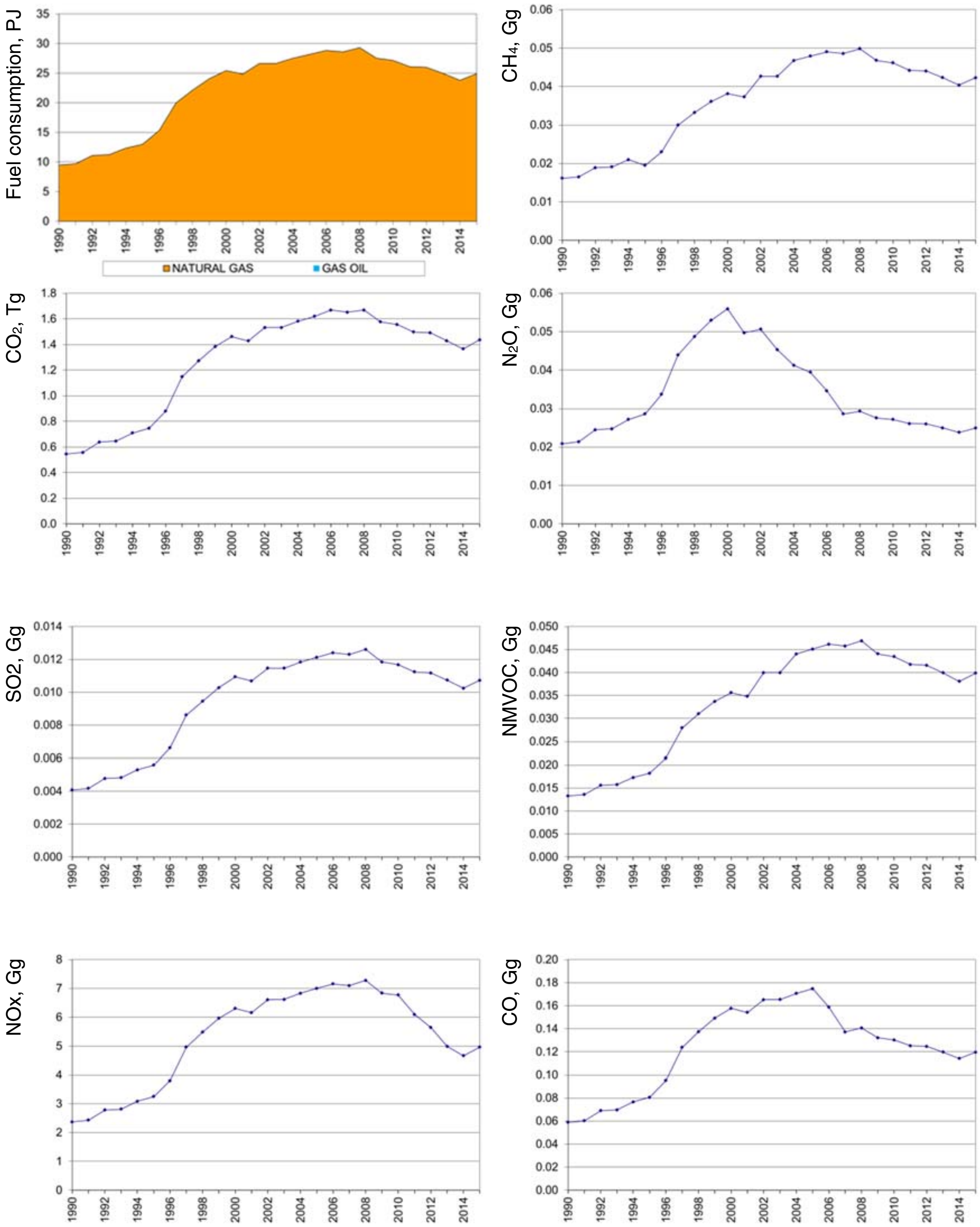


Figure 45 Time series for subcategory 1A1c Oil and gas extraction.

5.2 1A2 Industry

Manufacturing industries and construction (Industry) consists of both stationary and mobile sources. In this report, only stationary sources are included.

The emission source category *1A2 Industry* consists of the subcategories:

- 1A2a Iron and steel
- 1A2b Non-ferrous metals
- 1A2c Chemicals
- 1A2d Pulp, Paper and Print
- 1A2e Food processing, beverages and tobacco
- 1A2f Non-metallic minerals
- 1A2 g viii Other manufacturing industry

The figures 46 – 51 show the time series for fuel consumption and emissions. The subsectors *Non-metallic minerals*, *Other manufacturing industry* and *Food processing, beverages and tobacco* are the main subsectors for fuel consumption and emissions.

The total fuel consumption in industrial combustion was 24 % lower in 2015 than in 1990. The consumption of natural gas has increased since 1990 whereas the consumption of coal has decreased. The consumption of residual oil has decreased, but the consumption of petroleum coke increased. The biomass consumption has increased 13 % since 1990.

The greenhouse gas emission and the CO_2 emission are both rather stable until 2006 following the small fluctuations in fuel consumption. After 2006, the fuel consumption has decreased. Due to change of applied fuels, the greenhouse gas and CO_2 emissions have decreased more than the fuel consumption since 1990; both emissions have decreased 34 %.

The CH_4 emission has increased from 1994-2001 and decreased again from 2001-2007. In 2015, the emission was 81 % higher than in 1990. The CH_4 emission follows the consumption of natural gas in gas engines (Figure 46). Most industrial CHP plants based on gas engines came in operation in the years 1995 to 1999. The decrease after 2004 is a result of the liberalisation of the electricity market.

The N_2O emission has decreased 32 % since 1990, mainly due to the decreased residual oil consumption. The emission from other manufacturing industries increased from 1994 to 1995. This increase is related to combustion of coke oven coke in mineral wool production. Plant specific fuel consumption data are only available from 1995 onwards for the mineral wool production plants.

The SO_2 emission has decreased 81 % since 1990. This is mainly a result of lower consumption of residual oil in the industrial sector (Figure 3.2.37). Further, the sulphur content of residual oil and several other fuels has decreased since 1990 due to legislation and tax laws.

The NO_x emission has decreased 60 % since 1990 due to the reduced emission from industrial boilers in general. Cement production is the main emission source accounting for more than 50 % of the industrial emission in 1990-2010[8].

[8] More than 80 % of sector 1A2f i.

After 2010, the NO_x emission from cement production was reduced considerably and in 2015, the NO_x emission from cement industry was 38 % of the total emission from manufacturing industries and construction. The NO_x emission from cement production was reduced 72 % since 1990. The reduced emission is a result of installation of SCR on all production units at the cement production plant in 2004-2007[9] and improved performance of the SCR units in recent years. A NO_x tax was introduced in 2010 (DMT, 2008).

The NMVOC emission has decreased 76 % since 1990. The decrease is mainly a result of decreased emission factor for combustion of wood in industrial boilers. The emission from gas engines has however increased considerably after 1995 due to the increased fuel consumption that is a result of the installation of a large number of industrial CHP plants (Figure 46). The NMVOC emission factor for gas engines is much higher than for boilers regardless of the fuel.

The CO emission in 2015 was 21 % lower than in 1990. The main sources of emission are combustion of wood and cement production. The CO emission from mineral wool production is included in the industry sector (2A6). The increased emission in 1998 is related to the cement production plant in Denmark. The CO emission increased due to combustion of more paper pulp. In the following years, the combustion of this fuel was improved to decrease the CO emission (Annual environmental reports from Aalborg Portland, 1998-2002).

The PM emissions from the cement production plant are underestimated for 1990-1999. This will be corrected in the next emission inventory. In addition, an error for BC emission will be corrected.

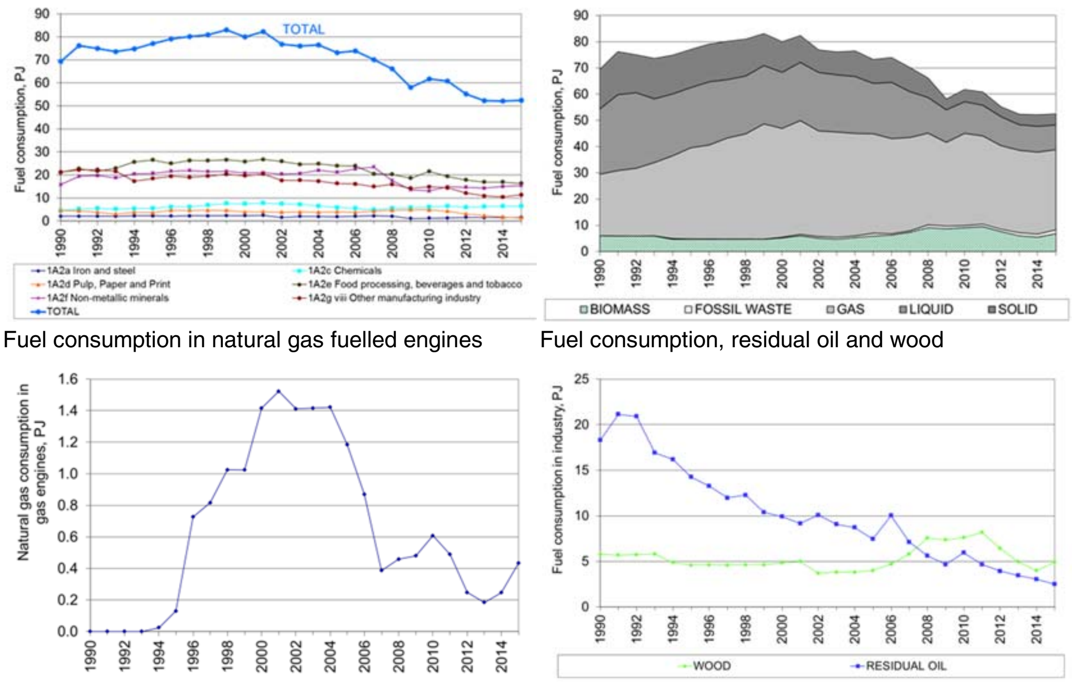


Figure 46   Time series for fuel consumption in source category 1A2 Industry.

[9] To meet emission limit.

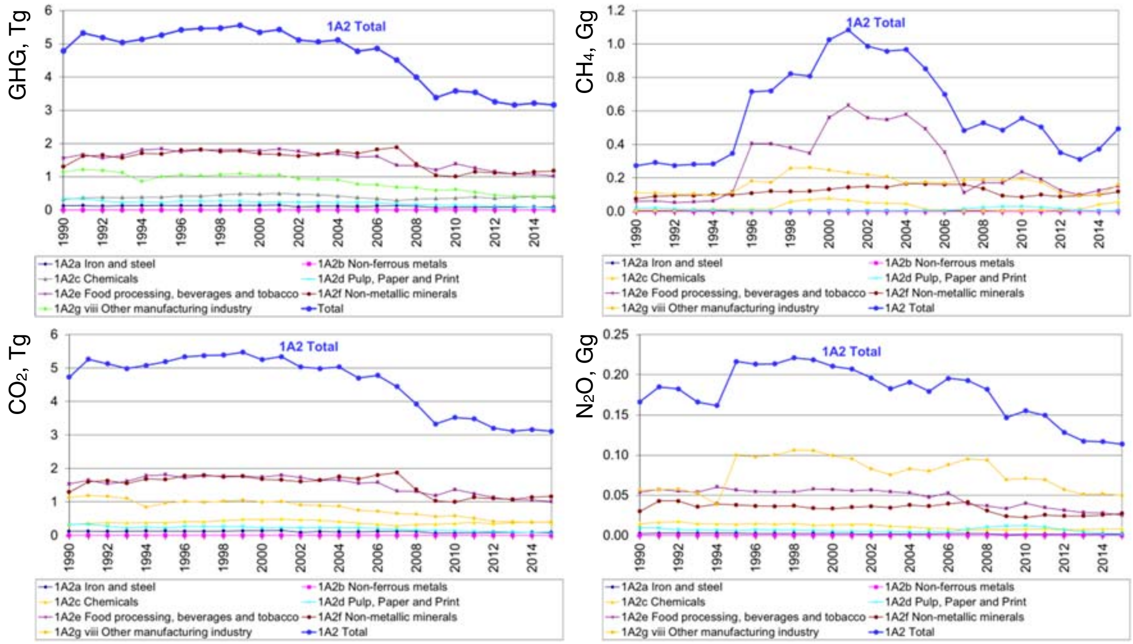


Figure 47 Time series for greenhouse gas emission in source category 1A2 Industry.

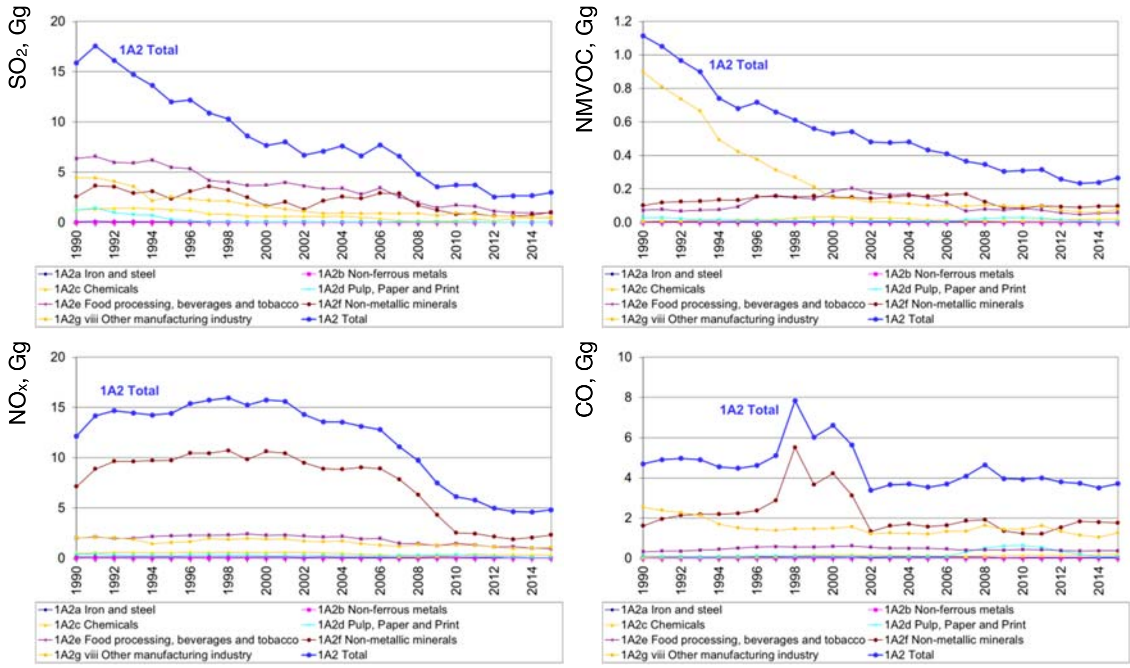


Figure 48 Time series for SO_2, NO_x, NMVOC and CO emission in source category 1A2 Industry.

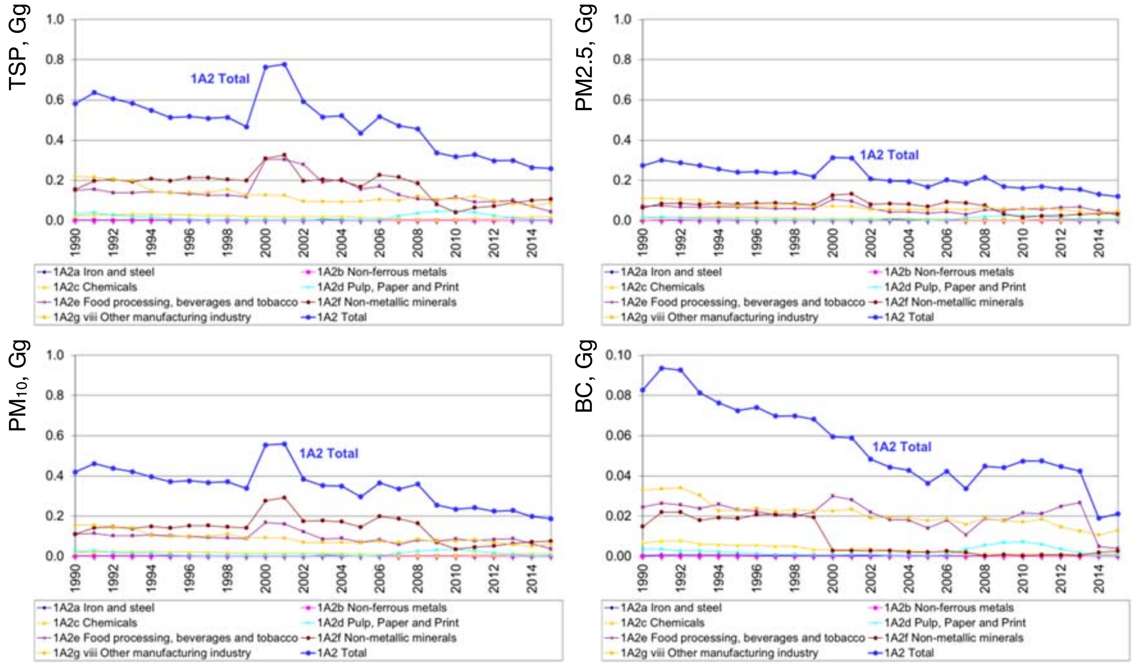


Figure 49 Time series for PM and BC emission in source category 1A2 Industry.

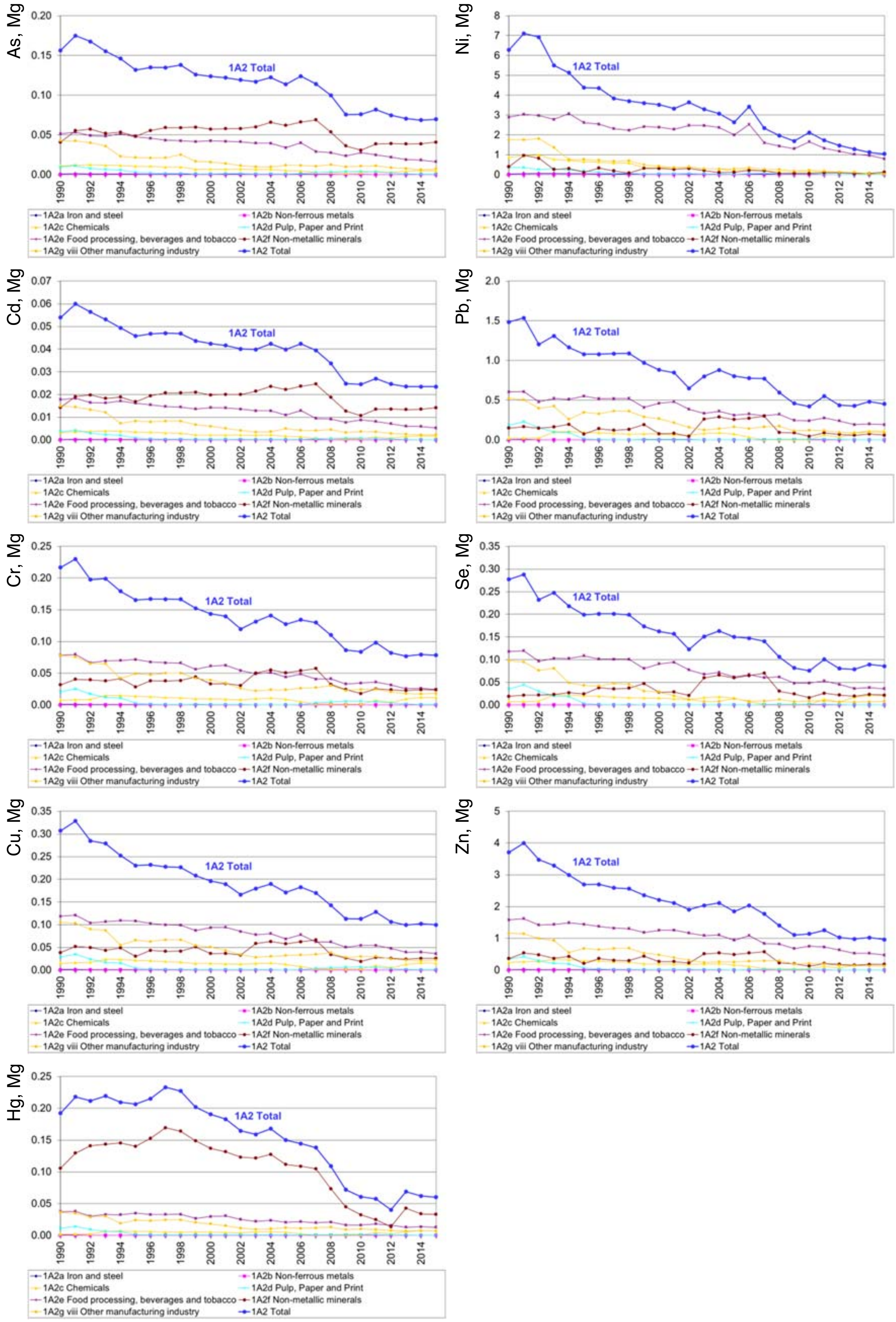


Figure 50 Time series for HM emission in source category 1A2 Industry.

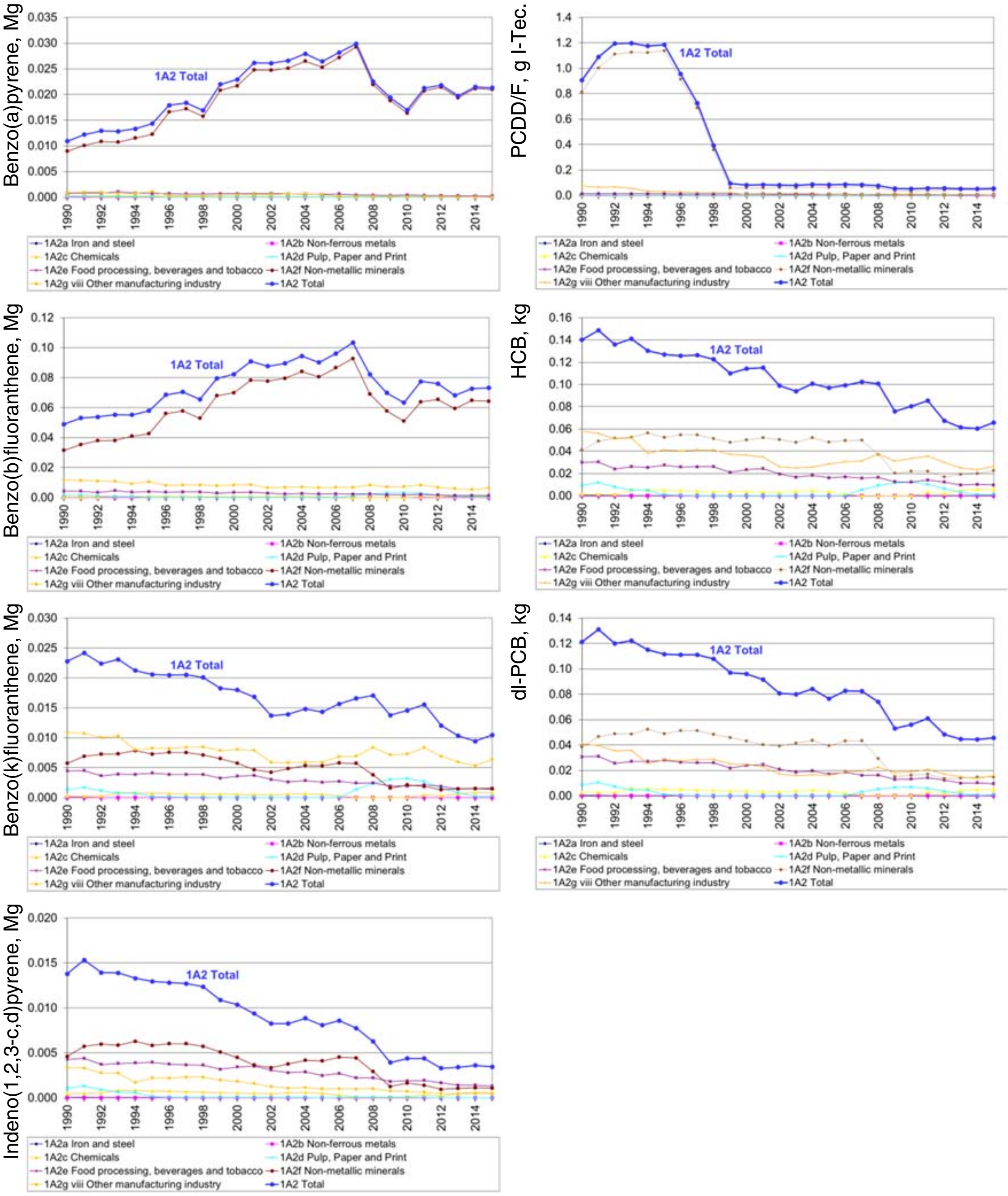


Figure 51 Time series for PAH, PCDD/F, HCB and dioxin-like PCB emission in source category 1A2 Industry.

5.2.1 1A2a Iron and steel

Iron and steel is a very small emission source category. Figure 52 shows the time series for fuel consumption and emissions.

Natural gas is the main fuel in the subsector.

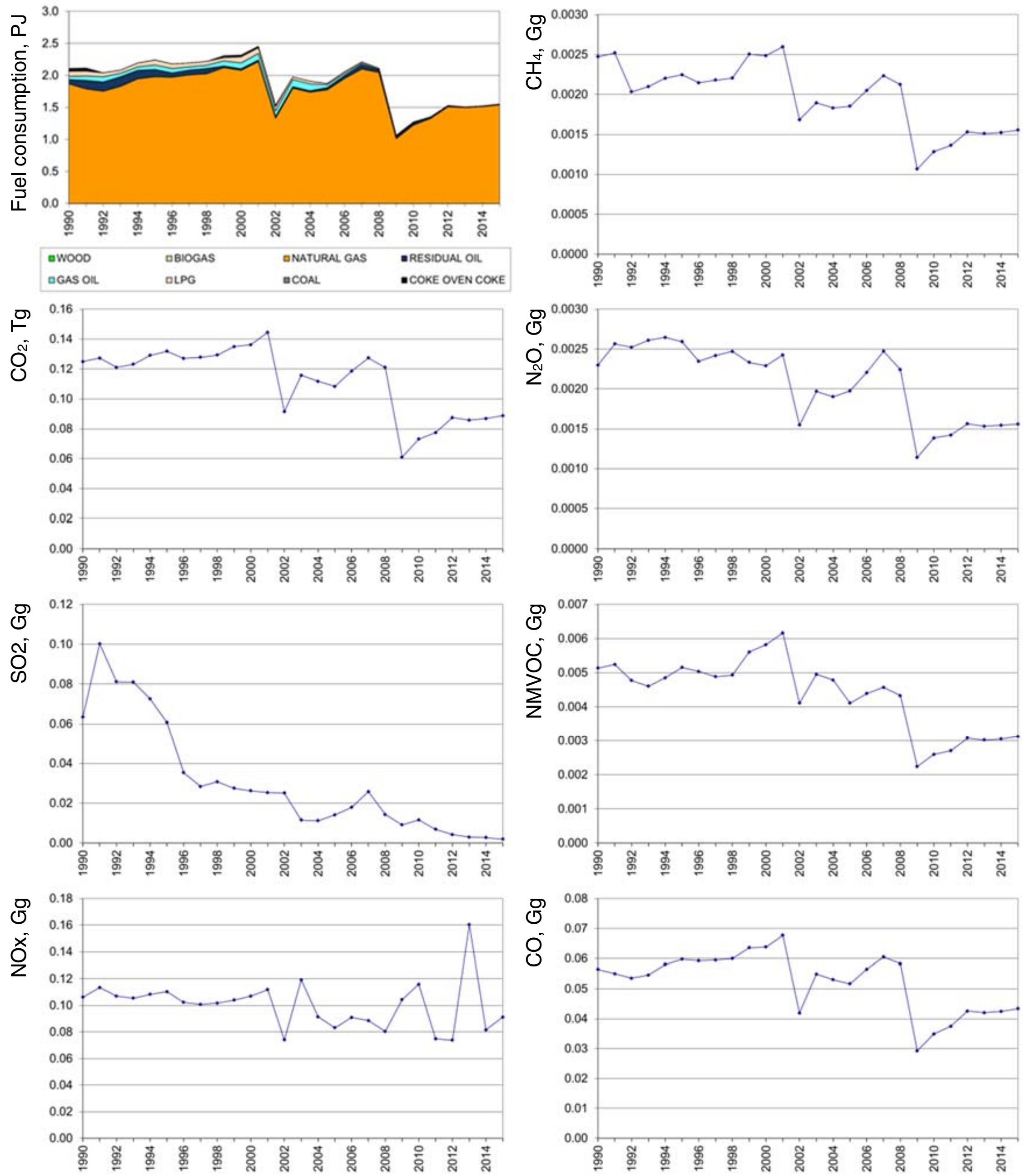


Figure 52 Time series for subcategory 1A2a Iron and steel.

5.2.2 1A2b Non-ferrous metals

The energy statistics have been recalculated and now no fuel consumption is reported for non-ferrous metals.

5.2.3 1A2c Chemicals

Chemicals is a minor emission source category. Figure 53 shows the time series for fuel consumption and emissions.

Natural gas is the main fuel in this subsector. The CO_2 emission time series follow the time series for fuel consumption. The time series for CH_4 emission 1997-2012 is related to consumption of natural gas in gas engines. The increased CH_4 emission in 2014 and 2015 is related to one biogas fuelled engine. The decreasing time series for N_2O emission is related to the decreasing consumption of residual oil.

The consumption of residual oil has decreased and the SO_2 emission follows this fuel consumption.

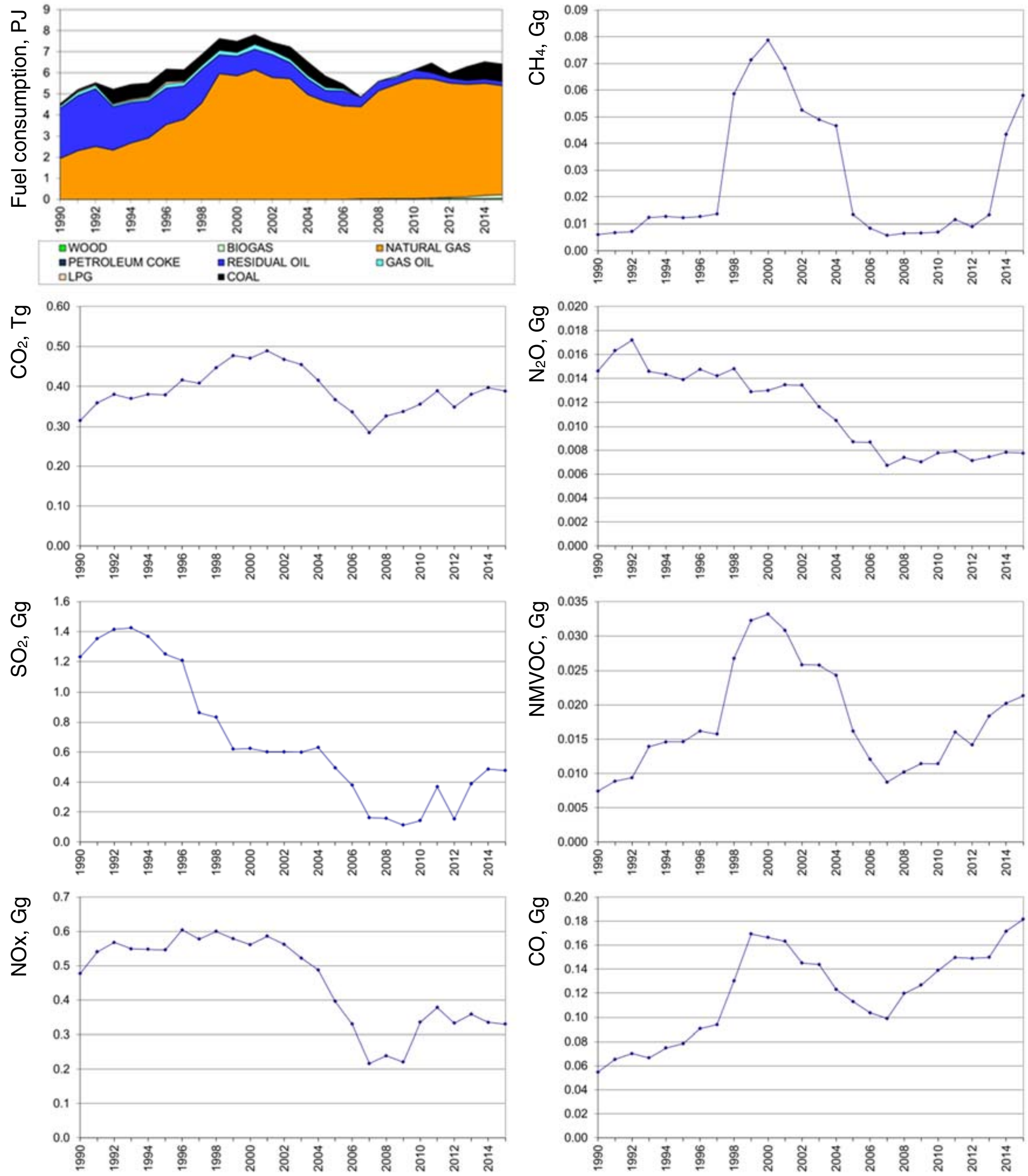


Figure 53 Time series for subcategory 1A2c Chemicals.

5.2.4 1A2d Pulp, paper and print

Pulp, paper and print is a minor emission source category. Figure 54 shows the time series for fuel consumption and emissions.

Natural gas, and in 2007-2013 also wood, are the main fuels in the subsector. The increased use of wood from 2007 is reflected in the CO_2 emission time series.

The increased consumption of wood in 2007-2013 is also reflected in the CH_4 and N_2O emission time series.

The consumption of coal and residual oil has decreased and this is reflected in the SO_2 emission time series. The increased consumption of wood in 2007-2012 has resulted in a considerable increase and decrease of NMVOC and CO emission in 2007-2012.

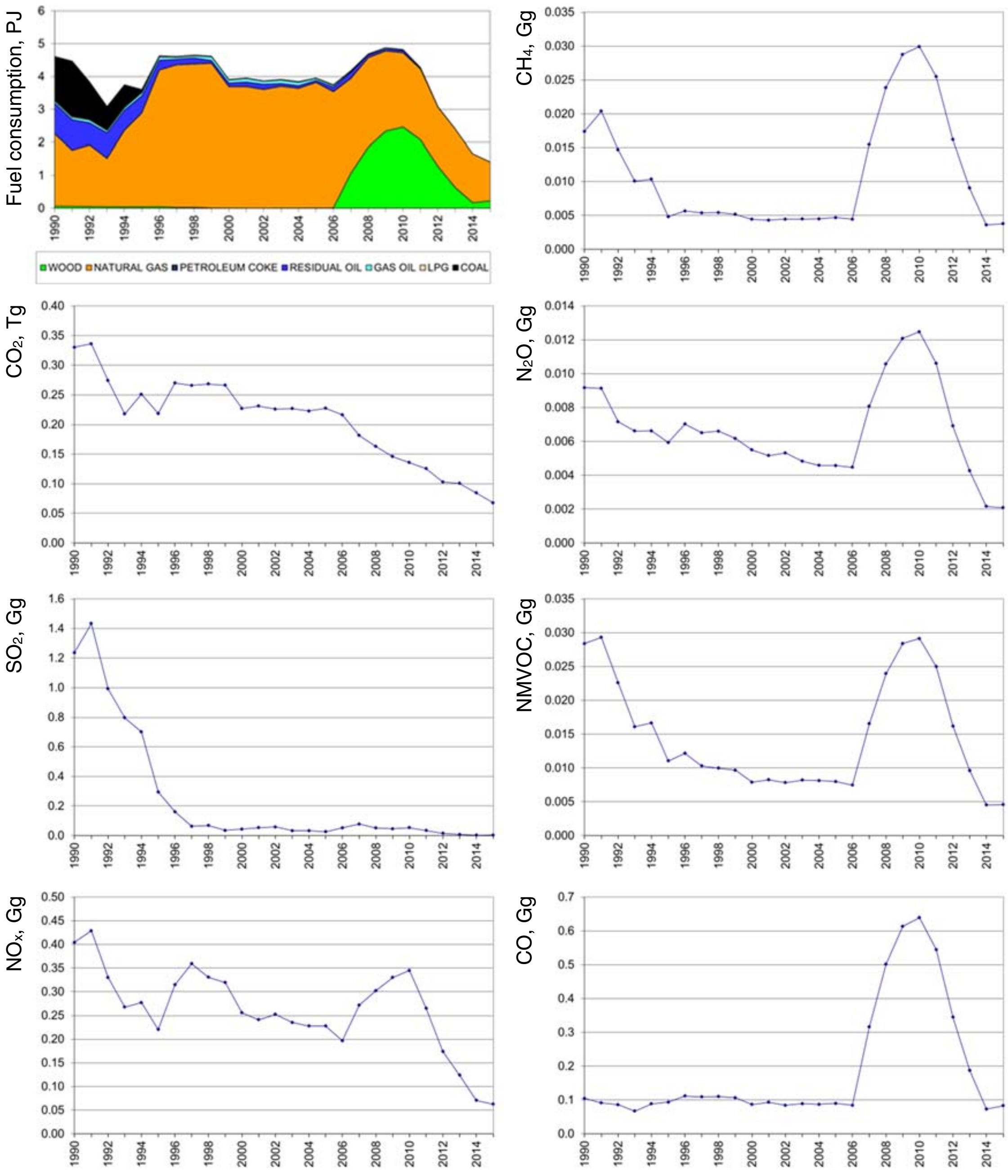


Figure 54 Time series for subcategory 1A2d Pulp, paper and print.

5.2.5 1A2e Food processing, beverages and tobacco

Food processing, beverages and tobacco is a considerable industrial subsector. Figure 55 shows the time series for fuel consumption and emissions.

Natural gas, residual oil and coal are the main fuels in the subsector. The consumption of coal and residual oil has decreased whereas the consumption of natural gas has increased.

The time series for CH_4 emission follows the consumption of natural gas in gas engines.

The decreased consumption of residual oil and coal has is reflected in the SO_2 emission time series.

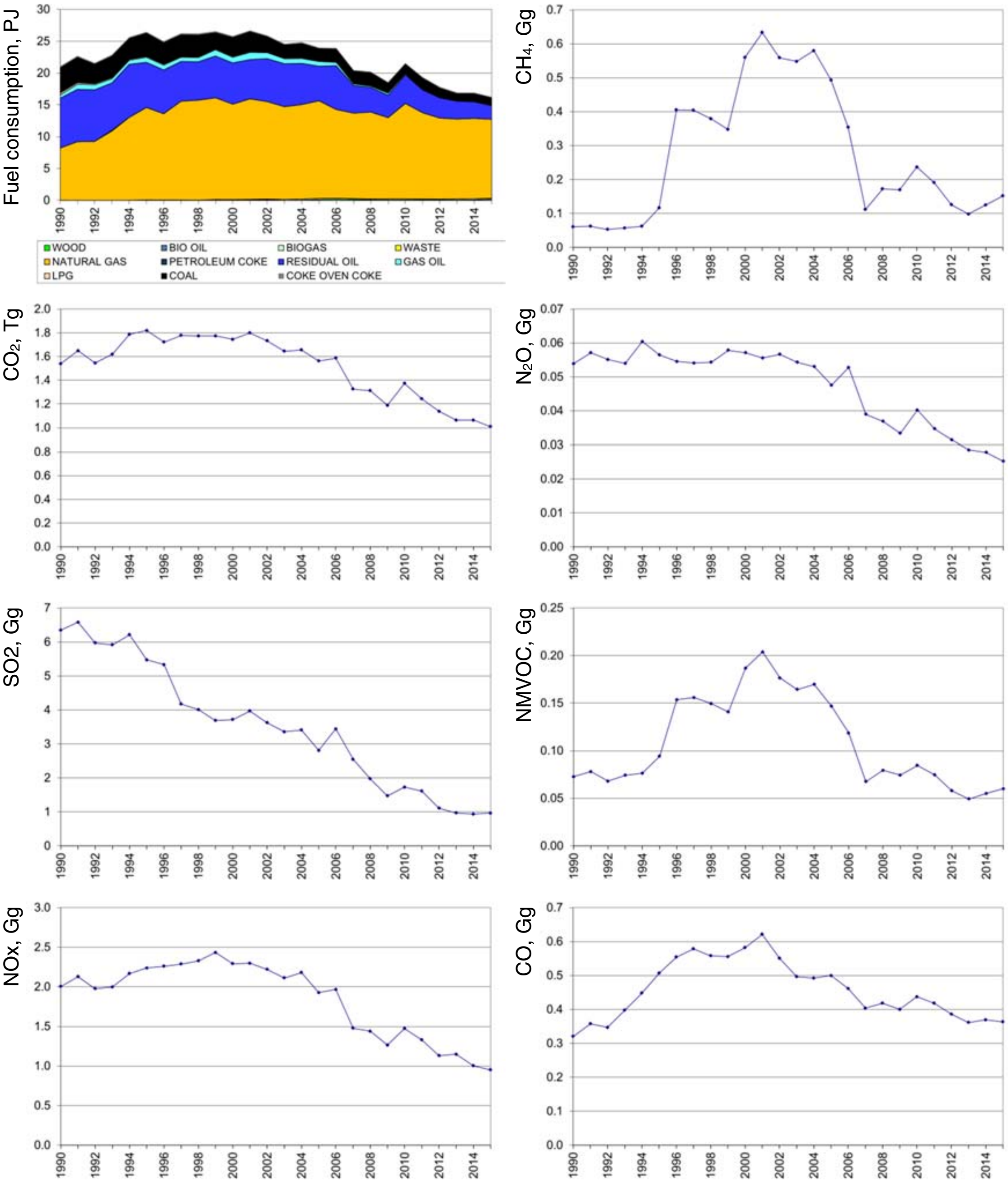


Figure 55 Time series for subcategory 1A2e Food processing, beverages and tobacco.

5.2.6 1A2f Non-metallic minerals

Non-metallic minerals is a considerable industrial subsector. The subsector includes cement production that is a major industrial emission source in Denmark. Figure 56 shows the time series for fuel consumption and emissions.

Petroleum coke, natural gas, industrial waste and coal are the main fuels in the subsector in recent years. The consumption of coal and residual oil has decreased.

Due to the global recession cement production decreased in 2008 and 2009, but then has slightly increased since. This is reflected in the time series.

The NO_x time series is discussed above in Chapter 5.2.

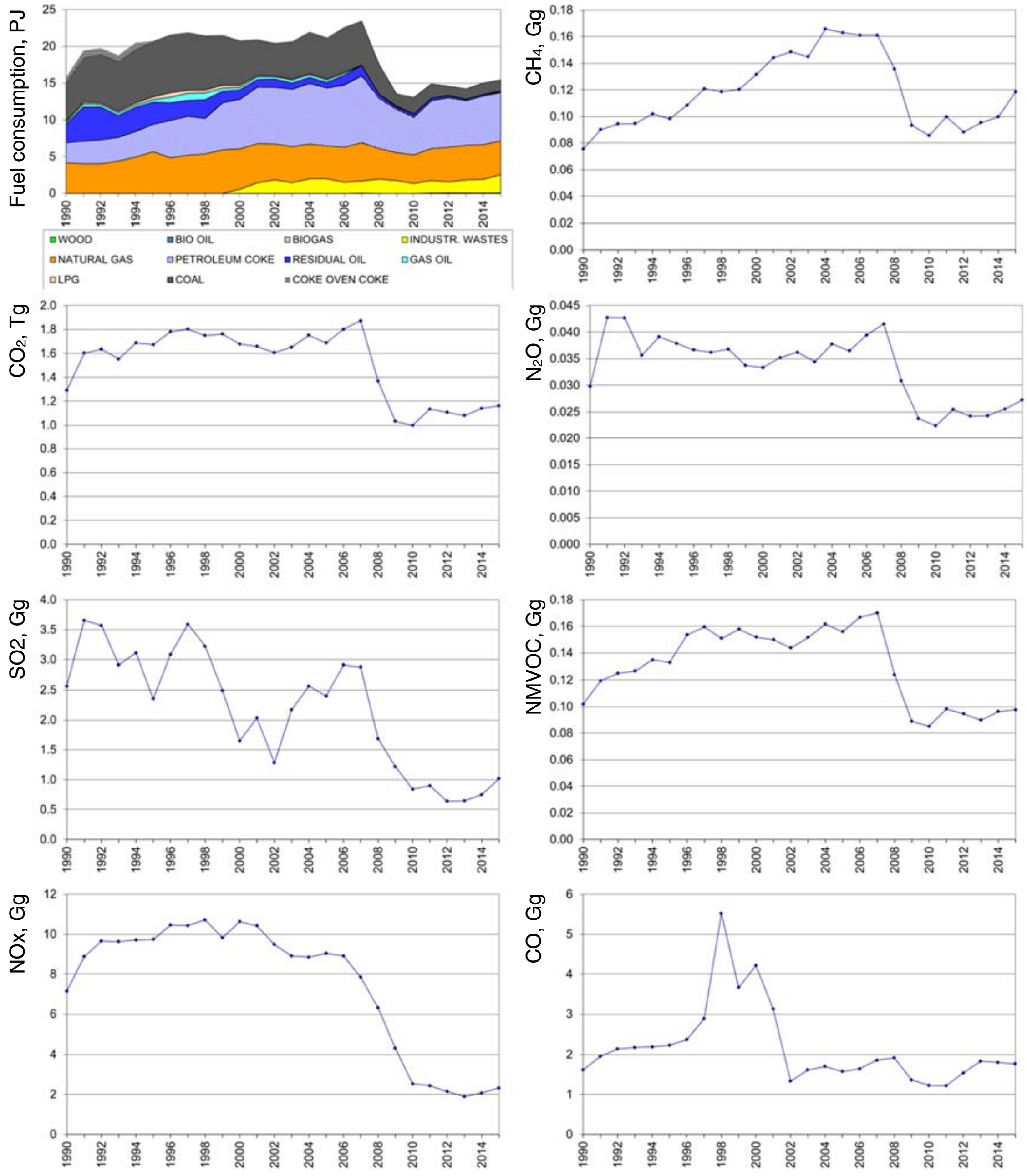


Figure 56 Time series for subcategory 1A2f Non-metallic minerals.

5.2.7 1A2g Other manufacturing industry

Other manufacturing industry is a considerable industrial subsector. Figure 57 shows the time series for fuel consumption and emissions.

Natural gas and wood are the main fuels in the subsector in recent years. The consumption of coal and residual oil has decreased.

The time series for CH_4 is related to the consumption of natural gas in gas engines.

Combustion of coke oven coke in mineral wood production is a large emission source for N_2O. Plant specific fuel consumption rates for the mineral wool production plants are available from 1995. This causes the increase in N_2O emission between 1994 and 1995.

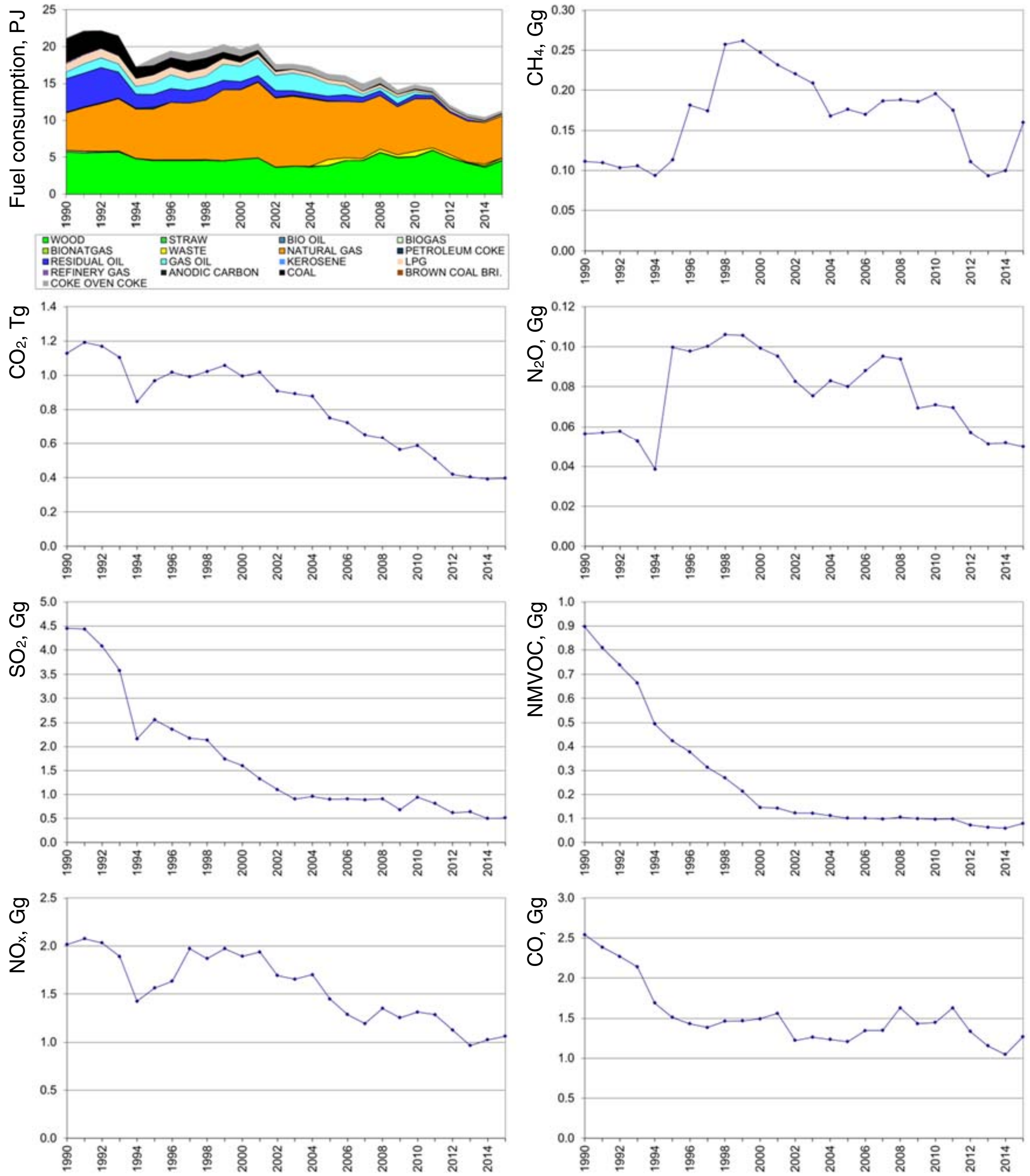


Figure 57 Time series for subcategory 1A2g Industry - other.

5.3 1A4 Other Sectors

The emission source category *1A4 Other Sectors* consists of the subcategories:

- 1A4a Commercial / Institutional plants
- 1A4b Residential plants
- 1A1c Agriculture / Forestry

The Figures 58 - 63 present time series for this emission source category. Residential plants are the dominant subcategory accounting for the largest part of all emissions. Time series are discussed below for each subcategory.

The HCB emission time series follows the fuel consumption of coal in residential plants. The HCB emission factor for coal used in residential plants is high compared to other fuels.

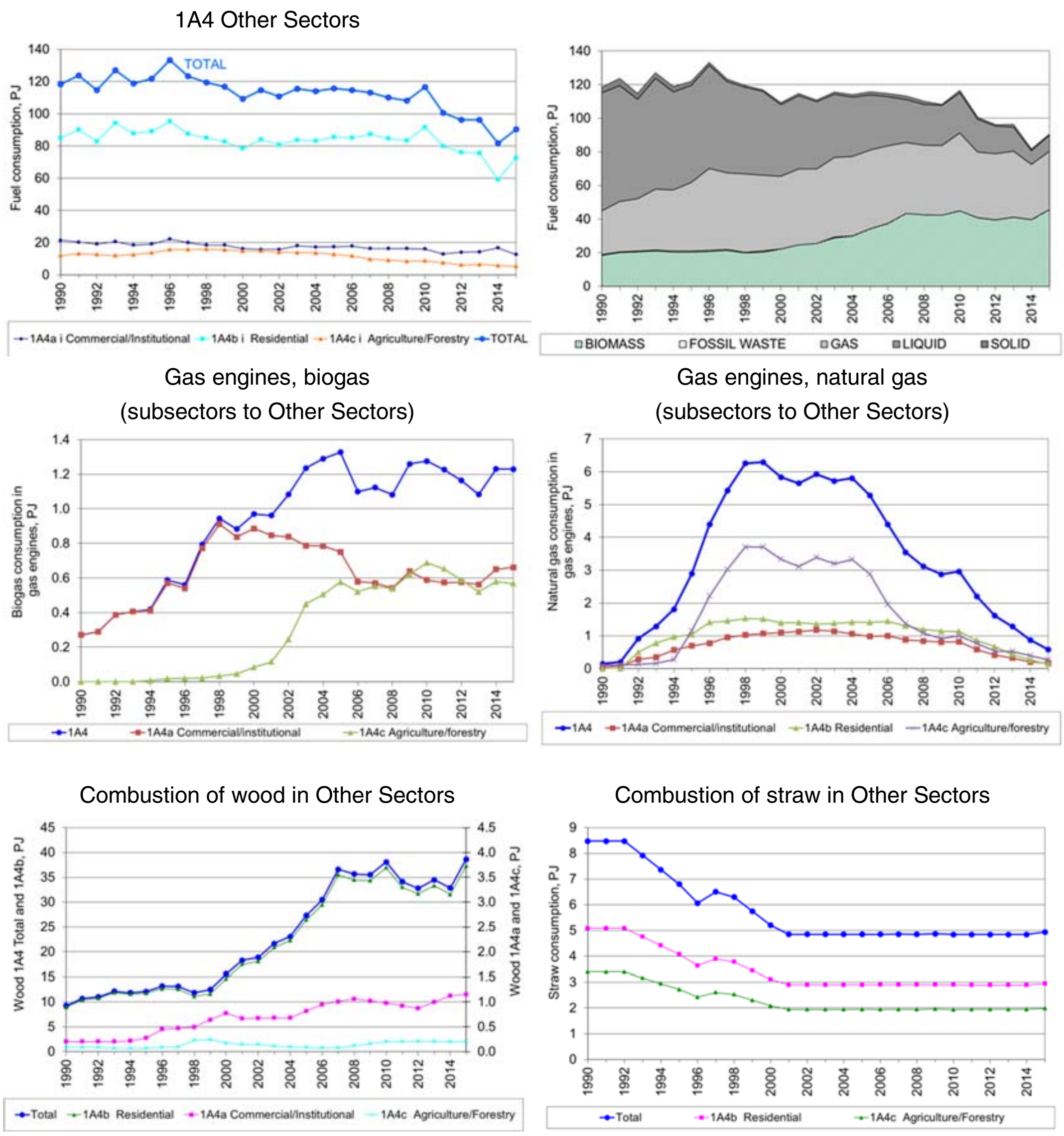


Figure 58 Time series for fuel consumption in source category 1A4 Other Sectors.

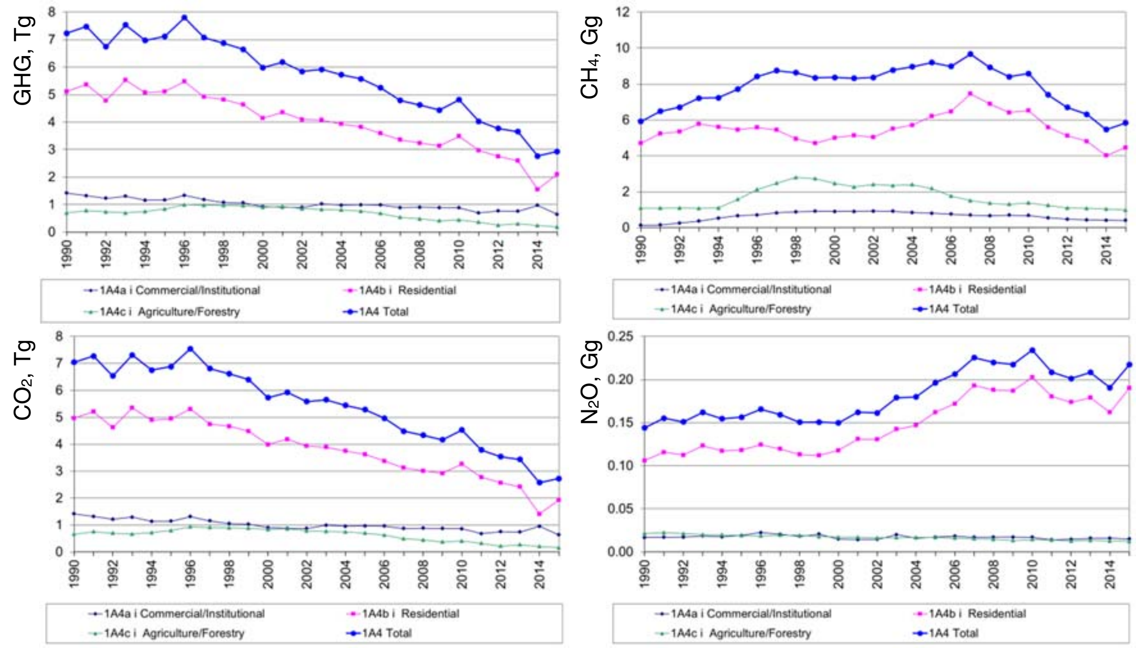


Figure 59 Time series for greenhouse gas emissions in source category 1A4 Other Sectors.

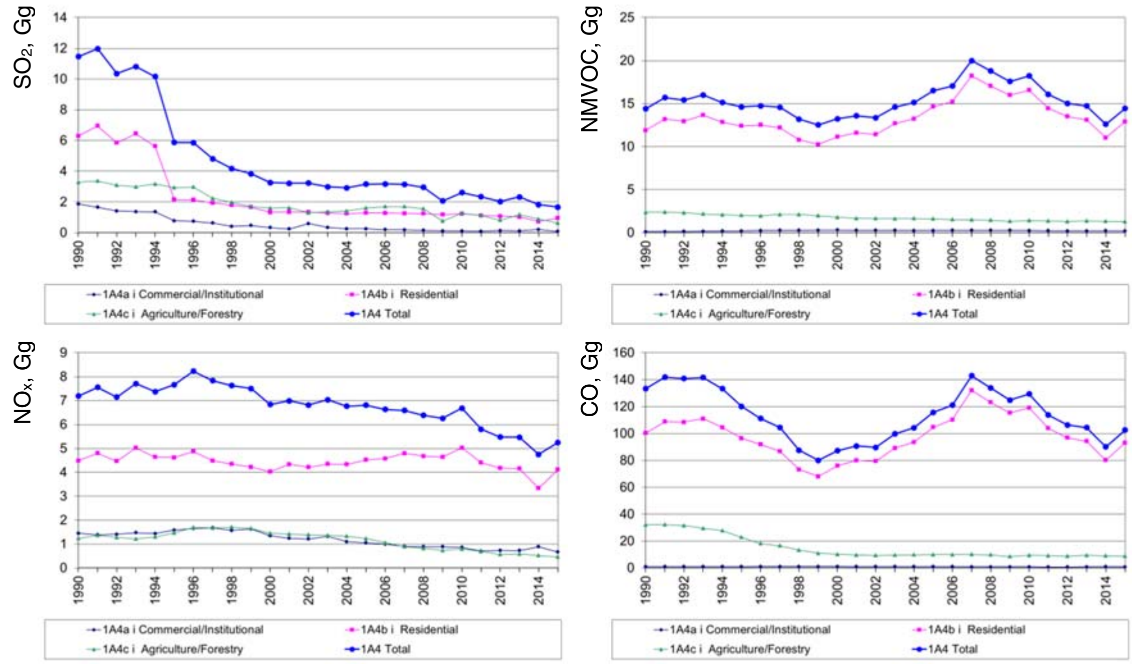


Figure 60 Time series for SO_2, NO_x, NMVOC and CO emissions in source category 1A4 Other sectors.

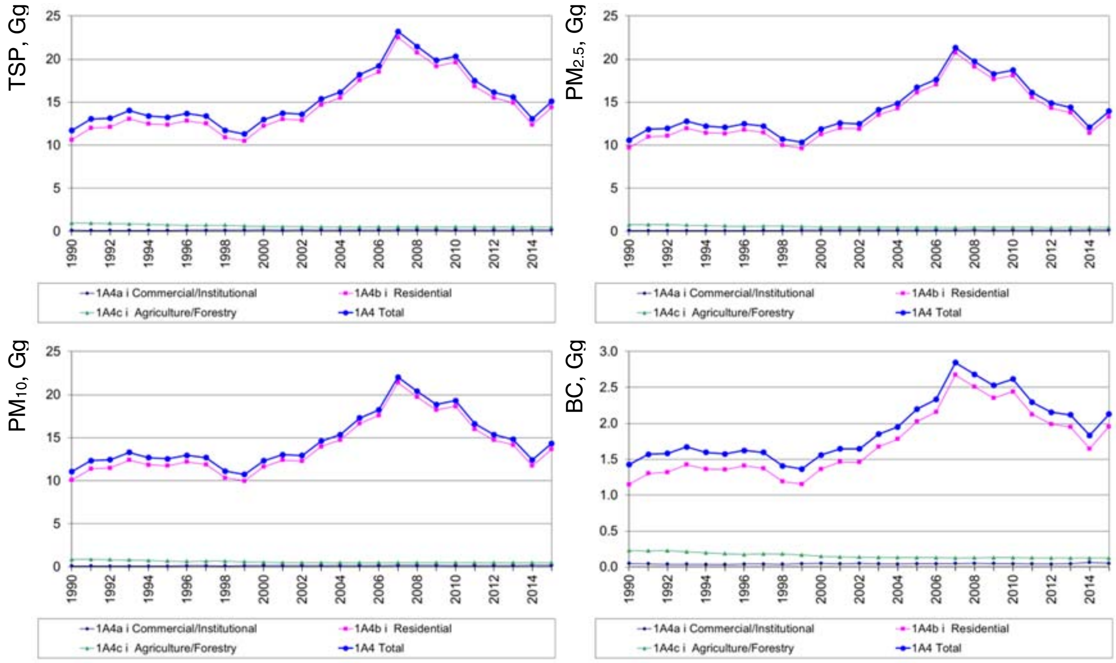


Figure 61 Time series for PM and BC emissions in source category 1A4 Other Sectors.

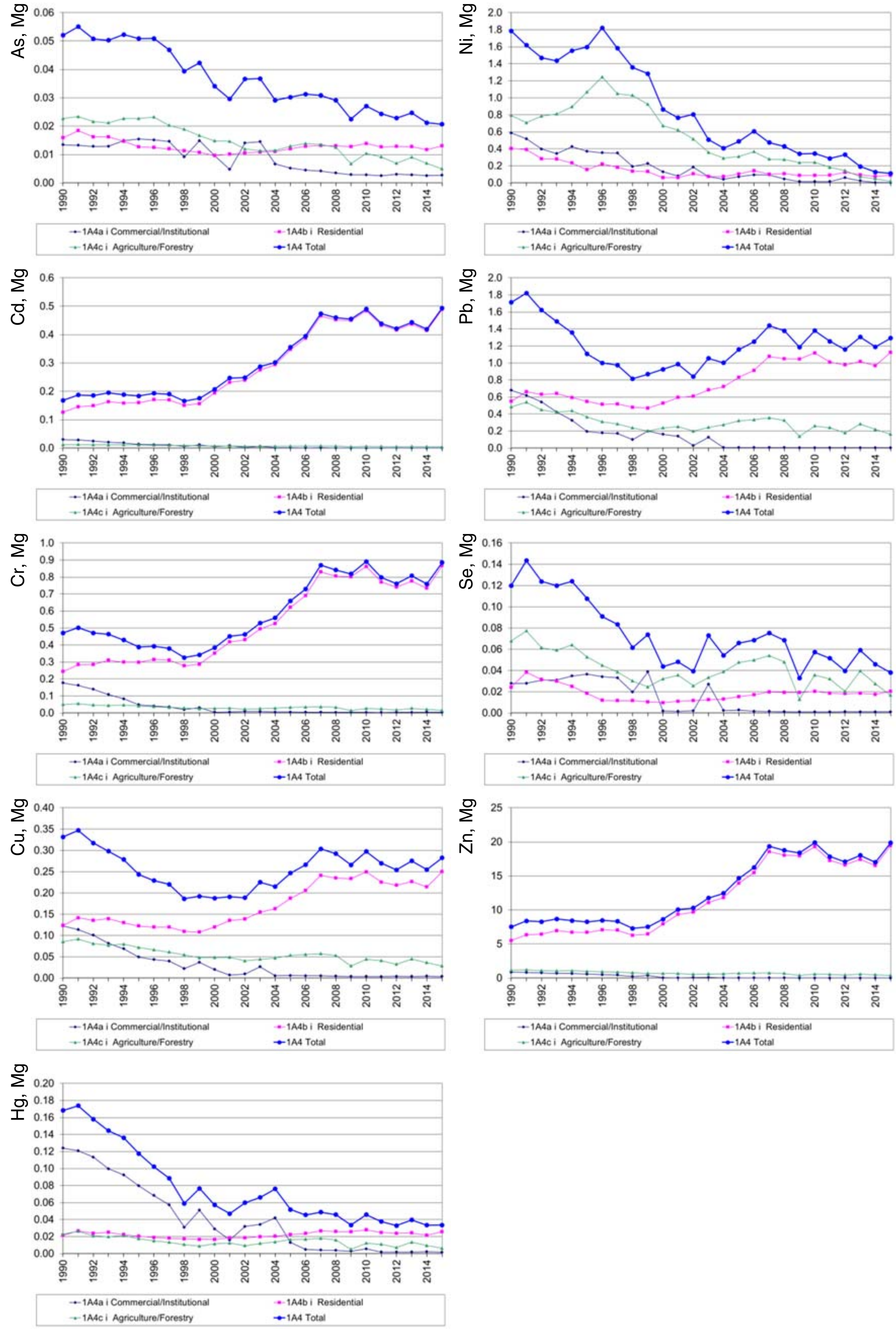


Figure 62 Time series for HM emission in source category 1A4 Other Sectors.

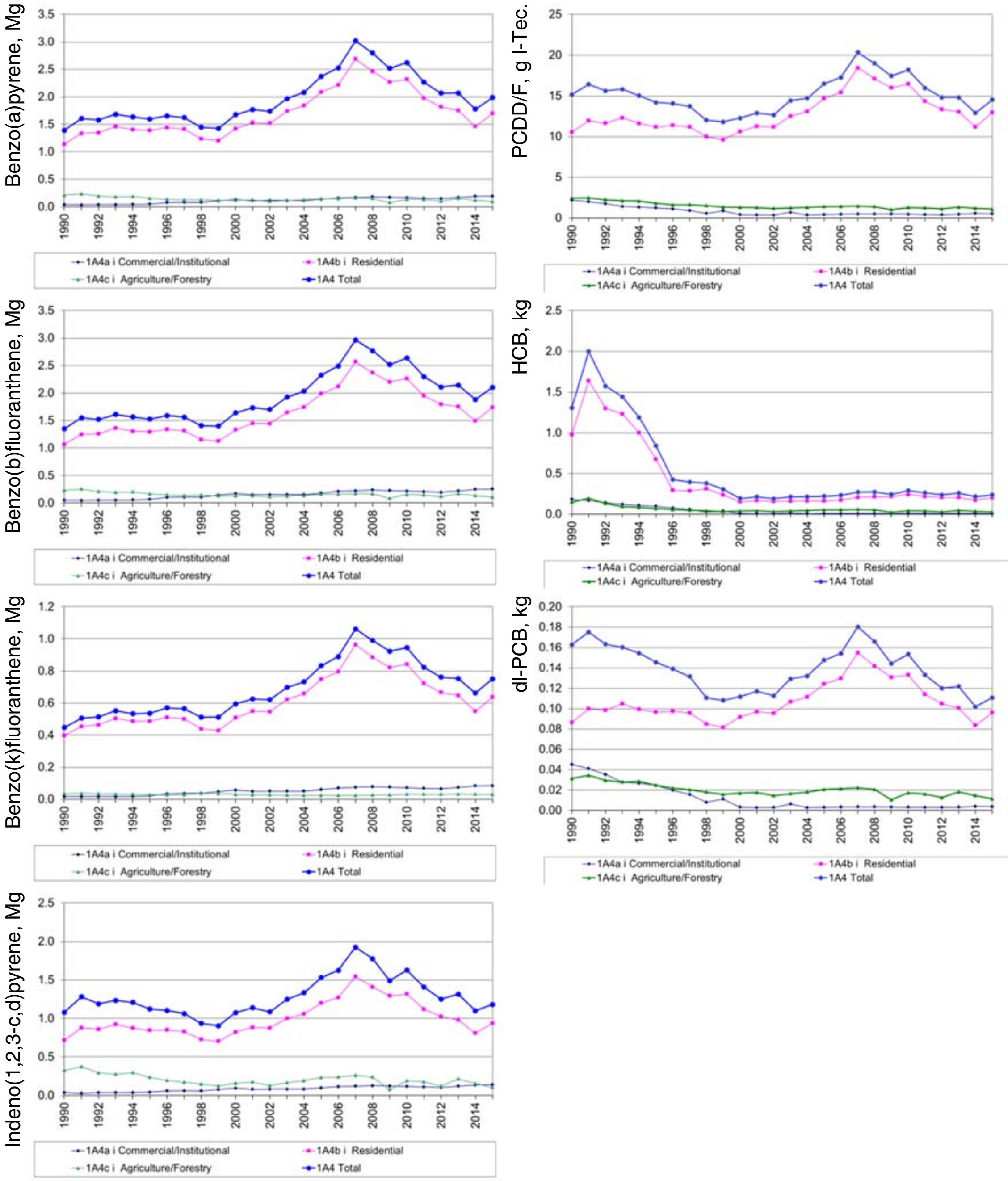


Figure 63 Time series for PAH, PCDD/F, HCB and dioxin-like PCB emission in source category 1A4 Other Sectors.

5.3.1 1A4a Commercial and institutional plants

The subcategory *Commercial and institutional plants* consists of both stationary and mobile sources. In this chapter, only stationary sources are included. Figure 64 shows the time series for fuel consumption and emissions.

The subcategory *Commercial and institutional plants* has low fuel consumption and emissions compared to the other stationary combustion emission source categories.

The fuel consumption in commercial/institutional plants has decreased 41 % since 1990 and the fuels applied have changed. The fuel consumption consists mainly of gas oil and natural gas. The consumption of gas oil has decreased since 1990. The consumption of wood and biogas has increased. The wood consumption in 2015 was 5.6 times the consumption in 1990.

The CO_2 emission has decreased 55 % since 1990. Both the decrease of fuel consumption and the change of fuels – from gas oil to natural gas - contribute to the decreased CO_2 emission.

The CH_4 emission in 2015 was 3.1 times the 1990 level. The increase is mainly a result of the increased emission from natural gas fuelled engines. The emissions from biogas-fuelled engines and from combustion of wood also contribute to the increase. The time series for consumption of natural gas and biogas are shown in Figure 58.

The N_2O emission in 2015 was 11 % lower than in 1990. The fluctuations of the N_2O emission are mainly a result of fluctuations in consumption of natural gas and waste.

The SO_2 emission has decreased 95 % since 1990. The decrease is a result of both the change of fuel from gas oil to natural gas and of the lower sulphur content in gas oil and in residual oil. The lower sulphur content (0.05 % for gas oil since 1995 and 0.7 % for residual oil since 1997) is a result of Danish tax laws (DEPA, 1998).

The NO_x emission was 54 % lower in 2015 than in 1990. The decrease is mainly a result of the lower fuel consumption but also the change from gas oil to natural gas has contributed to the decrease. The emission from wood combustion has increased.

The NMVOC emission in 2015 was 67 % higher than the 1990 emission level. The large increase is a result of the increased combustion of wood that is the main source of emission. The increase and decrease of natural gas consumption in gas engines (Figure 58) is also reflected in the time series for NMVOC emission.

The CO emission has decreased 17 % since 1990. The emission from wood has increased whereas the emission from gas oil has decreased. This is a result of the change of fuels used in the sector.

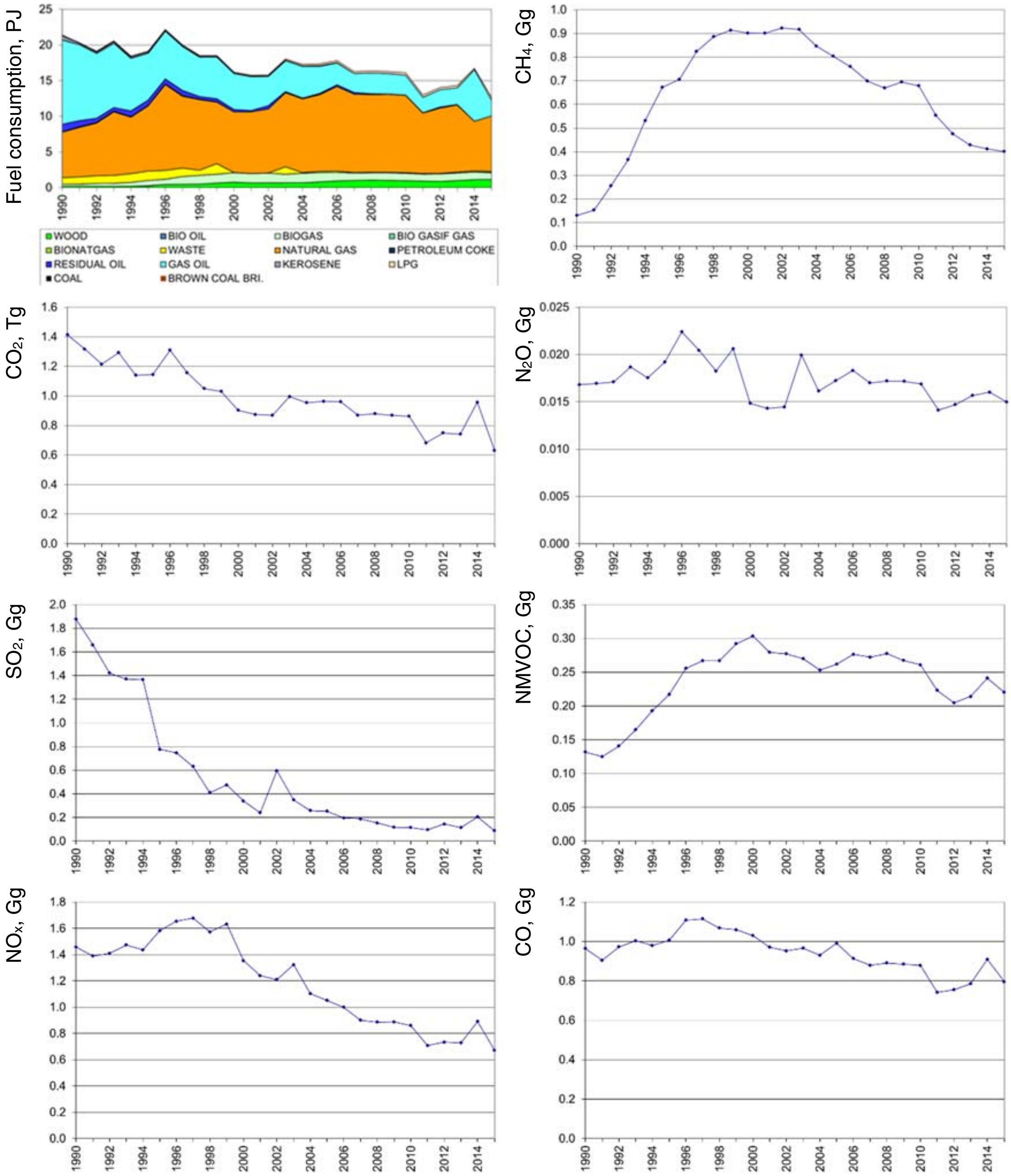


Figure 64 Time series for subcategory 1A4a Commercial / institutional.

5.3.2 1A4b Residential plants

The emission source category *Residential plants* consists of both stationary and mobile sources. In this chapter, only stationary sources are included. Figure 65 shows the time series for fuel consumption and emissions.

For residential plants, the total fuel consumption was 15 % lower in 2015 than in 1990. The large decrease from 2010 to 2011 was caused by high temperature in the winter season of 2011 compared to the cold winter of 2010. The low consumption of gas oil in 2014 seems to be related to an incorrect disaggregation of gas oil between sector 1A4a and 1A4b. This will be improved in the next inventory. The consumption of gas oil has decreased since 1990 whereas the consumption of wood has increased considerably (4.2 times the 1990 level). The consumption of natural gas has also increased since 1990.

The CO_2 emission has decreased by 61 % since 1990. This decrease is mainly a result of the considerable change in fuels used from gas oil to wood and natural gas.

The CH_4 emission from residential plants was 5 % lower in 2015 than in 1990. Residential wood combustion is a large source of CH_4 emission and the consumption of wood has increased whereas the emission factor has decreased since 1990.

The change of fuel from gas oil to wood has resulted in a 79 % increase of N_2O emission since 1990 due to a higher emission factor for wood than for gas oil.

The large decrease (85 %) of SO_2 emission from residential plants is mainly a result of a change of sulphur content in gas oil since 1995. The lower sulphur content (0.05 %) is a result of Danish tax laws (DEPA, 1998). In addition, the consumption of gas oil has decreased and the consumption of natural gas that results in very low SO_2 emissions has increased.

The NO_x emission has decreased by 8 % since 1990. As mentioned above the fuel consumption has also decreased. The emission factor for wood is higher than for natural gas and gas oil and both consumption and the emission factor for wood have increased. However, the NO_x emission factor for natural gas has decreased.

The emission of NMVOC has increased 9 % since 1990. The consumption of wood has increased but the emission factor for wood has decreased since 1990. The emission factors for wood and straw are higher than for liquid or gaseous fuels.

The CO emission has decreased 7 % since 1990. The use of wood that is the main source of emission has increased whereas the emission factor has decreased. The emission from combustion of straw has decreased since 1990.

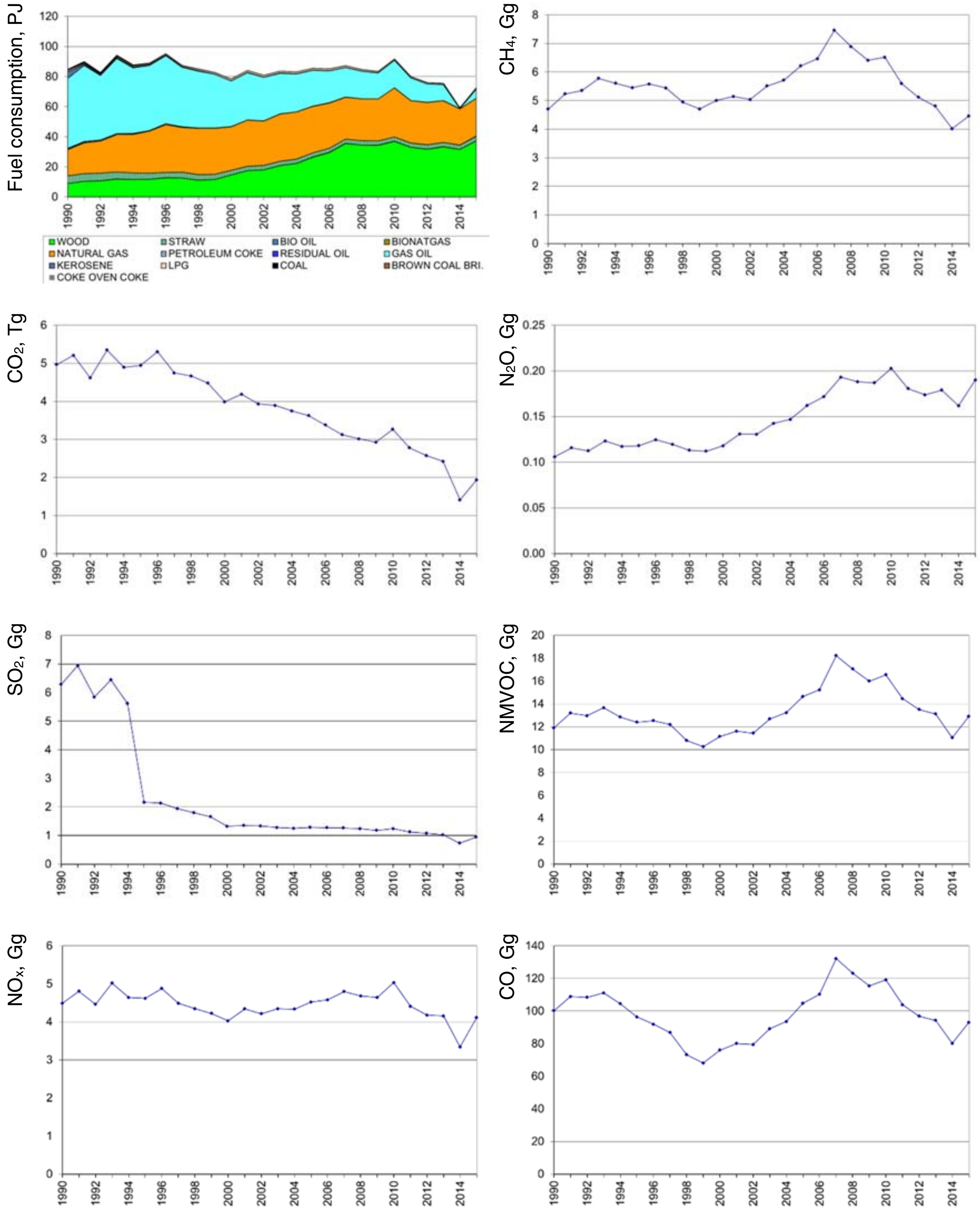


Figure 65 Time series for subcategory 1A4b Residential plants.

5.3.3 1A4c Agriculture/forestry

The emission source category *Agriculture/forestry* consists of both stationary and mobile sources. In this chapter, only stationary sources are included. Figure 66 shows the time series for fuel consumption and emissions.

For plants in agriculture / forestry, the fuel consumption has decreased 46 % since 1990. A remarkable decrease of fuel consumption has taken place since year 2000.

The type of fuel that has been applied has changed since 1990. In the years 1994-2004, the consumption of natural gas was high, but after 2004, the consumption decreased again. A large part of the natural gas consumption has been applied in gas engines (Figure 58). Most CHP plants in agriculture / forestry based on gas engines came in operation in 1995-1999. The decrease after 2004 is a result of the liberalisation of the electricity market.

The consumption of coal, residual oil and straw has decreased since 1990. The consumption of biogas has increased.

The CO_2 emission in 2015 was 76 % lower than in 1990. The CO_2 emission increased from 1990 to 1996 due to increased fuel consumption. Since 1996, the CO_2 emission has decreased in line with the decrease in fuel consumption.

The CH_4 emission in 2015 was 10 % lower than in 1990. The emission follows the time series for natural gas combusted in gas engines (Figure 58). The emission from combustion of straw has decreased as a result of the decreasing consumption of straw in the sector.

The emission of N_2O has decreased by 43 % since 1990. The decrease is a result of the lower fuel consumption as well as the change of fuel. The decreasing consumption of straw contributes considerably to the decrease of emission.

The SO_2 emission was 81 % lower in 2015 than in 1990. The emission decreased mainly in the years 1996-2002.

The emission of NO_x was 63 % lower in 2015 than in 1990.

The emission of NMVOC has decreased 45 % since 1990.

The CO emission has decreased 73 % since 1990. The major emission source is combustion of straw. In addition to the decrease of straw consumption, the emission factor for straw has also decreased since 1990.

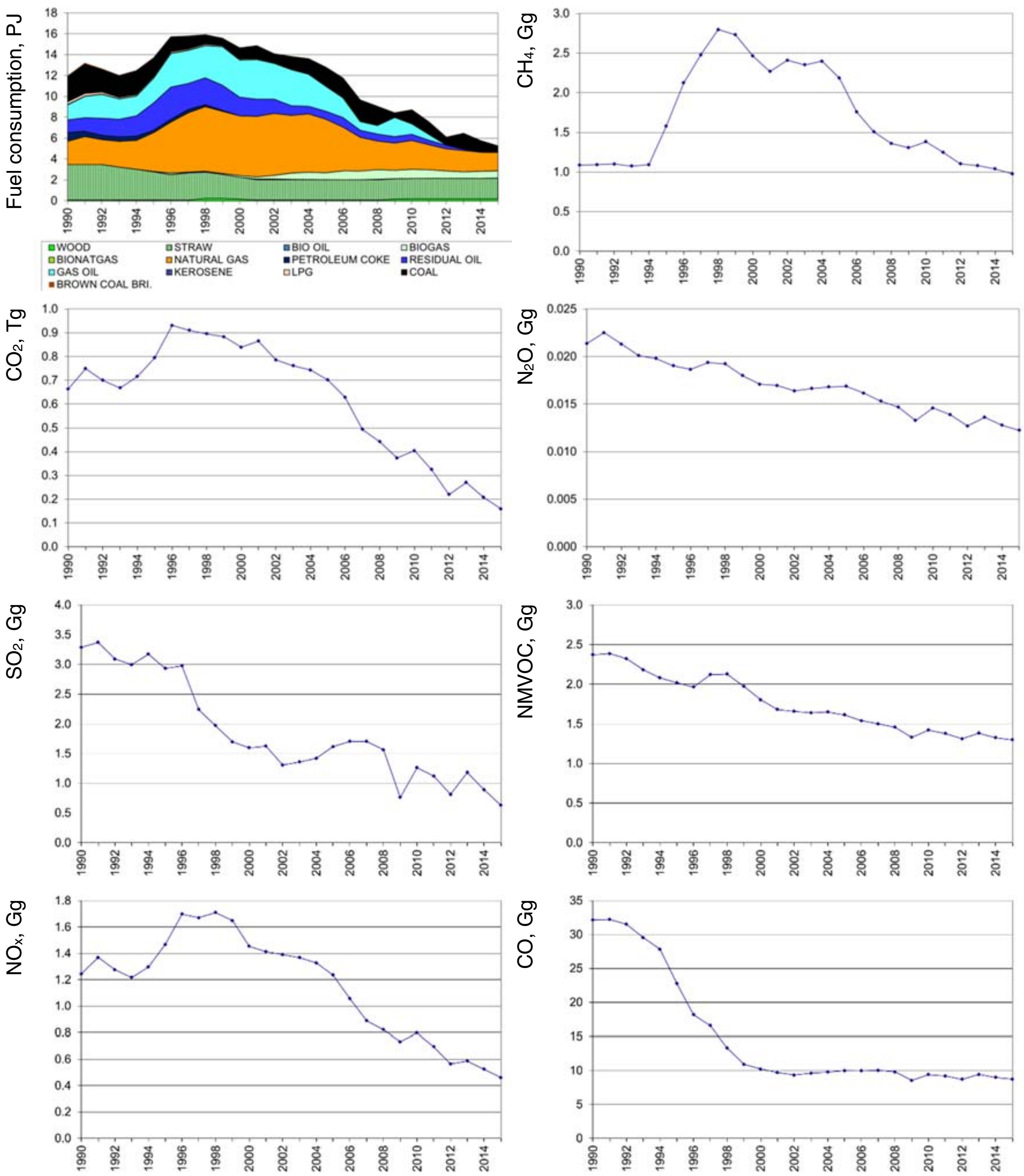


Figure 66 Time series for subcategory 1A4c Agriculture/Forestry.

6. 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 EEA Guidebook (EEA, 2016). Emission data are stored in MS Access databases, from which data are transferred to the reporting formats.

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 source categories. Aggregation to the source category codes used in CRF is based on a correspondence list enclosed in Annex 1.

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.

Recalculations and improvements are shown in Chapter 10.

6.1 Metodological tiers used in estimating greenhouse gas emissions

The type of GHG emission factor and the applied tier level for each emission source are shown in Table 25 below. The tier levels have been determined based on the IPCC Guidelines (IPCC, 2006). The fuel consumption data for transformation are technology specific. For end-use of fuels, the disaggregation to specific technologies is less detailed. However, for residential wood combustion technology specific fuel consumption rates have been estimated.

The tier level definitions have been interpreted as follows:

- Tier 1: The emission factor is an IPCC default tier 1 value.
- Tier 2: The emission factors are country-specific and based on a limited number of emission measurements or a technology specific IPCC tier 2 emission factor.
- Tier 3: Emission data are based on:
  - plant specific emission measurements or
  - technology specific fuel consumption data and country-specific emission factors based on a considerable number of emission measurements from Danish plants.

Table 25 gives an overview of the calculation methods and type of emission factor. The table also shows which of the source categories are key in any of the key category analysis (including LULUCF, approach 1/approach 2, level/trend)[10].

Table 25 Methodology and type of emission factor for CO_2, 2015.

		Tier	EMF[1)]	Key category[2)]
1A Stationary combustion, Coal, ETS data	CO_2	Tier 3	PS	Yes
1A Stationary combustion, Coal, no ETS data	CO_2	Tier 3 / Tier 1 [3)]	CS (1A1) or D (1A2, 1A4)	Yes
1A Stationary combustion, BKB	CO_2	Tier 1	D	No
1A Stationary combustion, Coke oven coke	CO_2	Tier 1	D	No
1A Stationary combustion, Fossil waste, ETS data	CO_2	Tier 3	PS	Yes
1A Stationary combustion, Fossil waste, no ETS data	CO_2	Tier 2	CS	Yes
1A Stationary combustion, Petroleum coke, ETS data	CO_2	Tier 3	PS	Yes
1A Stationary combustion, Petroleum coke, no ETS data	CO_2	Tier 2	CS	Yes
1A Stationary combustion, Residual oil, ETS data	CO_2	Tier 3	PS	Yes
1A Stationary combustion, Residual oil, no ETS data	CO_2	Tier 2 [4)]	CS	Yes
1A Stationary combustion, Gas oil	CO_2	Tier 2 / Tier 3 [5)]	CS / PS	Yes
1A Stationary combustion, Kerosene	CO_2	Tier 1	D	Yes
1A Stationary combustion, LPG	CO_2	Tier 1	D	No
1A1b Stationary combustion, Petroleum refining, Refinery gas	CO_2	Tier 3	CS	Yes
1A Stationary combustion, Natural gas, onshore	CO_2	Tier 3	CS	Yes
1A1c_ii Stationary combustion, Oil and gas extraction, Offshore gas turbines, Natural gas	CO_2	Tier 3	CS	Yes
1A1 Stationary Combustion, Solid fuels	CH_4	Tier 2	D(2)	No
1A1 Stationary Combustion, Liquid fuels	CH_4	Tier 1 / Tier 2	D / D(2) / CS	No
1A1 Stationary Combustion, not engines, gaseous fuels	CH_4	Tier 2	CS / D(2)	No
1A1 Stationary Combustion, Waste	CH_4	Tier 2	CS	No
1A1 Stationary Combustion, not engines, Biomass	CH_4	Tier 3 / Tier 2 / Tier 1	CS / D(2) / D	No
1A2 Stationary Combustion, solid fuels	CH_4	Tier 1	D	No
1A2 Stationary Combustion, Liquid fuels	CH_4	Tier 1 / Tier 2	D / D(2) / CS	No
1A2 Stationary Combustion, not engines, gaseous fuels	CH_4	Tier 2	CS / D(2)	No
1A2 Stationary Combustion, Waste	CH_4	Tier 1	D	No
1A2 Stationary Combustion, not engines, Biomass	CH_4	Tier 2 / Tier 1	D(2) / D	No
1A4 Stationary Combustion, Solid fuels	CH_4	Tier 1	D	No
1A4 Stationary Combustion, Liquid fuels	CH_4	Tier 1 / Tier 2	D / D(2)	No
1A4 Stationary Combustion, not engines, gaseous fuels	CH_4	Tier 2	D(2)	No
1A4 Stationary Combustion, Waste	CH_4	Tier 1	D	No
1A4 Stationary Combustion, not engines, not residential wood and not residential/agricultural straw, Biomass	CH_4	Tier 1 / Tier 2	D / D(2) / CS	No
1A4b_i Stationary combustion, Residential wood combustion	CH_4	Tier 2	CS	Yes
1A4b_i/1A4c_i Stationary Combustion, Residential and agricultural straw combustion	CH_4	Tier 1	D	Yes
1A Stationary combustion, Natural gas fuelled engines, gaseous fuels	CH_4	Tier 3	CS	No
1A Stationary combustion, Biogas fuelled engines, Biomass	CH_4	Tier 3	CS	No
1A1 Stationary Combustion, Solid fuels	N_2O	Tier 2	CS / D(2)	Yes
1A1 Stationary Combustion, Liquid fuels	N_2O	Tier 2 / Tier 1	D(2) / CS / D	No
1A1 Stationary Combustion, Gaseous fuels	N_2O	Tier 3 / Tier 2	CS / D(2)	Yes
1A1 Stationary Combustion, Waste	N_2O	Tier 2	CS	Yes
1A1 Stationary Combustion, Biomass	N_2O	Tier 2 / Tier 1	CS / D(2) / D	Yes
1A2 Stationary Combustion, Solid fuels	N_2O	Tier 1	D	No
1A2 Stationary Combustion, Liquid fuels	N_2O	Tier 2 / Tier 1	D(2) / CS / D	Yes
1A2 Stationary Combustion, Gaseous fuels	N_2O	Tier 3 / Tier 2	CS / D(2)	Yes
1A2 Stationary Combustion, Waste	N_2O	Tier 1	D	No
1A2 Stationary Combustion, Biomass	N_2O	Tier 1 / Tier 2	D / CS	No
1A4 Stationary Combustion, Solid fuels	N_2O	Tier 1	D	No
1A4 Stationary Combustion, Liquid fuels	N_2O	Tier 2 / Tier 1	D(2) / CS / D	Yes
1A4 Stationary Combustion, Gaseous fuels	N_2O	Tier 3 / Tier 2	CS / D(2)	Yes
1A4 Stationary Combustion, Waste	N_2O	Tier 1	D	No
1A4 Stationary Combustion, not residential wood and not residential/agricultural straw, Biomass	N_2O	Tier 1 / Tier 2	D / CS	No
1A4b_i Stationary Combustion, Residential wood combustion	N_2O	Tier 1	D	Yes
1A4b_i/1A4c_i Stationary Combustion, Residential and agricultural straw combustion	N_2O	Tier 1	D	No

[1)] D: IPCC (2006) default, tier 1. D(2): IPCC (2006) default, tier 2. CS: Country specific. PS: Plant specific.
[2)] KCA approach 1 or approach 2 for Denmark (excluding Greenland and Faroe Islands), including LULUCF, level 1990 or level 2015 or trend 1990-2015.
[3)] Only 2.5 % of the total coal consumption is included in the non-ETS category in 2015.
[4)] Only 15 % of the total residual oil consumption is included in the non-ETS category in 2015.
[5)] Tier 3 for 2 % of the gas oil consumption in 2015.

[10] Key category according to the KCA approach 1 or approach 2 for Denmark (excluding Greenland and Faroe Islands), including LULUCF, level 1990/ level 2015/ trend.

6.2 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 2015, 76 stationary combustion plants are specified as large point sources. Plant specific emission data are available from 70 of the plants. The point sources include:

- Power plants and decentralised CHP plants
- Waste incineration plants
- Large industrial combustion plants
- Petroleum refining plants

The criteria for selection of point sources are:

- All centralized power plants, including smaller units
- All units with a capacity of above 25 MW_e
- All district heating plants with an installed effect of 50 MW_{th} or above and significant fuel consumption
- All waste incineration plants obligated to report environmental data annually according to Danish law (DEPA, 2010b)
- Industrial plants,
  - With an installed effect of 50 MW_{th} or above and significant fuel consumption.
  - With a significant process related emission

The fuel consumption of stationary combustion plants registered as large point sources in the 2015 inventory was 199 PJ. This corresponds to 51 % of the overall fuel consumption for stationary combustion.

A list of the large point sources for 2015 is provided in Annex 5. The number of large point sources registered in the databases increased from 1990 to 2015. Aggregated fuel consumption rates for the large point sources are also shown in Annex 5.

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.

The plant-specific emission data from the EU ETS data represent 66 % of the total CO_2 emission from stationary combustion. CO_2 emission factors are plant specific for the major power plants, refineries, offshore gas turbines and for cement production. Plant-specific emission data are obtained from CO_2 data reported under the EU Emission Trading Scheme (ETS). The EU ETS data are discussed in Chapter 7.1.

Emission measurement data for CH_4 and N_2O are applied for estimating emission factors but not implemented as plant specific data.

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.

The emission shares from point sources with plant specific data are shown in Table 26.

Table 26 Emission share for plant specific data.

Pollutant	Share from plant specific data, %
CO_2	66
CH_4	-
N_2O	-
SO_2	45
NO_x	41
NMVOC	0.10
CO	3
NH_3	3.8
TSP	2.0
PM_{10}	1.7
$PM_{2.5}$	1.2
BC	0.4
As	12
Cd	0.9
Cr	3
Cu	5
Hg	50
Ni	4
Pb	2
Se	57
Zn	1.0
PCDD/F	0.9

SO_2 and NO_x emissions from large point sources are often plant-specific based on continuous emission measurements. Emissions of CO, NMVOC, PM, HM and PCDD/F are also plant-specific for some plants. Plant-specific emission data are obtained from:

- Annual environmental reports / environmental reporting available on the Danish EPA home page[11] (PRTR data), DEPA (2016)
- Annual plant-specific reporting of SO_2 and NO_x from power plants >25MW$_e$ prepared for the Danish Energy Agency (DEA) and Energinet.dk
- Emission data reported by DONG Energy, the major power plant operator
- Emission data reported from industrial plants
- CO_2 data reported under the EU Emission Trading Scheme (ETS).

6.3 Area sources

Fuels not combusted in large point sources are included as source category 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 in the Chapter 7.

[11] https://miljoeoplysninger.mst.dk/

6.4 Methodologies and assumptions for fuel consumption

6.4.1 Fuels used for non-energy purposes

The Danish national energy statistics includes three fuels used for non-energy purposes; bitumen, white spirit and lubricants. The total consumption for non-energy purposes is relatively low, e.g. 10.5 PJ in 2015. The use of fuels for non-energy purposes is included in the inventory in sector 2D Non-energy products from fuels and solvent use; see Nielsen et al. (2017a).

The non-energy use of fuels is included in the reference approach for Climate Convention reporting and appropriately corrected in line with the IPCC Guidelines (IPCC, 2006). The reference approach is included in Chapter 11.1 in this report.

6.4.2 Fuel consumption, area sources

The fuel consumption rates are based on the official Danish energy statistics prepared by the Danish Energy Agency (DEA). DCE aggregates fuel consumption rates to SNAP categories. Some fuel types in the official Danish energy statistics are added to obtain a less detailed fuel aggregation level, see Annex 3. The calorific values (LCV) on which the energy statistics are based are also enclosed in Annex 3. The correspondence list between the energy statistics and SNAP categories is enclosed in Annex 1.

The fuel consumption of the CRF category *Manufacturing industries and construction* (corresponding to SNAP category 03) is disaggregated into industrial subsectors based on the DEA data set aggregated for the Eurostat reporting (DEA, 2016c).

The data flow for fuel consumption is shown in Figure 67.

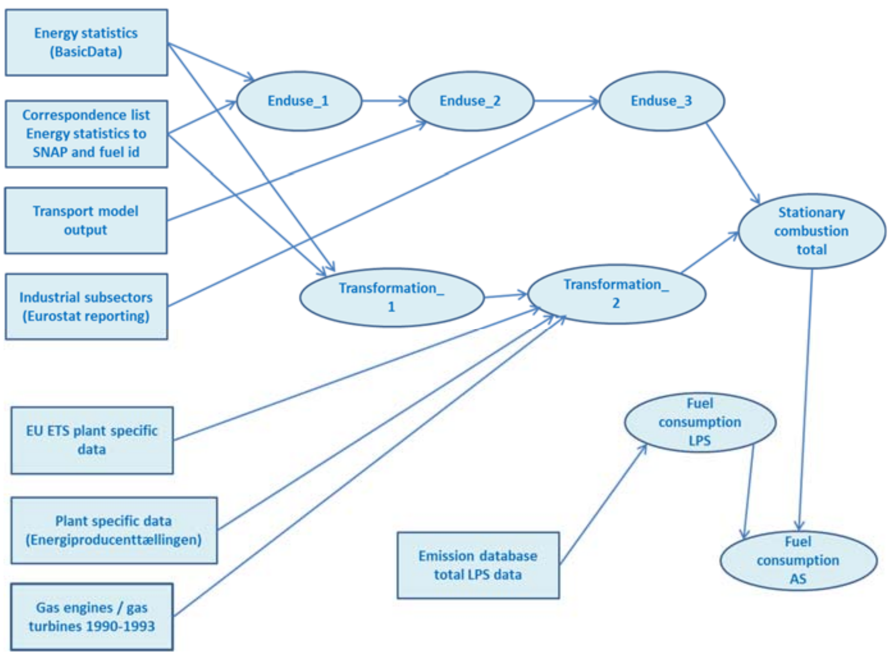


Figure 67 Fuel consumption data flow.

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 628 TJ in 2015) is not included in the Danish inventory. This is in agreement with the IPCC Guidelines (IPCC, 2006).

The fuel consumption data for large point sources refer to the EU Emission Trading Scheme (EU ETS) data for plants for which the CO_2 emission also refer to EU ETS.

For all other large point sources, the fuel consumption refers to an annually updated DEA database; the Energy Producers Survey (DEA, 2016b). The Energy Producers Survey includes the fuel consumption of each district heating and power-producing plant, based on data reported by plant operators. The consistency between EU ETS reporting and the Energy Producers Survey (DEA, 2016b) is checked by the DEA and discrepancies are corrected prior to the use in the emission inventory.

The fuel consumption of area sources is calculated as total fuel consumption in the energy statistics minus fuel consumption included in the emission inventory database in large point sources.

In Denmark, all waste incineration are utilised for heat and power production. Thus, incineration of waste is included in stationary combustion in the source category *Fuel combustion* (subcategories *1A1*, *1A2* and *1A4)*.

Fuel consumption data are presented in Chapter 2.

6.4.3 Fuel consumption for 1A1c Oil and gas extraction

The consumption of natural gas reported in the EU ETS data are not in agreement with the energy statistics. This is because the energy statistics is based on the default net calorific value (NCV) for natural gas applied in Denmark whereas the EU ETS data are based on fuel analysis of the natural gas applied offshore at each individual platform. The total consumption of natural gas in 1A1c Oil and gas extraction applied in the emission inventories is based on the EU ETS data.

6.4.4 Fuel consumption for 1A1b Petroleum refining

The EU ETS data for fuel consumption reported by the two Danish refineries are not always in agreement with the energy statistics due to the use of default values for NCV in the energy statistics. The EU ETS data are based on fuel analysis. Refinery gas is only applied in the two refineries. The total consumption of refinery gas applied in the emission inventories is based on the EU ETS data.

6.4.5 Fuel consumption, town gas

Town gas has been included in the fuel category natural gas. The consumption of town gas in Denmark is very low, e.g. 0.6 PJ in 2015. In 1990, the town gas consumption was 1.6 PJ and the consumption has been steadily decreasing throughout the time series.

In Denmark, town gas is produced based on natural gas. The use of coal for town gas production has ceased in the early 1980s.

An indicative composition of town gas according to the largest supplier of town gas in Denmark is shown in Table 27 (KE, 2015).

Table 27 Composition of town gas currently used (KE, 2015).

Component	Town gas, % (mol.)
Methane	43.9
Ethane	2.9
Propane	1.1
Butane	0.5
Carbon dioxide	0.4
Nitrogen	40.5
Oxygen	10.7

The lower heating value of the town gas currently used is 20.31 MJ per Nm^3 and the CO_2 emission factor 56.1 kg per GJ. This is very close to the emission factor used for natural gas of 57.06 kg per GJ. According to the supplier, both the composition and heating value will change during the year. It has not been possible to obtain a yearly average.

Biogas has been added to the town gas grid since 2014. This biogas distributed in the town gas grid will be treated as a separate fuel in future emission inventories and thus not included in the data for town gas.

In earlier years, the composition of town gas was somewhat different. Table 28 shows data for town gas composition in 2000-2005. These data are constructed with the input from Københavns Energi (KE) (Copenhagen Energy) and Danish Gas Technology Centre (DGC), (Jeppesen, 2007; Kristensen, 2007). The data refer to three measurements performed several years apart, the first in 2000 and the latest in 2005.

Table 28 Composition of town gas, data from 2000-2005.

Component	Town gas, % (mol.)
Methane	22.3-27.8
Ethane	1.2-1.8
Propane	0.5-0.9
Butane	0.13-0.2
Higher hydrocarbons	0-0.6
Carbon dioxide	8-11.6
Nitrogen	15.6-20.9
Oxygen	2.3-3.2
Hydrogen	35.4-40.5
Carbon monoxide	2.6-2.8

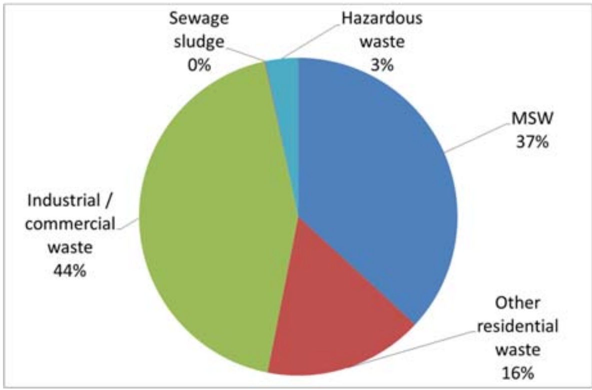
The lower calorific value has been between 15.6 and 17.8 MJ per Nm^3. The CO_2 emission factors - derived from the few available measurements - are in the range of 52-57 kg per GJ.

The Danish approach includes town gas as part of the fuel category natural gas and thus indirectly assumes the same CO_2 emission factor. This is a conservative approach ensuring that the CO_2 emissions are not underestimated.

Due to the scarce data available and the very low consumption of town gas compared to consumption of natural gas (< 0.5 %), the methodology will be applied unchanged in future inventories.

6.4.6 Fuel consumption, waste

All waste incineration in Denmark is utilised for heat and / or power production and thus included in the energy sector. The waste incinerated in Denmark for energy production consists of the waste fractions shown in Figure 68. In 2015, 3 % of the incinerated waste was hazardous waste.



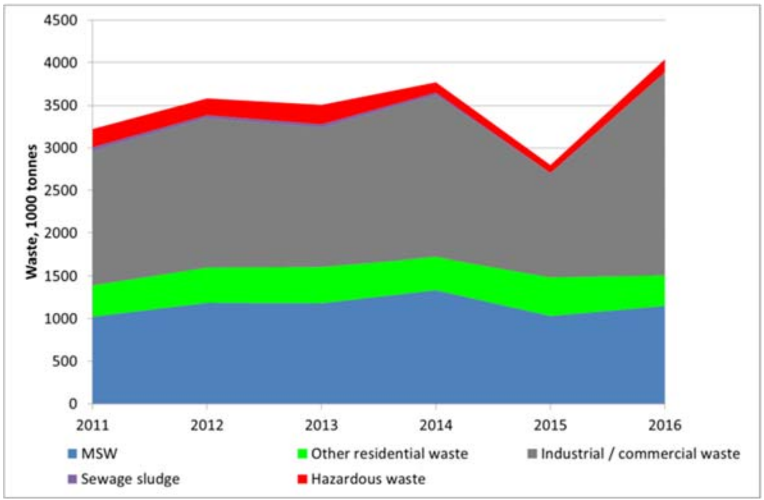


Figure 68 Waste fractions (weight) for incinerated waste in 2015 and the corresponding time series 2011-2016 (ADS, 2017).

In connection to the project estimating an improved CO_2 emission factor for waste (Astrup et al., 2012), the fossil energy fraction was calculated. The fossil fraction was not measured or estimated as part of the project, but the flue gas measurements combined with data from Fellner & Rechberger (2010) indicated a fossil energy part of 45 %. The energy statistics also applies this fraction in the national statistics.

6.4.7 Fuel consumption, biogas

Biogas includes landfill gas, sludge gas and manure / organic waste gas[12]. The Danish energy statistics specifies production and consumption of each of the biogas types. In 2015, 83 % of the applied biogas was based on manure / organic waste.

Biogas upgraded for distribution in the natural gas grid (bio natural gas) is not included in the fuel category "biogas" and in the figures below. This is also the case for bio gasification gas.

[12] Based on manure with addition of other organic waste. In the Danish energy statistics this biogas is called *Biogas, other*.

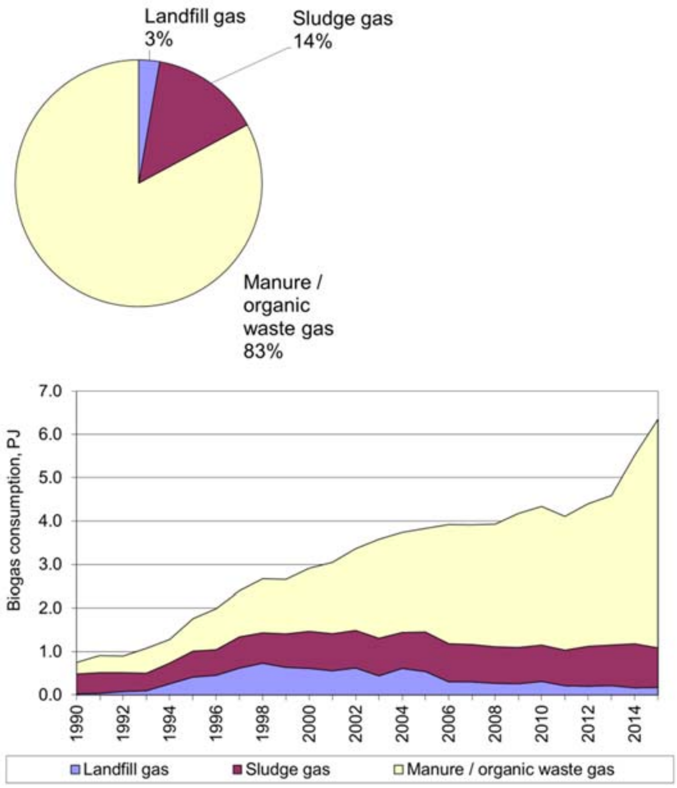


Figure 69 Biogas types 2015 and the corresponding time series 1990-2015 (DEA, 2016a).

6.4.8 Fuel consumption, upgraded biogas distributed in the natural gas grid

Biogas upgraded for distribution in the natural gas grid (bio natural gas) has now been included as a separate fuel in the energy statistics and in the emission inventory.

6.4.9 Fuel consumption, biogas distributed in the town gas grid

The energy statistics includes a consumption of biogas for town gas production. This biogas is distributed in the town gas grid (55 TJ in 2014 and 98 TJ in 2015). This fuel consumption has been included in the fuel category town gas in the fuel consumption data of the energy statistics and also in this emission inventory. In the next emission inventory, the consumption will be included in the fuel category biogas.

6.5 Residential wood combustion

Residential wood combustion is the main emission source for some pollutants. The model applied for estimating emissions from residential wood combustion takes into account the replacement of old units, the different fuel consumption rates and emission factors of the applied technologies.

6.5.1 Residential wood combustion, fuel consumption

The emission inventory is based on the total wood consumption data from the Danish energy statistics (DEA, 2016a). To break the consumption down to the different technologies, the number of appliances and the consumption per appliance has been estimated.

The consumptions per unit for the different types of appliances are shown in Table 29 (Illerup et al., 2007).

Table 29 Definition of the different wood burning technologies and the estimated annual consumption per appliance.

Technology	Description	Annual consumption per unit, GJ
Old stove	Stove pre-1990	19.8
New stove	Stove with DS mark 1990-2005	26.9
Modern stove (2008-2015)	Stove conforming with Danish legislation (2008)	25.1
Modern stove (2015-2017)	Stove conforming with Danish legislation (2015)	25.1
Modern stove (2017-)	Stove conforming with Danish legislation (2015)	25.1
Eco labelled stove / new advanced stove (-2015)	Until 2015	25.1
Eco labelled stove / new advanced stove (2015-)	From 2015	25.1
Other stoves (e.g. fireplaces)		17.9
Old boilers with hot water storage	pre-1980	162.8
Old boilers without hot water storage		140.7
New boilers with hot water storage	post-1980	146.1
New boilers without hot water storage		142.6
Pellet stoves / boilers		144.7

The number of wood stoves in Denmark is estimated to be around 750 000 excluding fireplaces (Evald 2010; Evald 2012).The number of fireplaces is estimated at around 16 000 (Illerup et al., 2007).The number of residential wood boilers is estimated to be around 47 000 (Illerup et al., 2007).

For wood stoves, the following assumptions are made:

- Prior to 2004 and after 2008, a replacement rate of 25 000 wood stoves per annum (Hessberg, 2012)
- Between 2004 and 2008, the replacement rate was higher peaking with 40 000 in 2006 (Hessberg, 2012)
- Before 2007, the replacements are considered to be 75 % modern stoves and 25 % new stoves (Hessberg, 2012)
- From 2007, the replacements are considered to be 90 % eco-labelled stoves and 10 % modern stoves (Hessberg, 2012)
- Until 2020 it is considered that the replaced stoves are distributed to 60 % old stoves, 30 % new stoves and 10 % modern stoves (Hessberg, 2012)
- The stock distribution in 2010 is estimated as 27 % old stoves, 42 % new stoves, 16 % modern stoves and 15 % eco-labelled stoves (Evald, 2010; Evald, 2012; Hessberg, 2012)
- The number of other stoves has been assumed constant for all years (Nielsen, 2013b)

For wood boilers the following assumptions are made:

- The annual replacement is 5 % (Illerup et al., 2007)
- The replacements are all considered new boilers and 80 % with accumulation tank (Illerup et al., 2007)
- The replaced boilers are all old boilers (Nielsen, 2013b)
- The number of wood boilers has been assumed constant for all years (Nielsen, 2013b)

The energy statistics provides the consumption of wood pellets. Emissions are calculated based on the amount of wood pellets in the energy statistics and no breakdown into different technologies are made.

The number of wood burning appliances in 2015 is shown in Table 30.

Table 30 Number of wood burning appliances in 2015.

Technology	Number of appliances
Old stove	187 500
New stove	307 500
Modern stove (2008-2015)	120 000
Modern stove (2015-2017)	
Modern stove (2017-)	
Eco labelled stove / new advanced stove (-2015)	135 000
Eco labelled stove / new advanced stove (2015-)	0
Other stoves (e.g. fireplaces)	16 210
Old boilers with hot water storage	6181
Old boilers without hot water storage	4726
New boilers with hot water storage	23 620
New boilers without hot water storage	12 111
Pellet stoves / boilers	

The wood consumption is calculated by multiplying the number of appliances (as shown in Table 30) with the estimated wood consumption per appliance (as shown in Table 29). This bottom-up calculated consumption is then scaled to match the total wood consumption as reported by the DEA in the Danish energy statistics.

Time series for the technology specific wood consumption rates are shown in Figure 70.

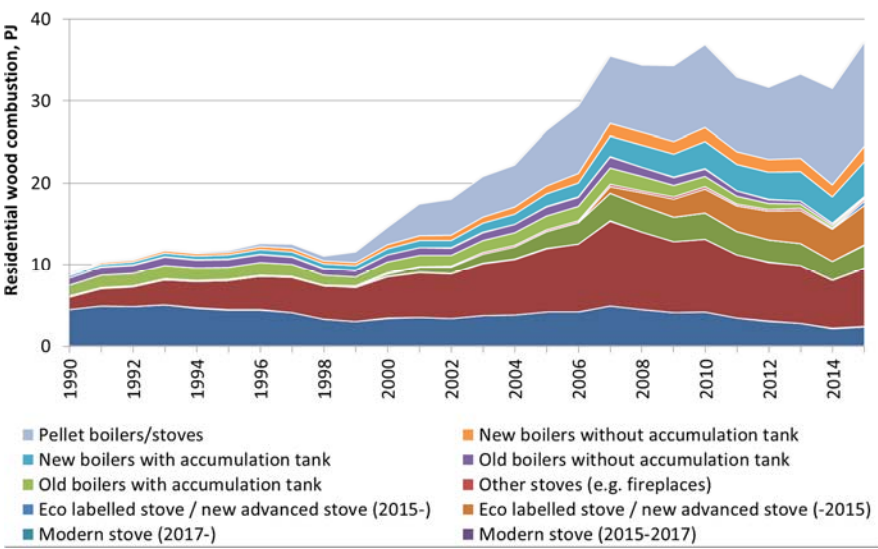


Figure 70 Technology specific wood consumption in residential plants.

Based on newly acquired data from the Danish chimneysweepers and the latest study on wood consumption (EA Energianalyse, 2016), the model for estimating emissions from residential wood combustion will be updated for the 2018 reporting.

6.5.2 Residential wood combustion, technology specific EMFs

For the pollutants NO_x, NMVOC, CO, NH_3, TSP, PM_{10}, $PM_{2.5}$, BC, PCDD/F, PCB, PAH and CH_4 emission factors have been based on fuel consumption data and technology specific emission factors for 13 different technologies. Technology specific emission factors and implied emission factors for 2015 are shown in Table 31. References for the technology specific emission factors are shown in Table 32 and time series for implied emission factors (IEFs) are shown in Table 33.

For pollutants not included in Table 31, technology specific emission factors and time series have not been estimated and the emission factors are included in Chapter 7.

Table 31 Technology specific emission factors for residential wood combustion and IEF for 2015.

Technology	CH_4 g/GJ	NO_x, g/GJ	NMVOC, g/GJ	CO, g/GJ	NH_3, g/GJ	TSP, g/GJ	PM_{10}, g/GJ	$PM_{2.5}$, g/GJ	BC, g/GJ
Old stove	430	50	1200	8000	70	1000	950	930	93
New stove	215	50	600	4000	70	800	760	740	74
Stove according to resent Danish legislation (2008-2015)	125	80	350	4000	37	556	528	514	82
Modern stove (2015-2017)	125	80	350	4000	37	278	264	257	41
Modern stove (2017-)	125	80	350	4000	37	222	211	205	33
Eco labelled stove / new advanced stove (-2015)	2	95	175	1117	37	222	211	206	58
Eco labelled stove / new advanced stove (-2015)	2	95	175	1117	37	167	159	155	43
Other stoves	430	50	600	4000	70	800	760	740	74
Old boilers with hot water storage	211	80	350	4000	74	1000	950	900	144
Old boilers without hot water storage	256	80	350	4000	74	2000	1900	1800	288
New boilers with hot water storage	50	95	175	1117	37	222	211	206	58
New boilers without hot water storage	50	95	350	2234	37	444	422	413	116
Pellet boilers	3	80	10	300	12	31	29	29	4
IEF residential wood combustion, 2015	**93**	**77**	**293**	**2158**	**37**	**367**	**348**	**340**	**51**

(continued)

Technology	PCDD/F, ng/GJ	dl-PCB, ng/GJ	Benzo(a) pyrene, mg/GJ	Benzo(b) fluoranthene, mg/GJ	Benzo(k) fluoranthene, mg/GJ	Indeno (1.2.3-c,d) pyrene, mg/GJ
Old stove	800	7049	121	111	42	71
New stove	800	7049	121	111	42	71
Stove according to resent Danish legislation (2008-2015)	250	931	61	56	21	36
Modern stove (2015-2017)	250	931	61	56	21	36
Modern stove (2017-)	250	931	61	56	21	36
Eco labelled stove / new advanced stove (-2015)	100	466	10	16	5	4
Eco labelled stove / new advanced stove (-2015)	100	466	10	16	5	4
Other stoves	800	7049	121	111	42	71
Old boilers with hot water storage	550	7049	121	111	42	71
Old boilers without hot water storage	550	7049	121	111	42	71
New boilers with hot water storage	100	466	10	16	5	4
New boilers without hot water storage	200	931	20	32	10	8
Pellet boilers	100	466	10	16	5	4
IEF residential wood combustion, 2015	**304**	**2308**	**44.5**	**45.6**	**16.5**	**24.8**

Technology specific references and assumptions

The technology specific emission factor for each pollutant and technology are shown in Table 32. The reference and assumptions for each of the emission factor are also included in the table.

Table 32 Emission factors for residential wood combustion.

	Pollutant	Emission factor (g/GJ)	Reference
Old stove	NO_x	50	EEA (2016), Small combustion, table 3.40, conventional stoves.
New stove	NO_x	50	EEA (2016), Small combustion, table 3.40, conventional stoves.
Modern stove (2008-2015)	NO_x	80	EEA (2016), Small combustion, table 3.41, energy efficient stoves.
Modern stove (2015-2017)	NO_x	80	Same as modern stove (2008-2015)
Modern stove (2017-)	NO_x	80	Same as modern stove (2008-2015)
Eco labelled stove / new advanced stove (-2015)	NO_x	95	EEA (2016), Small combustion, table 3.42, advanced / eco-labelled stoves and boilers.
Eco labelled stove / new advanced stove (2015-)	NO_x	95	EEA (2016), Small combustion, table 3.42, advanced / eco-labelled stoves and boilers.
Other stove	NO_x	50	EEA (2016), Small combustion, table 3.40, conventional stoves.
Old boilers with hot water storage	NO_x	80	EEA (2016), Small combustion, table 3.43, conventional boilers.
Old boilers without hot water storage	NO_x	80	EEA (2016), Small combustion, table 3.43, conventional boilers.
New boilers with hot water storage	NO_x	95	EEA (2016), Small combustion, table 3.42, advanced / eco-labelled stoves and boilers.
New boilers without hot water storage	NO_x	95	EEA (2016), Small combustion, table 3.42, advanced / eco-labelled stoves and boilers.
Pellet boilers/stoves	NO_x	80	EEA (2016), Small combustion, table 3.44, pellet stoves and boilers.
Old stove	NMVOC	1200	Assumed two times conventional stoves. EEA (2016),Small combustion, table 3.40, conventional stoves; 600 g/GJ (20 g/GJ - 3000 g/GJ).
New stove	NMVOC	600	EEA (2016), Small combustion, table 3.40, conventional stoves.
Modern stove (2008-2015)	NMVOC	350	EEA (2016), Small combustion, table 3.41, energy efficient stoves.
Modern stove (2015-2017)	NMVOC	350	Same as modern stove (2008-2015)
Modern stove (2017-)	NMVOC	350	Same as modern stove (2008-2015)
Eco labelled stove / new advanced stove (-2015)	NMVOC	175	Assumed ½ modern stove. The EEA (2016) emission factor for advanced / ecolabelled stoves and boilers is 250 g/GJ, but this emission factor has not been revised since the 2009 version of the Guidebook.
Eco labelled stove / new advanced stove (2015-)	NMVOC	175	Same as ecolabelled stoves.
Other stove	NMVOC	600	EEA (2016), Small combustion, table 3.40, conventional stoves.
Old boilers with hot water storage	NMVOC	350	EEA (2016), Small combustion, table 3.43, conventional boilers.
Old boilers without hot water storage	NMVOC	350	EEA (2016), Small combustion, table 3.43, conventional boilers.
New boilers with hot water storage	NMVOC	175	Assumed equal to ecolabelled stoves.
New boilers without hot water storage	NMVOC	350	Assumed 2 times the emission from new boilers with heat accumulation tank
Pellet boilers/stoves	NMVOC	10	EEA (2016), Small combustion, table 3.44, pellet stoves and boilers.
Old stove	CH_4	430	Methane emissions from residential biomass combustion, Paulrud et al. (2005) (SMED report, Sweden).
New stove	CH_4	215	Assumed ½ the emission factor for old stoves.
Modern stove (2008-2015)	CH_4	125	Estimated based on the emission factor for new stoves and the emission factors for NMVOC.
Modern stove (2015-2017)	CH_4	125	Same as modern stove (2008-2016).
Modern stove (2017-)	CH_4	125	Same as modern stove (2008-2016).
Eco labelled stove / new advanced stove (-2015)	CH_4	2	Low emissions from wood burning in an ecolabelled residential boiler. Olsson & Kjällstrand (2005).
Eco labelled stove / new advanced stove (2015-)	CH_4	2	Same as advanced / ecolabelled stoves.
Other stove	CH_4	430	Assumed equal to old stove.
Old boilers with hot water storage	CH_4	211	Methane emissions from residential biomass combustion, Paulrud et al 2005 (SMED report, Sweden)
Old boilers without hot water storage	CH_4	256	Methane emissions from residential biomass combustion, Paulrud et al 2005 (SMED report, Sweden)
New boilers with hot water storage	CH_4	50	Emission characteristics of modern and old-type residential boilers fired with wood logs and wood pellets. Johansson et al. (2004).

	Pollutant	Emission factor (g/GJ)	Reference
New boilers without hot water storage	CH_4	50	Emission characteristics of modern and old-type residential boilers fired with wood logs and wood pellets. Johansson et al. (2004).
Pellet boilers/stoves	CH_4	3	Methane emissions from residential biomass combustion, Paulrud et al., (2005) (SMED report, Sweden)
Old stove	CO	8000	Assumed two times conventional stoves. EEA (2016),Small combustion, table 3.40, conventional stoves; 4000 g/GJ (1000 g/GJ - 10,000 g/GJ).
New stove	CO	4000	EEA (2016), Small combustion, table 3.40, conventional stoves.
Modern stove (2008-2015)	CO	4000	EEA (2016), Small combustion, table 3.41, energy efficient stoves.
Modern stove (2015-2017)	CO	4000	Same as modern stove (2008-2015).
Modern stove (2017-)	CO	4000	Same as modern stove (2008-2015).
Eco labelled stove / new advanced stove (-2015)	CO	1117	Nordic Ecolabelling limit. The EEA (2016) emission factor for advanced / ecolabelled stoves and boilers is 2000 g/GJ.
Eco labelled stove / new advanced stove (2015-)	CO	1117	Same as ecolabelled stoves.
Other stove	CO	4000	EEA (2016), Small combustion, table 3.40, conventional stoves.
Old boilers with hot water storage	CO	4000	EEA (2016), Small combustion, table 3.43, conventional boilers.
Old boilers without hot water storage	CO	4000	EEA (2016), Small combustion, table 3.43, conventional boilers.
New boilers with hot water storage	CO	1117	Assumed equal to ecolabelled stoves.
New boilers without hot water storage	CO	2234	Assumed 2 times the emission from new boilers with heat accumulation tank.
Pellet boilers/stoves	CO	300	EEA (2016), Small combustion, table 3.44, pellet stoves and boilers.
Old stove	NH_3	70	EEA (2016), Small combustion, table 3.40, conventional stoves.
New stove	NH_3	70	EEA (2016), Small combustion, table 3.40, conventional stoves.
Modern stove (2008-2015)	NH_3	37	EEA (2016), Small combustion, table 3.41, energy efficient stoves.
Modern stove (2015-2017)	NH_3	37	Same as modern stove (2008-2015).
Modern stove (2017-)	NH_3	37	Same as modern stove (2008-2015).
Eco labelled stove / new advanced stove (-2015)	NH_3	37	EEA (2016), Small combustion, table 3.42, advanced / ecolabelled stoves and boilers.
Eco labelled stove / new advanced stove (2015-)	NH_3	37	EEA (2016), Small combustion, table 3.42, advanced / ecolabelled stoves and boilers.
Other stove	NH_3	70	EEA (2016), Small combustion, table 3.40, conventional stoves.
Old boilers with hot water storage	NH_3	74	EEA (2016), Small combustion, table 3.43, conventional boilers.
Old boilers without hot water storage	NH_3	74	EEA (2016), Small combustion, table 3.43, conventional boilers.
New boilers with hot water storage	NH_3	37	EEA (2016), Small combustion, table 3.42, advanced / ecolabelled stoves and boilers.
New boilers without hot water storage	NH_3	37	EEA (2016), Small combustion, table 3.42, advanced / ecolabelled stoves and boilers.
Pellet boilers/stoves	NH_3	12	EEA (2016), Small combustion, table 3.44, pellet stoves and boilers.
Old stove	TSP	1000	Glasius et al. (2005).
New stove	TSP	800	EEA (2016), Small combustion, table 3.40, conventional stoves.
Modern stove (2008-2015)	TSP	556	Limit value 10 g/kg. Calculation based on 18 MJ/kg.
Modern stove (2015-2017)	TSP	278	Limit value 5 g/kg. Calculation based on 18 MJ/kg.
Modern stove (2017-)	TSP	222	Limit value 4 g/kg. Calculation based on 18 MJ/kg.
Eco labelled stove / new advanced stove (-2015)	TSP	222	Nordic Ecolabelling limit 2012 update for hand fed stove for temporary firing or inset stove (4 g/kg). Calculation based on 18 MJ/kg. The EEA (2016), Small combustion, table 3.42, advanced/ecolabelled stoves and boilers is 100 g/GJ.
Eco labelled stove / new advanced stove (2015-)	TSP	167	Nordic Ecolabelling label limit 2012 update for hand fed stove for temporary firing or inset stove (3 g/kg). Calculation based on 18 MJ/kg. EEA (2016), Small combustion, table 3.42, advanced / ecolabelled stoves and boilers is 100 g/GJ.
Other stove	TSP	800	EEA (2016), Small combustion, table 3.40, conventional stoves.
Old boilers with hot water storage	TSP	1000	Illerup et al. (2007). EEA (2016) emission factor, Small combustion, table 3.43, conventional boilers is 500 g/GJ.
Old boilers without hot water storage	TSP	2000	Illerup et al. (2007). EEA (2016) emission factor, Small combustion, table 3.43, conventional boilers is 500 g/GJ.
New boilers with hot water storage	TSP	222	Assumed equal to ecolabelled stoves.
New boilers without hot water storage	TSP	444	Assumed two times the emission from new boilers with accumulation tank.
Pellet boilers/stoves	TSP	31	Boman et al. (2011)

	Pollutant	Emission factor (g/GJ)	Reference
Old stove	PM_{10}	950	PM fractions refer to EEA (2016), Small combustion, table 3.40, conventional stoves.
New stove	PM_{10}	760	EEA (2016), Small combustion, table 3.40, conventional stoves.
Modern stove (2008-2015)	PM_{10}	528	PM fractions refer to EEA (2016), Small combustion, table 3.41, energy efficient stoves.
Modern stove (2015-2017)	PM_{10}	264	PM fractions refer to EEA (2016), Small combustion, table 3.41, energy efficient stoves.
Modern stove (2017-)	PM_{10}	211	PM fractions refer to EEA (2016), Small combustion, table 3.41, energy efficient stoves.
Eco labelled stove / new advanced stove (-2015)	PM_{10}	211	PM fractions refer to EEA (2016), Small combustion, table 3.42, advanced / ecolabelled stoves and boilers.
Eco labelled stove / new advanced stove (2015-)	PM_{10}	159	PM fractions refer to EEA (2016), Small combustion, table 3.42, advanced / ecolabelled stoves and boilers.
Other stove	PM_{10}	760	EEA (2016), Small combustion, table 3.40, conventional stoves.
Old boilers with hot water storage	PM_{10}	950	Illerup et al. (2007). The EEA (2016) emission factor, Small combustion, table 3.43, conventional boilers is 480 g/GJ.
Old boilers without hot water storage	PM_{10}	1900	Illerup et al. (2007). The EEA (2016) emission factor, Small combustion, table 3.43, conventional boilers is 480 g/GJ.
New boilers with hot water storage	PM_{10}	211	Assumed equal to ecolabelled stoves.
New boilers without hot water storage	PM_{10}	422	Assumed two times the emission from new boilers with accumulation tank.
Pellet boilers/stoves	PM_{10}	29	Boman et al. (2011)
Old stove	$PM_{2.5}$	930	PM fractions refer to EEA (2016), Small combustion, table 3.40, conventional stoves.
New stove	$PM_{2.5}$	740	EEA (2016), Small combustion, table 3.40, conventional stoves.
Modern stove (2008-2015)	$PM_{2.5}$	514	PM fractions refer to EEA (2016), Small combustion, table 3.41, energy efficient stoves.
Modern stove (2015-2017)	$PM_{2.5}$	257	PM fractions refer to EEA (2016), Small combustion, table 3.41, energy efficient stoves.
Modern stove (2017-)	$PM_{2.5}$	205	PM fractions refer to EEA (2016), Small combustion, table 3.41, energy efficient stoves.
Eco labelled stove / new advanced stove (-2015)	$PM_{2.5}$	206	PM fractions refer to EEA (2016), Small combustion, table 3.42, advanced / ecolabelled stoves and boilers.
Eco labelled stove / new advanced stove (2015-)	$PM_{2.5}$	155	PM fractions refer to EEA (2016), Small combustion, table 3.42, advanced / ecolabelled stoves and boilers.
Other stove	$PM_{2.5}$	740	EEA (2016), Small combustion, table 3.40, conventional stoves.
Old boilers with hot water storage	$PM_{2.5}$	900	Illerup et al. (2007). The EEA (2016) emission factor, Small combustion, table 3.43, conventional boilers is 470 g/GJ.
Old boilers without hot water storage	$PM_{2.5}$	1800	Illerup et al. (2007). The EEA (2016) emission factor, Small combustion, table 3.43, conventional boilers is 470 g/GJ.
New boilers with hot water storage	$PM_{2.5}$	206	Assumed equal to ecolabelled stoves.
New boilers without hot water storage	$PM_{2.5}$	413	Assumed two times the emission from new boilers with accumulation tank.
Pellet boilers/stoves	$PM_{2.5}$	29	Boman et al. (2011)
Old stove	PCDD/F	800	EEA (2016), Small combustion, table 3.40, conventional stoves.
New stove	PCDD/F	800	EEA (2016), Small combustion, table 3.40, conventional stoves.
Modern stove (2008-2015)	PCDD/F	250	EEA (2016), Small combustion, table 3.41, energy efficient stoves.
Modern stove (2015-2017)	PCDD/F	250	Same as modern stove (2008-2015).
Modern stove (2017-)	PCDD/F	250	Same as modern stove (2008-2015).
Eco labelled stove / new advanced stove (-2015)	PCDD/F	100	EEA (2016), Small combustion, table 3.42, advanced / ecolabelled stoves and boilers.
Eco labelled stove / new advanced stove (2015-)	PCDD/F	100	EEA (2016), Small combustion, table 3.42, advanced / ecolabelled stoves and boilers.
Other stove	PCDD/F	800	EEA (2016), Small combustion, table 3.40, conventional stoves.
Old boilers with hot water storage	PCDD/F	550	EEA (2016), Small combustion, table 3.43, conventional boilers.
Old boilers without hot water storage	PCDD/F	550	EEA (2016), Small combustion, table 3.43, conventional boilers.
New boilers with hot water storage	PCDD/F	100	EEA (2016), Small combustion, table 3.42, advanced / ecolabelled stoves and boilers.
New boilers without hot water storage	PCDD/F	200	Assumed two times the emission from new boilers with accumulation tank.
Pellet boilers/stoves	PCDD/F	100	EEA (2016), Small combustion, table 3.44, pellet stoves and boilers.
Old stove	Benzo(a)	121	EEA (2016), Small combustion, table 3.40, conventional stoves.
New stove	Benzo(a)	121	EEA (2016), Small combustion, table 3.40, conventional stoves.

	Pollutant	Emission factor (g/GJ)	Reference
Modern stove (2008-2015)	Benzo(a)	61	Assumed ½ the emission from old/new stoves
Modern stove (2015-2017)	Benzo(a)	61	Same as modern stove (2008-2015).
Modern stove (2017-)	Benzo(a)	61	Same as modern stove (2008-2015).
Eco labelled stove / new advanced stove (-2015)	Benzo(a)	10	EEA (2016), Small combustion, table 3.42, advanced / eco-labelled stoves and boilers.
Eco labelled stove / new advanced stove (2015-)	Benzo(a)	10	EEA (2016), Small combustion, table 3.42, advanced / eco-labelled stoves and boilers.
Other stove	Benzo(a)	121	EEA (2016), Small combustion, table 3.40, conventional stoves.
Old boilers with hot water storage	Benzo(a)	121	EEA (2016), Small combustion, table 3.43, conventional boilers.
Old boilers without hot water storage	Benzo(a)	121	EEA (2016), Small combustion, table 3.43, conventional boilers.
New boilers with hot water storage	Benzo(a)	10	EEA (2016), Small combustion, table 3.42, advanced / eco-labelled stoves and boilers.
New boilers without hot water storage	Benzo(a)	20	Assumed two times the emission from new boilers with accumulation tank.
Pellet boilers/stoves	Benzo(a)	10	EEA (2016), Small combustion, table 3.44, pellet stoves and boilers.
Old stove	Benzo(b)	111	EEA (2016), Small combustion, table 3.40, conventional stoves.
New stove	Benzo(b)	111	EEA (2016), Small combustion, table 3.40, conventional stoves.
Modern stove (2008-2015)	Benzo(b)	56	Assumed ½ the emission from old/new stoves.
Modern stove (2015-2017)	Benzo(b)	56	Same as modern stove (2008-2015).
Modern stove (2017-)	Benzo(b)	56	Same as modern stove (2008-2015).
Eco labelled stove / new advanced stove (-2015)	Benzo(b)	16	EEA (2016), Small combustion, table 3.42, advanced / eco-labelled stoves and boilers.
Eco labelled stove / new advanced stove (2015-)	Benzo(b)	16	EEA (2016), Small combustion, table 3.42, advanced / eco-labelled stoves and boilers.
Other stove	Benzo(b)	111	EEA (2016), Small combustion, table 3.40, conventional stoves.
Old boilers with hot water storage	Benzo(b)	111	EEA (2016), Small combustion, table 3.43, conventional boilers.
Old boilers without hot water storage	Benzo(b)	111	EEA (2016), Small combustion, table 3.43, conventional boilers.
New boilers with hot water storage	Benzo(b)	16	EEA (2016), Small combustion, table 3.42, advanced / eco-labelled stoves and boilers.
New boilers without hot water storage	Benzo(b)	32	Assumed two times the emission from new boilers with accumulation tank.
Pellet boilers/stoves	Benzo(b)	16	EEA (2016), Small combustion, table 3.44, pellet stoves and boilers.
Old stove	Benzo(k)	42	EEA (2016), Small combustion, table 3.40, conventional stoves.
New stove	Benzo(k)	42	EEA (2016), Small combustion, table 3.40, conventional stoves.
Modern stove (2008-2015)	Benzo(k)	21	Assumed ½ the emission from old/new stoves.
Modern stove (2015-2017)	Benzo(k)	21	Same as modern stove (2008-2015).
Modern stove (2017-)	Benzo(k)	21	Same as modern stove (2008-2015).
Eco labelled stove / new advanced stove (-2015)	Benzo(k)	5	EEA (2016), Small combustion, table 3.42, advanced / eco-labelled stoves and boilers.
Eco labelled stove / new advanced stove (2015-)	Benzo(k)	5	EEA (2016), Small combustion, table 3.42, advanced / eco-labelled stoves and boilers.
Other stove	Benzo(k)	42	EEA (2016), Small combustion, table 3.40, conventional stoves.
Old boilers with hot water storage	Benzo(k)	42	EEA (2016), Small combustion, table 3.43, conventional boilers.
Old boilers without hot water storage	Benzo(k)	42	EEA (2016), Small combustion, table 3.43, conventional boilers.
New boilers with hot water storage	Benzo(k)	5	EEA (2016), Small combustion, table 3.42, advanced / eco-labelled stoves and boilers.
New boilers without hot water storage	Benzo(k)	10	Assumed two times the emission from new boilers with accumulation tank.
Pellet boilers/stoves	Benzo(k)	5	EEA (2016), Small combustion, table 3.44, pellet stoves and boilers.
Old stove	Indeno	71	EEA (2016), Small combustion, table 3.40, conventional stoves.
New stove	Indeno	71	EEA (2016), Small combustion, table 3.40, conventional stoves.
Modern stove (2008-2015)	Indeno	36	Assumed ½ the emission from old/new stoves.
Modern stove (2015-2017)	Indeno	36	Same as modern stove (2008-2015).
Modern stove (2017-)	Indeno	36	Same as modern stove (2008-2015).
Eco labelled stove / new advanced stove (-2015)	Indeno	4	EEA (2016), Small combustion, table 3.42, advanced / eco-labelled stoves and boilers.
Eco labelled stove / new advanced stove (2015-)	Indeno	4	EEA (2016), Small combustion, table 3.42, advanced / eco-labelled stoves and boilers.
Other stove	Indeno	71	EEA (2016), Small combustion, table 3.40, conventional stoves.
Old boilers with hot water storage	Indeno	71	EEA (2016), Small combustion, table 3.43, conventional boilers.
Old boilers without hot water storage	Indeno	71	EEA (2016), Small combustion, table 3.43, conventional boilers.

	Pollutant	Emission factor (g/GJ)	Reference
New boilers with hot water storage	Indeno	4	EEA (2016), Small combustion, table 3.42, advanced / eco-labelled stoves and boilers.
New boilers without hot water storage	Indeno	8	Assumed two times the emission from new boilers with accumulation tank.
Pellet boilers/stoves	Indeno	4	EEA (2016), Small combustion, table 3.44, pellet stoves and boilers.
Old stove	dl-PCB	7049	Hedman (2006), old boiler. Recalculation from TEQ to sum of dioxin-like PCB *133 (Thistlethwaite, 2001).
New stove	dl-PCB	7049	Hedman (2006), old boiler. Recalculation from TEQ to sum of dioxin-like PCB *133 (Thistlethwaite, 2001).
Modern stove (2008-2015)	dl-PCB	931	Hedman (2006), modern boiler. Recalculation from TEQ to sum of dioxin-like PCB *133 (Thistlethwaite, 2001).
Modern stove (2015-2017)	dl-PCB	931	Same as modern stove (2008-2016).
Modern stove (2017-)	dl-PCB	931	Same as modern stove (2008-2016).
Eco labelled stove / new advanced stove (-2015)	dl-PCB	466	Hedman (2006), assumed ½ modern boiler
Eco labelled stove / new advanced stove (2015-)	dl-PCB	466	Same as advanced / ecolabelled stoves.
Other stove	dl-PCB	7049	Hedman (2006), old boiler. Recalculation from TEQ to sum of dioxin-like PCB *133 (Thistlethwaite, 2001).
Old boilers with hot water storage	dl-PCB	7049	Hedman (2006), old boiler. Recalculation from TEQ to sum of dioxin-like PCB *133 (Thistlethwaite, 2001).
Old boilers without hot water storage	dl-PCB	7049	Hedman (2006), old boiler. Recalculation from TEQ to sum of dioxin-like PCB *133 (Thistlethwaite, 2001).
New boilers with hot water storage	dl-PCB	466	Assumed equal to ecolabelled stoves.
New boilers without hot water storage	dl-PCB	931	Hedman (2006), modern boiler. Recalculation from TEQ to sum of dioxin-like PCB *133 (Thistlethwaite, 2001).
Pellet boilers/stoves	dl-PCB	466	Hedman (2006), assumed ½ modern boiler.
Old stove	BC	10% of $PM_{2.5}$	EEA (2016), Small combustion, table 3.40, conventional stoves.
New stove	BC	10% of $PM_{2.5}$	EEA (2016), Small combustion, table 3.40, conventional stoves.
Modern stove (2008-2015)	BC	16% of $PM_{2.5}$	EEA (2016), Small combustion, table 3.41, energy efficient stoves.
Modern stove (2015-2017)	BC	16% of $PM_{2.5}$	Same as modern stove (2008-2015).
Modern stove (2017-)	BC	16% of $PM_{2.5}$	Same as modern stove (2008-2015).
Eco labelled stove / new advanced stove (-2015)	BC	28% of $PM_{2.5}$	EEA (2016), Small combustion, table 3.42, advanced / eco-labelled stoves and boilers.
Eco labelled stove / new advanced stove (2015-)	BC	28% of $PM_{2.5}$	EEA (2016), Small combustion, table 3.42, advanced / eco-labelled stoves and boilers.
Other stove	BC	10% of $PM_{2.5}$	EEA (2016), Small combustion, table 3.40, conventional stoves.
Old boilers with hot water storage	BC	16% of $PM_{2.5}$	EEA (2016), Small combustion, table 3.43, conventional boilers.
Old boilers without hot water storage	BC	16% of $PM_{2.5}$	EEA (2016), Small combustion, table 3.43, conventional boilers.
New boilers with hot water storage	BC	28% of $PM_{2.5}$	EEA (2016), Small combustion, table 3.42, advanced / eco-labelled stoves and boilers.
New boilers without hot water storage	BC	28% of $PM_{2.5}$	EEA (2016), Small combustion, table 3.42, advanced / eco-labelled stoves and boilers.
Pellet boilers/stoves	BC	15% of $PM_{2.5}$	Schmidl et al. (2011).

Emission factor time series for residential wood

The time series for the residential wood combustion emission factors have been estimated based on the time series for wood consumption in each technology. The time series are shown in Table 33.

Table 33 Implied emission factor time series for residential wood combustion.

Year	NO_x, g/GJ	NMVOC, g/GJ	CH_4, g/GJ	CO, g/GJ	NH_3, g/GJ	TSP, g/GJ	PM_{10}, g/GJ	$PM_{2.5}$, g/GJ	BC, g/GJ	PCDD/F, ng/GJ	dl-PCB, ng/GJ	Benzo(a)pyrene, mg/GJ	Benzo(b)fluoranthene, mg/GJ	Benzo(k)fluoranthene, mg/GJ	Indeno (1,2,3-c,d)pyrene, mg/GJ
1990	60	813	318	5833	69	1015	964	933	115	696	6648	114	105	40	67
1991	60	799	312	5732	68	1004	954	923	113	695	6622	114	105	40	67
1992	60	785	306	5623	68	992	943	912	112	694	6588	113	105	39	66
1993	60	772	300	5520	68	981	932	902	111	693	6559	113	104	39	66
1994	60	756	293	5401	68	967	918	889	109	690	6510	112	103	39	65
1995	60	738	286	5270	67	950	903	874	107	685	6445	111	103	39	65
1996	61	715	276	5098	66	926	879	851	104	675	6327	109	101	38	64
1997	61	694	267	4946	66	905	859	832	102	667	6231	107	100	37	63
1998	61	670	257	4771	64	879	835	808	99	656	6101	105	98	37	61
1999	62	618	237	4423	61	818	777	753	92	619	5708	99	92	35	57
2000	64	581	222	4189	59	776	738	714	88	590	5390	94	88	33	55
2001	65	520	198	3783	54	698	663	642	80	537	4834	85	80	30	49
2002	66	496	189	3635	52	669	635	616	77	516	4609	82	78	29	47
2003	67	492	187	3619	52	665	632	612	77	512	4548	81	77	29	47
2004	67	486	184	3596	52	660	627	608	77	507	4477	81	77	29	47
2005	68	464	175	3457	50	633	601	583	74	487	4267	78	74	28	45
2006	68	439	165	3297	48	602	572	555	71	465	4028	74	71	26	43
2007	69	448	166	3350	49	612	582	564	74	470	4050	75	71	27	43
2008	70	429	157	3195	48	580	551	535	71	446	3801	70	68	25	40
2009	71	401	144	2983	45	536	509	495	67	416	3496	65	63	23	37
2010	72	387	137	2869	44	511	485	472	64	399	3309	62	60	22	35
2011	73	373	129	2757	43	488	463	451	63	383	3138	59	58	21	33
2012	74	360	123	2652	43	466	443	431	61	368	2974	56	55	20	32
2013	75	332	111	2450	40	426	405	394	57	343	2710	51	52	19	29
2014	76	291	95	2161	37	371	352	343	50	308	2362	45	46	17	25
2015	77	293	93	2158	37	367	348	340	51	304	2308	44	46	17	25

7. 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 GHG emission factors are either nationally referenced or based on IPCC Guidelines (2006)[13]. The emission factors for other pollutants are either nationally referenced or based on the EEA Guidebook (EEA, 2016)[14].

An overview of the CO_2 emission factors is shown in Chapter 7.2.

7.1 EU ETS data for CO_2

The CO_2 emission factors for some large power plants and for combustion in the cement industry and refineries are plant specific and based on the reporting to the EU Emission Trading Scheme (EU ETS). In addition, emission factors for offshore gas turbines and refinery gas is based on EU ETS data. The EU ETS data have been applied for the years 2006-2015.

7.1.1 ETS data, methodology, criteria for implementation and QA/QC

The Danish emission inventory for stationary combustion only includes CO_2 emission data from plants using higher tier methods as defined in the EU decision (EU Commission, 2007), where the specific methods for determining carbon contents, oxidation factor and calorific value are specified. The EU decision includes rules for measuring, reporting and verification.

Fuel consumption data from EU ETS are included for some additional plants and fuels, e.g. biomass fuels.

For each of the plants included with plant and fuel specific CO_2 emission factors in the Danish inventory all applied methodologies are specified in individual monitoring plans that are approved by Danish authorities (DEA) prior to the reporting of the emissions. The plant and fuel specific CO_2 emission factors included in the Danish inventory all apply the Tier 3 methodology for calculating the CO_2 emission factor. This selection criteria results in a dataset for which the emission factor values are based on fuel quality measurements[15], not default values from the Danish UNFCCC reporting. All fuel analyses are performed according to ISO 17025.

The data sets are selected based on emission factor methodology. The data applied for the selected data sets are activity data, net calorific value (NCV), emission factor and oxidation factor. The Tier 3 methodologies for estimating CO_2 emissions from coal and residual oil are specified below.

Coal

The CO_2 emission factor for coal is based on analysis of carbon (C) content of the coal (g C per kg) and coal weight measurements. However, NCV values are also measured according to high tier methods in spite of the fact that this value is not input data for the calculation of total CO_2 emission.

[13] However, the CO_2 emission factor for gas oil refers to the EEA Guidebook (EEA, 2007).
[14] And former editions of the EEA Guidebook.
[15] Applying specific methods defined in the EU decision.

- Fuel flow: Tier 4 methodology (± 1.5 %). For coal, the activity data (weight) is based on measurements on belt conveyor scale. The uncertainty is below the required ± 1.5 %.
- NCV: Tier 3 methodology. Data are based on measurements according to ISO 13909 / ISO 18283 (sampling) and ISO 1928 (NCV). The uncertainty for data is below ± 0.5 %.
- Emission factor: The emission factor is C-content of the coal. Tier 3 methodology (± 0.5 %) is applied and the measurements are performed according to ISO 13909 (sampling) and ISO / TS 12902 (C-content).
- Oxidation factor: Based on Tier 3 methodology except for sevel plants that applies Tier 1 methodology[16]. The Tier 3 methodology is based on measurements of C-content in bottom ash and fly ash according to ISO / TS 12902 or on burning loss measurements according to ISO 1171. The uncertainty has been estimated to 0.5 %. For Tier 1 the oxidation factor is assumed to be 1.

Residual oil

- Fuel flow: Tier 4 methodology (± 1.5 %) for most plants. However, a few of the included plants apply Tier 3 methodology (± 2.5 %).
- NCV: Tier 3 methodology. Data are based on sampling according to API Manual of Petroleum Measurement Standards / ASTM D 270 and fuel analysis (NCV) according to ASTM D 240 / ISO 1928 / data stated by the fuel supplier.
- Emission factor: Tier 3 methodology according to API Manual of Petroleum Measurement Standards / ASTM D 4057 (sampling) and ISO 12902 / ASTM D 5291 (C-content).
- Oxidation factor: Based on Tier 2 or Tier 3 methodology, both resulting in the oxidation factor 1 with an uncertainty of 0.8 %.

For coal and residual oil fuel analyses are required for each 20000 tonnes or at least six times each year. The fuel analyses are performed by accredited laboratories[17].

7.1.2 EU ETS data presentation

The EU ETS data include plant specific emission factors for coal, residual oil, gas oil, natural gas, refinery gas, petroleum coke, coke oven coke and fossil waste. The EU ETS data accounted for 66 % of the CO_2 emission from stationary combustion in 2015.

EU ETS data for coal

EU ETS data for 2015 were available from 18 coal-fired plants. The plant specific information accounts for 97 % of the Danish coal consumption and 38 % of the total fossil CO_2 emission from stationary combustion plants.

[16] In addition, DCE have assumed the oxidation factor to be 1 for a plant for which the stated oxidation factor was rejected in the internal QC work.

[17] EN ISO 17025.

Data from 17 of the 18 plants have been applied for estimating an average CO_2 emission factor for coal[18]. The average CO_2 emission factor for coal for these 17 units was 94.46 kg per GJ (Table 34). The plants all apply bituminous coal.

Table 34 EU ETS data for 17 coal fired plants, 2015.

	Average	Min	Max
Heating value, GJ per tonne	24.0	23.1	32.4
CO_2 implied emission factor, kg per GJ[1)]	94.46	93.154	98.140
Oxidation factor	0.9958	0.9896	1.0000

[1)] Including oxidation factor.

Table 35 CO_2 implied emission factor time series for coal fired plants based on EU ETS data.

Year	CO_2 implied emission factor, kg per GJ[1)]
2006	94.4
2007	94.3
2008	94.0
2009	93.6
2010	93.6
2011	94.7
2012	94.25
2013	93.95
2014	94.17
2015	94.46

[1)] Including oxidation factor.

EU ETS data for residual oil

EU ETS data for 2015 based on higher tier methodologies were available from 15 plants combusting residual oil. The EU ETS data accounts for 93 % of the residual oil consumption in stationary combustion.

Data from 10 of the 15 plants have been applied for estimating an average CO_2 emission factor for residual oil[19]. Aggregated data and time series are shown in Table 36 and Table 37.

Table 36 EU ETS data for 10 plants combusting residual oil.

	Average	Min	Max
Heating value, GJ per tonne	40.75	40.18	41.10
CO_2 implied emission factor, kg per GJ	79.17	78.66	79.77
Oxidation factor	1.000	1.000	1.000

Table 37 CO_2 implied emission factor time series for residual oil fired power plant units based on EU ETS data.

Year	CO_2 implied emission factor, kg per GJ[1)]
2006	78.2
2007	78.1
2008	78.5
2009	78.9
2010	79.2
2011	79.25
2012	79.21
2013	79.28
2014	79.49

[18] Fuel consumption of the 17 plants adds up to 87% of the fuel consumption of the 18 plants. The remaining plant is not considered representative for the coal consumption in Denmark.

[19] Fuel consumption of the 10 plants adds up to 92% of the fuel consumption of the 15 plants. The remaining plants are not considered representative for the residual oil consumption in Denmark.

2015	79.17

1) Including oxidation factor.

EU ETS data for gas oil combusted in power plants or refineries

EU ETS data for 2015 based on higher tier methodologies were included from two plants combusting gas oil. Aggregated data and time series are shown in Table 38 and Table 39. The EU ETS data accounts for 2 % of the gas oil consumption in stationary combustion.

Table 38 EU ETS data for gas oil applied in power plants/refineries.

	Average	Min	Max
Heating value, GJ per tonne	36.68	36.55	36.69
CO_2 implied emission factor, kg per GJ	73.75	73.74	73.99
Oxidation factor	1.000	1.000	1.000

Table 39 CO_2 implied emission factor time series for gas oil based on EU ETS data.

Year	CO_2 implied emission factor, kg per GJ[1]
2006	75.1
2007	74.9
2008	73.7
2009	75.1
2010	74.8
2011	74.7
2012	73.9
2013	72.7
2014	74.18
2015	73.75

1) Including oxidation factor.

EU ETS data for waste

EU ETS data for 2015 based on higher tier methodologies were included from nine waste incineration plants. The EU ETS data for waste incineration are based on emission measurements. The average emission factor value for the plants is 43.3 kg / GJ. The emission factors are in the interval 34.0 kg / GJ to 58.6 kg / GJ. The EU ETS data accounts for 63 % of the incinerated waste.

Table 40 EU ETS data for waste incineration.

	Average	Min	Max
Heating value, GJ per tonne	10.65	10.50	11.30
CO_2 implied emission factor, kg per GJ	43.3	34.0	58.6
Oxidation factor	1.0	1.0	1.0

Table 41 CO_2 implied emission factor time series for waste incineration.

Year	CO_2 implied emission factor, kg per GJ[1]
2013	43.0
2014	40.8
2015	43.3

1) kg fossil CO_2 per GJ total waste.

EU ETS data for petroleum coke, coke oven coke, industrial waste and natural gas

The implemented EU ETS data set also includes CO_2 emission factors for industrial waste, petroleum coke, coke oven coke and natural gas. The industrial plants with additional EU ETS data include cement industry, sugar production, mineral wool production, lime production, and vegetable oil production.

EU ETS data for natural gas applied in offshore gas turbines

EU ETS data have been applied to estimate an average CO_2 emission factor for natural gas combusted in offshore gas turbines, see Chapter 7.

EU ETS data for refinery gas

EU ETS data are also applied for the two refineries in Denmark. The emission factor for refinery gas is based on EU ETS data see Chapter 7.2.12.

7.2 CO_2 emission factors

The CO_2 emission factors that are not included in EU ETS data or that are included but based on lower tier methodologies are not plant specific in the Danish inventory. The emission factors that are not plant specific accounts for 34 % of the fossil CO_2 emission.

The CO_2 emission factors applied for 2015 are presented in Table 42. Time series have been estimated for:

- Coal applied for production of electricity and district heating
- Residual oil applied for production of electricity and district heating
- Refinery gas
- Natural gas applied in offshore gas turbines
- Natural gas, other
- Industrial waste, biomass part

For all other fuels, the same emission factor has been applied for 1990-2015.

In the reporting to the UNFCCC, the CO_2 emission is aggregated to six fuel types: solid fuels, liquid fuels, gaseous fuels, other fossil fuels, peat, and biomass. Peat is not used in Denmark. The correspondence list between the DCE fuel categories and the IPCC fuel categories is also provided in Table 42.

Only emissions from fossil fuels are included in the total national CO_2 emission. The biomass emission factors are also included in the table, because emissions from biomass are reported to the UNFCCC as a memo item.

The CO_2 emission from incineration of waste (37 + 75.1 kg per GJ) is divided into two parts: The emission from combustion of the fossil content of the waste, which is included in the national total, and the emission from combustion of the biomass part, which is reported as a memo item. In the CRF, the fuel consumption and emissions from the fossil content of the waste is reported in the fuel category Other fossil fuels.

Table 42 CO_2 emission factors, 2015.

Fuel	Emission factor kg per GJ Bio-mass	Emission factor kg per GJ Fossil fuel	Reference type	IPCC fuel category
Coal, source category 1A1a Public electricity and heat production		94.46 1)	Country specific	Solid
Coal, Other source categories		94.6 3)	IPCC (2006)	Solid
Brown coal briquettes		97.5	IPCC (2006)	Solid
Coke oven coke		107 3)	IPCC (2006)	Solid
Other solid fossil fuels 6)		118 1)	Country specific	Solid
Fly ash fossil (from coal)		95.4	Country specific	Solid
Petroleum coke		93 3)	Country-specific	Liquid
Residual oil, source category 1A1a Public electricity and heat production		79.17 1)	Country-specific	Liquid
Residual oil, other source categories		78.6 3)	Country-specific	Liquid
Gas oil		74 1)	EEA (2007)	Liquid
Kerosene		71.9	IPCC (2006)	Liquid
Orimulsion		80 2)	Country-specific	Liquid
LPG		63.1	IPCC (2006)	Liquid
Refinery gas		57.508	Country-specific	Liquid
Natural gas, offshore gas turbines		57.615	Country-specific	Gas
Natural gas, other		56.06	Country-specific	Gas
Waste	75.1 3)4)	+ 37 3)4)	Country-specific	Biomass and Other fuels
Straw	100		IPCC (2006)	Biomass
Wood	112		IPCC (2006)	Biomass
Bio oil	70.8		IPCC (2006)	Biomass
Biogas	84.1		Country-specific	Biomass
Biomass gasification gas	142.9 5)		Country-specific	Biomass
Bio natural gas	55.55		Country-specific	Biomass

1) Plant specific data from EU ETS incorporated for individual plants.
2) Not applied in 2015. Orimulsion was applied in Denmark in 1995–2004.
3) Plant specific data from EU ETS incorporated for cement industry and sugar, lime and mineral wool production.
4) The emission factor for waste is (37+75.1) kg CO_2 per GJ waste. The fuel consumption and the CO_2 emission have been disaggregated to the two IPCC fuel categories *Biomass* and *Other fossil fuels* in CRF. The corresponding IEF for CO_2, Other fuels is 82.22 kg CO_2 per GJ fossil waste (not including plant specific data).
5) Includes a high content of CO_2 in the gas.
6) Anodic carbon. Not applied in Denmark in 2015.

7.2.1 Coal

As mentioned in Chapter 6, EU ETS data have been utilised for the years 2006-2015 in the emission inventory. The emission factor for coal applied in 1A1a is the implied emission factor for plants that report EU ETS data that are based on fuel analysis. Data for industrial plants have been included. In 2015, the implied emission factor (including oxidation factor) was 94.46 kg per GJ. The implied emission factor values were between 93.15 and 98.14 kg per GJ.

The emission factors for coal combustion in *Public electricity and heat production* in the years 2006-2015 refer to the implied emission factors of the EU ETS data estimated for each year. For the years 1990-2005, the emission factor for coal combusted in public electricity and heat production plants refer to the average IEF for 2006-2009.

Time series for net calorific value (NCV) of coal are available in the Danish energy statistics. NCV for *Electricity plant coal* fluctuates in the interval 24.1-25.8 GJ per tonne.

The correlation between NCV and CO_2 IEF (including the oxidation factor) in the EU ETS data (2006-2009) have been analysed and the results are shown in Annex 9. However, a significant correlation between NCV and IEF have not been found in the dataset and thus an emission factor time series based on the NCV time series was not relevant. In addition, the correlation of NCV and CO_2 emission factors (not including the oxidation factor) has been analysed. This analysis is also shown in Annex 9. As expected, the correlation was better in this dataset, but still insufficient for estimating a time series for the CO_2 emission factor based on the NCV time series.

As mentioned above all coal applied in Denmark is bituminous coal and within the range of coal qualities applied in the plants reporting data to EU ETS a correlation could not be documented.

For other sectors apart from 1A1a, the applied emission factor 94.6 kg per GJ refers to IPCC Guidelines (IPCC, 2006). This emission factor has been applied for all years.

In 2015, only 0.12 % of the CO_2 emission from coal consumption was based on the emission factor for 1A1a (94.46 kg / GJ). However, 12.5 % of the CO_2 from coal combustion was based on the IPCC (2006) default emission factor 94.6 kg / GJ. The emission factor for coal applied in other sectors than 1A1a (94.6 kg / GJ) was applied for 2.4 % of the coal consumption. The remaining 85 % was covered by EU ETS data. All coal applied in Denmark is bituminous coal (DEA, 2016c).

Time series for the CO_2 emission factor are shown in Table 43.

Table 43 CO_2 emission factor time series for coal.

Year	1A1a Public electricity and heat production kg per GJ	Other source categories kg per GJ
1990-2005	94.0	94.6
2006	94.4	94.6
2007	94.3	94.6
2008	94.0	94.6
2009	93.6	94.6
2010	93.6	94.6
2011	93.73	94.6
2012	94.25	94.6
2013	93.95	94.6
2014	94.17	94.6
2015	94.46	94.6

7.2.2 Brown coal briquettes

The emission factor for brown coal briquettes, 97.5 kg per GJ refers to the IPCC Guidelines, 2006 (IPCC, 2006). The oxidation factor has been assumed equal to 1. The same emission factor has been applied for 1990-2015.

7.2.3 Coke oven coke

The emission factor for coke oven coke, 107 kg per GJ, refers to the IPCC Guidelines 2006 (IPCC, 2006). The oxidation factor has been assumed equal to 1. The same emission factor has been applied for 1990-2015.

7.2.4 Other solid fossil fuels (Anodic carbon)

Anodic carbon was not applied in 2015. Anodic carbon has been applied in Denmark in 2009-2013 in two mineral wool production units. The emission factor 118 kg / GJ refer to EU ETS data from one of the plants in 2012.

The emission factor is not applied because plant specific data are available from the EU ETS dataset.

7.2.5 Fly ash fossil (from coal)

Fly ash from coal combustion is applied in some power plants. The emission factor 95.4 kg / GJ refer to plant specific EU ETS data for 2011 and 2012 assuming full oxidation.

The emission factor is not applied because plant specific data are available from the EU ETS dataset.

7.2.6 Petroleum coke

The emission factor 93 kg per GJ is based on EU ETS data for 2006-2010. The data includes one power plant and the cement production plant.

Plant specific EU ETS data have been utilised for the cement production for the years 2006 - 2015.

EU ETS data were available for 100 % of the petroleum coke consumption in 2015.

7.2.7 Residual oil

The emission factor for residual oil applied in public electricity and heat production is based on EU ETS data.

EU ETS data have been utilised for the 2006-2015 emission inventories. In 2015, the implied emission factor (including oxidation factor) for the plants combusting residual oil was 79.17 kg per GJ. The implied emission factor values were between 78.66 and 79.77 kg per GJ.

The emission factors for residual oil combustion in *Public electricity and heat production* in the years 2006-2015 refer to the implied emission factors of the EU ETS data estimated for each year. For the years 1990-2005, the emission factor for residual oil in *Public electricity and heat production* refer to the average IEF for 2006-2009.

For residual oil combusted in other sectors than *1A1a Public electricity and heat production*, the applied emission factor is 78.6 kg per GJ. This emission factor refers to the average EU ETS data 2006-2009. The emission factor has been applied for all years for other sectors than public electricity and heat production.

In 2015, 15 % of the CO_2 emission from residual oil consumption was based on the emission factor, whereas 85 % of the residual oil consumption was covered by EU ETS data.

Time series for the CO_2 emission factor are shown in Table 44.

Table 44 CO_2 emission factor time series for residual oil.

Year	Source category 1A1a Public electricity and heat production kg per GJ	Other source categories kg per GJ
1990-2005	78.6	78.6
2006	78.6	78.6
2007	78.5	78.6
2008	78.5	78.6
2009	78.9	78.6
2010	79.2	78.6
2011	79.25	78.6
2012	79.21	78.6
2013	79.28	78.6
2014	79.49	78.6
2015	79.17	78.6

7.2.8 Gas oil

The emission factor for gas oil, 74 kg per GJ, refers to EEA (2007). The emission factor is consistent with the IPCC default emission factor for gas oil (74.1 kg per GJ assuming full oxidation). The CO_2 emission factor has been confirmed by the two major power plant operators in 1996 (Christiansen, 1996 and Andersen, 1996). The same emission factor has been applied for 1990-2015.

Plant specific EU ETS data have been utilised for a few plants in the 2006 - 2015 emission inventories. In 2015, the implied emission factor for the power plants using gas oil was 73.75 kg per GJ. The EU ETS CO_2 emission factors were in the interval 73.74 – 73.99 kg per GJ. In 2015, only 2 % of the CO_2 emission from gas oil consumption was based on EU ETS data.

7.2.9 Kerosene

The emission factor for kerosene, 71.9 kg per GJ, refers to IPCC Guidelines (IPCC, 2006). The same emission factor has been applied for 1990-2015.

7.2.10 Orimulsion

The emission factor for orimulsion, 80 kg per GJ, refers to the Danish Energy Agency (DEA, 2016a). The IPCC default emission factor is almost the same: 80.7 kg per GJ assuming full oxidation. The CO_2 emission factor has been confirmed by the only major power plant operator using orimulsion (Andersen, 1996). The same emission factor has been applied for all years. Orimulsion was used in Denmark in 1995-2004.

7.2.11 LPG

The emission factor for LPG, 63.1 kg per GJ, refers to IPCC Guidelines (IPCC, 2006). The same emission factor has been applied for 1990-2015.

7.2.12 Refinery gas

The emission factor applied for refinery gas refers to EU ETS data for the two refineries in operation in Denmark. Since 2006, implied emission factors for Denmark have been estimated annually based on the EU ETS data. The average implied emission factor (57.6 kg per GJ) for 2006-2009 have been applied for the years 1990-2005. This emission factor is consistent with the emission factor stated in the 2006 IPCC Guidelines (IPCC, 2006). The time series is shown in Table 45.

Table 45 CO_2 emission factor time series for refinery gas.

Year	CO_2 emission factor, kg per GJ
1990-2005	57.6
2006	57.812
2007	57.848
2008	57.948
2009	56.814
2010	57.134
2011	57.861
2012	58.108
2013	58.274
2014	57.620
2015	57.508

7.2.13 Natural gas, offshore gas turbines

EU ETS data for the fuel consumption and CO_2 emission for offshore gas turbines are available for the years 2006-2015. Based on data for each oilfield, implied emission factors have been estimated for 2006-2015. The average value for 2006-2009 has been applied for the years 1990-2005. The time series is shown in Table 46.

Table 46 CO_2 emission factor time series for offshore gas turbines.

Year	CO_2 emission factor, kg per GJ
1990-2005	57.469
2006	57.879
2007	57.784
2008	56.959
2009	57.254
2010	57.314
2011	57.379
2012	57.423
2013	57.295
2014	57.381
2015	57.615

7.2.14 Natural gas, other source categories

The emission factor for natural gas is estimated by the Danish gas transmission company, Energinet.dk[20]. The calculation is based on gas analysis carried out daily by Energinet.dk at Egtved.

In 2015, the natural gas import was 25 PJ, the natural gas export 82 PJ and the consumption added up to 121 PJ. Before 2010, only natural gas from the Danish gas fields was utilised in Denmark. If the import of natural gas increases further, the methodology for estimating the CO_2 emission factor might have to be revised in future inventories. DCE has an on-going dialog with the Danish Energy Agency and Energinet.dk about this. However, Energinet.dk have stated that the difference between the emission factor for 2011 based on measurements at Egtved and the average value at Froeslev very close to the border differed less than 0.3 % for 2011 (Bruun, 2012).

[20] Former Gastra and before that part of DONG. Historical data refer to these companies.

Energinet.dk and the Danish Gas Technology Centre have calculated emission factors for 2000-2015. The emission factor applied for 1990-1999 refers to Fenhann & Kilde (1994). This emission factor was confirmed by the two major power plant operators in 1996 (Christiansen, 1996 and Andersen, 1996). The time series for the CO_2 emission factor is provided in Table 47.

Table 47 CO_2 emission factor time series for natural gas.

Year	CO_2 emission factor, kg per GJ
1990-1999	56.9
2000	57.1
2001	57.25
2002	57.28
2003	57.19
2004	57.12
2005	56.96
2006	56.78
2007	56.78
2008	56.77
2009	56.69
2010	56.74
2011	56.97
2012	57.03
2013	56.79
2014	56.95
2015	57.06

7.2.15 Waste

The CO_2 emission from incineration of waste is divided into two parts: The emission from combustion of the fossil 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 CO_2 emission factor is based on the project, *Biogenic carbon in Danish combustible waste* that included emission measurements from five Danish waste incineration plants (Astrup et al., 2012). The average fossil emission factors for waste have been estimated to be 37 kg / GJ waste and the interval for the five plants was 25 – 51 kg / GJ. The five plants represented 44 % of the incinerated waste in 2010. The emission factor 37 kg / GJ waste corresponds to 82.22 kg / GJ fossil waste.

The total CO_2 emission factor for waste refers to a Danish study (Jørgensen & Johansen, 2003). Based on emission measurements on five waste incineration plants the total CO_2 emission factor for waste incineration has been determined to 112.1 kg per GJ. Thus, the biomass emission factor has been determined to 75.1 kg / GJ waste.

In the 2006-2015 emission inventories, plant specific EU ETS data have been utilised for industrial waste combusted in cement production.

For 2013-2015, plant specific EU ETS data have been reported by CHP plants incinerating waste and for 2015, plant specific emission factors have been implemented for 10 plants. In 2015, the average emission factor for the 9 plants (the cement production plant not included) was 43.3 kg fossil CO_2 per GJ total waste. This is above the current emission factor, but due to waste supply differences, the emission factors vary between plants – 34.0 kg / GJ to 58.6 kg / GJ.

The 10 plants reporting data to EU ETS represent 70 % of the incinerated waste.

7.2.16 Wood

The emission factor for wood, 112 kg per GJ refers IPCC (2006). The same emission factor has been applied for 1990-2015.

7.2.17 Straw

The emission factor for wood, 100 kg per GJ refers IPCC (2006) for other primary solid biomass. The same emission factor has been applied for 1990-2015.

7.2.18 Bio oil

The emission factor, 70.8 kg per GJ refers to the IPCC (2006). The consumption of bio oil is below 1 PJ.

7.2.19 Biogas

In Denmark, three different types of biogas are applied: Manure/organic waste based biogas, landfill based biogas and wastewater treatment biogas (sludge gas). Manure / organic waste based biogas represent 83 % of the consumption, see page 95.

The emission factor for biogas, 84.1 kg per GJ refer to Kristensen (2015a) and the emission factor is based on a biogas with 65 % (vol.) CH_4 and 35 % (vol.) CO_2. Danish Gas Technology Centre has stated that this is a typical manure-based biogas as utilised in stationary combustion plants (Kristensen, 2015a). The same emission factor has been applied for 1990-2015.

7.2.20 Biomass gasification gas

Biomass gasification gas applied in Denmark is based on wood. The gas composition is known for three different plants and the applied emission factor have been estimated by Danish Gas Technology Centre (Kristensen, 2010) based on the gas composition measured on the plant with the highest consumption.

The consumption of biomass gasification gas is below 0.5 PJ for all years.

7.2.21 Bio natural gas

Biogas upgraded for distribution in the natural gas grid is referred to as bio natural gas in this report. Other references might refer to this fuel as bio-methane or upgraded biogas. Bio natural gas has been applied in Denmark since 2014. The emission factor is based on the gas composition of bio natural gas: 98.5 % CH_4 and 1.5 % CO_2. These data refer to Danish Gas Technology Centre (Kristensen, 2015b).

7.3 CH_4 emission factors

The CH_4 emission factors applied for 2015 are presented in Table 48. In general, the same emission factors have been applied for 1990-2015. However, time series have been estimated for both natural gas fuelled engines and biogas fuelled engines, residential wood combustion, natural gas fuelled gas turbines[21] and waste incineration plants.

Emission factors for CHP plants < 25 MW_e refer to emission measurements carried out on Danish plants (Nielsen et al., 2010a; Nielsen & Illerup, 2003; Nielsen et al., 2008). The emission factors for residential wood combustion are based on technology dependent data.

Emission factors that are not nationally referenced all refer to the IPCC Guidelines (IPCC, 2006).

Gas engines combusting natural gas or biogas account for 40% of the CH_4 emission from stationary combustion plants. The relatively high emission factor for gas engines is well documented and further discussed below.

[21] A minor emission source.

Table 48 CH_4 emission factors, 2015.

Fuel group	Fuel	CRF source category	CRF source category	SNAP	Emission factor, g per GJ	Reference
SOLID	COAL	1A1a	Public electricity and heat production	0101 0102	0.9	IPCC (2006), Tier 3, Table 2-6, Utility Boiler, Pulverised bituminous coal combustion, Wet bottom.
		1A2 a-g	Industry	03	10	IPCC (2006), Tier 1, Table 2-3, Manufacturing industries.
		1A4b i	Residential	0202	300	IPCC (2006), Tier 1, Table 2.5, Residential, Bituminous coal.
		1A4c i	Agriculture/ Forestry	0203	10	IPCC (2006), Tier 1, Table 2-4, Commercial, coal.[1)]
	BROWN COAL BRI.	1A4b i	Residential	0202	300	IPCC (2006), Tier 1, Table 2-5, Residential, brown coal briquettes
	COKE OVEN COKE	1A2 a-g	Industry	03	10	IPCC (2006), Tier 1, Table 2-4, Commercial, coke oven coke.
		1A4b i	Residential	0202	300	IPCC (2006), Tier 1, Table 2-5, Residential, coke oven coke.
	ANODIC CARBON	1A2 a-g	Industry	03	10	IPCC (2006), Tier 1, Table 2-3, Manufacturing industries.
	FOSSIL FLY ASH	1A1a	Public electricity and heat production	0101	0.9	IPCC (2006), Tier 3, Table 2-6, Utility Boiler, Pulverised bituminous coal combustion, Wet bottom.
LIQUID	PETROLEUM COKE	1A2 a-g	Industry	03	3	IPCC (2006), Tier 1, Table 2-3, Industry, petroleum coke.
		1A4a	Commercial/ Institutional	0201	10	IPCC (2006), Tier 1, Table 2-4, Commercial, Petroleum coke.
		1A4b	Residential	0202	10	IPCC (2006), Tier 1, Table 2-5, Residential / agricultural, Petroleum coke.
		1A4c	Agriculture/ Forestry	0203	10	IPCC (2006), Tier 1, Table 2-5, Residential / agricultural, Petroleum coke.
	RESIDUAL OIL	1A1a	Public electricity and heat production	010101	0.8	IPCC (2006), Tier 3, Table 2-6, Utility Boiler, Residual fuel oil.
				010102 010103	1.3	Nielsen et al. (2010a).
				010104	3	IPCC (2006), Tier 1, Table 2-2, Energy industries, residual oil.
				010105	4	IPCC (2006), Tier 3, Table 2-6, Utility, Large diesel engines.
				010203	0.8	IPCC (2006), Tier 3, Table 2-6, Utility Boiler, Residual fuel oil.
		1A1b	Petroleum refining	010306	3	IPCC (2006), Tier 1, Table 2-2, Energy industries, residual fuel oil.
		1A2 a-g	Industry	03	1.3	Nielsen et al. (2010a)
				Engines	4	IPCC (2006), Tier 3, Table 2-6, Utility, Large diesel engines.
		1A4a	Commercial/ Institutional	0201	1.4	IPCC (2006), Tier 3, Table 2-10, Commercial, residual fuel oil boilers.
		1A4b	Residential	0202	1.4	IPCC (2006), Tier 3, Table 2-9, Residential, residual fuel oil.
		1A4c	Agriculture/ Forestry	0203	1.4	IPCC (2006), Tier 3, Table 2-10, Commercial, residual fuel oil boilers.[1)].
	GAS OIL	1A1a	Public electricity and heat production	010101 010102 010103	0.9	IPCC (2006), Tier 3, Table 2-6, Utility, gas oil, boilers.
				010104	3	IPCC (2006), Tier 1, Table 2-2, Energy industries, gas oil.
				010105	24	Nielsen et al. (2010a).
				010202 010203	0.9	IPCC (2006), Tier 3, Table 2-6, Utility, gas oil, boilers.
		1A1b	Petroleum refining	010306	3	IPCC (2006), Tier 1, Table 2-2, Energy industries, gas oil.
		1A1c	Oil and gas extraction	010504	3	IPCC (2006), Tier 1, Table 2-2, Energy industries, gas oil.
		1A2 a-g	Industry	03	0.2	IPCC (2006), Tier 3, Table 2-7, Industry, gas oil, boilers.
				Turbines	3	IPCC (2006), Tier 1, Table 2-3, Industry, gas oil.
				Engines	24	Nielsen et al. (2010a)
		1A4a	Commercial/ Institutional	0201	0.7	IPCC (2006), Tier 3, Table 2-10, Commercial, gas oil.
				020105	24	Nielsen et al. (2010a).
		1A4b i	Residential	0202	0.7	IPCC (2006), Tier 3, Table 2.9, Residential, gas oil.

Fuel group	Fuel	CRF source category	CRF source category	SNAP	Emission factor, g per GJ	Reference
		1A4c	Agriculture/ Forestry	0203	0.7	IPCC (2006), Tier 3, Table 2-10, Commercial, gas oil[1].
				020304	24	Nielsen et al. (2010a).
	KEROSENE	1A2 a-g	Industry	all	3	IPCC (2006), Tier 1, Table 2-3, Industry, other kerosene.
		1A4a	Commercial/ Institutional	0201	10	IPCC (2006), Tier 1, Table 2-4, Commercial, other kerosene.
		1A4b i	Residential	0202	10	IPCC (2006), Tier 1, Table 2-5, Residential/agricultural, other kerosene.
		1A4c i	Agriculture/ Forestry	0203	10	IPCC (2006), Tier 1, Table 2-5, Residential/agricultural, other kerosene.
	LPG	1A1a	Public electricity and heat production	0101 0102	1	IPCC (2006), Tier 1, Table 2-2, Energy Industries, LPG.
		1A1b	Petroleum refining	0103	1	IPCC (2006), Tier 1, Table 2-2, Energy Industries, LPG.
		1A2 a-g	Industry	03	1	IPCC (2006), Tier 1, Table 2-3, Industry, LPG.
		1A4a	Commercial/ Institutional	0201	5	IPCC (2006), Tier 1, Table 2-4, Commercial, LPG.
		1A4b i	Residential	0202	5	IPCC (2006), Tier 1, Table 2-5, Residential / agricultural, LPG.
		1A4c i	Agriculture/ Forestry	0203	5	IPCC (2006), Tier 1, Table 2-5, Residential / agricultural, LPG.
	REFINERY GAS	1A1b	Petroleum refining	010304	1.7	Assumed equal to natural gas fuelled gas turbines. Nielsen et al. (2010a).
				010306	1	IPCC (2006), Tier 1, Table 2-2, refinery gas.
GAS	NATURAL GAS	1A1a	Public electricity and heat production	010101 010102 010103	1	IPCC (2006), Tier 3, Table 2-6, Utility, natural gas, boilers.
				010104	1.7	Nielsen et al. (2010a).
				010105	481	Nielsen et al. (2010a).
				010202 010203	1	IPCC (2006), Tier 3, Table 2-6, Utility, natural gas, boilers.
		1A1b	Petroleum refining	010306	1	Assumed equal to industrial boilers.
		1A1c	Oil and gas extraction	010503	1	Assumed equal to industrial boilers.
				010504	1.7	Nielsen et al. (2010a).
		1A2 a-g	Industry	Other	1	IPCC (2006), Tier 3, Table 2-7, Industry, natural gas boilers.
				Gas turbines	1.7	Nielsen et al. (2010a).
				Engines	481	Nielsen et al. (2010a).
		1A4a	Commercial/ Institutional	0201	1	IPCC (2006), Tier 3, Table 2-10, Commercial, natural gas boilers.
				020105	481	Nielsen et al. (2010a).
		1A4b i	Residential	0202	1	IPCC (2006), Tier 3, Table 2-9. Residential, natural gas boilers.
				020204	481	Nielsen et al. (2010a).
		1A4c i	Agriculture/ Forestry	0203	1	IPCC (2006), Tier 3, Table 2-10, Commercial, natural gas boilers[1].
				020304	481	Nielsen et al. (2010a).
WASTE	WASTE	1A1a	Public electricity and heat production	0101 0102	0.34	Nielsen et al. (2010a).
		1A2 a-g	Industry	03	30	IPCC (2006), Tier 1, Table 2-3, Industry, municipal wastes.
		1A4a	Commercial/ Institutional	0201	30	IPCC (2006), Tier 1, Table 2-3, Industry, municipal wastes [2].
	INDUSTRIAL WASTE	1A2f	Industry	0316	30	IPCC (2006), Tier 1, Table 2-3, Industry, industrial wastes.
BIO-MASS	WOOD	1A1a	Public electricity and heat production	0101	3.1	Nielsen et al. (2010a).
				0102	11	IPCC (2006), Tier 3, Table 2-6, Utility boilers, wood
		1A2 a-g	Industry	03	11	IPCC (2006), Tier 3, Table 2-7, Industry, wood, boilers.
		1A4a	Commercial/ Institutional	0201	11	IPCC (2006), Tier 3, Table 2-10, Commercial, wood.
		1A4b i	Residential	0202	93.19	DCE estimate based on technology distribution [3].
		1A4c i	Agriculture/ Forestry	0203	11	IPCC (2006), Tier 3, Table 2-10, Commercial, wood.[1].
	STRAW	1A1a	Public electricity and heat production	0101	0.47	Nielsen et al. (2010a).

Fuel group	Fuel	CRF source category	CRF source category	SNAP	Emission factor, g per GJ	Reference
				0102	30	IPCC (2006), Tier 1, Table 2-2, Energy industries, other primary solid biomass.
		1A4b i	Residential	0202	300	IPCC (2006), Tier 1, Table 2-5, Residential, other primary solid biomass.
		1A4c i	Agriculture/ Forestry	020300	300	IPCC (2006), Tier 1, Table 2-5, Agriculture, other primary solid biomass.
				020302	30	IPCC (2006), Tier 1, Table 2-2, Energy industries, other primary solid biomass (large agricultural plants considered equal to this plant category).
	BIO OIL	1A1a	Public electricity and heat production	010102	3	IPCC (2006), Tier 1, Table 2-2, Energy industries, biodiesels.
				010105	24	Nielsen et al. (2010a) assumed same emission factor as for gas oil fuelled engines.
				0102	3	IPCC (2006), Tier 1, Table 2-2, Energy industries, biodiesels.
		1A2 a-g	Industry	03	3	IPCC (2006), Tier 1, Table 2-3, Industry, biodiesels.
				030902	0.2	-
		1A4b i	Residential	0202	10	IPCC (2006), Tier 1, Table 2-5, Residential, biodiesels.
	BIOGAS	1A1a	Public electricity and heat production	0101	1	IPCC (2006), Tier 1, Table 2-2, Energy industries, other biogas.
				010105	434	Nielsen et al. (2010a).
				0102	1	IPCC (2006), Tier 1, Table 2-2, Energy industries, other biogas.
		1A2 a-g	Industry	03	1	IPCC (2006), Tier 1, Table 2-3, Industry, other biogas.
				Engines	434	Nielsen et al. (2010a).
		1A4a	Commercial/ Institutional	0201	5	IPCC (2006), Tier 1, Table 2-4, Commercial, other biogas.
				020105	434	Nielsen et al. (2010a)
		1A4b	Residential	0202	1	Assumed equal to natural gas.
		1A4c i	Agriculture/ Forestry	0203	5	IPCC (2006), Tier 1, Table 2-5, Agriculture, other biogas.
				020304	434	Nielsen et al. (2010a).
	BIO GASIF GAS	1A1a	Public electricity and heat production	010101	1	Assumed equal to biogas.
				010105	13	Nielsen et al. (2010a).
		1A4a	Commercial/Institutional	020105	13	Nielsen et al. (2010a).
	BIONATGAS	1A1a	Public electricity and heat production	0101	1	Assumed equal to natural gas.
		1A2 a-g	Industry	03	1	Assumed equal to natural gas.
		1A4a	Commercial/ Institutional	0201	1	Assumed equal to natural gas.
		1A4b	Residential	0202	1	Assumed equal to natural gas.
		1A4c	Agriculture/ Forestry	0203	1	Assumed equal to natural gas.

1) Assumed same emission factors as for commercial plants. Plant capacity and technology are similar for Danish plants.
2) Assumed same emission factor as for industrial plants. Plant capacity and technology is similar to industrial plants rather than to residential plants.
3) Aggregated emission factor based on the technology distribution in the sector (DEPA, 2013) and technology specific emission factors that refer to Paulrud et al. (2005), Johansson et al. (2004) and Olsson & Kjällstrand (2005). The emission factor is below the IPCC (2006) interval for residential wood combustion (100-900 g/GJ).

7.3.1 CHP plants

A considerable part 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, Energinet.dk, emission factors for CHP plants <$25MW_e$ have been estimated. The work was reported in 2010 (Nielsen et al., 2010a).

The work included waste incineration plants, CHP plants combusting wood and straw, natural gas and biogas-fuelled (reciprocating) engines, natural gas fuelled gas turbines, gas oil fuelled engines, gas oil fuelled gas turbines, steam turbines fuelled by residual oil and engines fuelled by biomass gasification gas. CH_4 emission factors for these plants all refer to Nielsen et al. (2010a). The estimated emission factors were based on existing emission measurements as well as on emission measurements carried out within the project. The number of emission data sets was comprehensive. Emission factors for subgroups of each plant type were estimated, e.g. the CH_4 emission factor for different gas engine types were determined.

Time series for CH_4 emission factors are based on a similar project estimating emission factors for year 2000 (Nielsen & Illerup, 2003).

Natural gas, gas engines

SNAP 010105, 030905, 030705, 031005, 031205, 031305, 031405, 031605, 032005, 020105, 020204 and 020304

The emission factor for natural gas engines refers to the Nielsen et al. (2010a). The emission factor includes the increased emission during start / stop of the engines estimated by Nielsen et al. (2008). Emission factor time series for the years 1990-2007 have been estimated based on Nielsen & Illerup (2003). These three references are discussed below.

Nielsen et al. (2010a):

> *CH_4 emission factors for gas engines were estimated for 2003-2006 and for 2007-2010. The dataset was split in two, due to new emission limits for engines from October 2006. The emission factors were based on emission measurements from 366 (2003-2006) and 157 (2007-2010) engines respectively. The engines from which emission measurements were available for 2007-2010 represented 38 % of the gas consumption. The emission factors were estimated based on fuel consumption for each gas engine type and the emission factor for each engine type. The majority of emission measurements that were not performed within the project related solely to the emission of total unburned hydrocarbon (CH_4 + NMVOC). A constant disaggregation factor was estimated based on 9 emission measurements including both CH_4 and NMVOC.*

Nielsen & Illerup (2003):

> *The emission factor for natural gas engines was based on 291 emission measurements in 114 different plants. The plants from which emission measurements were available represented 44 % of the total gas consumption in gas engines in year 2000.*

Nielsen et al. (2008):

> *This study calculated a start/stop correction factor. This factor was applied to the time series estimated in Nielsen & Illerup (2003). Further, the correction factors were applied in Nielsen et al. (2010a).*

The emission factor for lean-burn gas engines is relatively high, especially for pre-chamber engines, which account for more than half the gas consumption in Danish gas engines. However, the emission factors for different pre-chamber engine types differ considerably.

The installation of natural gas engines in decentralised CHP plants in Denmark has taken place since 1990. The first engines installed were relatively small open-chamber engines but later mainly pre-chamber engines were installed. As mentioned above, pre-chamber engines have a higher emission factor than open-chamber engines; therefore, the emission factor has increased during the period 1990-1995. After that, technical improvements of the engines have been implemented as a result of upcoming emission limits that most installed gas engines had to meet in late 2006 (DEPA, 2005).

The time series were based on:

- Full load emission factors for different engine types in year 2000 (Nielsen & Illerup, 2003), 2003-2006 and 2007-2010 (Nielsen et al., 2010a)
- Data for year of installation for each engine and fuel consumption of each engine 1994-2002 from the Danish Energy Agency (DEA, 2003)
- Research concerning the CH_4 emission from gas engines carried out in 1997 (Nielsen & Wit, 1997)
- Correction factors including increased emission during start/stop of the engines (Nielsen et al., 2008)

Table 49 Time series for the CH_4 emission factor for natural gas fuelled engines.

Year	Emission factor, g per GJ
1990	266
1991	309
1992	359
1993	562
1994	623
1995	632
1996	616
1997	551
1998	542
1999	541
2000	537
2001	522
2002	508
2003	494
2004	479
2005	465
2006	473
2007-2015	481

Gas engines, biogas

SNAP 010105, 030905, 020105 and 020304

The emission factor for biogas engines was estimated to 434 g per GJ in 2015. The emission factor is lower than the factor for natural gas mainly because most biogas-fuelled engines are lean-burn open-chamber engines - not pre-chamber engines.

Time series for the emission factor have been estimated. The emission factors for biogas engines were based on Nielsen et al. (2010a) and Nielsen & Illerup (2003). The two references are discussed below. The time series are shown in Table 50.

Nielsen et al. (2010a):

> *CH_4 emission factors for gas engines were estimated for 2006 based on emission measurements performed in 2003-2010. The emission factor was based on emission measurements from 10 engines. The engines from which*

emission measurements were available represented 8 % of the gas consumption. The emission factor was estimated based on fuel consumption for each gas engine type and the emission factor for each engine type. The majority of emission measurements that were not performed within the project related solely to the emission of total unburned hydrocarbon (CH_4 + NMVOC). A constant disaggregation factor was estimated based on 3 emission measurements including both CH_4 and NMVOC.

Nielsen & Illerup (2003):

The emission factor for natural gas engines was based on 18 emission measurements from 13 different engines. The engines from which emission measurements were available represented 18 % of the total biogas consumption in gas engines in year 2000.

Table 50 Time series for the CH_4 emission factor for biogas-fuelled engines.

Year	Emission factor, g per GJ
1990	239
1991	251
1992	264
1993	276
1994	289
1995	301
1996	305
1997	310
1998	314
1999	318
2000	323
2001	342
2002	360
2003	379
2004	397
2005	416
2006	434
2007-2015	434

Gas turbines, natural gas

SNAP 010104, 010504, 030604 and 031104

The emission factor for gas turbines was estimated to be below 1.7 g per GJ in 2005 (Nielsen et al., 2010a). The emission factor was based on emission measurements on five plants. The emission factor in year 2000 was 1.5 g per GJ (Nielsen & Illerup, 2003). A time series have been estimated.

CHP, wood

SNAP 010101, 010102, 010103 and 010104

The emission factor for CHP plants combusting wood was estimated to be below 3.1 g per GJ (Nielsen et al., 2010a) and the emission factor 3.1 g per GJ has been applied for all years. The emission factor was based on emission measurements on two plants.

CHP, straw

SNAP 010101, 010102, 010103 and 010104

The emission factor for CHP plants combusting straw was estimated to be below 0.47 g per GJ (Nielsen et al., 2010a) and the emission factor 0.47 g per GJ has been applied for all years. The emission factor was based on emission measurements on four plants.

CHP, waste

SNAP 010102, 010103, 010104 and 010203

The emission factor for CHP plants combusting waste was estimated to be below 0.34 g per GJ in 2006 (Nielsen et al., 2010a) and 0.59 g per GJ in year 2000 (Nielsen & Illerup, 2003). A time series have been estimated. The emission factor was based on emission measurements on nine plants.

The emission factor has also been applied for district heating plants.

7.3.2 Residential wood combustion

SNAP 020200, 020202 and 020204

The emission factor for residential wood combustion is based on technology specific data. The emission factor time series and references are included in Chapter 6.5.2.

7.3.3 Other stationary combustion plants

Emission factors for other plants refer to the IPCC Guidelines (IPCC, 2006).

7.4 N_2O emission factors

The N_2O emission factors applied for the 2015 inventory are listed in Table 51. Time series have been estimated for natural gas fuelled gas turbines and refinery gas fuelled turbines. All other emission factors have been applied unchanged for 1990-2015.

Emission factors for natural gas fuelled reciprocating engines, natural gas fuelled gas turbines, CHP plants < 300 MW combusting wood, straw or residual oil, waste incineration plants, engines fuelled by gas oil and gas engines fuelled by biomass gasification gas all refer to emission measurements carried out on Danish plants, Nielsen et al. (2010a).

The emission factor for coal-powered plants in public power plants refers to research conducted by Elsam (now part of DONG Energy).

The emission factor for offshore gas turbines has been assumed to follow the time series for natural gas fuelled gas turbines in Danish CHP plants. There is no evidence to suggest that offshore gas turbines have different emission characteristics for N_2O compared to on-shore natural gas turbines and the emission factor is considered applicable.

The emission factor for natural gas fuelled gas turbines has been applied for refinery gas fuelled gas turbines. Refinery gas has similar properties as natural gas, i.e. similar nitrogen content in the fuel, which means that N_2O formation will be similar under similar combustion conditions.

All emission factors that are not nationally referenced refer to the IPCC Guidelines (IPCC, 2006).

Table 51 N_2O emission factors, 2015.

Fuel group	Fuel	CRF source category	CRF source category	SNAP	Emission factor, g per GJ	Reference
SOLID	COAL	1A1a	Public electricity and heat production	0101	0.8	Henriksen (2005).
				0102	1.4	IPCC (2006), Tier 3, Table 2.6, Utility source, pulverised bituminous coal, wet bottom boiler.
		1A2 a-g	Industry	03	1.5	IPCC (2006), Tier 1, Table 2-3, Manufacturing industries, coal
		1A4b i	Residential	0202	1.5	IPCC (2006), Tier 1, Table 2-5, Residential, coal.
		1A4c i	Agriculture/ Forestry	0203	1.5	IPCC (2006), Tier 1, Table 2-4, Commercial, coal[1)].
	BROWN COAL BRI.	1A4b i	Residential	0202	1.5	IPCC (2006), Tier 1, Table 2-5, Residential, brown coal briquettes
	COKE OVEN COKE	1A2 a-g	Industry	03	1.5	IPCC (2006), Tier 1, Table 2-3, Industry, coke oven coke.
		1A4b i	Residential	020200	1.5	IPCC (2006), Tier 1, Table 2-5, Residential, coke oven coke.
	ANODIC CARBON	1A2 a-g	Industry	03	1.5	IPCC (2006), Tier 1, Table 2-3, manufacturing industries, other bituminous coal.
	FOSSIL FLY ASH	1A1a	Public electricity and heat production	0101	0.8	Assumed equal to coal.
LIQUID	PETROLEUM COKE	1A2 a-g	Industry – other	03	0.6	IPCC (2006), Tier 1, Table 2-3, Industry, petroleum coke.
		1A4a	Commercial/ Institutional	0201	0.6	IPCC (2006), Tier 1, Table 2-4, Commercial, petroleum coke.
		1A4b i	Residential	0202	0.6	IPCC (2006), Tier 1, Table 2-5, Residential, petroleum coke.
		1A4c i	Agriculture/ Forestry	0203	0.6	IPCC (2006), Tier 1, Table 2-5, Residential/Agricultural, petroleum coke.
	RESIDUAL OIL	1A1a	Public electricity and heat production	010101	0.3	IPCC (2006), Tier 3, Table 2-6, Utility, residual fuel oil.
				010102 010103	5	Nielsen et al. (2010a).
				010104	0.6	IPCC (2006), Tier 1, Table 2-2, Energy industries, residual fuel oil.
				010203	0.3	IPCC (2006), Tier 3, Table 2-6, Utility, residual fuel oil.
		1A1b	Petroleum refining	010306	0.6	IPCC (2006), Tier 1, Table 2-2, Energy industries, residual fuel oil.
		1A2 a-g	Industry	03	5	Nielsen et al. (2010a).
				Engines	0.6	IPCC (2006), Tier 1, Table 2-3, manufacturing industries and construction, residual fuel oil.
		1A4a	Commercial/ Institutional	0201	0.3	IPCC (2006), Tier 3, Table 2-10, Commercial, fuel oil boilers.
		1A4b i	Residential	0202	0.6	IPCC (2006), Tier 1, Table 2-5, Residential, residual fuel oil.
		1A4c i	Agriculture/ Forestry	0203	0.3	IPCC (2006), Tier 3, Table 2-10, Commercial, fuel oil boilers[1)].
	GAS OIL	1A1a	Public electricity and heat production	010101 010102 010103	0.4	IPCC (2006), Tier 3, Table 2-6, Utility, gas oil boilers.
				010104	0.6	IPCC (2006), Tier 1, Table 2-2, Energy industries, gas oil.
				010105	2.1	Nielsen et al. (2010a).
				0102	0.4	IPCC (2006), Tier 3, Table 2-6, Utility, gas oil boilers.

Fuel group	Fuel	CRF source category	CRF source category	SNAP	Emission factor, g per GJ	Reference
		1A1b	Petroleum refining	010306	0.6	IPCC (2006), Tier 1, Table 2-2, Energy industries, gas oil.
		1A1c	Oil and gas extraction	010504	0.6	IPCC (2006), Tier 1, Table 2-2, Energy industries, gas oil.
		1A2 a-g	Industry	03	0.4	IPCC (2006), Tier 3, Table 2-7, Industry, gas oil boilers.
				Turbines	0.6	IPCC (2006), Tier 1, Table 2-3, Industry, gas oil.
				Engines	2.1	Nielsen et al. (2010a)
		1A4a	Commercial/ Institutional	0201	0.4	IPCC (2006), Tier 3, Table 2-10, Commercial, gas oil boilers.
				Engines	2.1	Nielsen et al. (2010a).
		1A4b i	Residential	0202	0.6	IPCC (2006), Tier 1, Table 2-5, Residential, gas oil.
		1A4c	Agriculture/ Forestry	0203	0.4	IPCC (2006), Tier 3, Table 2-10, Commercial, gas oil boilers[1)].
				020304	2.1	Nielsen et al. (2010a).
	KEROSENE	1A2 a-g	Industry	03	0.6	IPCC (2006), Tier 1, Table 2-3, Industry, other kerosene.
		1A4a	Commercial/ Institutional	0201	0.6	IPCC (2006), Tier 1, Table 2-4, Commercial, other kerosene.
		1A4b i	Residential	0202	0.6	IPCC (2006), Tier 1, Table 2-5, Residential, other kerosene.
		1A4c i	Agriculture/ Forestry	0203	0.6	IPCC (2006), Tier 1, Table 2-4, Commercial, other kerosene [1)].
	LPG	1A1a	Public electricity and heat production	0101 0102	0.1	IPCC (2006), Tier 1, Table 2-2, Energy industries, LPG.
		1A1b	Petroleum refining	010306	0.1	IPCC (2006), Tier 1, Table 2-2, Energy industries, LPG.
		1A2 a-g	Industry	03	0.1	IPCC (2006), Tier 1, Table 2-3, Industry, LPG.
		1A4a	Commercial/ Institutional	0201	0.1	IPCC (2006), Tier 1, Table 2-4, Commercial, LPG.
		1A4b i	Residential	0202	0.1	IPCC (2006), Tier 1, Table 2-5, Residential, LPG.
		1A4c i	Agriculture/ Forestry	0203	0.1	IPCC (2006), Tier 1, Table 2-5, Residential/Agricultural, LPG.
	REFINERY GAS	1A1b	Petroleum refining	010304	1	Assumed equal to natural gas fuelled turbines. Based on Nielsen et al. (2010a).
				010306	0.1	IPCC (2006), Tier 1, Table 2-2, Energy industries, refinery gas.
GAS	NATURAL GAS	1A1a	Public electricity and heat production	010101 010102 010103	1	IPCC (2006), Tier 3, Table 2-6, Natural gas, Utility, boiler.
				010104	1	Nielsen et al. (2010a).
				010105	0.58	Nielsen et al. (2010a).
				0102	1	IPCC (2006), Tier 3, Table 2-6, Natural gas, Utility, boiler.
		1A4b	Petroleum refining	010306	1	IPCC (2006), Tier 3, Table 2-6, Natural gas, Utility, boiler.
		1A1c	Oil and gas extraction	010504	1	Nielsen et al. (2010a).
		1A2 a-g	Industry	03	1	IPCC (2006), Tier 3, Table 2-7, Industry, natural gas boilers.
				Gas turbines	1	Nielsen et al. (2010a).
				Engines	0.58	Nielsen et al. (2010a).
		1A4a	Commercial/ Institutional	020100 020103	1	IPCC (2006), Tier 3, Table 2-10, Commercial, natural gas boilers.
				Engines	0.58	Nielsen et al. (2010a).

Fuel group	Fuel	CRF source category	CRF source category	SNAP	Emission factor, g per GJ	Reference
		1A4b i	Residential	0202	1	IPCC (2006), Tier 3, Table 2-9, Residential, natural gas boilers.
				Engines	0.58	Nielsen et al. (2010a).
		1A4c i	Agriculture/ Forestry	0203	1	IPCC (2006), Tier 3, Table 2-10, Commercial, natural gas boilers [1)].
				Engines	0.58	Nielsen et al. (2010a)
WASTE	WASTE	1A1a	Public electricity and heat production	0101 0102	1.2	Nielsen et al. (2010a)
		1A2 a-g	Industry	03	4	IPCC (2006), Tier 1, Table 2-3, Industry, wastes.
		1A4a	Commercial/ Institutional	0201	4	IPCC (2006), Tier 1, Table 2-4, Commercial, municipal wastes.
	INDUSTR. WASTE	1A2 a-g	Industry	03	4	IPCC (2006), Tier 1, Table 2-3, Industry, industrial wastes.
BIO-MASS	WOOD	1A1a	Public electricity and heat production	0101	0.8	Nielsen et al. (2010a).
				0102	4	IPCC (2006), Tier 1, Table 2-2, Energy industries, wood.
		1A2 a-g	Industry	03	4	IPCC (2006), Tier 1, Table 2-3, Industry, wood.
		1A4a	Commercial/ Institutional	0201	4	IPCC (2006), Tier 1, Table 2-4, Commercial, wood.
		1A4b i	Residential	0202	4	IPCC (2006), Tier 1, Table 2-5, Residential, wood.
		1A4c i	Agriculture/ Forestry	0203	4	IPCC (2006), Tier 1, Table 2-5, Agriculture, wood.
	STRAW	1A1a	Public electricity and heat production	0101	1.1	Nielsen et al. (2010a)
				0102	4	IPCC (2006), Tier 1, Table 2-2, Energy industries, other primary solid bio-mass.
		1A4b i	Residential	0202	4	IPCC (2006), Tier 1, Table 2-5, Residential, other primary solid biomass.
		1A4c i	Agriculture/ Forestry	0203	4	IPCC (2006), Tier 1, Table 2-5, Agriculture, other primary solid biomass.
	BIO OIL	1A1a	Public electricity and heat production	0101 0102	0.6	IPCC (2006), Tier 3, Table 2-2, Utility, biodiesels.
				Engines	2.1	Assumed equal to gas oil. Based on Nielsen et al. (2010a).
		1A2 a-g	Industry	03	0.6	IPCC (2006), Tier 1, Table 2-3, Industry, biodiesels.
				030902	0.4	-
		1A4b i	Residential	0202	0.6	IPCC (2006), Tier 1, Table 2-5, Residential, biodiesels.
	BIOGAS	1A1a	Public electricity and heat production	0101 0102	0.1	IPCC (2006), Tier 1, Table 2-2, Energy industries, other biogas.
				Engines	1.6	Nielsen et al. (2010a)
		1A2 a-g	Industry	03	0.1	IPCC (2006), Tier 1, Table 2-3, Industry, other biogas
				Engines	1.6	Nielsen et al. (2010a).
		1A4a	Commercial/ Institutional	0201	0.1	IPCC (2006), Tier 1, Table 2,4, Commercial, other biogas.
				Engines	1.6	Nielsen et al. (2010a).
		1A4b	Residential	0202	1	Assumed equal to natural gas.
		1A4c i	Agriculture/ Forestry	0203	0.1	IPCC (2006), Tier 1, Table 2-5, Agriculture, other biogas.
				Engines	1.6	Nielsen et al. (2010a).
	BIO GASIF GAS	1A1a	Public electricity and heat production	010101	0.1	Assumed equal to biogas.

Fuel group	Fuel	CRF source category	CRF source category	SNAP	Emission factor, g per GJ	Reference
				010105	2.7	Nielsen et al. (2010a).
		1A4a	Commercial/ Institutional	020105	2.7	Nielsen et al. (2010a).
	BIONATGAS	1A1a	Public electricity and heat production	0101 or 0102	1	Assumed equal to natural gas.
		1A2 a-g	Industry	03	1	Assumed equal to natural gas.
		1A4a	Commercial/ Institutional	0201	1	Assumed equal to natural gas.
		1A4b	Residential	0202	1	Assumed equal to natural gas.
		1A4c	Agriculture/ Forestry	020,3	1	Assumed equal to natural gas.

[1)] In Denmark, plants in Agriculture/Forestry are similar to Commercial plants.

7.5 SO_2 emission factors

The SO_2 emission factors and references are shown in Table 52. Below the table further details about the references, additional references, and time series are discussed.

Time series have been estimated for:

- Combustion of coal in power plants
- Combustion of coal in other plants (including district heating)
- Combustion of coal, petroleum coke and industrial waste in cement industry
- Combustion of petroleum coke in other sectors than cement industry.
- Combustion of residual oil in power plants
- Combustion of residual oil in refineries
- Combustion of residual oil in other plants
- Combustion of gas oil
- Combustion of orimulsion
- Waste incineration in CHP plants
- Waste incineration in district heating and other plants

Table 52 SO_2 emission factors and references, 2015.

Fuel type	Fuel	NFR	NFR_name	SNAP	SO_2 emission factor, g/GJ	Reference
SOLID	ANODIC CARBON	1A2g	Industry - other	032002	855	DCE estimate based on plant specific data.
	COAL	1A1a	Public electricity and heat production	0101	10	DCE estimate based on data reported by plant owners and EU ETS (2016).
				0102	467	DCE estimate based on country specific coal data from Dong Energy (Jensen, 2017) and coal import data from DEA (2016c).
		1A2a-g	Industry	03 except 0309 and 0316	467	DCE estimate based on country specific coal data from Dong Energy (Jensen, 2017) and coal import data from DEA (2016c).
		1A2e	Industry, food, beverages and tobacco	0309	231	DCE estimate based on plant specific data for 2010.
		1A2f	Cement industry	0316	67	DCE estimate based on plant specific data for 2011-2015.
		1A2g	Mineral wool production	Mineral wool 032002	861	DCE estimate based on plant specific data for 2010-2015.
		1A4b i	Residential	020200	467	DCE estimate based on country specific coal data from Dong Energy (Jensen, 2017) and coal import data from DEA (2016c).
		1A4c i	Agriculture/ Forestry	0203	467	DCE estimate based on country specific coal data from Dong Energy (Jensen, 2017) and coal import data from DEA (2016c).
	FLY ASH FOSSIL	1A1a	Public electricity and heat production	010104	10	Assumed equal to coal.
	BROWN COAL BRI.	1A4b	Residential	0202	467	Assumed equal to coal. DCE assumption.
	COKE OVEN COKE	1A2a-g	Industry	03	467	Assumed equal to coal. DCE assumption.
		1A2g	Mineral wool production	Mineral wool 032002	837	DCE estimate based on plant specific data for 2010-2015.
		1A4b	Residential	0202	467	Assumed equal to coal. DCE assumption.
LIQUID	PETROLEUM COKE	1A2a-g	Industry	03	605	DCE calculation based on DEPA (2001b), DEPA (2014), DEA (2016a) and EMEP (2006).
		1A2g	Cement industry	0316	67	DCE estimate based on plant specific data for 2011-2015.
		1A4a	Commercial/ Institutional	0201	605	DCE calculation based on DEPA (2001b), DEPA (2014), DEA (2016a) and EMEP (2006).
		1A4b	Residential	0202	605	DCE calculation based on DEPA (2001b), DEPA (2014), DEA (2016a) and EMEP (2006).
		1A4c	Agriculture/ Forestry	0203	605	DCE calculation based on DEPA (2001b), DEPA (2014), DEA (2016a) and EMEP (2006).
	RESIDUAL OIL	1A1a	Electricity and heat production	0101	100	DCE estimate based on plant specific data for 2008 and 2009.
				0102	344	DCE estimate based on EOF (2017) and DEA (2016a).
		1A1b	Petroleum refining	010306	286	DCE estimate based on plant specific data for year 2015.
		1A2a-g	Industry	03	344	DCE estimate based on EOF (2017) and DEA (2016a).

Fuel type	Fuel	NFR	NFR_name	SNAP	SO_2 emission factor, g/GJ	Reference
		1A4a	Commercial/ Institutional	0201	344	DCE estimate based on EOF (2017) and DEA (2016a).
		1A4b	Residential	0202	344	DCE estimate based on EOF (2017) and DEA (2016a).
		1A4c i	Agriculture/ Forestry	0203	344	DCE estimate based on EOF (2017) and DEA (2016a).
	GAS OIL	1A1a	Public electricity and heat production	0101 0102	23	DCE estimate based on DEPA (1998), Miljø- og planlægningsudvalget (1998) and DEA (2016a). Confirmed in Q8 (2017), Shell (2013) and Circle K (2017).
		1A1b	Petroleum refining	010306	23	DCE estimate based on DEPA (1998), Miljø- og planlægningsudvalget (1998) and DEA (2016a). Confirmed in Q8 (2017), Shell (2013) and Circle K (2017).
		1A1c	Oil and gas extraction	0105	23	DCE estimate based on DEPA (1998), Miljø- og planlægningsudvalget (1998) and DEA (2016a). Confirmed in Q8 (2017), Shell (2013) and Circle K (2017).
		1A2a-g	Industry	03	23	DCE estimate based on DEPA (1998), Miljø- og planlægningsudvalget (1998) and DEA (2016a). Confirmed in Q8 (2017), Shell (2013) and Circle K (2017).
		1A4a	Commercial/ Institutional	0201	23	DCE estimate based on DEPA (1998), Miljø- og planlægningsudvalget (1998) and DEA (2016a). Confirmed in Q8 (2017), Shell (2013) and Circle K (2017).
		1A4b i	Residential	0202	23	DCE estimate based on DEPA (1998), Miljø- og planlægningsudvalget (1998) and DEA (2016a). Confirmed in Q8 (2017), Shell (2013) and Circle K (2017).
		1A4c	Agriculture/Forestry	0203	23	DCE estimate based on DEPA (1998), Miljø- og planlægningsudvalget (1998) and DEA (2016a). Confirmed in Q8 (2017), Shell (2013) and Circle K (2017).
	KEROSENE	1A2g	Industry - other	03	5	DCE estimate based on Tønder (2004) and Shell (2013).
		1A4a	Commercial/ Institutional	0201	5	DCE estimate based on Tønder (2004) and Shell (2013).
		1A4b i	Residential	0202	5	DCE estimate based on Tønder (2004) and Shell (2013).
		1A4c i	Agriculture/ Forestry	0203	5	DCE estimate based on Tønder (2004) and Shell (2013).
	LPG	1A1a	Public electricity and heat production	All	0.13	DCE estimate based on Augustesen (2003), Krebs (2003) and DEA (2016a).
		1A2a-g	Industry	03	0.13	DCE estimate based on Augustesen (2003), Krebs (2003) and DEA (2016a).
		1A4a	Commercial/ Institutional	0201	0.13	DCE estimate based on Augustesen (2003), Krebs (2003) and DEA (2016a).
		1A4b i	Residential	0202	0.13	DCE estimate based on Augustesen (2003), Krebs (2003) and DEA (2016a).
		1A4c i	Agriculture/ Forestry	0203	0.13	DCE estimate based on Augustesen (2003), Krebs (2003) and DEA (2016a).
	REFINERY GAS	1A1b	Petroleum refining	0103	1	DCE estimate based on plant specific data for one plant, average value for 1995-2002.
GAS	NATURAL GAS	1A1a	Public electricity and heat production	0101, 0102, except engines	0.43	DCE estimate based on data from Energinet.dk (2017) and Energinet.dk (2013).

Fuel type	Fuel	NFR	NFR_name	SNAP	SO_2 emission factor, g/GJ	Reference
				010105, engines	0.5	Kristensen (2003).
		1A1b	Petroleum refining	0103	0.43	DCE estimate based on data from Energinet.dk (2017) and Energinet.dk (2013).
		1A1c	Oil and gas extraction	0105	0.43	DCE estimate based on data from Energinet.dk (2017) and Energinet.dk (2013).
		1A2a-g	Industry	03 except engines	0.43	DCE estimate based on data from Energinet.dk (2017) and Energinet.dk (2013).
				Engines	0.5	Kristensen (2003).
		1A4a	Commercial/ Institutional	0201 except engines	0.43	DCE estimate based on data from Energinet.dk (2017) and Energinet.dk (2013).
				Engines	0.5	Kristensen (2003).
		1A4b i	Residential	0202 except engines	0.43	DCE estimate based on data from Energinet.dk (2017) and Energinet.dk (2013).
				Engines	0.5	Kristensen (2003).
		1A4c i	Agriculture/ Forestry	0203 except engines	0.43	DCE estimate based on data from Energinet.dk (2017) and Energinet.dk (2013).
				Engines	0.5	Kristensen (2003).
WASTE	WASTE	1A1a	Public electricity and heat production	0101	8.3	Nielsen et al. (2010a).
				0102	14	DCE estimate based on plant specific data for four plants, 2009 data.
		1A2a-g	Industry	03	14	Assumed equal to district heating plants (DCE assumption).
		1A4a	Commercial/ Institutional	0201	14	Assumed equal to district heating plants (DCE assumption).
	INDU-STRIAL WASTE	1A2f	Industry – non-metallic minerals	031600	14	Assumed equal to waste. DCE assumption.
BIO-MASS	WOOD	1A1a	Public electricity and heat production	0101	1.9	Nielsen et al. (2010a).
				0102	11	EEA (2016).
		1A2a-g	Industry	03	11	EEA (2016).
		1A4a	Commercial/ Institutional	0201	11	EEA (2016).
		1A4b i	Residential	0202	11	EEA (2016).
		1A4c i	Agriculture/ Forestry	0203	11	EEA (2016).
	STRAW	1A1a	Public electricity and heat production	0101	49	Nielsen et al. (2010a).
				0102	115	Assumed equal to farmhouse boilers.
		1A4b i	Residential	0202	115	Jensen et al. (2017).
		1A4c i	Agriculture/ Forestry	0203	115	Jensen et al. (2017).

Fuel type	Fuel	NFR	NFR_name	SNAP	SO_2 emission factor, g/GJ	Reference
	BIO OIL	1A1a	Public electricity and heat production	0101	0.3	DCE estimate based on Folkecenter for Vedvarende Energi (2000) and DEA (2016a).
				0102	0.3	DCE estimate based on Folkecenter for Vedvarende Energi (2000) and DEA (2016a).
		1A2a-g	Industry	03	0.3	DCE estimate based on Folkecenter for Vedvarende Energi (2000) and DEA (2016a).
		1A4b i	Residential	0202	0.3	DCE estimate based on Folkecenter for Vedvarende Energi (2000) and DEA (2016a).
	BIOGAS	1A1a	Public electricity and heat production	0101, except engines	25	DCE estimate based on Christiansen (2003), Hjort-Gregersen (1999) and DEA (2016a).
				Engines	19.2	Nielsen & Illerup (2003).
				0102	25	DCE estimate based on Christiansen (2003), Hjort-Gregersen (1999) and DEA (2016a).
		1A2a-g	Industry	03, except engines	25	DCE estimate based on Christiansen (2003), Hjort-Gregersen (1999) and DEA (2016a).
				03, engines	19.2	Nielsen & Illerup (2003).
		1A4a	Commercial/ Institutional	0201, except engines	25	DCE estimate based on Christiansen (2003), Hjort-Gregersen (1999) and DEA (2016a).
				020105	19.2	Nielsen & Illerup (2003).
		1A4b	Residential	0202	25	DCE estimate based on Christiansen (2003), Hjort-Gregersen (1999) and DEA (2016a).
		1A4c i	Agriculture/ Forestry	0203, except engines	25	DCE estimate based on Christiansen (2003), Hjort-Gregersen (1999) and DEA (2016a).
				020304	19.2	Nielsen & Illerup (2003).
	BIO GASIF GAS	1A1a	Public electricity and heat production	010105	7	Kristensen (2017a) and Kristensen (2017b).
	BIONATGAS	1A1a	Public electricity and heat production	0101	0.43	Assumed equal to natural gas.
		1A2a-g	Industry	03	0.43	Assumed equal to natural gas.
		1A4a	Commercial/ Institutional	0201	0.43	Assumed equal to natural gas.
		1A4b	Residential	0202	0.43	Assumed equal to natural gas.
		1A4c	Agriculture/ Forestry	0203	0.43	Assumed equal to natural gas.

7.5.1 Anodic carbon

Anodic carbon has been used two industrial plants in 2009-2013. Plant specific emission data are available for all years and thus the emission factor has not been applied in the inventory. The SO_2 emission factor, 855 g / GJ, have been estimated based on the plant specific data assuming that the total SO_2 emission is related only to anodic carbon, coal and coke oven coke. The average implied emission factor taking into account only the three mentioned fuels is 855 g / GJ.

7.5.2 Coal, large power plants

Sector 1A1a, SNAP 0101
Data for SO_2 emission and fuel consumption for Danish power plants >25MW_e are available for all plants for the years 1990 and onwards. In general, the plant specific data are included in the emission inventories. However, for some years, a small part of the coal consumption has been included as an area source. The SO_2 emission factor for coal is estimated as an average value based on the annual reporting from the power plant operators to the electricity transmission company in Denmark, Energinet.dk[22] or reported in annual environmental reports.

From 2010 onwards, the emission factor have been estimated based on a database query including power plants for which the coal consumption makes up more than 90 % of the total fuel consumption. The total SO_2 emission from these plants is assumed to originate from the coal consumption.

For 2008-2009, the emission factors have been based on emission data for power plants that are primarily fuelled by coal and the emission is assumed to originate from coal, residual oil, gas oil or biomass / waste.

For 1990-2007, the emission factors is based on the total SO_2 emission from all power plants divided by the fuel consumption of coal and residual oil. This methodology results in a small overestimation of the emission factor. From 2003 onwards, the fuel consumption data were stated in TJ.

The calculated time series for the SO_2 emission factor are shown in Table 53.

[22] Eltra and Elkraft System in the beginning of the time series.

Table 53 SO_2 emission factor for coal combusted in centralised power plants.

Year	SO_2 emission factor [g/GJ]
1990	506
1991	571
1992	454
1993	386
1994	343
1995	312
1996	420
1997	215
1998	263
1999	193
2000	64
2001	47
2002	45
2003	61
2004	42
2005	41
2006	37
2007	40
2008	26
2009	14
2010	10
2011	9
2012	11
2013	12
2014	8
2015	10

7.5.3 Coal, other plants

Sector 1A1a, 1A2a-g, 1A4a, 1A4b, 1A4c, SNAP 0102, 03, 02
The fuel consumption for non-power producing plants in 2015 was 4.4 PJ. The fuel was mainly applied in cement production, chemical/petrochemical industry, food and tobacco industry and agriculture. In 1990, the consumption was 23 PJ and the largest consumption was in district heating plants, cement production, food and tobacco industry and in agriculture. Sector specific emission factors have been estimated for cement production and food and tobacco industry.

EEA (2016)
The tier 1 emission factor in the EEA Guidebook (EEA, 2016) is 820 g/GJ (1A1a, based on 1 % sulphur) or 900 g/GJ (1A2 and 1A4, based on 1.2% sulphur) depending on source category.

Data for Russian coal
In recent years, the major part of the coal applied in Denmark in other plants than power plants is Russian coal. A company that import a substantial part of the coal in this category has stated that the sulphur content of this Russian coal is approximately 0.4 % w/w (0.3-0.5%) (Faaborg, 2017). This sulphur content corresponds to an emission factor of 312 g/GJ assuming no sulphur retention in ash.

The sulphur content applied for Russian coal was 0.5 % in the time series estimate below based on data from Dong Energy (Jensen, 2017). The data from Dong Energy have been applied because it is part of a dataset including NCV and sulphur content for other countries.

Legislation

According to Danish legislation, the maximum sulphur content of the applied coal is 0.9% (DEPA, 2014). This value has been in force since 1989 (DEPA, 1994; DEPA, 1988; DEPA, 2001b; DEPA, 2010c). However, larger sulphur content can be applied in some plants with flue gas desulphurisation. The average net calorific value (NCV) of coal applied in 2010-2015 was 24.39 GJ / tonnes (DEA, 2016a). The sulphur retention in ash has been assumed 5% referring to EEA (2006) and IPCC (1996). Based on these data the emission factor 701 g / GJ has been calculated (see below).

$$EMF_{SO2} = 10^6 \cdot ((2 \cdot C_s \cdot (1-\alpha_s)) \;/\; H_u)$$

$$EMF_{SO2} = 10^6 \cdot ((2 \cdot 0.9 \cdot 0.01 \cdot (1-0.05)) \;/\; 24.39) = 701 \text{ g / GJ}$$

Estimate based on import data

Coal import data for a large number of countries are available in the Danish energy statistics (DEA, 2016c). Dong Energy have stated typical NCV and sulphur content for six different countries[23] from which Denmark import the largest amount of coal (Jensen, 2017). These countries represent 72-100 % of the Danish coal import (more than 90 % of the import in 2000-2015). Based on these data and a 5 % sulphur retention in ash (IPCC, 1996), a time series for the SO_2 emission have been estimated. For 2015, the estimated emission factor is 485 g / GJ. However, the sulphur content of coal imported from USA is above the limit value 0.9 %, and thus it can only be combusted in plants with desulphurisation.

Excluding the data for coal from USA mainly influences the estimated emission factor for 1990-1992. The estimated 2015 emission factor based on this methodology is 467 g / GJ. The time series is shown below.

The time series have been compared to the time series for power plants and for 1990-1991 the estimated emission factors for other plants is lower than the emission factor for power plants. This is unlikely, and instead the emission factor for power plants is applied for other plants in 1990-1991.

[23] Australia, Colombia, Norway, Poland, Russia, South Africa and USA.

Table 54 Time series for the SO_2 emission factor for coal applied in non-power-producing plants.

Year	Emission factor, g/GJ	Emission factor for power plants, g/GJ
1990	478	506
1991	468	571
1992	467	454
1993	476	386
1994	467	343
1995	471	312
1996	503	420
1997	493	215
1998	490	263
1999	470	193
2000	471	64
2001	464	47
2002	475	45
2003	520	61
2004	482	42
2005	496	41
2006	496	37
2007	506	40
2008	500	26
2009	487	14
2010	495	10
2011	513	9
2012	508	11
2013	490	12
2014	489	8
2015	467	10

7.5.4 Coal, cement production

SNAP 0316

The cement production plant in Denmark has installed desulphurisation.

Based on plant specific data for SO_2 an emission factor time series have been estimated. The IEF have been estimated based on the total fuel consumption and the emission factor has been implemented for coal, petroleum coke and industrial waste applied in cement production (SNAP 0316). However, as plant specific data are available for cement production the emission factor have only been estimated to ensure a complete set of emission factors.

Table 55 SO_2 emission factor for coal combusted in cement production plant.

Year	IEF average SO_2 emission factor [g/GJ]
1990-1995	158
1996-2000	163
2001-2005	89
2006-2010	100
2011-2015	67

7.5.5 Coal, food and tobacco industry

SNAP 0309

Plant specific emission data are available from three plants. The consumption of coal from these three plants represented more than 80 % of the consumption in this subsector in 2015.

The average emission factor for 2010 was 231 g / GJ. This emission factor will be applied for food and tobacco industry for 2010 onwards. Sufficient data for estimating time series are not available. For 1990-2009 the emission factor time series for coal applied in other plants (see Chapter 7.5.3) is applied.

7.5.6 Coal, district heating plants

SNAP 0102

The consumption of coal in district heating plants was large in 1990s but has been below 0.02 PJ since year 2000. No plant specific data are available for district heating plants for 1990–1994 and thus the emission factor time series for other plants is applied, see Chapter 7.5.3.

7.5.7 Coal, mineral wool production

SNAP 032002

The average implied emission factor 2010-2015 for the two mineral wool production plants in Denmark that use coal and / or coke oven coke was 861 g / GJ. In this estimate, it has been assumed that all SO_2 origin from coal and coke oven coke. This emission factor has been applied for all years.

The high emission factors might be related to sulphur content of the input raw materials and to a high sulphur content in the coke oven coke applied in the mineral wool production plants. However, the implied emission factor is applied for coal as well as for coke oven coke. The emission factor does not actually influence the total emission data estimated in the inventory because plant specific data are available all years.

7.5.8 Fly ash fossil

The emission factor for fossil fly ash has been assumed equal to coal.

7.5.9 Brown coal briquettes

Sector 1A2g, 1A4a, 1A4b, 1A4c, SNAP 03, 0201, 0202, and 0203

The consumption of brown coal briquettes (BKB) is below 0.2 PJ all years and in 2015, BKB was not combusted in Denmark. Since 1999, the consumption has been only in residential plants.

The emission factor for brown coal briquettes have been assumed the same as for coal applied in residential plants in 2015 (467 g / GJ applied for all years).

7.5.10 Coke oven coke

Sector 1A2a-g, 1A4b, SNAP 03, 0202

The consumption of coke oven coke is below 1.5 PJ all years. Coke oven coke is mainly applied in mineral wool production that covers more than 70 % of the consumption for all years.

The average implied emission factor 2010-2015 for the two mineral wool production plants in Denmark that use coal and / or coke oven coke was 861 g / GJ. In this estimate, it has been assumed that all SO_2 origin from coal and coke oven coke. This emission factor has been applied for all years.

The emission factors for coke oven coke applied in other sectors have been assumed the same as for coal.

7.5.11 Petroleum coke

Sector 1A1a, 1A2a-g, 1A4a, 1A4b, 1A4c, SNAP: All

Petroleum coke is mainly applied in the cement production plant. Plant specific emission factors are available for this plant and as for coal combustion, a sector specific emission factor is applied for cement production.

Petroleum coke consumption in other sectors is below 5 PJ all years and below 0.4 PJ from year 2000 onwards. A high consumption in central power plants in 1994 is in agreement with the Danish energy statistics. In later years, the only considerable consumption is in non-metallic minerals (SNAP 0307).

7.5.12 Petroleum coke, cement production

Sector 1A2f, SNAP 0316

Based on plant specific data for SO_2 an emission factor time series have been estimated. The IEF have been estimated based on the total fuel consumption and the emission factor has been implemented for coal, petroleum coke and industrial waste applied in cement production (SNAP 0316). However, as plant specific data are available for cement production the emission factor have only been estimated to ensure a complete set of emission factors.

Table 56 SO_2 implied emission factor for petroleum coke combusted in cement production plant.

Year	IEF average SO_2 emission factor [g/GJ]
1990-1995	158
1996-2000	163
2001-2005	89
2006-2010	100
2011-2015	67

7.5.13 Petroleum coke, other sectors than cement production

A default emission factor for petroleum coke based on the sulphur content accepted in Danish legislation is applied for all other sectors than cement production.

The emission factor for petroleum coke (605 g/GJ) has been based on maximum sulphur content according to Danish legislation and on the lower heating value, which is part of the Danish energy statistics.

The lower heating value for petroleum coke used in Denmark is 31.4 GJ/tonnes (DEA, 2016a).

According to Danish legislation, the sulphur content of petroleum coke should be below 1% in 2001 and onwards (DEPA, 2014; DEPA, 2001b). In the years 1990 – 2000, the maximum sulphur content according to Danish legislation was 1.3% (DEPA, 1994; DEPA, 1988).

The sulphur retention in ash has been assumed 0.05 referring to EMEP (2006). It has been assumed that sulphur flue gas cleaning is not installed in plants combusting petroleum coke.

$$EMF_{SO2} = 10^6 \cdot ((2 \cdot C_s \cdot (1-\alpha_s)) \;/\; H_u)$$

1990-2000: $EMF_{SO2} = 10^6 \cdot ((2 \cdot 1.3 \cdot 0.01 \cdot (1-0.05)) \;/\; 31.4) = 787$ g/GJ

2001-2015: $EMF_{SO2} = 10^6 \cdot ((2 \cdot 1.0 \cdot 0.01 \cdot (1-0.05)) \ / \ 31.4) = 605$ g / GJ

7.5.14 Petroleum coke, non-metallic minerals

SNAP 0307

Plant specific emission data from year 2014 suggest an emission factor higher than the default emission factor for petroleum coke (812 g / GJ). However, part of the emission from brick production is included in another part of the inventory as is it process emission. Thus, the default emission factor for petroleum coke is applied for non-metallic minerals.

7.5.15 Residual oil, large power plants

Sector 1A1a, SNAP 0101

The fuel consumption of residual oil in large power plants was 1.0 PJ in 2015. The largest consumption in 1990-2015 was 22 PJ. The consumption in large power plants is 21 % - 59 % of the total consumption of residual oil.

Data for SO_2 emission and fuel consumption for Danish power plants >25MW_e are available for all plants for the years 1990 and onwards. In general, the plant specific data have been included in the emission inventories. However, for some years, a small part of the residual oil consumption has been included as an area source. The SO_2 emission factor for residual oil has been estimated as an average value based on annual environmental reports or on the annual reporting from the power plant operators to the electricity transmission company in Denmark, Energinet.dk[24].

For 1990-2001, DCE has estimated the SO_2 emission factor for residual oil based on the sulphur content of the residual oil used in power plants >25MW_e. This information was part of the reporting from the power plant owners, Eltra and Elkraft System, to the Danish Energy Agency at that time. The lower heating value for residual oil refers to DEA (2016a). Sulphur retention in ash is not relevant for oil and sulphur flue gas cleaning has not been taken into account. The estimated emission factors are shown below.

The emission factors applied for 2002-2007 are based on plant specific data for a few large power plant units combusting primarily residual oil. Data for this estimate refers to annual data from Eltra & Elkraft System.

For 2008 and onwards, the applied emission factor is an average value of the plant specific data for 2008 and 2009. In general, plant specific data are available.

[24] Eltra and Elkraft System in the beginning of the time series.

Table 57 Emission factors time series for residual oil used in power plants.

Year	Average sulphur content [%][1)]	Sulphur retention in ash [kg/kg]	Lower heating value [GJ/tonne][2)]	Emission factor [g/GJ]
1990	0.9	0	40.4	446
1991	0.95	0	40.4	470
1992	0.99	0	40.4	490
1993	0.96	0	40.4	475
1994	3.16	0	40.4	543
1995	0.71	0	40.4	351
1996	0.83	0	40.7	408
1997	0.7	0	40.65	344
1998	0.75	0	40.65	369
1999	0.75	0	40.65	369
2000	0.82	0	40.65	403
2001	0.641	0	40.65	315
2002				290
2003				334
2004				349
2005				283
2006				308
2007				206
2008				100
2009				100
2010				100
2011				100
2012				100
2013				100
2014				100
2015				100

1. Eltra & Elkraft System annual reporting.

2. DEA (2016a).

7.5.16 Residual oil, refineries

Sector 1A1b, SNAP 010306

The fuel consumption of residual oil in refineries was 0.6 PJ in 2015. The largest consumption in 1990-2015 was 3.6 PJ. The consumption in refineries is 2 % - 15 % of the total consumption of residual oil.

The refineries have been included in the Danish inventory as point sources with plant specific SO_2 emission data from 1994 onwards. Thus, the emission factor has only been applied for a small amount of residual oil.

The emission factors for 1995-2015 are based on plant specific data for 1995, 2000, 2005, 2010 and 2015 from the refineries. It has been assumed that all SO_2 originate from residual oil and a linear decrease has been assumed for each of the 5-years intervals.

The emission factor estimated for 1995 has been applied for 1990-1994.

The time series for the emission factor is shown in Table 58.

Table 58 SO_2 emission factor for residual oil combusted in refineries.

Year	SO_2 emission factor, g/GJ
1990	877
1991	877
1992	877
1993	877
1994	877
1995	877
1996	787
1997	697
1998	608
1999	518
2000	428
2001	419
2002	411
2003	402
2004	394
2005	385
2006	369
2007	353
2008	337
2009	321
2010	306
2011	302
2012	298
2013	294
2014	290
2015	286

7.5.17 Residual oil, other plants

Sector 1A1a, 1A2a-g, 1A4a, 1A4b, 1A4c, SNAP 0102, 03, 0201, 0202, 0203
The fuel consumption of residual oil in other plants was 2.5 PJ in 2015. The largest consumption in 1990-2015 was 26 PJ. The consumption has decreased but is a large part of the residual oil consumption (37 % -71 %).

Plant specific emission data are available for a large part of the consumption.

The legislative limit for sulphur content in residual oil sold in Denmark is 1% (DEPA, 2014; DEPA, 2010c; DEPA, 2001b; DEPA, 1994).

However, the sulphur content of residual oil sold in Denmark has been somewhat lower in recent years; 0.75 % or 0.5% (EOF, 2017). According to Danish Oil Industry Association, the average sulphur content has been 0.7% from 1997 to 2005 (EOF, 2003). The same sulphur content has been assumed for the years 2006-2015.

For the years 1990-1996, the legislative maximum sulphur content of 1% has been assumed by DCE.

The lower heating value for residual oil is 40.65 GJ/tonnes in 1997-2015 and 40.40 GJ/tonnes in 1990-1995 (DEA, 2016a).

The emission factors are estimated below:

$EMF_{SO2} = 10^6 \cdot (2 \cdot C_s \ / \ H_u)$

1990-1996: 495 g/GJ

1997-2015: 344 g/GJ

7.5.18 Gas oil

Sector 1A1a, 1A1b, 1A2a-g, 1A4a, 1A4b, 1A4c, SNAP: all
The total fuel consumption of residual oil was 9 PJ in 2015. The consumption in 1990-2015 was 8 - 67 PJ. The consumption has declined since 1990.

The Danish legislation for gas oil requires sulphur content below 0.1 % since 2006 (DEPA, 2010c; DEPA, 2014; DEPA, 2006). Until 2006, the limit was 0.2% sulphur (DEPA, 1994; DEPA, 2000; DEPA, 2001c).

The sulphur content has been lower than the 0.2% due to Danish tax laws (DEPA, 1998). According to the tax laws, the base sulphur content (no tax) for gas oil has been 0.05% since 1995.

The low average sulphur content for gas oil used in Denmark refers to a note from the parliamentary committee for environment (Miljø- og planlægningsudvalget, 1998). According to this reference, the oil sold in Denmark in 1998 had a sulphur content of 0.05 % regardless of the legislative limit of 0.2% sulphur. The sulphur content of max 0.05 % (0.001 %, 0.005 % or 0.05 %) has been confirmed by product data sheets from Q8 (2017), Shell (2013), and Circle K (2017). The lower heating value for gas oil is 42.7 GJ/tonnes (DEA, 2016a).

For the years 1995-2015, the emission factor is 23 g/GJ. This emission factor is based on a sulphur content of 0.05% and a lower heating value of 42.7 GJ/tonnes.

For the years 1990-1994 the emission factor 94 g/GJ refers to Danish legislation (DEPA, 1994; DEPA, 1988) concerning sulphur content (0.2%) and the lower heating value 42.7 GJ/tonnes (DEA, 2016a).

7.5.19 Kerosene

Sector 1A2g, 1A4a, 1A4b, 1A4c, SNAP: all
The fuel consumption of kerosene was 0.03 PJ in 2015. The largest consumption in 1990-2015 was 5.1 PJ in 1990. The consumption was below one PJ all other years. The consumption in residential plants is above 50 % of the total consumption most years. The large decrease of consumption in residential plants between 1990 and 1991 is unlikely, but in agreement with the Danish energy statistics.

According to a product sheet from Shell (2013), the maximum sulphur content of kerosene is 0.05 %. However, this maximum sulphur content has been stated in the product sheets as it is the maximum sulphur content allowed to avoid sulphur taxes (DEPA, 1998). The actual sulphur content is somewhat lower. According to Tønder (2004), the sulphur content was approximately 95-107 mg S/litre. According to the product sheet from Shell (2013) the density of kerosene is 775-840 g/litre and thus the actual sulphur content is approximately 0.012 % sulphur.

The lower heating value 43.1 GJ/tonnes refers to the product data sheet from Shell (2013).

The emission factor 5 g/GJ has been based on a sulphur content of 0.01% (Tønder, 2004) and the NCV 43.1 GJ/tonnes (Shell, 2013).

7.5.20 Orimulsion

Sector 1A1a, SNAP 010101
The use of orimulsion in Denmark ceased in 2005.

Orimulsion has only been used in a single large power plant boiler in Denmark. This power plant boiler has been included in the inventories as a point source with plant specific SO_2 emission data included all years. Thus, the emission factors are only included for information.

The emission factors have been estimated based on the plant specific data from the power plant boiler combusting orimulsion. The plant specific SO_2 emission data refer to Eltra & Elkraft System (annual reporting) and the fuel consumption data refer to DEA (2012b). The emission factor is 149 g/GJ in 1995-2000 and 12 g/GJ in 2001-2004.

7.5.21 LPG

Sector 1A1a, 1A1b, 1A2a-g, 1A4a, 1A4b, 1A4c, SNAP: all
The consumption of LPG was 1.4 PJ in 2015. The consumption of LPG in residential plants was 54 % of the total LPG consumption in stationary combustion in 2015.

The main part of the sulphur content in LPG originates from the added odorant (Krebs, 2003). The maximum sulphur content of LPG is 50 mg S/kg (Krebs, 2003). The added odorant is Ethylmercaptan (Augustesen, 2003). According to the Danish legislation concerning fuel gas, a minimum of 8.8 mg odorant/m^3 should be added if ethylmercaptan (C_2H_6S) is used (Gasreglementet, 2001, Gasreglementet C-12, 2013). According to specifications from Statoil, a minimum of 12 mg odorant/m^3 is added (Augustesen, 2003). The S content in the odorant is 51.61% corresponding to a sulphur content of $12 \cdot 0.5161 = 6.19$ mg S/m^3. The weight of 1 m^3 propane is 1.96 kg/m^3, whereas the weight of butane is 2.59 kg/m^3. A 40 % propane / 60 % butane weights 2.34 kg/m^3. Thus, the sulphur content is at least 6.19/2.34=2.65 mg S/kg corresponding to 0.000265%.

The sulphur content of LPG is in the interval 0.000265% to 0.005%. DCE has assumed that the sulphur content is slightly above the specified minimum: 0.0003% S.

The lower heating value 46 GJ/tonnes refers to DEA (2016a) and the estimated emission factor is 0.13 g/GJ.

7.5.22 Refinery gas

Sector 1A1a, 1A1b, 1A2g, SNAP: all
The consumption of refinery gas was 16 PJ in 2015.

The SO_2 emission from combustion of refinery gas in refinery furnaces has been included as a point source with plant specific SO_2 emission data in 1994 and onwards.

The emission factor (1 g/GJ) has been estimated by DCE based on plant specific emission data from a gas turbine only combusting refinery gas. The turbine is installed in a Danish refinery. Plant specific emission data for 1995-2002 have been included in the estimate. This emission factor has been applied for all technologies.

7.5.23 Natural gas

Sector 1A1a, 1A2a-g, 1A4a, 1A4b, 1A4c, SNAP: all
The consumption of natural gas was 121 PJ in 2015.

The sulphur content originates from the H_2S content of natural gas and from the added odorant (THT, C_4H_8S).

The Danish gas transmission company Energinet.dk states the H_2S content 3.2 mg / m_n^3 for 2012 (Energinet.dk, 2017). This corresponds to 3.2· 32 / 34 = 3.0 mg S / m_n^3.

According to Energinet.dk, the added THT corresponds to 5.5 mg S / m_n^3 (Energinet.dk, 2013).

Thus, the total sulphur content is 8.5 mg S / m_n^3.

The lower heating value in 2012 was 39.548 MJ / m_n^3 (Energinet.dk, 2017).

DCE has estimated the SO_2 emission factor 8.5· 2 / 39.548 = 0.43 mg SO_2 / MJ or 0.43 g / GJ.

The emission factor has also been estimated for 2004 based on data from the former gas transmission company Gastra. In 2004, the H_2S content was 3.16 mg H_2S / m_n^3 (Gastra, 2005) and the THT content was 15 mg THT / m_n^3 (Gastra, 2005). The sulphur content in THT is 32 / 88. Based on these data the emission factor 0.42 g / GJ was estimated.

The emission factor 0.43 g / GJ have been applied for all years.

7.5.24 Natural gas, gas engines

The SO_2 emission from gas engines is somewhat higher than for other plants due to the consumption of lube oil. The emission factor for gas engines 0.5 g / GJ refers to Kristensen (2003).

7.5.25 Waste, CHP plants

Sector 1A1a, SNAP 0101
The emission factor for 2006 onwards is 8.3 g / GJ referring to Nielsen et al. (2010a). The emission factor is based on 43 emission measurements from seven waste incineration plants representing 30 % of the waste consumption in CHP plants.

The implied emission factor for waste incineration plants 2015 was 6.9 g / GJ and thus updated plant specific data confirm the emission factor level.

New emission limit values (26 g / GJ[25]) came into force for waste incineration plants in 2006 (DEPA, 2003). The SO_2 emission limit in the current legislation (DEPA, 2012) is unchanged since 2006.

[25] 50 mg / m^3_n (ref. 11 % O_2).

The emission factor for the years 2000-2003 is 24 g/GJ. This emission factor refers to another Danish study (Nielsen & Illerup, 2003) that included emission measurements from 16 waste incineration plants (19 units) representing more than 70% of the waste consumption in CHP plants in the year 2000.

Modifications of the plants between 2000 and 2006 are assumed to have taken place over several years prior to 2006 and a linear reduction of emission factor has been assumed between 2003 and 2006.

The flue gas cleaning systems in CHP waste incineration plants have been developed considerably during the last two decades. Thus, the emission factor applied for 2000 and onwards is not valid for the previous years.

The emission factors applied for the years 1990 and 1995 also refers to Nielsen & Illerup (2003). The estimates for 1990 and 1995, included in this report, were based on knowledge of flue gas cleaning systems of the plants in 1990 and 1995 (Illerup et al., 1999). The estimated emission factors were 138 g/GJ in 1990 and 30 g/GJ in 1995. The time series for the emission factor between 1990 and 1995 and between 1995 and 2000 have been assumed linear (DCE assumption).

The time series for the SO_2 emission factor for waste incineration plants, CHP, is shown below.

Table 59 Emission factor time series for SO_2 from waste incineration CHP plants.

Year	Emission factor [g/GJ]
1990	138
1991	116
1992	95
1993	73
1994	52
1995	30
1996	29
1997	28
1998	26
1999	25
2000	24
2001	24
2002	24
2003	24
2004	19
2005	14
2006	8.3
2007	8.3
2008	8.3
2009	8.3
2010	8.3
2011	8.3
2012	8.3
2013	8.3
2014	8.3
2015	8.3

7.5.26 Waste, district heating and other plants

Sector 1A1a, 1A2a-g, 1A4a, SNAP 0102, 03, 0201

2007-2015:

The emission factor 14 g / GJ that have been applied since 2007 refers to plant specific data for 2009. The estimate was based on plant specific data for 4 units without power production. The emission limit value (DEPA, 2012) corresponds to 26 g / GJ.

2000:

DCE has estimated the emission factor for the year 2000 based on plant specific fuel consumption data in year 2000 (DEA, 2012b) and on SO_2 emission data (annual environmental reports 2001) for each of the 5 non-power producing plants. The estimated emission factor is 67 g / GJ.

1990:

The emission factor for 1990 has been estimated by DCE based on:

- Technology applied in 1990 (Illerup et al., 1999)
- Fuel consumption for each technology (Illerup et al., 1999)
- Emission factors for each sulphur flue gas cleaning technology in the year 2000 (Nielsen & Illerup, 2003).

The estimated emission factor for 1990 is 138 g / GJ[26]. Data for this estimate is shown in Table 60. The emission factor time series between 1990 and 2000 have been assumed linear (DCE assumption).

Table 60 SO_2 emission factors for waste incineration plants without power production, 1990.

Flue gas cleaning [1)]	Waste combustion 1990[2)] [tonne]	SO_2 emission factor[3)] [g/GJ]
No sulphur cleaning	1327760	169
ESP WET	30700	50.5
SD (CYK) FB	148430	10.3
Other WET	12000	26.6
Other DRY	156900	20.6
Total	1675790	

1) WET: wet flue gas cleaning. SD: semidry flue gas cleaning. DRY: dry flue gas cleaning. ESP: electrostatic precipitator. FB: fabric filter. CYK: cyclone.
2) Illerup et al. (1999).
3) Nielsen & Illerup (2003).

Time series:

The time series for the SO_2 emission factor is shown below.

[26] The emission factor happens to be equal to the factor for CHP plants. The reference is however not the same.

Table 61 Emission factors time series for non-power producing waste incineration plants.

Year	Emission factor [g/GJ]
1990	138
1991	131
1992	124
1993	117
1994	110
1995	103
1996	95
1997	88
1998	81
1999	74
2000	67
2001	60
2002	52
2003	45
2004	37
2005	30
2006	22
2007-2015	14

The same emission factor time series have been assumed for industrial plants and commercial/institutional plants.

7.5.27 Industrial waste

Since the waste incinerated in the Danish cement production plant differs from waste incinerated in other plants a separate fuel category is applied.

Based on plant specific data for SO_2 an emission factor time series have been estimated. The IEF have been estimated based on the total fuel consumption and the emission factor has been implemented for coal, petroleum coke and industrial waste applied in cement production (SNAP 0316). However, as plant specific data are available for cement production the emission factor have only been estimated to ensure a complete set of emission factors.

7.5.28 Wood, CHP plants

Sector 1A1a, SNAP 0101
The SO_2 emission factor for wood combusted in CHP plants, 1.9 g/GJ, refers to a Danish study (Nielsen et al., 2010a) that included four emission measurements from two plants. This emission factor has been applied for all years.

7.5.29 Wood, other plants

Sector 1A1a, 1A2a-g, 1A4a, 1A4b, 1A4c, SNAP 0102, 03, 0201, 0202, 0203
The emission factor 11 g/GJ refer to the EEA (2016) for biomass, small combustion.

Emission data are available from two Danish reports: Serup et al. (1999) and Christiansen et al. (1997). According to Serup et al. (1999), the emission factor is in the interval 5-30 g/GJ and a typical value is 15 g/GJ. According to Christiansen et al. (1997), the emission factor is in the interval 15-30 g/GJ.

7.5.30 Straw, CHP plants and power plants

Sector 1A1a, SNAP 0101
The SO_2 emission factor for straw combusted power plants and CHP plants (49 g / GJ) refers to a Danish study (Nielsen et al., 2010a) that included 15 emission measurements from five CHP plants combusting straw. The emission factor is also been applied for large power plants. However, plant specific SO_2 emission data are usually available for large power plants. The emission factor has been applied for all years.

7.5.31 Straw, farmhouse boilers

The sulphur content of straw have been measured in a Danish study (Jensen et al., 2017) to 0.06% - 0.10 % (dry basis). The NCV was 16.98-17.40 MJ / kg (dry). The estimated SO_2 emission factor (assuming full oxidation) is 70-115 g / GJ. The emission factor based on 0.1 % S is 115 g / GJ and this emission factor is applied for all years.

Another Danish reference states the emission factor 130 g / GJ (Nikolaisen et al., 1998).

Several references include data for S-content in straw, see below.

- Skøtt (2011), 0.13-0.16 %
- Launhardt & Thoma (2000), wheat straw 0.1-0.14 %
- Krugly et al. (2014), 0.053 %
- Zeng et al. (2017), 0.19%-0.09, 0.06 %-0.1%

7.5.32 Straw, district heating plants

Sector 1A1a, SNAP 0102
The SO_2 emission factor has been assumed equal to the emission factor for farmhouse boilers: 115 g / GJ.

7.5.33 Bio oil

Sector 1A1a, 1A2a-g, 1A4a, 1A4b, 1A4c, SNAP: all
The consumption of bio oil was 0.6 PJ in 2015 and below 2 PJ all years.

The sulphur content of rape oil is below 0.001% and typically 0.0005% (Folkecenter for Vedvarende Energi, 2000). The lower heating value is 37.2 GJ / tonnes (DEA, 2016a). Based on these data the estimated emission factor is below 0.5 g / GJ and typically 0.3 g / GJ. The emission factor 0.3 g / GJ have been applied.

7.5.34 Biogas, gas engines

Sector 1A1a, 1A2a-g, 1A4a, 1A4c; SNAP 010105, 030905, 020105, and 020304
The SO_2 emission factor for biogas-fuelled engines, 19.2 g / GJ, refers to a Danish study (Nielsen & Illerup, 2003) that included emission measurements from five biogas engines. Despite the limited number of emission measurements, the fuel consumption of the plants represented 11% of the biogas consumption in gas engines in year 2000.

7.5.35 Biogas, other plants

Sector 1A1a, 1A2a-g, 1A4a, 1A4c, SNAP: all that are not included above
The emission factor 25 g / GJ has been estimated based on a H_2S content of 200 ppm. The sulphur content refers to Christiansen (2003) and to Hjort-Gregersen (1999).

The density of H_2S is 1.521 kg / m^3.

The lower heating value of biogas is 23 MJ / m_n^3 (DEA, 2016a).

Based on these data DCE has estimated the SO_2 emission factor:

H_2S: 200·1.521 / 23 = 13.2 mg H_2S / MJ

S: 13.2·32 / 34 = 12.4 mg S / MJ

SO_2: 64 / 32·12.4=25 mg SO_2 / MJ

7.5.36 Biomass gasification gas

The consumption of biomass gasification gas was 0.5 PJ. Biomass gasification gas is combusted in gas engines.

The sulphur content of biomass gasification gas have been analysed by DGC for the Danish EPA (Kristensen, 2017a). The sulphur content in gasification gas from three Danish plants was 8.2 – 24 ppm (vol.). The average sulphur content corresponds to a SO_2 emission of 7 g / GJ (Kristensen, 2017b). This emission factor is applied all years.

7.5.37 Bio natural gas

The emission factors for bio natural gas are assumed equal to the emission factors for natural gas.

7.6 NO_x emission factors

The NO_x emission factors and references are shown in Table 62. Below the table, further details about the references, additional references, and time series are discussed.

Time series are estimated for:

- Combustion of coal in power plants
- Combustion of coal in district heating and non-industrial plants
- Combustion of coal in industrial plants
- Combustion of coal, petroleum coke, residual oil and industrial waste in cement industry
- Combustion of BKB
- Combustion of residual oil in power plants
- Combustion of residual oil in industrial plants
- Combustion of gas oil in power plants
- Combustion of orimulsion in power plants
- Combustion of refinery gas
- Combustion of natural gas in power plants
- Combustion of natural gas in gas turbines
- Combustion of natural gas in offshore gas turbines

- Combustion of natural gas in gas engines
- Combustion of natural gas in large boilers
- Combustion of natural gas in residential boilers
- Combustion of natural gas in non-metallic minerals (bricks and tiles)
- Waste incineration in CHP plants
- Waste incineration in other plants
- Combustion of wood in residential plants
- Combustion of biogas in gas engines

Table 62 NO_x emission factors and references 2015.

Fuel type	Fuel	NFR	NFR_name	SNAP	NOx emission factor, g/GJ	Reference
SOLID	ANODIC CARBON	1A2g	Industry - other	032000	183	Assumed equal to coal. DCE assumption.
	COAL	1A1a	Public electricity and heat production	0101	29	DCE estimate based on plant specific emission data and EU ETS (2016).
				0102	95	DEPA (2001a).
		1A2a-g	Industry	03 except cement produc-tion	183	DCE estimate based on plant specific data for four plants in 2015.
		1A2f	Industry, cement production	0316	179	DCE estimate based on plant specific data for 2015.
		1A4b i	Residential	020200	95	DEPA (2001a).
		1A4c i	Agriculture/ Forestry	0203	95	DEPA (2001a).
	FLY ASH FOSSIL	1A1a	Public electricity and heat production	0101	29	Assumed equal to the emission factor for coal.
	BROWN COAL BRI.	1A4b	Residential	0202	95	Assumed equal to coal. DCE assumption.
	COKE OVEN COKE	1A2a-g	Industry	03	183	Assumed equal to coal. DCE assumption.
		1A4b	Residential	0202	95	Assumed equal to coal. DCE assumption.
LIQUID	PETROLEUM COKE	1A2a-g	Industry	03	138	Assumed equal to residual oil. DCE assumption.
			Industry, non-metallic minerals	0316	179	DCE estimate based on plant specific data for 2015.
		1A4a	Commercial/ Institutional	0201	51	EEA (2016). Tier 1, Small combustion, liquid fuels applied in residential plants.
		1A4b	Residential	0202	51	EEA (2016). Tier 1, Small combustion, liquid fuels applied in residential plants.
		1A4c	Agriculture/ Forestry	0203	51	EEA (2016). Tier 1, Small combustion, liquid fuels applied in residential plants.
	RESIDUAL OIL	1A1a	Public electricity and heat production	0101	138	DCE estimate based on plant specific data for 2008, 2009 and 2010. Plant specific data refer to: Energinet.dk (2009); Energinet.dk (2010); Energinet.dk (2011): EU ETS (2009-2011).
				0102	142	DEPA (2001a).
		1A1b	Petroleum refining	010306	142	EEA(2016).
		1A2a-g	Industry	03	129	DCE estimate based on plant specific data for 2015.
				0316	179	DCE estimate based on plant specific data for 2015.
		1A4a	Commercial/ Institutional	0201	142	DEPA (2001a).
		1A4b	Residential	0202	142	DEPA (2001a).
		1A4c i	Agriculture/ Forestry	0203	142	DEPA (2001a).
	GAS OIL	1A1a	Public electricity and heat production	010101, 010102, 010103	114	DCE estimate based on plant specific data for 2011.
				0102	130	DEPA (2016), DEPA (2012b), DEPA (2003b) and DEPA (1990)
				010104	230	DCE estimate based on plant specific data year 2015.
				010105	942	Nielsen et al. (2010a).
		1A1b	Petroleum refining	010306	65	EEA (2016).

Fuel type	Fuel	NFR	NFR_name	SNAP	NOx emission factor, g/GJ	Reference
		1A1c	Oil and gas extraction	010504	230	Assumed equal to gas turbines applied in CHP plants. DCE assumption.
		1A2a-g	Industry	03 except engines	130	DEPA (2016), DEPA (2012b), DEPA (2003b) and DEPA (1990).
		1A2a-g	Industry	Engines	942	Nielsen et al. (2010a).
		1A4a	Commercial/ Institutional	0201	52	DEPA (2001a).
				Engines	942	Nielsen et al. (2010a).
		1A4b i	Residential	0202	52	DEPA (2001a).
				Engines	942	Nielsen et al. (2010a).
		1A4c	Agriculture/Forestry	0203	52	DEPA (2001a).
				Engines	942	Nielsen et al. (2010a).
	KEROSENE	1A2g	Industry - other	03	50	EEA (2016). The emission factor is for liquid fuels combusted in residential plants.
		1A4a	Commercial/ Institutional	0201	50	EEA (2016). The emission factor is for liquid fuels combusted in residential plants.
		1A4b i	Residential	0202	50	EEA (2016). The emission factor is for liquid fuels combusted in residential plants.
		1A4c i	Agriculture/ Forestry	0203	50	EEA (2016). The emission factor is for liquid fuels combusted in residential plants.
	LPG	1A1a	Public electricity and heat production	All	96	IPCC (1997).
		1A2a-g	Industry	03	96	IPCC (1997).
		1A4a	Commercial/ Institutional	0201	71	IPCC (1997).
		1A4b i	Residential	0202	47	IPCC (1997).
		1A4c i	Agriculture/ Forestry	0203	71	IPCC (1997).
	REFINERY GAS	1A1b	Petroleum refining	010304	170	DCE estimate based on plant specific data for a gas turbine in year 2000.
				010306	56	DCE estimate based on plant specific data for year 2015.
GAS	NATURAL GAS	1A1a	Public electricity and heat production	010101, 010102	55	DEPA (2003b), DEPA (2012), DEPA (2015) and DEPA (2016).
				010103	33.04	Schweitzer & Kristensen (2015).
				010104	48	Nielsen et al. (2010a).
				010105	135	Nielsen et al. (2010a).
				0102	33.04	Schweitzer & Kristensen (2015).
		1A1b	Petroleum refining	0103	33.04	Schweitzer & Kristensen (2015).
		1A1c	Oil and gas extraction	010504	199	Estimate based on plant specific data. Malinovsky (2016a; Malinovsky, 2016b).
		1A2a-g	Industry	03	33.04	Schweitzer & Kristensen (2015).
				Engines	135	Nielsen et al. (2010a).
				Turbines	48	Nielsen et al. (2010a).
		1A2f		030700	87	DCE estimate based on plant specific data for 11 clay production plants, EU ETS (2011-2012); DEPA (2012).
		1A4a	Commercial/ Institutional	0201	33.04	Schweitzer & Kristensen (2015).
				Engines	135	Nielsen et al. (2010a).

Fuel type	Fuel	NFR	NFR_name	SNAP	NOx emission factor, g/GJ	Reference
		1A4b i	Residential	0202	24.30	Schweitzer & Kristensen (2014).
				Engines	135	Nielsen et al. (2010a).
		1A4c i	Agriculture/ Forestry	0203	33.04	Schweitzer & Kristensen (2015).
				Engines	135	Nielsen et al. (2010a).
WASTE	WASTE	1A1a	Public electricity and heat production	0101	75	DCE estimate based on plant specific data for year 2015.
				0102	164	DCE estimate based on plant specific data for year 2000.
		1A2a-g	Industry	03	164	DCE estimate based on plant specific data for district heating plants in year 2000.
		1A4a	Commercial/ Institutional	0201	164	DCE estimate based on plant specific data for district heating plants in year 2000.
	INDUSTRIAL WASTE	1A2f	Industry – non-metallic minerals	031600	179	DCE estimate based on plant specific data for 2015.
BIO-MASS	WOOD	1A1a	Public electricity and heat production	0101	81	Nielsen et al. (2010a).
				0102	90	Serup et al. (1999).
		1A2a-g	Industry	03	90	Serup et al. (1999).
		1A4a	Commercial/ Institutional	0201	90	Serup et al. (1999).
		1A4b i	Residential	0202	76.76	DCE estimate based on DEA (2016a), DEPA (2013) and EEA (2013). The methodology for estimating this emission factor is included in Chapter 6.5.
		1A4c i	Agriculture/ Forestry	0203	90	Serup et al. (1999).
	STRAW	1A1a	Public electricity and heat production	0101	125	Nielsen et al. (2010a).
				0102	90	Nikolaisen et al. (1998).
		1A4b i	Residential	0202	154	Jensen et al. (2017).
		1A4c i	Agriculture/ Forestry	0203	154	Jensen et al. (2017).
	BIO OIL	1A1a	Public electricity and heat production	0101	114	Assumed equal to gas oil. DCE assumption.
				0102	130	Assumed equal to gas oil. DCE assumption.
		1A2a-g	Industry	03	130	Assumed equal to gas oil. DCE assumption.
				Engines	942	Assumed equal to gas oil. DCE assumption.
		1A4b i	Residential	0202	52	Assumed equal to gas oil. DCE assumption.
	BIOGAS	1A1a	Public electricity and heat production	0101, not engines	55	Assumed equal to large natural gas fuelled boilers.
				Engines	202	Nielsen et al. (2010a).
				0102	28	DEPA (2001a).
		1A2a-g	Industry	03, not engines	55	Assumed equal to large natural gas fuelled boilers.
				03, engines	202	Nielsen et al. (2010a)
				030902	55	Assumed equal to large natural gas fuelled boilers.
		1A4a	Commercial/ Institutional	0201, not engines	28	DEPA (2001a).
				020105	202	Nielsen et al. (2010a).

Fuel type	Fuel	NFR	NFR_name	SNAP	NOx emission factor, g/GJ	Reference
		1A4b	Residential	0202	24.30	Assumed equal to natural gas (upgraded biogas).
		1A4c i	Agriculture/ Forestry	0203, not en-gines	28	DEPA (2001a).
				020304	202	Nielsen et al. (2010a).
	BIO GASIF GAS	1A1a	Public electricity and heat production	010105	173	Nielsen et al. (2010a).
	BIONATGAS	1A1a	Public electricity and heat production	0101	55	Assumed equal to natural gas. DCE assumption.
				0102	33.04	Assumed equal to natural gas. DCE assumption.
		1A2a-g	Industry	03	33.04	Assumed equal to natural gas. DCE assumption.
		1A4a	Commercial/ Institutional	0201	33.04	Assumed equal to natural gas. DCE assumption.
		1A4b	Residential	0202	24.30	Assumed equal to natural gas. DCE assumption.
		1A4c	Agriculture/ Forestry	0203	33.04	Assumed equal to natural gas. DCE assumption.

7.6.1 Anodic carbon

Anodic carbon has been used in two industrial plants in 2009-2013.

The NO_x emission factor, 183 g/GJ in 2015, have been assumed equal to the NO_x emission factor for coal combusted in industrial plants.

7.6.2 Coal, large power plants

Sector 1A1a, SNAP 0101

Data for NO_x emission and the fuel consumption for Danish power plants >25MW_e are available for all plants for the years 1990 and onwards. In general, the plant specific data have been included in the emission inventories.

However, for some years, a small part of the coal consumption has been included as an area source. The NO_x emission factor for coal has been estimated as an average value based on the annual data for fuel consumption and emission data from PRTR data, annual environmental reports or annual data reported by the power plant operators to the electricity transmission company in Denmark, Energinet.dk[27].

In 2010 onwards, the emission factor is estimated based on a database query including plant specific data for power plants for which the coal consumption makes up more than 90 % of the total fuel consumption. All NO_x emission from these plants is assumed to originate from the coal consumption.

For 2008-2009, the emission factor is based on plant specific emission data for power plants that are primarily fuelled by coal. The NO_x emissions from plants that are primarily fuelled by coal have been divided by the total fuel consumption of these plants.

For 1990-2007, the emission factor is based on the total NO_x emission from power plants (regardless of primary fuel category) divided by the total fuel consumption of the power plants. This emission factor has been applied for both coal and residual oil. From 2003 onwards, the fuel consumption data were stated in TJ.

The calculated time series for the NO_x emission factor is shown below.

[27] Eltra and Elkraft System in the beginning of the time series.

Table 63 NO_x emission factors for combustion of coal in power plants.

Year	NO_x emission factor [g/GJ]
1990	342
1991	384
1992	294
1993	289
1994	267
1995	239
1996	250
1997	200
1998	177
1999	152
2000	129
2001	122
2002	130
2003	144
2004	131
2005	127
2006	109
2007	98
2008	59
2009	39
2010	30
2011	30
2012	32
2013	29
2014	26
2015	29

7.6.3 Coal applied in district heating plants or in non-industrial plants

Sector 1A1a, 1A4a, 1A4b, 1A4c, SNAP 0102 and 02
The non-industrial consumption mainly takes place in agricultural plants and in 1990-1993 also in district heating plants.

The emission limit value for 5-50 MW boilers is 95 g/GJ (DEPA, 2001). However, this legislation is only a guidance note and for some plants, higher emission limits have been accepted in the environmental approval. The emission limit for 50-100 MW boilers (installed before 2013) is 104 g/GJ (DEPA, 2016).

The EEA Guidebook (EEA, 2016) states the emission factors: 209 g/GJ for public electricity and heat production and 173 g/GJ for agricultural plants (tier 1 values).

The 2001-2015 emission factors (95 g/GJ) refer to Danish legislation (DEPA, 2001a). The emission factor for 1990-2000 (209 g/GJ for district heating and 173 g/GJ for non-industrial plants) refer to EEA (2016).

7.6.4 Coal applied in industrial plants

Sector 1A2a-g, SNAP 03 (except 0316)
The emission factor for industrial combustion of coal (except for cement production) is based on plant specific data 2015 from four plants. The average emission factor for these plants is 183 g/GJ. The implied emission factor for 2011 has been estimated based on the same four plants. Finally, an emission factor has been estimated for 1995 based on one of the plants. The emission factor time series have been based on constant emission factor in 1990-1995, a

linear decline from 1995-2011 and a linear decline from 2011-2015. The time series are shown below.

Table 64 NO_x emission factor for industrial combustion of coal.

	NOx emission factor, g/GJ
1990-1995	247
1996	244
1997	242
1998	239
1999	236
2000	234
2001	231
2002	229
2003	226
2004	224
2005	221
2006	219
2007	216
2008	214
2009	211
2010	209
2011	206
2012	200
2013	195
2014	189
2015	183

Another emission factor is applied for cement industry; see below.

7.6.5 Coal applied in cement industry

Sector 1A2f, SNAP 0316

The NO_x emissions from cement industry have been implemented in the inventory as annual total emissions. However, a time series for the emission factor have been estimated.

The emission factor for coal applied in cement production plants is based on plant specific data for 2015. A time series have been estimated based on plants specific data. For 1990-2000, the applied emission factor is the average of the annual emission factors for 1990-2000. The time series is shown in Table 65 below. The same emission factor time series is applied for petroleum coke, residual oil and waste applied for cement production.

Table 65 NO_x emission factor for cement production.

	NOx, g/GJ
1990-1999	701
2000	588
2001	692
2002	621
2003	620
2004	550
2005	580
2006	536
2007	447
2008	457
2009	430
2010	244
2011	199
2012	176
2013	153
2014	162
2015	179

7.6.6 Brown coal briquettes

Sector 1A2g, 1A4a, 1A4b, 1A4c, SNAP 03, 0201, 0202, and 0203
The consumption of brown coal briquettes (BKB) is below 0.2 PJ all years and in 2015, BKB was not applied in Denmark. Since 1999, the consumption has been only in residential plants.

The emission factors for brown coal briquettes have been assumed the same as for coal: 95 g/GJ for non-industrial plants in 2001 onwards, 173 /GJ for non-industrial plants in 1990-2000 and a time series for industrial plants (179 g/GJ in 2015, see Chapter 7.6.4).

7.6.7 Fly ash fossil

The emission factor for fossil fly ash is assumed equal to coal.

7.6.8 Coke oven coke

Sector 1A2a-g and 1A4b, SNAP 03, 0202
The consumption of coke oven coke is 0.5 PJ in 2015 and below 1.5 PJ in 1990-2015. The largest consumption is in mineral wool production plants.

The emission factors for coke oven coke are assumed the same as for coal.

7.6.9 Petroleum coke, power plants and industry (not cement industry)

Sector 1A1a, 1A2a-g, SNAP 0101, 03
Petroleum coke consumption in power plants and industry (not cement industry) is below 5 PJ all years and below 0.4 PJ from year 2000 onwards. A high consumption in central power plants in 1994 is in agreement with the Danish energy statistics. In later years, the only considerable consumption is in non-metallic minerals (SNAP 0307).

The emission factor for petroleum coke combusted in power plants and industrial plants (not cement industry) is the same as for residual oil combustion in industrial plants. This is assumed for all years.

7.6.10 Petroleum coke applied in cement industry

Sector 1A2f, SNAP 0316

The emission factor for petroleum coke (179 g / GJ) applied for cement production is based on plant specific data for 2015. A time series have been estimated based on plants specific data. For 1990-2000, the applied emission factor is the average of the annual emission factors for 1990-2000. The same emission factor time series is applied for coal, petroleum coke, residual oil and waste applied for cement production. The time series for the emission factor is shown in Chapter 7.6.5.

7.6.11 Petroleum coke, residential plants, commercial/institutional plants and plants in agriculture/forestry

Sector 1A4a, 1A4b, 1A4c, SNAP 0201, 0202, and 0203
The emission factor 51 g / GJ refer to EEA (2016). The tier 1 emission factor for liquid fuels applied in residential plants is applied also for commercial / institutional plants and agricultural plants.

7.6.12 Residual oil, power plants

Sector 1A1a, SNAP 0101
The NO_x emission and the fuel consumption for Danish power plants >25MW_e are available for all plants for the years 1990 and onwards. In general, the plant specific data have been included in the emission inventories. However, for some years, a small part of the residual oil consumption has been included as an area source.

The NO_x emission factor for residual oil has been estimated as an average value based on the annual PRTR data, annual environmental reports or annual data reported by the power plant operators to the electricity transmission company in Denmark, Energinet.dk[28].

From 2008 onwards, the emission factor (138 g / GJ) is estimated based on an average value for 2008, 2009 and 2010. The emission factor for each year is based on a database query that include plant specific data for power plants for which the residual oil consumption is more than 90 % of the total fuel consumption. All NO_x emissions from these plants are assumed to originate from the residual oil consumption. NO_x emission data refer to Energinet.dk (2009), Energinet.dk (2010), and Energinet.dk (2011). Fuel consumption data refer to EU ETS (2009-2011). The emission factor 138 g / GJ is the average for the years 2008, 2009 and 2010.

For 1990-2007, the emission factor is based on the total NO_x emission from power plants (regardless of primary fuel category) divided by the total fuel consumption of the power plants. This emission factor has been applied for both coal and residual oil. From 2003 onwards, the fuel consumption data were stated in TJ.

The time series for the NO_x emission factor are shown below.

[28] Eltra and Elkraft System in the beginning of the time series.

Table 66 NO_x emission factors for residual oil applied in power plants.

Year	NO_x emission factor [g/GJ]
1990	342
1991	384
1992	294
1993	289
1994	267
1995	239
1996	250
1997	200
1998	177
1999	152
2000	129
2001	122
2002	130
2003	144
2004	131
2005	127
2006	109
2007	98
2008	138
2009	138
2010	138
2011	138
2012	138
2013	138
2014	138
2015	138

7.6.13 Residual oil, industrial plants (not cement industry)

Sector 1A2a-g, SNAP 03

In 2015, 90 % of the industrial consumption of residual oil (not including cement industry) was used in the food and tobacco industry. Several plants are included as point sources with plant specific data in the Danish emission inventory. Implied emission factors for plants in the food and tobacco industry are included in the table below. The table also shows other references relevant for the emission factor.

The time series for the emission factor are based on the implied emission factors for 2011 and 2015. The 2011 value is applied for 1990-2011. A linear decline has been assumed for 2011-2015. The time series are shown in Table 68.

Table 67 Emission factors for industrial plants combusting residual oil.

Technology	Emission factor (or emission limit value), g/GJ	Reference
Emission limit value for plants 50-100 MW. The legislation includes a number of exceptions	130	DEPA (2016)
Emission limit value for plants 100-300 MW. The legislation includes a number of exceptions	58	DEPA (2016)
Emission limit value for plants > 300 MW. The legislation includes a number of exceptions	43	DEPA (2016)
CHP plants, residual oil fuelled steam turbine.	136	Nielsen et al. (2010a)
IEF for three plants in the food and tobacco industry, 2011	159	DCE estimate (2017)
IEF for three plants in the food and tobacco industry, 2015	129	DCE estimate (2017)
EEA (2016), tier 1 for liquid fuels applied in industrial plants	513	EEA (2016)
EEA (2016), tier 1 for heavy fuel oil applied in power plants	142	EEA (2016)
Industry, oil	200	IPCC (1997)

Table 68 NO_x emission factor time series for industrial combustion of residual oil.

Year	Emission factor, g/GJ
1990-2010	159
2011	159
2012	152
2013	144
2014	137
2015	129

7.6.14 Residual oil applied in cement industry

Sector 1A2f, SNAP 0316

The emission factor for residual oil applied for cement production (179 g / GJ) is based on plant specific data for 2015. A time series have been estimated based on plants specific data. For 1990-2000, the applied emission factor is the average of the annual emission factors for 1990-2000. The same emission factor time series is applied for coal, petroleum coke, residual oil and waste applied for cement production. The time series for the emission factor is shown in Chapter 7.6.5.

7.6.15 Residual oil applied in refineries

The emission factor for residual oil applied in refineries is 142 g / GJ referring to EEA (2016), Energy Industries, tier 2, petroleum refining plants, residual oil.

7.6.16 Residual oil, district heating and non-industrial plants

Sector 1A1a, 1A4a, 1A4b, 1A4c, SNAP 0102, 0201, 0202, and 0203

Residual oil combusted in plants that are neither power plants nor industrial plants is assumed to be boilers < 50MW. The emission limit value for these plants is 142 g / GJ (DEPA, 2001a).

The EEA Guidebook (EEA, 2016) states the tier 1 emission factor 51 g / GJ for residential plants, 306 g / GJ for commercial / institutional plants and agricultural plants. For district heating plants, the tier 1 value for heavy fuel oil is 142 g / GJ.

The IPCC Guidelines (IPCC, 1997) states the emission factor 100 g / GJ for other sectors and 200 g / GJ for energy industries.

The emission limit value is applied for all years.

7.6.17 Gas oil, power plants

Sector 1A1a, SNAP 010100, 010101, 010102, and 010103

The total fuel consumption of gas oil in power plant boilers was 0.3 PJ in 2015. The consumption in 1990-2015 was below 2.5 PJ.

The emission factor time series is based on implied emission factors for 2003 and 2011.

Based on plant specific data, DCE has estimated the emission factor for 2011 to 114 g / GJ.

The emission factor for 2003 (249 g / GJ) has been estimated by DCE based on plant specific emission data for 2003 (Eltra & Elkraft System, 2004) and fuel consumption data from DEA (2012b). The estimate was based on emission data from two power plant boilers that only combusted gas oil. This emission factor has been applied for 1990-2003.

A linear decrease of the emission factor between 2003 and 2011 is assumed.

7.6.18 Gas oil, gas turbines

Sector 1A1a, 1A2a-g, SNAP 010104, 03xx04
A large part of the gas oil combusted in gas turbines is used in gas turbines that are primarily fuelled by natural gas.

Implied emission factors for the years 2000, 2013 and 2015 are shown in Table 69. Emission factors from EEA (2016) and IPCC (1997) are also included in the table.

The IEF for 2015 was 230 g/GJ. This emission factor is applied for all years.

The IPCC Reference Manual (IPCC, 1997) states the emission factor 300 g/GJ for gas oil combustion in gas turbines. The EEA Guidebook (EEA, 2016) states the emission factor 398 g/GJ for gas oil fuelled gas turbines.

The current emission limit value for gas oil fuelled gas turbines is 65 g/GJ (DEPA, 2012b). This limit is, however, not valid for turbines in plants with a thermal input above 50 MW or with less than 500 operating hours per year.

Table 69 Emission factors for gas oil fuelled gas turbines.

	Emission factor, g/GJ
Implied emission factor, 2015	230
Implied emission factor, 2013	221
Implied emission factor, 2000	199
EEA (2016)	398
IPCC (1997)	300

The emission factor for offshore gas turbines is however assumed equal to the emission factor for natural gas fuelled offshore gas turbines.

7.6.19 Gas oil, stationary engines

Sector 1A1a, 1A2a-g, 1A4a, 1A4b, 1A4c, SNAP 010105, 03xx05, 20105, 020204, 020304
The consumption of gas oil in stationary engines is below 0.2 PJ all years.

The emission factor for gas oil combusted in stationary engines (942 g/GJ) refers to a Danish emission measurement project for CHP plants (Nielsen et al., 2010a). This emission factor has been applied for year 2000 onwards.

The emission limit is 178 g/GJ for existing engines (DEPA, 2012b). However, the limit value is not valid for engines with less than 500 operating hours per year.

The emission factor 942 g/GJ is applied for all years.

7.6.20 Gas oil, district heating plants and industrial boilers

Sector 1A1a, 1A1b, 1A2a-g, SNAP 0102, 03
The gas oil consumption in district heating and industry was below 0.8 PJ in 2015, but the consumption was higher in earlier years (up to 6 PJ).

The current emission limit for existing 50-100 MW boilers is 130 g / GJ (DEPA, 2016). For 5- 50 MW boilers the emission limit is 52 g / GJ or 118 g / GJ depending on installation year (DEPA, 2001a).

The EEA Guidebook (EEA, 2016) states the emission factors 65 g / GJ for gas oil applied in public electricity and heat production and 513 g / GJ for industrial combustion of liquid fuels. For small combustion in the agricultural sector, the emission factor is 306 g / GJ.

The IPCC Guidelines (IPCC, 1997) states the emission factor 200 g / GJ for energy industries and industry.

The emission factor 130 g / GJ have been applied all years referring to DEPA (2016), DEPA (2012b), DEPA (2003b) and DEPA (1990).

7.6.21 Gas oil applied in refineries

The emission factor for gas oil applied in refineries (65 g / GJ) refer to EEA (2016), the tier 2 emission factor for gas oil applied in petroleum refining. The emission factor is applied for all years.

7.6.22 Gas oil applied in non-industrial plants

Sector 1A4a, 1A4b, 1A4c, SNAP 0201, 0202, and 0203
The consumption of gas oil in non-industrial plants was 8 PJ in 2015. The consumption was up to 51 PJ in 1990-2015. The consumption in residential plants is higher than in commercial / institutional plant and in agricultural plants.

Residential plants, commercial and institutional plants and plants in agriculture / forestry are all small plants. The emission limit for 120 kW - 50 MW boilers is 52 g / GJ for plants installed after 2001 and 118 g / GJ for plants installed before 2001 (DEPA, 2001a).

The EEA Guidebook (EEA, 2016) states the emission factors 51 g / GJ for residential plants, 306 g / GJ for commercial / institutional plant and agricultural plants (liquid fuels).

IPCC Guidelines (IPCC, 1997) states the tier 1 emission factor 100 g / GJ for residential or commercial / institutional plants and the tier 2 emission factor 65 g / GJ for distillate oil combusted in residential or commercial plants.

The applied emission factor 52 g / GJ refers to DEPA (2001a). DCE has assumed the same emission factor for residential plants, commercial / institutional plants and plants in agriculture / forestry. The same emission factor has been applied all years.

7.6.23 Kerosene

Sector 1A2g, 1A4a, 1A4b, 1A4c, SNAP 03, 0201, 0202, and 0203
The emission factor for kerosene, 51 g / GJ, refers to the EEA Guidebook (EEA, 2016). The emission factor for liquid fuels applied in residential plants has been applied.

7.6.24 Orimulsion

Sector 1A1a, SNAP 010101
The use of orimulsion in Denmark ceased in 2005.

Orimulsion has only been used in a single large power plant boiler in Denmark. This power plant boiler has been included in the inventories as a point source with plant specific NO_x emission data included all years. Thus, the emission factors that are stated in the area source emission factor time series are only included for information.

The emission factors have been estimated based on plant specific data. The plant specific NO_x emission data refer to Eltra & Elkraft System (annual reporting) and the fuel consumption data refer to DEA (2012b) and the similar DEA data reported in former years. The use of orimulsion in Denmark ceased in 2005.

7.6.25 LPG

Sector 1A1a, 1A1b, 1A2a-g, 1A4a, 1A4b, 1A4c, SNAP: all
The consumption of LPG was 1.4 PJ in 2015. The consumption was 0.9-3.0 in 1990-2015.

The emission factors applied for LPG refer to the IPCC Guidelines (IPCC, 1997). The applied tier 2 emission factors are:

- 96 g / GJ for industrial boilers (Table 1-16). The emission factor is also applied for plants in energy industries
- 71 g / GJ for combustion in commercial and institutional plants (Table 1-19). The emission factor is also applied for agricultural plants
- 47 g / GJ for residential plants (Table 1-18)

The same emission factors have been applied for all years.

7.6.26 Refinery gas, gas turbine

Sector 1A1b, SNAP 010300, 010304
The applied emission factor for refinery gas combusted in gas turbines (170 g / GJ) refers to plant specific data in year 2000. However, the only refinery gas fuelled gas turbine in operation in Denmark has been included as a point source with plant specific emission data since 1994.

7.6.27 Refinery gas, other

Sector 1A1b, SNAP 0103
The refineries have been included as point sources with plant specific emission factors in the Danish inventory since 1994.

Based on plant specific data for 2015, the implied emission factor 56 g / GJ have been estimated[29].

Based on plant specific data for 2011, the implied emission factor 94 g / GJ have been estimated.

For 1994, the implied emission factor 83 g / GJ have been estimated.

The implied emission factor for 1994 is applied for 1990-2008, the implied emission factor for 2011 is applied for 2009-2014 and the implied emission factor for 2015 is applied for 2015 onwards.

7.6.28 Natural gas, power plants

Sector 1A1a, SNAP 010101, 010102
In general, plant specific data are available for natural gas fuelled power plants.

The emission factor for 2016 onwards is 28 g / GJ. This emission factor refers to Danish legislation for plants installed before 2003 from 2016 onwards (DEPA, 2012; DEPA, 2015; DEPA 2016).

The emission factor for SNAP 010101 in 2008-2015 (55 g / GJ) refers to Danish legislation for large combustion plants >500 MW_{th} installed before 2003 (DEPA, 2003b; DEPA, 2012b; DEPA, 2015; DEPA 2016).

The emission factor for SNAP 010100 and 010102 in 2008-2015 (83 g / GJ) refers to Danish legislation for large combustion plants 50-500 MW_{th} installed before 2003 (DEPA, 2003b; DEPA, 2012b; DEPA, 2015; DEPA 2016).

The emission factor for 2004-2007 (97 g / GJ) refers to the same legislation.

The emission factor applied for 1990-2003 (115 g / GJ) has been estimated by DCE based on plant specific emission data for year 2000. Gas turbine plants were not included in the estimate.

7.6.29 Natural gas, gas turbines (and combined cycle plants)

Sector 1A1a, 1A2a-g, 1A4a, SNAP 010104, 03xx04, 020104
Gas turbines > $25MW_e$ have been included in the inventory as point sources with plant specific NO_x emission data.

The emission factor 48 g / GJ refers to Nielsen et al. (2010a). This emission measurement programme for decentralised CHP plants included estimation of emission factors for the years 2003-2006 and for 2007 onwards. The emission factor for 2007 onwards (48 g / GJ) have been applied in the inventory for the years 2007 onwards. The 2003-2006 emission factor (98 g / GJ) has been applied for 2005. The decline rate between 2005 and 2007 has been assumed linear.

The emission factor for year 2000 (124 g / GJ) refers to another Danish study (Nielsen & Illerup, 2003). This study included emission measurements from 17 gas turbine plants < $25MW_e$. The emission measurements included in the estimate represented 67% of the natural gas consumption in gas turbines < 25

[29] SNAP 010306, two refineries, all fuels included.

MW_e in 2000. The decline rate of the emission factor in 2000-2005 has been assumed linear.

Emission factors for 1990 (161 g/GJ) and 1995 (141 g/GJ) was also included in Nielsen & Illerup (2003). The decline rate in 1990-1995 and 1995-2000 respectively, have been assumed linear.

7.6.30 Natural gas, offshore gas turbines

Sector 1A1c, SNAP 010504
The emission factors for 2013, 2014 and 2015, 201 g/GJ, 196 g/GJ and 199 g/GJ, are based on NO_x emission reporting from each of the offshore gas turbines (Malinovsky, 2016a; Malinovsky, 2016b).

The emission factor for 1990-2010, 250 g/GJ, refer to Kristensen (2004). The emission factor estimate is based on plant specific data. The estimate was performed by Danish Gas Technology Centre for a DEPA NO_x working group.

For 2010-2013 a linear decline of the emission factor have been assumed.

7.6.31 Natural gas, gas engines

Sector 1A1a, 1A2a-g, 1A4a, 1A4b, 1A4c, SNAP 010105, 03xx05, 020105, 020204, 020304
The emission factor for natural gas fuelled engines refers to Nielsen et al. (2010a). In this Danish emission measurement programme for CHP plants, emission factors for 2007 and 2003-2006 have been estimated. New emission limits were valid for existing engines from end 2006 (DEPA, 1998). The emission factor for 2007 (135 g/GJ) have been applied in the inventories for 2007 onwards. The emission factor based on emission measurements from 2003-2006 (143 g/GJ) have been applied for 2005. A linear decline rate has been assumed from 2005 to 2007.

The emission factor for year 2000 (168 g/GJ) refer to the full load emission factors estimated in the previous emission factor survey (Nielsen & Illerup, 2003) and the correction factors for start-up and shut-down developed in another project (Nielsen et al., 2008). The decline rate between year 2000 and 2005 have been assumed linear.

The emission factors for 1990 (176 g/GJ) and 1995 (194 g/GJ) also refer to Nielsen & Illerup (2003). Time series for 1990-1995 and 1995-2000 have been estimated assuming linear increase/decrease.

7.6.32 Natural gas, boilers in district heating, industry, petroleum refining, commercial/institutional and agriculture

Sector 1A1a, 1A1b, 1A2a-g, SNAP 010103, 0102, 0103, 03xx00-03xx03, 0201, 0203
The emission factor time series refer to a Danish study from Danish Gas Technology Centre evaluating the NO_x emissions of the Danish population of gas boilers above 120 kW (Schweitzer & Kristensen, 2015).

Table 70 NO_x emission factor time series for large (>120 kW) natural gas fuelled boilers.

	Emission factor, g/GJ
1990	41.54
1991	41.20
1992	40.86
1993	40.52
1994	40.18
1995	39.84
1996	39.50
1997	39.16
1998	38.82
1999	38.48
2000	38.14
2001	37.80
2002	37.46
2003	37.12
2004	36.78
2005	36.44
2006	36.10
2007	35.76
2008	35.42
2009	35.08
2010	34.74
2011	34.40
2012	34.06
2013	33.72
2014	33.38
2015	33.04

7.6.33 Natural gas, non-metallic minerals

The emission factor for production of bricks and tiles is higher than the emission factor for other industrial combustion plants. Since this production is included in the industrial subsector non-metallic minerals, the emission factor for this category is higher (87 g/GJ).

The emission factor has been estimated based on plant specific data for 11 plants for years 2010 or 2011. Data for the estimate are based on EU ETS data for fuel consumption (EU ETS, 2011-2012) and NO_x emission data from annual environmental reports (DEPA, 2012b).

7.6.34 Natural gas, residential boilers

Sector 1A4b, SNAP 0202
The fuel consumption in residential boilers was 25 PJ in 2015. The consumption has been between 17 PJ and 32 PJ in 1990-2015.

The emission factor time series refer to a study from Danish Gas Technology Centre: Evaluation of the NO_x emissions of the Danish population of gas boilers below 120 kW (Schweitzer & Kristensen, 2014). The emission factor for 2012 (28.3 g/GJ) was estimated based on a large number of emission measurement and detailed data for the installed gas boilers in Denmark. In addition, a time series from 2000 (34 g/GJ) to 2030 (10.7 g/GJ) was estimated. For the years 1990-1999, the emission factor for year 2000 have been applied.

The emission limit value for 120 kW- 5 MW boilers installed after 2001 is 29 g/GJ (DEPA, 2001a). The emission limit for boilers installed before 2001 is 57 g/GJ.

Table 71 Emission factor time series for NO_x, 1990-2015.

Year	NO_x emission factor, g/GJ
1990-1999	34.00
2000	34.01
2001	33.94
2002	33.80
2003	33.53
2004	33.12
2005	32.57
2006	31.83
2007	31.34
2008	30.75
2009	30.07
2010	29.49
2011	28.90
2012	28.30
2013	26.90
2014	25.60
2015	24.30

7.6.35 Waste, CHP plants

Sector 1A1a, SNAP 0101

The waste consumption in CHP plants was 36 PJ in 2015 and the consumption have increased since 1990.

The emission factor for 2006 onwards (102 g / GJ) refers to Nielsen et al. (2010a) that is a Danish measurement project for CHP plants. In 2006, 68 % of the waste was incinerated in plants installed with SNCR.

Most waste incineration plants report plant specific emission data. The implied emission factor for waste incineration plants was 100 g / GJ in 2011 and 75 in 2015. Thus, the emission data for 2011 confirm the current emission factor. A revised emission factor time series will be applied in the next inventory for 2011-2015.

The decrease in recent years is related to lower emission limit values for waste incineration plants. The emission limit for plants installed before 2003 in the current legislation (DEPA, 2012a) is 105 g / GJ if the plant capacity is above six tonnes per hour. If the capacity is below six tonnes per hour, the emission limit for plants installed before 2003 is 190 g / GJ. The emission limit for all plants installed after 2003 is 105 g / GJ. In 2015, more than 95 % of the consumption in this category was in plants with a capacity above six tonnes per hour. In 2004, the share of the larger units was 77 %.

The NO_x emission factor for year 2000 refers to an earlier Danish study (Nielsen & Illerup, 2003). The emission factor (124 g / GJ) has been applied for the inventories for year 2000-2003. A linear decline rate has been assumed for 2003-2006.

The first SNCR unit was installed in a waste incineration plant in 1998. The emission factor for 1990-1998 (134 g / GJ) refers to Nielsen et al. (2010a), the emission factor for plants without SNCR. This emission factor might be underestimated since the combustion technology might also have been improved and contributed to the lower emission level.

The time series of the NO_x emission factor for waste incineration in CHP plants is shown in Table 72.

Table 72 NO_x emission factor for waste incineration, 1990-2015.

Year	Emission factor, g/GJ
1990-1998	134
1999	129
2000	124
2001	124
2002	124
2003	124
2004	117
2005	110
2006	102
2007	102
2008	102
2009	102
2010	102
2011	102
2012	102[1)]
2013	102[1)]
2014	102[1)]
2015	102[1)]

1) Will be revised in the next inventory

7.6.36 Waste, other plants

Sector 1A1a, 1A2a-g, 1A4a, SNAP 0102, 03, 0201

The NO_x emission factor (164 g / GJ) applied for non-power producing plants (mainly district heating plants) has been estimated by DCE based on plant specific emission data from non-power producing plants in year 2000. The same emission factor has been applied for all years. In recent years, the main part of waste incineration plants that do not produce power has been replaced by power producing plants.

The current legislation for plants < 6 tonnes / hour installed before 2003 is 190 g / GJ (DEPA, 2012a).

7.6.37 Industrial waste applied in cement industry

Sector 1A2f, SNAP 0316

The emission factor for industrial waste applied for cement production (179 g / GJ) is based on plant specific data for 2015. A time series have been estimated based on plants specific data for 2000-2015.

For 1990-2000, the applied emission factor is the average of the annual emission factors for 1990-2000. The same emission factor time series is applied for coal, petroleum coke, residual oil and waste applied for cement production.

The time series for the emission factor is shown in Chapter 7.6.5.

7.6.38 Wood, CHP plants and large power plants

Sector 1A1a, SNAP 0101

The NO_x emission factor for wood combusted in CHP plants (81 g / GJ) refers to Nielsen et al. (2010a). This emission factor is based on 5 emission measurements from 2 plants. The fuel consumption of the two plants represented 42%

of the wood consumption in CHP plants in year 2006. The emission factor is applied for all years.

7.6.39 Wood, residential plants

Sector 1A4b, SNAP 0202
DCE estimate based on DEA (2016a), DEPA (2013) and EEA (2013). The methodology for estimating this emission factor is included in Chapter 6.5.

7.6.40 Wood, other plants

Sector 1A1a, 1A2a-g, 1A4a, 1A4c, SNAP 0102, 03, 0201, and 0203
The consumption of wood in district heating, industry, commercial/institutional and agricultural plants was 19 PJ in 2015. The largest fuel consumption is in district heating.

The emission factor is 90 g/GJ referring to Serup et al. (1999). According to Setup et al. (1999), the emission factor for Danish district heating plants combusting wood is 40-140 g/GJ and the typical value is 90 g/GJ.

The EEA (2016) emission factor for biomass applied commercial, institutional and agricultural plants is 91 g/GJ.

The emission factor 90 g/GJ is applied for all years.

7.6.41 Straw, CHP plants and large power plants

Sector 1A1a, SNAP 0101
The emission factor for straw combusted in CHP plants and power plants (125 g/GJ) refers to Nielsen et al. (2010a). This emission measurement programme included 14 datasets from five plants representing 83 % of the straw consumption in CHP plants[30] in 2006.

The emission factor has also been applied for combustion of straw in large power plants. However, plant specific NO_x emission data are usually available for large power plants.

The emission factor has been applied for all years.

7.6.42 Straw, farmhouse and residential boilers

Sector 1A4b, 1A4c, SNAP 0202, 0203
The emission factor for farmhouse boilers refer to a Danish study for a batch-fired 400 kW boiler (Jensen et al., 2017). The NO_x emission data for this boiler tested with three different straw types was 147 g/GJ, 188 g/GJ and 126 g/GJ. The average emission factor 154 g/GJ is applied for all years.

7.6.43 Straw, other plants

Sector 1A1a, 1A2a-g, 1A4a, SNAP 0102, 03, 0201
The emission factor, 90 g/GJ, refers to Nikolaisen et al. (1998). According to Nikolaisen et al. (1998), the typical emission factor for Danish district heating plants combusting straw is 90 g/GJ with a typical interval of 40-150 g/GJ.

[30] < $25MW_e$

Due to lack of data from other non-power producing plants, the emission factor 90 g / GJ have been applied for these as well.

EEA (2016) states the emission factor 91 g / GJ for biomass combustion in commercial / institutional plants and thus confirms the emission level.

The emission factor has been applied for all years.

7.6.44 Bio oil

All sectors
The consumption of bio oil is below 2 PJ all years. The NO_x emission factors for bio oil have been assumed equal to the emission factors for gas oil.

7.6.45 Biogas, gas engines

Sector 1A1a, 1A2, 1A4a, 1A4c, SNAP 010105, 03xx05, 020105, 020304
The consumption of biogas in gas engines has been increasing since 1990. In 2015, the consumption was 4.2 PJ.

The emission factor for 2006 onwards (202 g / GJ) refers to Nielsen et al. (2010a). The emission factor is based on emission measurements from 10 engines. A new emission limit (297 g / GJ) was valid for existing biogas engines from 2013 (DEPA, 2012c).

The emission factor for year 2000 (540 g / GJ) refers to an earlier Danish study (Nielsen & Illerup, 2003). This study included emission measurements on 15 gas engines. The emission measurements included in the estimate represented 21% of the biogas consumption in gas engines in year 2000. A linear decline rate of the emission factor has been assumed from year 2000 to year 2006.

Emission factors for 1990 (711 g / GJ) and 1995 (635 g / GJ) also refer to Nielsen & Illerup (2003). The decline rates in 1990-1995 and in 1995-2000 have been assumed constant.

7.6.46 Biogas, large boilers

Sector 1A1a, 1A2, SNAP 0101 (except engines), 03xx01, and 03xx02
For large biogas fuelled boilers the emission factor has been assumed equal to the emission factor for large natural gas fuelled boilers.

7.6.47 Biogas, other boilers

Sector 1A1a, 1A2a-g, 1A4a, 1A4c, SNAP 0102, 03, 0201, and 0203
Boilers are in general < 50 MW and the emission factor refers to Danish legislation (DEPA, 2001a). The emission limit value for 120 kW – 50 MW is 28 g / GJ[31] (DEPA, 2001a) and this emission factor has been applied for all years.

7.6.48 Bio gasification gas

The consumption of bio gasification gas is below 0.5 PJ all years. Bio gasification gas is combusted in gas engines.

The emission factor, 173 g / GJ, refers to Nielsen et al. (2010a).

[31] In some cases, the limit is 54 g / GJ for existing plants.

7.6.49 Bio natural gas

Bio natural gas is biogas upgraded for distribution in the natural gas grid. In 2015, the consumption of bio natural gas was 1 PJ. Bio natural gas has only been applied in 2014 and 2015.

The NO_x emission factors for bio natural gas have been assumed equal to the NO_x emission factors for natural gas applied in the same emission source category.

7.7 NMVOC emission factors

The NMVOC emission factors and references are shown in Table 73.

The emission factors for NMVOC refer to:

- An emission measurement program for decentralised CHP plants (Nielsen et al., 2010a).
- The EEA Guidebook (EEA, 2016) and former editions.
- Aggregated emission factor based on the technology distribution for residential wood combustion and guidebook (EEA, 2013) emission factors. Technology distribution based on DEPA (2013).
- DGC Danish Gas Technology Centre 2001, Naturgas – Energi og miljø (DGC, 2001).
- Gruijthuijsen & Jensen (2000). Energi- og miljøoversigt, Danish Gas Technology Centre, 2000 (In Danish).

Time series have been estimated for:

- Natural gas applied in gas engines
- Natural gas applied in gas turbines
- Natural gas applied in gas turbines offshore
- Waste incineration plants with power production
- Wood applied in the industrial sector
- Wood applied in residential plants
- Wood applied in institutional/commercial plants
- Wood applied in agricultural plants
- Biogas applied in gas engines

The time series are included in Annex 4.

Table 73 NMVOC emission factors and references 2015.

Fuel type	Fuel	NFR	NFR_name	SNAP	NMVOC, g/GJ	Reference
SOLID	ANODIC CARBON	1A2g	Industry - other	0320	10	Assumed equal to coal. DCE assumption.
	COAL	1A1a	Public electricity and heat production	0101 0102	1.0	EEA (2016), Tier 1, Energy Industries Table 3-2.
		1A2a-g	Industry	03	10	EEA (2016), Tier 1, Industry Table 3-2, assumed lower interval.
		1A4c i	Agriculture/ Forestry	0203	88.8	EEA (2016), Tier 1, Small combustion Table 3-7.
	FLY ASH FOSSIL	1A1a	Public electricity and heat production	0101	1.0	Assumed equal to coal. DCE assumption.
	BROWN COAL BRI.	1A4b i	Residential	0202	484	EEA (2016), Tier 1, Small combustion Table 3-3.
	COKE OVEN COKE	1A2a-g	Industry	03	10	EEA (2016), Tier 1, Industry Table 3-2, assumed lower interval.
		1A4b	Residential	0202	484	EEA (2016), Tier 1, Small combustion Table 3-3 (and Table 3-2).
LIQUID	PETROLEUM COKE	1A2a-g	Industry	03	25	EEA (2016) Tier 1, Industry Table 3-4.
		1A4a	Commercial/ Institutional	0201	20	EEA (2016), Tier 1, Small combustion Table 3-9.
		1A4b	Residential	0202	20	EEA (2016), Tier 1 for 1A4a/1A4c have been applied (DCE assumption). Small combustion Table 3-9.
		1A4c	Agriculture/ Forestry	0203	20	EEA (2016), Tier 1, Small combustion Table 3-9.
	RESIDUAL OIL	1A1a	Public electricity and heat production	010101 010102 010103	0.8	Nielsen et al. (2010a).
				010104	2.3	EEA (2016), Tier 1, Energy Industries Table 3-5.
				010105	2.3	EEA (2016), Tier 1, Energy Industries Table 3-5.
				010203	2.3	EEA (2016), Tier 1, Energy Industries Table 3-5.
		1A1b	Petroleum refining	010306	2.3	EEA (2016), Tier 1, Energy Industries Table 3-5 (and Table 4.1).
		1A2a-g	Industry	03 except engines	0.8	Nielsen et al. (2010a).
				Engines	25	EEA (2016), Tier 1, Industry Table 3-4.
		1A4a	Commercial/ Institutional	0201	20	EEA (2016), Tier 1, Small combustion Table 3-9.
		1A4b	Residential	0202	20	EEA (2016), Tier 1, Small combustion Table 3-9, assumed equal to 1A4a/1A4c.
		1A4c i	Agriculture/ Forestry	0203	20	EEA (2016), Small combustion Tier 1, Table 3-9.
	GAS OIL	1A1a	Public electricity and heat production	010101 010102 010103	0.8	EEA (2016), Tier 1, Energy Industries Table 3-6.
				010104	0.19	EEA (2016), Tier 2, Energy Industries Table 3-18.
				010105	37.1	EEA (2016), Tier 2, Energy Industries Table 3-19.
				0102	0.8	EEA (2016), Tier 1, Energy Industries Table 3-6.

Fuel type	Fuel	NFR	NFR_name	SNAP	NMVOC, g/GJ	Reference
		1A1b	Petroleum refining	010306	0.8	EEA (2016), Tier 1, Energy Industries Table 3-6 (and Table 4.1).
		1A1c	Oil and gas extraction	010504	0.19	EEA (2016), Tier 2, Energy Industries Table 3-18.
		1A2a-g	Industry	03 boilers > 50 MW	0.8	EEA (2016), Tier 1, Energy Industries Table 3-6.
				Gas turbines	0.19	EEA (2016), Tier 2, Energy Industries Table 3-18.
				Engines	37.1	EEA (2016), Tier 2, Energy Industries Table 3-19.
		1A4a	Commercial/ Institutional	0201 except engines	20	EEA (2016), Tier 1, Small Combustion Table 3-9.
				Engines	37.1	EEA (2016), Tier 2, Energy Industries Table 3-19.
		1A4b i	Residential	0202	20	EEA (2016), Tier 1, Small Combustion Table 3-9.
		1A4c	Agriculture/Forestry	020302	20	EEA (2016), Tier 1, Small Combustion Table 3-9.
	KEROSENE	1A2a-g	Industry	03	0.8	EEA (2016), Tier 1, Energy Industries Table 3-6.
		1A4a	Commercial/ Institutional	0201	20	EEA (2016), Tier 1, Small Combustion Table 3-9.
		1A4b i	Residential	0202	20	EEA (2016), Tier 1, Small Combustion Table 3-9.
		1A4c i	Agriculture/ Forestry	0203	20	EEA (2016), Tier 1, Small Combustion Table 3-9.
	LPG	1A1a	Public electricity and heat production	0101 0102	0.8	EEA (2016), Tier 1, Energy Industries Table 3-6.
		1A2a-g	Iron and steel	03	0.8	EEA (2016), Tier 1, Energy Industries Table 3-6.
		1A4a	Commercial/ Institutional	0201	20	EEA (2016), Tier 1, Small Combustion Table 3-9.
		1A4b i	Residential	0202	20	EEA (2016), Tier 1, Small Combustion Table 3-9.
		1A4c i	Agriculture/ Forestry	0203	20	EEA (2016), Tier 1, Small Combustion Table 3-9.
	REFINERY GAS	1A1b	Petroleum refining	0103	1.4	Assumed equal to natural gas fuelled gas turbines. DCE assumption.
GAS	NATURAL GAS	1A1a	Public electricity and heat production	010101 010102 010103	2	Danish Gas Technology Centre (2001).
				010104	1.6	Nielsen et al. (2010a).
				010105	92	Nielsen et al. (2010a).
				0102	2	Danish Gas Technology Centre (2001).
		1A1b	Petroleum refining	0103	2	Danish Gas Technology Centre (2001).
		1A1c	Oil and gas extraction	0105	1.6	Nielsen et al. (2010a)
		1A2a-g	Industry	03 except engines and turbines	2	Danish Gas Technology Centre (2001).
				Turbines	1.6	Nielsen et al. (2010a).
				Engines	92	Nielsen et al. (2010a).
		1A4a	Commercial/ Institutional	0201 except engines	2	Danish Gas Technology Centre (2001).
				Engines	92	Nielsen et al. (2010a).
		1A4b i	Residential	0202 except engines	4	Gruijthuijsen & Jensen (2000).
				Engines	92	Nielsen et al. (2010a).
		1A4c i	Agriculture/ Forestry	0203 except engines	2	Danish Gas Technology Centre (2001).

Fuel type	Fuel	NFR	NFR_name	SNAP	NMVOC, g/GJ	Reference
				Engines	92	Nielsen et al. (2010a).
WASTE	WASTE	1A1a	Public electricity and heat production	0101	0.56	Nielsen et al. (2010a).
				0102	0.56	Nielsen et al. (2010a). The CHP emission factor has been applied for other plant categories.
		1A2a-g	Industry	03	0.56	Nielsen et al. (2010a). The CHP emission factor has been applied for other plant categories.
		1A4a	Commercial/ Institutional	0201	0.56	Nielsen et al. (2010a). The CHP emission factor has been applied for other plant categories.
	INDISTRIAL WASTE	1A2f	Industry	0316	0.56	Nielsen et al. (2010a). The CHP emission factor has been applied for other plant categories.
BIO-MASS	WOOD	1A1a	Public electricity and heat production	0101	5.1	Nielsen et al. (2010a)
				0102	7.3	EEA (2016), Tier 1, Energy Industries Table 3-7.
		1A2a-g	Industry	03	95	Estimate based on country specific data, see (1).
		1A4a	Commercial/ Institutional	0201	58	Estimate based on country specific data, see (1).
		1A4b i	Residential	0202	293	DCE estimate based on DEA (2016a), DEPA (2013) and EEA (2013). The methodology for estimating this emission factor is included in Chapter 6.5.
		1A4c i	Agriculture/ Forestry	0203	58	Estimate based on country specific data, see (1).
	STRAW	1A1a	Public electricity and heat production	0101	0.78	Nielsen et al. (2010a).
				0102	7.3	EEA (2016), Tier 1, Energy Industries Table 3-7.
		1A4b i	Residential	0202	600	EEA (2016), Tier 1, Small Combustion Table 3-6.
		1A4c i	Agriculture/ Forestry	0203	600	EEA (2016). Plants are assumed equal to residential plants.
				020302	12	EEA (2016), Tier 2, Small Combustion Table 3-45.
	BIO OIL	1A1a	Public electricity and heat production	010102	0.8	EEA (2016), Tier 1, Energy Industries Table 3-6 (gas oil).
				010105	37	EEA (2016), Tier 2, Energy Industries Table 3-19 (gas oil, large stationary CI reciprocating engines).
				0102	0.8	EEA (2016), Tier 1, Energy Industries Table 3-6 (gas oil).
		1A2a-g	Industry	03, not engines	0.8	EEA (2016), Tier 1, Energy Industries Table 3-6 (gas oil).
				010105	37	EEA (2016), Tier 2, Energy Industries Table 3-19 (gas oil, large stationary CI reciprocating engines).
		1A4b i	Residential	0202	20	EEA (2016), Tier 1, Small combustion Table 3-9 (liquid fuels).
	BIOGAS	1A1a	Public electricity and heat production	0101	2	Assumed equal to natural gas. DCE assumption.
				010105	10	Nielsen et al. (2010a).

Fuel type	Fuel	NFR	NFR_name	SNAP	NMVOC, g/GJ	Reference
				0102	2	Assumed equal to natural gas. DCE assumption.
		1A2a-g	Industry	03 except engines	2	Assumed equal to natural gas. DCE assumption.
				Engines	10	Nielsen et al. (2010a).
		1A4a	Commercial/ Institutional	0201 except engines	2	Assumed equal to natural gas. DCE assumption.
				Engines	10	Nielsen et al. (2010a).
		1A4b	Residential	0202	4	Assumed equal to natural gas. DCE assumption.
		1A4c i	Agriculture/ Forestry	0203 except engines	2	Assumed equal to natural gas. DCE assumption.
				Engines	10	Nielsen et al. (2010a).
	BIO GASIF GAS	1A1a	Public electricity and heat production	010105	2	Nielsen et al. (2010a).
				0101 except engines	2	Assumed equal to natural gas. DCE assumption.
	BIONATGAS	1A1a	Public electricity and heat production	0101 and 0102	2	Assumed equal to natural gas. DCE assumption.
		1A2a-g	Industry	03	2	Assumed equal to natural gas. DCE assumption.
		1A4a	Commercial/ Institutional	0201	2	Assumed equal to natural gas. DCE assumption.
		1A4b	Residential	0202	4	Assumed equal to natural gas. DCE assumption.
		1A4c	Agriculture/ Forestry	0203	2	Assumed equal to natural gas. DCE assumption.

[1)] The emission factor for combustion of wood in commercial/institutional plants, agricultural plants and industrial plants have been aggregated based on technology specific emission factors: Pellet boilers: 10 g/GJ (EEA, 2016), industrial plants with production of electricity or district heating: 12 g/GJ (EEA, 2016) and other plants 350 g/GJ (EEA, 2016) in 1990-1995 and 175 g/GJ (EEA, 2016) since 2002. The aggregated emission factors for 2015 are 95 g/GJ for industrial plants and 58 g/GJ for commercial/institutional/agricultural plants. A time series have been applied in the inventory.

7.8 CO emission factors

The CO emission factors and references are shown in Table 74.

The emission factors for CO refer to:

- The EEA Guidebook (EEA, 2016) and EEA (2007).
- An emission measurement program for decentralised CHP plants (Nielsen et al., 2010a).
- Danish legislation (DEPA, 2001a)
- Aggregated emission factor based on the technology distribution for residential wood combustion and guidebook (EEA, 2013) emission factors. Technology distribution based on DEPA (2013). See Chapter 6.5
- DCE estimate based on annual environmental reports for Danish waste incineration plants without power production, year 2000
- Nikolaisen et al. (1998)
- Jensen & Nielsen (1990)
- Bjerrum (2002)
- Sander (2002)
- Gruijthuijsen & Jensen (2000)
- Kristensen & Kristensen (2004)

Time series is estimated for:

- Natural gas fuelled engines
- Natural gas fuelled gas turbines
- Waste incineration, CHP plants
- Waste incineration, other plants
- Wood combustion in district heating plants
- Wood combustion in industrial plants
- Wood combustion in commercial/institutional plants
- Wood combustion in agricultural plants
- Wood combustion in residential plants
- Straw combustion in district heating plants
- Straw combustion in residential / agricultural plants

The time series are included in Annex 4.

Table 74 CO emission factors and references 2015.

Fuel type	Fuel	NFR	NFR_name	SNAP	CO emission factor g/GJ	Reference
SOLID	ANODIC CARBON	1A2a-g	Industry	03	10	Assumed the same emission factor as for coal. DCE assumption.
	COAL	1A1a	Public electricity and heat production	0101 and 0102	10	Sander (2002).
		1A2a-g	Industry	03	10	Assumed equal to boilers in public electricity and heat production. DCE assumption.
		1A4c i	Agriculture/ Forestry	0203	931	EEA (2016), Tier 2, Small Combustion Table 3.15, residential boilers, solid fuels.
	FLY ASH FOSSIL	1A1a	Public electricity and heat production	0101	10	EEA (2016), Tier 1, Small Combustion Table 3.7.
	BROWN COAL BRI.	1A4b i	Residential	0202	4787	Assumed equal to coal. DCE assumption.
	COKE OVEN COKE	1A2a-g	Industry	03	10	EEA (2016), Tier 2, Small Combustion Table 3.15, residential boilers, solid fuels.
		1A4b	Residential	0202	4787	Assumed the same emission factor as for coal. DCE assumption.
LIQUID	PETROLEUM COKE	1A2a-g	Industry	03	66	EEA (2016), Tier 2, Small Combustion Table 3.15, residential boilers, solid fuels.
		1A4a	Commercial/Institutional	0201	93	EEA (2016), Tier 1, Manufacturing industries and construction Table 3.4 for liquid fuels.
		1A4b	Residential	0202	93	EEA (2016), Tier 1, Manufacturing industries and construction Table 3.4 for liquid fuels.
		1A4c	Agriculture/ Forestry	0203	93	EEA (2016), Tier 1, Small Combustion Table 3.9.
	RESIDUAL OIL	1A1a	Electricity and heat production	010101 010104 010105	15	EEA (2016), Tier 1, Small Combustion Table 3.9 (assumed equal to the emission factor for 1A4a/1A4c).
				010102 010103	2.8	EEA (2016), Tier 1, Small Combustion Table 3.9.
				0102	15.1	Sander (2002).
		1A1b	Petroleum refining	010306	6	Nielsen et al. (2010a).
		1A2a-g	Industry	03 except engines	2.8	EEA (2016), Tier 1, Energy Industries Table 3.5.
				Engines	130	EEA (2016), Tier 2, Energy Industries Table 4.4.
		1A4a	Commercial/Institutional	0201	40	Nielsen et al. (2010a).
		1A4b	Residential	0202	57	EEA (2016). Tier 2 emission factor for gas oil fuelled engines in Energy Industries. Refers to Nielsen et al. (2010a).
		1A4c i	Agriculture/ Forestry	0203	40	EEA (2016). Tier 2, Small Combustion Table 3.25.
	GAS OIL	1A1a	Public electricity and heat production	0101 except engines	15	EEA (2016), Tier 1, Small Combustion Table 3.5.
				Engines	130	EEA (2016). Tier 2, Small Combustion Table 3.25.
				0102	16.2	Sander (2002).

Fuel type	Fuel	NFR	NFR_name	SNAP	CO emission factor g/GJ	Reference
		1A1b	Petroleum refining	010306	16.2	Nielsen et al. (2010a).
		1A1c	Oil and gas extraction	0105	15	EEA (2016), Tier 1, Energy Industries Table 3.6
		1A2a-g	Industry	03 except gas turbines and engines	66	EEA (2016), Tier 1, Energy Industries Table 4.5.
				Gas turbines	15	Sander (2002).
				Engines	130	EEA (2016), Tier 1, Manufacturing industries and construction Table 3.4 for liquid fuels.
		1A4a	Commercial/ Institutional	0201 except engines	40	Sander (2002).
				Engines	130	Nielsen et al. (2010a)
		1A4b i	Residential	0202	3.7	EEA (2016). Tier 2, Small Combustion Table 3.24.
		1A4c	Agriculture/Forestry	0203	40	Nielsen et al. (2010a).
	KEROSENE	1A2a-g	Industry	03	66	EEA (2016). Tier 2, Small Combustion Table 3.18. Gas oil applied in small residential boilers.
		1A4a	Commercial/ Institutional	0201	40	EEA (2016). Tier 2, Small Combustion Table 3.24.
		1A4b i	Residential	0202	3.7	EEA (2016), Tier 1, Manufacturing industries and construction Table 3.4 for liquid fuels.
		1A4c i	Agriculture/ Forestry	0203	40	EEA (2016). Tier 2, Small Combustion Table 3.24.
	LPG	1A1a	Public electricity and heat production	0101 and 0102	16.2	EEA (2016). Tier 2, Small Combustion Table 3.18. Gas oil applied in small residential boilers.
		1A2a-g	Industry	03	66	EEA (2016). Tier 2, Small Combustion Table 3.24.
		1A4a	Commercial/ Institutional	0201	40	EEA (2016), Tier 1, Energy Industries Table 3.6.
		1A4b i	Residential	0202	3.7	EEA (2016), Tier 1, Manufacturing industries and construction Table 3.4 for liquid fuels.
		1A4c i	Agriculture/ Forestry	0203	40	EEA (2016). Tier 2, Small Combustion Table 3.24.
	REFINERY GAS	1A1b	Petroleum refining	0103	12.1	EEA (2016). Tier 2, Small Combustion Table 3.18. Gas oil applied in small residential boilers.
GAS	NATURAL GAS	1A1a	Public electricity and heat production	010101 and 010102	15	EEA (2016). Tier 2, Small Combustion Table 3.24.
				010103	28	EEA (2016). Tier 1, Energy Industries Table 4.2 for refinery gas applied in petroleum refining.
				010104	4.8	Sander (2002).
				010105	58	DEPA (2001a).
				0102	28	Nielsen et al. (2010a).
		1A1b	Petroleum refining	0103	28	Nielsen et al. (2010a).
		1A1c	Oil and gas extraction	0105	4.8	DEPA (2001a).
		1A2a-g	Industry	03 except gas turbines and engines	28	Assumed equal to district heating plants.
				Gas turbines	4.8	Nielsen et al. (2010a).
				Engines	58	DEPA (2001a).

Fuel type	Fuel	NFR	NFR_name	SNAP	CO emission factor g/GJ	Reference
		1A4a	Commercial/ Institutional	0201 except engines	28	Nielsen et al. (2010a).
				Engines	58	Nielsen et al. (2010a).
		1A4b i	Residential	0202 except engines	20	DEPA (2001a).
				Engines	58	Nielsen et al. (2010a).
		1A4c i	Agriculture/ Forestry	0203 except engines	28	Gruijthuijsen & Jensen (2000).
				Engines	58	Nielsen et al. (2010a).
WASTE	WASTE	1A1a	Public electricity and heat production	0101	3.9	DEPA (2001a).
				0102	10	Nielsen et al. (2010a).
		1A2a-g	Industry	03	10	Nielsen et al. (2010a).
		1A4a	Commercial/ Institutional	0201	10	DCE calculation based on annual environmental reports for Danish plants year 2000.
	INDISTRIAL WASTE	1A2f	Industry	0316	10	Assumed equal to district heating plants. DCE assumption.
BIO-MASS	WOOD	1A1a	Public electricity and heat production	0101	90	Assumed equal to district heating plants. DCE assumption.
				010203	240	Assumed equal to waste, district heating plants. DCE assumption.
		1A2a-g	Industry	03	240	Nielsen et al. (2010a).
		1A4a	Commercial/ Institutional	020100	240	DEPA (2001a).
		1A4b i	Residential	0202	2158	DEPA (2001a).
		1A4c i	Agriculture/ Forestry	020300	240	DEPA (2001a).
	STRAW	1A1a	Public electricity and heat production	0101	67	DCE estimate based on DEA (2016a), DEPA (2013) and EEA (2013). The methodology for estimating this emission factor is included in Chapter 6.5.
				0102	325	DEPA (2001a).
		1A4b i	Residential	0202	2000	Nielsen et al. (2010a).
		1A4c i	Agriculture/ Forestry	0203	2000	DEPA (2001a); Nikolaisen et al (1998)
				020302	325	EEA (2007); Jensen & Nielsen (1990) and Bjerrum (2002), Kristensen & Kristensen (2004). Time series.
	BIO OIL	1A1a	Public electricity and heat production	0101 and 0102	15	Assumed same emission factor as for gas oil. DCE assumption.
		1A2a-g	Industry	03	66	DEPA (2001a); Nikolaisen et al (1998).
		1A4b i	Residential	0202	3.7	Assumed same emission factor as for gas oil. DCE assumption.
	BIOGAS	1A1a	Public electricity and heat production	0101 except engines	36	Assumed same emission factor as for gas oil. DCE assumption.
				Engines	310	Assumed same emission factor as for gas oil. DCE assumption.

Fuel type	Fuel	NFR	NFR_name	SNAP	CO emission factor g/GJ	Reference
				0102	36	Assumed same emission factor as for gas oil. DCE assumption.
		1A2a-g	Industry	03 except engines	36	Assumed same emission factor as for gas oil. DCE assumption.
				Engines	310	DEPA (2001a).
		1A4a	Commercial/ Institutional	0201 except engines	36	Nielsen et al. (2010a).
				Engines	310	DEPA (2001a).
		1A4b	Residential	0202	20	DEPA (2001a).
		1A4c i	Agriculture/ Forestry	0203 except engines	36	Nielsen et al. (2010a).
				Engines	310	DEPA (2001a).
	BIO GASIF GAS	1A1a	Public electricity and heat production	010105	586	Nielsen et al. (2010a).
				010101	36	Assumed equal to natural gas. DCE assumption.
	BIONATGAS	1A1a	Public electricity and heat production	0101	15	DEPA (2001a).
				0102	28	Nielsen et al. (2010a).
		1A2a-g	Industry	03	28	Nielsen et al. (2010a).
		1A4a	Commercial/ Institutional	0201	28	DEPA (2001a).
		1A4b i	Residential	0202	20	Assumed equal to natural gas. DCE assumption.
		1A4c i	Agriculture/ Forestry	0203	28	Assumed equal to natural gas. DCE assumption.

7.9 NH_3 emission factors

NH_3 emission factors are estimated for:

- Wood combustion in residential plants
- Wood combustion in commercial/institutional, agricultural and industrial plants
- Straw combustion in residential and agricultural plants
- Straw combustion in commercial/institutional and industrial plants
- Waste incineration in public power production
- Residential combustion of coal
- Residential combustion of BKB
- Residential combustion of coke oven coke

The NH_3 emission factors and references are shown in Table 75.

The emission factor for waste incineration plants refers to a Danish emission measurement programme (Nielsen et al., 2010a). The emission factor for residential wood combustion is based on technology distribution and emission factors from the EEA Guidebook (EEA, 2013). All other emission factors refer to the EEA (2016).

Time series are estimated for residential wood combustion; see Chapter 6.5 and Annex 4.

Table 75 NH_3 emission factors and references 2015.

Fuel	NFR (SNAP)	Emission factor, g/GJ	Reference
Coal	1A4b	0.3	EEA (2016), Tier 1, Small combustion Table 3-3.
BKB	1A4b	0.3	EEA (2016), Tier 1, Small combustion Table 3-3.
Coke oven coke	1A4b	0.3	EEA (2016), Tier 1, Small combustion Table 3-3.
Wood	1A4b	37.4	DCE estimate based on DEA (2016a), DEPA (2013) and EEA (2013). The methodology for estimating this emission factor is included in Chapter 6.5.
Wood	1A4a, 1A4c, 1A2	37	EEA (2016), Tier 1, Small Combustion Table 3-10.
Waste	1A1a	0.29	Nielsen et al. (2010a).
Straw	1A4b, 1A4c	70	EEA (2016), Tier 1, Small Combustion Table 3-6.
Straw	1A4a, 1A2	37	EEA (2016), Tier 1, Small Combustion Table 3-10.

7.10 Particulate matter (PM) emission factors

The PM emission factors and references are shown in Table 76.

The emission factors for PM refer to:

- The TNO/CEPMEIP emission factor database (TNO, 2001)
- Danish legislation:

- DEPA (2001a), The Danish Environmental Protection Agency, Luftvejledningen (legislation from Danish Environmental Protection Agency)
- DEPA (1990), The Danish Environmental Protection Agency, Bekendtgørelse 698 (legislation from Danish Environmental Protection Agency).

- Calculations based on plant-specific emission data from a considerable number of waste incineration plants
- Aggregated emission factors for residential wood combustion based on technology distribution (DEPA, 2013) and technology specific emission factors from EEA (2016), DEPA (2010a), and Glasius (2005). See Chapter 6.5
- Two emission measurement programs for decentralised CHP plants (Nielsen et al., 2010a; Nielsen & Illerup, 2003)
- An emission measurement program for large power plants (Livbjerg et al., 2001)
- Additional personal communication concerning straw combustion in residential plants (Kristensen, 2017c)

Emission factor time series have been estimated for residential wood combustion and waste incineration. All other emission factors are considered constant in 1990-2015. The time series are included in Annex 4.

Table 76 PM emission factors and references 2015.

fuel_type	fuel_id	fuel_gr_abbr	nfr_id_EA	snap_id	TSP, g/GJ	Reference for TSP	PM_{10}, g/GJ	$PM_{2.5}$, g/GJ	Reference for PM_{10} and $PM_{2.5}$ emission factors or for the PM_{10} and the $PM_{2.5}$ fraction
SOLID	101A	ANODIC CARBON	1A2g iii	0320	17	DEPA (1990), DEPA (1995)	12	7	TNO (2001)
	102A	COAL	1A1a	0101	3	Livbjerg et al. (2001)	2.6	2.1	Livbjerg et al. (2001)
				0102	6	TNO (2001)	6	5	TNO (2001)
			1A2 a-g	03	17	DEPA (1990), DEPA (1995)	12	7	TNO (2001)
			1A4c i	0203	17	DEPA (1990), DEPA (1995)	12	7	TNO (2001)
	103A	FLY ASH FOSSIL	1A1a	0101	3	Livbjerg et al. (2001)	2.6	2.1	Livbjerg et al. (2001)
	106A	BROWN COAL BRI.	1A4b i	0202	17	Same emission factor as for coal is assumed (DCE assumption)	12	7	Same emission factor as for coal is assumed (DCE assumption)
	107A	COKE OVEN COKE	1A2 a-g	03	17	Same emission factor as for coal is assumed (DCE assumption)	12	7	Same emission factor as for coal is assumed (DCE assumption)
			1A4b	0202	17	Same emission factor as for coal is assumed (DCE assumption)	12	7	Same emission factor as for coal is assumed (DCE assumption)
LIQUID	110A	PETROLEUM COKE	1A2a-g	03	10	TNO (2001)	7	3	TNO (2001)
			1A4a	0201	100	TNO (2001)	60	30	TNO (2001)
			1A4b	0202	100	TNO (2001)	60	30	TNO (2001)
			1A4c	0203	100	TNO (2001)	60	30	TNO (2001)
	203A	RESIDUAL OIL	1A1a	010101	3	Nielsen & Illerup (2003)	3	2.5	Nielsen & Illerup (2003)
				010102	9.5	Nielsen et al. (2010a)	9.5	7.9	TNO (2001)
				010103	9.5	Nielsen et al. (2010a)	9.5	7.9	TNO (2001)
				010104	3	TNO (2001)	3	2.5	TNO (2001)
				010105	3	TNO (2001)	3	2.5	TNO (2001)
				0102	3	TNO (2001)	3	2.5	TNO (2001)
			1A1b	010306	50	TNO (2001)	40	35	TNO (2001)
			1A2 a-g	03	9.5	Nielsen et al. (2010a)	7.1	4.8	TNO (2001)
			1A4a	0201	14	DEPA (1990), DEPA (1995)	10.5	7	TNO (2001)
			1A4b	0202	14	DEPA (1990), DEPA (1995)	10.5	7	TNO (2001)
			1A4c i	0203	14	DEPA (1990), DEPA (1995)	10.5	7	TNO (2001)
	204A	GAS OIL	1A1a	0101	5	TNO (2001)	5	5	TNO (2001)
				0102	5	TNO (2001)	5	5	TNO (2001)
			1A1b	010306	5	TNO (2001)	5	5	TNO (2001)
			1A1c	0105	5	TNO (2001)	5	5	TNO (2001)
			1A2a-g	03	5	TNO (2001)	5	5	TNO (2001)
			1A4a i	0201	5	TNO (2001)	5	5	TNO (2001)
			1A4b i	0202	5	TNO (2001)	5	5	TNO (2001)
			1A4c i	0203	5	TNO (2001)	5	5	TNO (2001)
	206A	KEROSENE	1A2 a-g	all	5	TNO (2001)	5	5	TNO (2001)
			1A4a i	0201	5	TNO (2001)	5	5	TNO (2001)

fuel_type	fuel_id	fuel_gr_abbr	nfr_id_EA	snap_id	TSP, g/GJ	Reference for TSP	PM_{10}, g/GJ	$PM_{2.5}$, g/GJ	Reference for PM_{10} and $PM_{2.5}$ emission factors or for the PM_{10} and the $PM_{2.5}$ fraction
			1A4b i	0202	5	TNO (2001)	5	5	TNO (2001)
			1A4c i	0203	5	TNO (2001)	5	5	TNO (2001)
	303A	LPG	1A1a	0101, 0102	0.2	TNO (2001)	0.2	0.2	TNO (2001)
			1A2 a-g	03	0.2	TNO (2001)	0.2	0.2	TNO (2001)
			1A4a i	0201	0.2	TNO (2001)	0.2	0.2	TNO (2001)
			1A4b i	0202	0.2	TNO (2001)	0.2	0.2	TNO (2001)
			1A4c i	0203	0.2	TNO (2001)	0.2	0.2	TNO (2001)
	308A	REFINERY GAS	1A1b	0103	5	TNO (2001)	5	5	TNO (2001)
GAS	301A	NATURAL GAS	1A1a	0101	0.1	TNO (2001)	0.1	0.1	TNO (2001)
				Gas turbines	0.1	Nielsen & Illerup (2003)	0.061	0.051	Nielsen & Illerup (2003)
				Engines	0.76	Nielsen & Illerup (2003)	0.189	0.161	Nielsen & Illerup (2003)
				0102	0.1	TNO (2001)	0.1	0.1	TNO (2001)
			1A1b	0103	0.1	TNO (2001)	0.1	0.1	TNO (2001)
			1A1c	0105	0.1	Nielsen & Illerup (2003)	0.061	0.051	Nielsen & Illerup (2003)
			1A2a-g	Engines	0.76	Nielsen & Illerup (2003)	0.189	0.161	Nielsen & Illerup (2003)
				Turbines	0.1	Nielsen & Illerup (2003)	0.061	0.051	Nielsen & Illerup (2003)
				Other	0.1	TNO (2001)	0.1	0.1	TNO (2001)
			1A4a i	0201	0.1	TNO (2001)	0.1	0.1	TNO (2001)
				Engines	0.76	Nielsen & Illerup (2003)	0.189	0.161	Nielsen & Illerup (2003)
			1A4b i	0202	0.1	TNO (2001)	0.1	0.1	TNO (2001)
				Engines	0.76	Nielsen & Illerup (2003)	0.189	0.161	Nielsen & Illerup (2003)
			1A4c i	0203	0.1	TNO (2001)	0.1	0.1	TNO (2001)
				Engines	0.76	Nielsen & Illerup (2003)	0.189	0.161	Nielsen & Illerup (2003)
WASTE	114A	WASTE	1A1a	0101	0.29	Nielsen et al. (2010a)	0.29	0.29	Nielsen & Illerup (2003)
				0102	4.2	The emission factor have been estimated by DCE based on plant specific data from MSW incineration plants, district heating, 2008	3.2	2.1	The emission factor have been estimated by DCE based on plant specific data from MSW incineration plants, district heating, 2008
			1A2 a-g	03	4.2	The emission factor have been estimated by DCE based on plant specific data from MSW incineration plants, district heating, 2008	3.2	2.1	The emission factor have been estimated by DCE based on plant specific data from MSW incineration plants, district heating, 2008
			1A4a i	0201	4.2	The emission factor have been estimated by DCE based on plant specific data from MSW incineration plants, district heating, 2008	3.2	2.1	The emission factor have been estimated by DCE based on plant specific data from MSW incineration plants, district heating, 2008

fuel_type	fuel_id	fuel_gr_abbr	nfr_id_EA	snap_id	TSP, g/GJ	Reference for TSP	PM_{10}, g/GJ	$PM_{2.5}$, g/GJ	Reference for PM_{10} and $PM_{2.5}$ emission factors or for the PM_{10} and the $PM_{2.5}$ fraction
	115A	INDUSTRIAL WASTE	1A2f	0316	4.2	The emission factor have been estimated by DCE based on plant specific data from MSW incineration plants, district heating, 2008	3.2	2.1	The emission factor have been estimated by DCE based on plant specific data from MSW incineration plants, district heating, 2008
BIOMASS	111A	WOOD	1A1a	0101	10	Nielsen et al. (2010a)	7.45	4.82	Estimated based on the TSP emission factor
				0102	19	DEPA (2001a)	13	10	DEPA (2001), TNO (2001)
			1A2 a-g	03	19	DEPA (2001a)	13	10	DEPA (2001), TNO (2001)
			1A4a i	0201	143	DEPA (2001a)	143	135	TNO (2001)
			1A4b i	0202	367	DCE estimate based on DEA (2016a), DEPA (2013), Glasius et al. (2005), EEA (2013), Illerup et al. (2007), Nordic Ecolabelling (2012). See Chapter 6.5.	348	340	DCE estimate based on DEA (2016a), DEPA (2013), Glasius et al. (2005), EEA (2013), Illerup et al. (2007), Nordic Ecolabelling (2012). See Chapter 6.5
			1A4c i	0203	143	DEPA (2001a)	143	135	TNO (2001)
	117A	STRAW	1A1a i	0101	2.3	Nielsen et al. (2010a)	1.71	1.11	Nielsen & Illerup (2003)
				0102	21	DEPA (2001a)	15	12	TNO (2001)
			1A4b i	0202	433	Kristensen (2017c)	433	433	Zefeng (2011)
			1A4c i	0203	433	Kristensen (2017c)	433	433	Zefeng (2011)
				020302	21	DEPA (2001a)	15	12	TNO (2001)
	215A	BIO OIL	1A1a	0101	5	Assuming same emission factors as for gas oil (DCE assumption)	5	5	Assuming same emission factors as for gas oil (DCE assumption)
				0102	5	Assuming same emission factors as for gas oil (DCE assumption)	5	5	Assuming same emission factors as for gas oil (DCE assumption)
			1A2a-g	03	5	Assuming same emission factors as for gas oil (DCE assumption)	5	5	Assuming same emission factors as for gas oil (DCE assumption)
			1A4b i	0202	5	Assuming same emission factors as for gas oil (DCE assumption)	5	5	Assuming same emission factors as for gas oil (DCE assumption)
	309A	BIOGAS	1A1a	0101, not engines	1.5	DEPA (1990), DEPA (1995)	1.5	1.5	All TSP emission is assumed to be <2,5µm (DCE assumption)
				010105	2.63	Nielsen & Illerup (2003)	0.451	0.206	Nielsen & Illerup (2003)
				0102	1.5	DEPA (1990), DEPA (1995)	1.5	1.5	All TSP emission is assumed to be <2,5µm (DCE assumption)
			1A2a-g	Engines	2.63	Nielsen & Illerup (2003)	0.451	0.206	Nielsen & Illerup (2003)
				Other	1.5	DEPA (1990), DEPA (1995)	1.5	1.5	All TSP emission is assumed to be <2,5µm (DCE assumption)
			1A4a i	0201	1.5	DEPA (1990), DEPA (1995)	1.5	1.5	All TSP emission is assumed to be <2,5µm (DCE assumption)

fuel_type	fuel_id	fuel_gr_abbr	nfr_id_EA	snap_id	TSP, g/GJ	Reference for TSP	PM_{10}, g/GJ	$PM_{2.5}$, g/GJ	Reference for PM_{10} and $PM_{2.5}$ emission factors or for the PM_{10} and the $PM_{2.5}$ fraction
				Engines	2.63	Nielsen & Illerup (2003)	0.451	0.206	Nielsen & Illerup (2003)
			1A4b	0202	0.1	Biogas upgraded for the town gas grid. Assumed equal to natural gas	0.1	0.1	Biogas upgraded for the town gas grid. Assumed equal to natural gas
			1A4c i	0203	1.5	DEPA (1990), DEPA (1995)	1.5	1.5	All TSP emission is assumed to be <2,5µm (DCE assumption)
				Engines	2.63	Nielsen & Illerup (2003)	0.451	0.206	Nielsen & Illerup (2003)
	310A	BIO GASIF GAS	1A1a	010105	2.63	Same emission factor as for biogas assumed (DCE assumption)	0.451	0.206	Same emission factor as for biogas assumed (DCE assumption)
				010101	0.2	Assumed equal to LPG	0.2	0.2	Assumed equal to LPG
	315A	BIONATGAS	1A1a	0101 and 0102	0.1	Assumed equal to natural gas	0.1	0.1	Assumed equal to natural gas
			1A2a-g	03	0.1	Assumed equal to natural gas	0.1	0.1	Assumed equal to natural gas
			1A4a	0201	0.1	Assumed equal to natural gas	0.1	0.1	Assumed equal to natural gas
			1A4b	0202	0.1	Assumed equal to natural gas	0.1	0.1	Assumed equal to natural gas
			1A4c	0203	0.1	Assumed equal to natural gas	0.1	0.1	Assumed equal to natural gas

7.11 Black carbon (BC) emission factors

The BC fractions of $PM_{2.5}$ and the references for the fractions are shown in Table 77.

Emission factor fractions for BC all refer to EEA (2013). All emission factors are expressed as percentage of $PM_{2.5}$.

Time series have been estimated for residential wood combustion and for waste incineration. The BC fraction of $PM_{2.5}$ is considered constant for each fuel/technology. The time series are included in Annex 4.

Table 77 BC fraction of $PM_{2.5}$, 2015.

Fuel_id	Fuel	NFR	SNAP	BC_%	Reference: EEA Guidebook 2013.
101A	Anodic carbon	1A2	03	2.2%	Energy Industries, Table 3-2
102A	Coal	1A1a	0101, 0102	2.2%	Energy Industries, Table 3-2
102A	Coal	1A4a	0201	6.4%	Small Combustion, Table 3-7
102A	Coal	1A4b	0202	6.4%	Small Combustion, Table 3-3
102A	Coal	1A4c	0203	6.4%	Small Combustion, Table 3-7
102A	Coal	1A2	03	6.4%	Manufacturing Industries, Table 3-2
103A	Fly ash fossil	1A1a	010104	2.2%	Assumed equal to coal. DCE assumption.
106A	Brown coal bri.	1A4a	0201	6.4%	Small Combustion, Table 3-7
106A	Brown coal bri.	1A4b	0202	6.4%	Small Combustion, Table 3-3
106A	Brown coal bri.	1A4c	0203	6.4%	Small Combustion, Table 3-7
106A	Brown coal bri.	1A2	03	6.4%	Manufacturing Industries, Table 3-2
107A	Coke oven coke	1A4b	0202	6.4%	Small Combustion, Table 3-3
107A	Coke oven coke	1A2	0301	6.4%	Manufacturing Industries, Table 3-2
110A	Petroleum coke	1A1a	0101	5.6%	Energy Industries, table 3-5
110A	Petroleum coke	1A4a	0201	56.0%	Small Combustion, Table 3-5
110A	Petroleum coke	1A4b	0202	8.5%	Small Combustion, Table 3-5
110A	Petroleum coke	1A4c	0203	56.0%	Small Combustion, Table 3-5
110A	Petroleum coke	1A2	03	56.0%	Manufacturing Industries, Table 3-4
111A	Wood	1A1a	0101, 0102	3.3%	Energy Industries, Table 3-7
111A	Wood	1A4a	0201	28.0%	Small Combustion, Table 3-10
111A	Wood	1A4b	0202	14.4%	See residential wood combustion, Chapter 6.5
111A	Wood	1A4c	0203	28.0%	Small Combustion, Table 3-10
111A	Wood	1A2	0301	28.0%	Manufacturing Industries, Table 3-5
114A	Waste	1A1a	0101, 0102	3.5%	Municipal waste Incineration, Table 3-1
114A	Waste	1A4a	0201	3.5%	Municipal waste Incineration, Table 3-1
114A	Waste	1A2	03	3.5%	Municipal waste Incineration, Table 3-1
117A	Straw	1A1a	0101, 0102	3.3%	Energy Industries, Table 3-7
117A	Straw	1A4a	020103	28.0%	Small Combustion, Table 3-10
117A	Straw	1A4b	0202	28.0%	Small Combustion, Table 3-10 (Assumed equal to agricultural plants)
117A	Straw	1A4c	020300	28.0%	Small Combustion, Table 3-10
117A	Straw	1A2	03	28.0%	Manufacturing Industries, Table 3-5
203A	Residual oil	1A1a	0101, 0102	5.6%	Energy Industries, Table 3-5
203A	Residual oil	1A1b	010306	5.6%	Energy Industries, Table 4-4
203A	Residual oil	1A4a	0201	56.0%	Small Combustion, Table 3-9
203A	Residual oil	1A4b	0202	8.5%	Small Combustion, Table 3-5
203A	Residual oil	1A4c	0203	56.0%	Small Combustion, Table 3-9
203A	Residual oil	1A2	03	56.0%	Manufacturing Industries, Table 3-4
204A	Gas oil	1A1a	0101, 0102	33.5%	Energy Industries, Table 3-6
204A	Gas oil	1A1a	010104	33.5%	Energy Industries, Table 3-18
204A	Gas oil	1A1a	010105	78.0%	Energy Industries, Table 3-19
204A	Gas oil	1A1a	010204	33.5%	Energy Industries, Table 3-18
204A	Gas oil	1A1a	010205	78.0%	Energy Industries, Table 3-19
204A	Gas oil	1A1b	010306	33.5%	Energy Industries, Table 4-5
204A	Gas oil	1A1c	010504	33.5%	Energy Industries, Table 3-18
204A	Gas oil	1A1c	010505	78.0%	Energy Industries, Table 3-19
204A	Gas oil	1A4a	0201	56.0%	Small Combustion, Table 3-9
204A	Gas oil	1A4a	020105	78.0%	Energy Industries, Table 3-37

Fuel_id	Fuel	NFR	SNAP	BC_%	Reference: EEA Guidebook 2013.
Continued					
204A	Gas oil	1A4b	0202	3.9%	Small Combustion, Table 3-21
204A	Gas oil	1A4b	020204	78.0%	Energy Industries, Table 3-19
204A	Gas oil	1A4c	0203	56.0%	Small Combustion, Table 3-9
204A	Gas oil	1A4c	020304	78.0%	Energy Industries, Table 3-37
204A	Gas oil	1A2	03	56.0%	Manufacturing Industries, Table 3-4
204A	Gas oil	1A2	03xx04	33.5%	Energy Industries, Table 3-18
204A	Gas oil	1A2	03xx05	78.0%	Energy Industries, Table 3-19
206A	Kerosene	1A4a	0201	56.0%	Small Combustion, Table 3-9
206A	Kerosene	1A4b	0202	8.5%	Small Combustion, Table 3-5
206A	Kerosene	1A4c	0203	56.0%	Small Combustion, Table 3-9
206A	Kerosene	1A2	03	56.0%	Manufacturing Industries, Table 3-4
215A	Bio oil	1A1a	0101	33.5%	Assumed equal to gas oil. DCE assumption.
215A	Bio oil	1A1a	010105	78.0%	Assumed equal to gas oil. DCE assumption.
215A	Bio oil	1A1a	0102	33.5%	Assumed equal to gas oil. DCE assumption.
215A	Bio oil	1A1a	020105	78.0%	Assumed equal to gas oil. DCE assumption.
215A	Bio oil	1A4b	020200	3.9%	Assumed equal to gas oil. DCE assumption.
215A	Bio oil	1A4b	020304	78.0%	Assumed equal to gas oil. DCE assumption.
215A	Bio oil	1A2	03	56.0%	Manufacturing Industries, Table 3-4
215A	Bio oil	1A2	03xx05	78.0%	Assumed equal to gas oil. DCE assumption.
225A	Orimulsion	1A1a	010101	2.2%	Assumed equal to coal. DCE assumption.
301A	Natural gas	1A1a	0101	2.5%	Energy Industries, Table 3-4
301A	Natural gas	1A1a	010104	2.5%	Energy Industries, Table 3-17
301A	Natural gas	1A1a	010105	2.5%	Energy Industries, Table 3-20
301A	Natural gas	1A1a	010200	2.5%	Energy Industries, Table 3-4
301A	Natural gas	1A1c	0105	2.5%	Energy Industries, Table 3-4
301A	Natural gas	1A1c	010504	2.5%	Energy Industries, Table 3-17
301A	Natural gas	1A1c	010505	2.5%	Energy Industries, Table 3-20
301A	Natural gas	A14a	0201	4.0%	Small Combustion, Table 3-8
301A	Natural gas	1A4a	020104	2.5%	Small Combustion, Table 3-34
301A	Natural gas	1A4a	020105	2.5%	Energy Industries, Table 3-36
301A	Natural gas	1A4b	0202	5.4%	Small Combustion, Table 3-19
301A	Natural gas	1A4b	020204	2.5%	Energy Industries, Table 3-20
301A	Natural gas	1A4c	020300	4.0%	Small Combustion, Table 3-8
301A	Natural gas	1A4c	020303	2.5%	Energy Industries, Table 3-17
301A	Natural gas	1A4c	020304	2.5%	Energy Industries, Table 3-36
301A	Natural gas	1A2	03	4.0%	Manufacturing Industries, Table 3-3
301A	Natural gas	1A2	03xx04	2.5%	Energy Industries, Table 3-17
301A	Natural gas	1A2	03xx05	2.5%	Energy Industries, Table 3-20
303A	LPG	1A1a	0101	2.5%	Assumed equal to natural gas. DCE assumption
303A	LPG	1A1a	010104	2.5%	Assumed equal to natural gas. DCE assumption
303A	LPG	1A1a	0102	2.5%	Assumed equal to natural gas. DCE assumption
303A	LPG	1A2b	010306	2.5%	Assumed equal to natural gas. DCE assumption.
303A	LPG	1A4a	020100	4.0%	Assumed equal to natural gas. DCE assumption
303A	LPG	1A4a	020105	4.0%	Assumed equal to natural gas. DCE assumption
303A	LPG	1A4b	0202	5.4%	Assumed equal to natural gas. DCE assumption
303A	LPG	1A4c	0203	4.0%	Assumed equal to natural gas. DCE assumption
303A	LPG	1A2	03	4.0%	Assumed equal to natural gas. DCE assumption
308A	Refinery gas	1A1a	010101	18.4%	Energy Industries, Table 4-2
308A	Refinery gas	1A1a	010203	18.4%	Energy Industries, Table 4-2
308A	Refinery gas	1A1b	0103	18.4%	Energy Industries, Table 4-2
308A	Refinery gas	1A2	03	18.4%	Energy Industries, Table 4-2
309A	Biogas	1A1a	0101	3.3%	Assumed % equal to wood. DCE assumption
309A	Biogas	1A1a	0102	3.3%	Assumed % equal to wood. DCE assumption
309A	Biogas	1A1c	010505	3.3%	Assumed % equal to wood. DCE assumption
309A	Biogas	1A4a	0201	28.0%	Assumed % equal to wood. DCE assumption
309A	Biogas	1A4c	0203	28.0%	Assumed % equal to wood. DCE assumption
309A	Biogas	1A2	03	28.0%	Assumed % equal to wood. DCE assumption
310A	Bio gasif. gas	1A1a	010105	3.3%	Assumed % equal to wood. DCE assumption
310A	Bio gasif. gas	1A4a	020105	3.3%	Assumed % equal to wood. DCE assumption
310A	Bio gasif. gas	1A4c	020304	28.0%	Assumed % equal to wood. DCE assumption
310A	Bio gasif. gas	1A2	03xx05	28.0%	Assumed % equal to wood. DCE assumption
315A	Bio natural gas	1A1a	0101	2.5%	Assumed equal to natural gas. DCE assumption

Fuel_id	Fuel	NFR	SNAP	BC_%	Reference: EEA Guidebook 2013.
Continued					
315A	Bio natural gas	1A1a	0102	2.5%	Assumed equal to natural gas. DCE assumption
315A	Bio natural gas	1A4a	0201	4.0%	Assumed equal to natural gas. DCE assumption
315A	Bio natural gas	1A4b	0202	5.4%	Assumed equal to natural gas. DCE assumption
315A	Bio natural gas	1A4c	0203	4.0%	Assumed equal to natural gas. DCE assumption
315A	Bio natural gas	1A2	03	4.0%	Assumed equal to natural gas. DCE assumption

7.12 Heavy metals emission factors

The heavy metal emission inventory is documented in detail in Nielsen et al. (2013c).

The HM emission factors and references are shown in Table 78.

The emission factors for HM refer to:

- Two emission measurement programmes carried out on Danish decentralised CHP plants (Nielsen et al., 2010a; Nielsen & Illerup, 2003).
- Implied Emission Factors for power plants based on plant specific data reported by the power plant owners
- A CONCAWE study (Gon & Kuenen, 2009)
- Data for Danish natural gas (Gruijthuijsen, 2001; Energinet.dk, 2010)
- The EEA Guidebook (EEA, 2016)
- Struschka et al. (2008)
- Hedberg et al. (2002)

Time series are estimated for:

- Coal combustion in electricity and district heat production plants
- Waste incineration plants in public power production plants
- Waste incineration in other combustion plants

The time series are included in Annex 4.

Table 78 HM emission factors and references, 2015.

fuel_type	fuel_gr_abbr	nfr	nfr_name	snap	As mg/GJ	Cd mg/GJ	Cr mg/GJ	Cu mg/GJ	Hg mg/GJ	Ni mg/GJ	Pb mg/GJ	Se mg/GJ	Zn mg/GJ	Reference
SOLID	ANODIC CARBON	1A2g	Industry	all	4	1.8	13.5	17.5	7.9	13	134	1.8	200	EEA (2016), Tier 1, Industry Table 3-2.
	COAL	1A1a	Public electricity and heat production	all	0.51	0.07	0.86	0.48	1.3	0.97	0.62	5.9	1.9	Implied emission factor 2008 estimated by DCE based on plant specific emission data for power plants.
		All other	All other	All	4	1.8	13.5	17.5	7.9	13	134	23	200	EEA (2016), Tier 1, Industry Table 3-2. For Se: Tier 1, Energy Industries Table 3-2. See also Nielsen et al. (2013c).
	FLY ASH FOSSIL	1A1a	Public electricity and heat production	0101	0.51	0.07	0.86	0.48	1.3	0.97	0.62	5.9	1.9	Implied emission factor 2008 estimated by DCE based on plant specific emission data for power plants.
	BROWN COAL BRI.	1A4b i	Residential	0202	2.5	1.5	11.2	22.3	5.1	12.7	130	1.8	220	EEA (2016), Tier 1, Small Combustion Table 3-3. For Se Tier 1, Small Combustion Table 3-7 (for 1A4a/c).
	COKE OVEN COKE	1A2 a-g	Industry	all	4	1.8	13.5	17.5	7.9	13	134	1.8	200	EEA (2016), Tier 1, Industry Table 3-2.
		1A4b	Residential	0202	2.5	1.5	11.2	22.3	5.1	12.7	130	1.8	220	EEA (2016), Tier 1, Small Combustion Table 3-3. For Se Tier 1, Small Combustion Table 3-7 (for 1A4a/c).
LIQUID	PETROLEUM COKE	all	All	all	3.98	1.2	2.55	5.31	0.341	255	4.56	2.06	87.8	EEA (2016), Tier 1, Energy Industries Table 3-5 (for heavy fuel oil).
	RESIDUAL OIL	1A1a	Public electricity and heat production	all	2.1	0.53	2.6	2.4	0.21	362	2.6	1.2	7.4	Implied emission factor 2008 estimated by DCE based on plant specific emission data for power plants.
		All other	All other	all	3.98	1.2	2.55	5.31	0.341	255	4.56	2.06	87.8	EEA (2016), Tier 1, Energy Industries Table 3-5 (for heavy fuel oil).
	GAS OIL	-	Engines (reciprocating)	all	0.055	0.011	0.2	0.3	0.11	0.013	0.15	0.22	58	Nielsen et al. (2010a).
		-	All other	all	0.002	0.001	0.2	0.13	0.12	0.005	0.012	0.002	0.42	Gon & Kuenen (2009).
	KEROSENE	All	All	all	0.002	0.001	0.2	0.13	0.12	0.005	0.012	0.002	0.42	Assumed equal to gas oil. DCE assumption.

fuel_type	fuel_gr_abbr	nfr	nfr_name	snap	As mg/GJ	Cd mg/GJ	Cr mg/GJ	Cu mg/GJ	Hg mg/GJ	Ni mg/GJ	Pb mg/GJ	Se mg/GJ	Zn mg/GJ	Reference
	LPG	All	All	all	0.002	0.001	0.2	0.13	0.12	0.005	0.012	0.002	0.42	EEA (2016), Tier 1, Small Combustion Table 3-5 (for 1A4b, other liquid fuels).
	REFINERY GAS	1A1b	Petroleum refining	all	0.343	0.712	2.74	2.22	0.086	3.6	1.79	0.42	25.5	EEA (2016), Tier 1, Energy Industries Table 4-2 (for refinery gas, 1A1b).
GAS	NATURAL GAS	-	Engines (reciprocating)	all	0.05	0.003	0.05	0.01	0.1	0.05	0.04	0.01	2.9	Nielsen et al. (2010a).
		-	All other	all	0.119	0.00025	0.00076	0.000076	0.1	0.00051	0.0015	0.0112	0.0015	Gruijthuijsen (2001). For Hg: Nielsen et al. (2010a), also applied in EEA (2016), Tier 1, Energy Industries Table 3-4. For Se: EEA (2016), Tier 1, Energy Industries Table 3-4.
WASTE	WASTE	-	All	all	0.59	0.44	1.56	1.3	1.79	2.06	5.52	1.11	2.33	Nielsen et al. (2010a).
	INDUSTRIAL WASTE	1A2f	Industry - Other	all	0.59	0.44	1.56	1.3	1.79	2.06	5.52	1.11	2.33	Nielsen et al. (2010a).
BIOMASS	WOOD	-	All non-residential	all	0.19	0.27	2.34	2.6	0.4	2.34	3.62	0.5	2.3	For Cd, Hg and Zn: Nielsen et al. (2010a). For Cr, Cu, Ni and Pb: Nielsen & Illerup (2003). For As and Se: EEA (2016), Tier 1, Small Combustion Table 3-10 (for solid biomass applied in 1A4a/c). Reference for As: Struschka et al. (2008). Reference for Se: Hedberg et al. (2002).
		1A4b i	Residential	all	0.19	13	23	6	0.56	2	27	0.5	512	EEA (2016)
	STRAW	1A1a	Public electricity and heat production	all	0.19	0.32	1.6	1.7	0.31	1.7	6.2	0.5	0.41	For Cd, Hg and Zn: Nielsen et al. (2010a). For Cr, Cu, Ni and Pb: Nielsen & Illerup (2003). For As and Se: EEA (2016), Tier 1, Small Combustion Table 3-10.
		1A4b i	Residential	0202	0.19	13	23	6	0.56	2	27	0.5	512	EEA (2016), Tier 1, Small Combustion Table 3-6.
		1A4c i	Agriculture/ Forestry	0203	0.19	13	23	6	0.56	2	27	0.5	512	EEA (2016), Tier 1, Small Combustion Table 3-6 (for 1A4b).

fuel_type	fuel_gr_abbr	nfr	nfr_name	snap	As mg/GJ	Cd mg/GJ	Cr mg/GJ	Cu mg/GJ	Hg mg/GJ	Ni mg/GJ	Pb mg/GJ	Se mg/GJ	Zn mg/GJ	Reference
	BIO OIL	-	Engines	en-gines	0.055	0.011	0.2	0.3	0.11	0.013	0.15	0.22	58	Assumed equal to gas oil. DCE assumption.
		-	All other	-	0.002	0.001	0.2	0.13	0.12	0.005	0.012	0.002	0.42	Assumed equal to gas oil. DCE assumption.
	BIOGAS	-	All non-residential	all	0.04	0.002	0.18	0.31	0.12	0.23	0.005	0.21	3.95	Nielsen et al. (2010a)
		1A4b	Residential	all	0.119	0.00025	0.00076	0.000076	0.1	0.00051	0.0015	0.0112	0.0015	Assumed equal to natural gas (biogas upgraded for distribution in the town gas grid).
	BIO GASIF GAS	1A1a	Public electricity and heat production	010105	0.12	0.009	0.029	0.045	0.54	0.014	0.022	0.18	0.058	Nielsen et al. (2010a).
				010101	0.002	0.001	0.2	0.13	0.12	0.005	0.012	0.002	0.42	Assumed equal to gas oil. DCE assumption.
	BIONATGAS	-	All	all	0.119	0.00025	0.00076	0.000076	0.1	0.00051	0.0015	0.0112	0.0015	Assumed equal to natural gas.

7.13 PAH emission factors

The PAH emission factors and references are shown in Table 79.

The emission factors for PAH refer to:

- Research carried out by TNO (Berdowski et al., 1995)
- Research carried out by Statistics Norway (Finstad et al., 2001)
- An emission measurement program performed on biomass-fuelled plants. The project was carried out for the Danish Environmental Protection Agency (Jensen & Nielsen, 1996)
- Finstad et al. (2001)
- Two emission measurement programs carried out on Danish decentralised CHP plants (Nielsen et al., 2010a; Nielsen & Illerup, 2003)
- Additional information from the gas sector (Jensen, 2001)
- EEA (2016)

For residential wood combustion, country specific emission factors are aggregated based on technology distribution in the sector (DEPA, 2013) and technology specific emission factors (EEA, 2013; DEPA 2010a).

In general, emission factors for PAH are uncertain.

Time series are estimated for:

- Residential wood combustion
- Natural gas fuelled engines
- Biogas-fuelled engines
- Waste incineration plants.

The time series are included in Annex 4.

Table 79 PAH emission factors and references, 2015.

fuel_type	fuel_id	fuel_gr_abbr	nfr_id	snap_id	Benzo(a)-pyrene µg per GJ	Benzo(b)-fluoranthene µg per GJ	Benzo(k)-fluoranthene µg per GJ	Indeno-(1,2,3-c,d)-pyrene µg per GJ	Reference
SOLID	102A	ANODIC CARBON	1A2g	0320	23	929	929	698	Finstad et al. (2001)
		COAL	1A1a	All	0.7	37	29	1.1	EEA (2016). Tier 1, Energy Industries Table 3-2
			1A2 a-g	All	23	929	929	698	Finstad et al. (2001)
			1A4c i	0203	59524	63492	1984	119048	Finstad et al. (2001)
	103A	FLY ASH FOSSIL	1A1a	0101	0.7	37	29	1.1	EEA (2016). Tier 1, Energy Industries Table 3-2
	106A	BROWN COAL BRI.	1A4b i	0202	59524	63492	1984	119048	Finstad et al. (2001) (Same emission factor as for coal is assumed. DCE assumption)
	107A	COKE OVEN COKE	1A2 a-g	all	23	929	929	698	Finstad et al. (2001)
			1A4b	0202	59524	63492	1984	119048	Finstad et al. (2001)
LIQUID	110A	PETROLEUM COKE	1A2 a-g	all	80	42	66	160	Finstad et al. (2001). Assumed equal to residual oil
			1A4a i	all	80	42	66	160	Finstad et al. (2001). Assumed equal to residual oil
			1A4b i	all	80	42	66	160	Finstad et al. (2001). Assumed equal to residual oil
			1A4c i	all	80	42	66	160	Finstad et al. (2001). Assumed equal to residual oil
	203A	RESIDUAL OIL	1A1a	All	109.6	475.41	93.21	177.28	Finstad et al. (2001)
			1A1b	010306	109.6	475.41	93.21	177.28	Finstad et al. (2001)
			1A2 a-g	all	80	42	66	160	Finstad et al. (2001)
			1A4a i	all	80	42	66	160	Finstad et al. (2001)
			1A4b i	all	80	42	66	160	Finstad et al. (2001)
			1A4c i	all	80	42	66	160	Finstad et al. (2001)
	204A	GAS OIL	1A1a	Not engines	109.6	475.41	93.21	177.28	Finstad et al. (2001)
				Engines	1.9	15	1.7	1.5	Nielsen et al. (2010a)
			1A1b	010306	109.6	475.41	93.21	177.28	Finstad et al. (2001)
			1A1c	010504	109.6	475.41	93.21	177.28	Finstad et al. (2001)
			1A2 a-g	Not engines	80	42	66	160	Finstad et al. (2001)
				Engines	1.9	15	1.7	1.5	Nielsen et al. (2010a)
			1A4a i	Not engines	80	42	66	160	Finstad et al. (2001)
				Engines	1.9	15	1.7	1.5	Nielsen et al. (2010a)
			1A4b i	0202	80	42	66	160	Finstad et al. (2001)
			1A4c i	0203	80	42	66	160	Finstad et al. (2001)
GAS	301A	NATURAL GAS	1A1a	010104	1	1	2	3	Nielsen & Illerup (2003)
				010105	1.2	9	1.7	1.8	Nielsen et al. (2010a)

fuel_type	fuel_id	fuel_gr_abbr	nfr_id	snap_id	Benzo(a)-pyrene	Benzo(b)-fluoranthene	Benzo(k)-fluoranthene	Indeno-(1,2,3-c,d)-pyrene	Reference
			1A1c	010504	1	1	2	3	Nielsen & Illerup (2003)
			1A2 a-g	Turbines	1	1	2	3	Nielsen & Illerup (2003)
				Engines	1.2	9	1.7	1.8	Nielsen et al. (2010a)
			1A4a i	020105	1.2	9	1.7	1.8	Nielsen et al. (2010a)
			1A4b i	020202	0.133	0.663	0.265	2.653	Jensen (2001)
				020204	1.2	9	1.7	1.8	Nielsen et al. (2010a)
			1A4c i	020304	1.2	9	1.7	1.8	Nielsen et al. (2010a)
WASTE	114A	WASTE	1A1a	all	0.8	1.7	0.9	1.1	Nielsen et al. (2010a)
			1A4a i	0201	0.8	1.7	0.9	1.1	Nielsen et al. (2010a)
	115A	INDUSTRIAL WASTE	1A2f	0316	0.8	1.7	0.9	1.1	Nielsen et al. (2010a)
BIOMASS	111A	WOOD	1A1a	0101	11	15	5	10	Nielsen et al. (2010a)
				0102	6.46	1292.52	1292.52	11.56	Finstad et al. (2001)
			1A2 a-g	all	6.46	1292.52	1292.52	11.56	Finstad et al. (2001)
			1A4a i	0201	168707	221769	73469	119728	Finstad et al. (2001)
			1A4b i	All	44471	45593	16511	24782	Aggregated emission factor based on the technology distribution in the sector and guidebook (EEA, 2013) emission factors. Technology distribution based on: DEPA (2013)
			1A4c i	all	168707	221769	73469	119728	Finstad et al. (2001)
	117A	STRAW	1A1a	0101	0.5	0.5	0.5	0.5	Nielsen et al. (2010a)
				0102	1529	3452	1400	1029	Berdowski et al. (1995)
			1A4b i	0202	12956	12828	6912	4222	Berdowski et al. (1995)
			1A4c i	0203	12956	12828	6912	4222	Berdowski et al. (1995)
	215A	BIO OIL	1A1a	all	109.6	475.41	93.21	177.28	Same emission factors as for gas oil is assumed (DCE assumption)
			1A2 a-g	all	80	42	66	160	Same emission factors as for gas oil is assumed (DCE assumption)
			1A4b i	0202	80	42	66	160	Same emission factors as for gas oil is assumed (DCE assumption)
	309A	BIOGAS	Engines	All	1.3	1.2	1.2	0.6	Nielsen et al. (2010a)
	310A	BIO GASIF GAS	Engines	010105	2	2	2	2	Nielsen et al. (2010a)

7.14 PCDD/F emission factors

The PCDD/F emission factors and references are shown in Table 80.

The emission factor for residential wood combustion refers to technology specific emission factors (EEA, 2013; DEPA 2010a) and to updated technology distribution data (DEPA, 2013).

The emission factors for decentralised CHP plants[32] refer to an emission measurement program for these plants (Nielsen et al. 2010a).

All other emission factors refer to research regarding PCDD/F emission carried out by NERI (now DCE) to prepare a new PCDD/F emission inventory (Henriksen et al., 2006).

In general, emission factors for PCDD/F are uncertain.

Time series are estimated for:

- Residential wood combustion
- Waste incineration plants

The time series are included in Annex 4.

Table 80 Emission factors for PCDD/F, 2015.

fuel_type	fuel_id	fuel_gr_abbr	nfr_id	snap_id	PCDD/F, ng per GJ
SOLID	102A	ANODIC CARBON COAL	1A2g	0320	1.32
			1A1a	0101 and 0102	1.32
			1A2 a-g	03	1.32
			1A4c i	0203	300
	103A	FLY ASH FOSSIL	1A1a	0101	1.32
	106A	BROWN COAL BRI.	1A4b i	0202	800
	107A	COKE OVEN COKE	1A2 a-g	03	1.32
			1A4c	0203	800
LIQUID	110A	PETROLEUM COKE	1A2 a-g	03	1.32
			1A4a i	0201	300
			1A4b i	0202	300
			1A4c i	0203	300
	203A	RESIDUAL OIL	1A1a	All	0.882
			1A1b	010306	0.882
			1A2 a-g	03	0.882
			1A4a i	0201	10
			1A4b i	0202	10
			1A4c i	0203	10
	204A	GAS OIL	1A1a	Not engines	0.882
				Engines	0.99
			1A1b	010306	0.882
			1A1c	010504	0.882
			1A2 a-g	Not engines	0.882
				Engines	0.99
			1A4a i	Not engines	10
				Engines	0.99
			1A4b i	0202	10
			1A4c i	0203	10
	206A	KEROSENE	1A2a-g	03	0.882
			1A4a i	0201	10
			1A4b i	0202	10

[32] Natural gas fueled engines, biogas fueled engines, gas oil fueled engines, engines fueled by biomass producer gas, CHP plants combusting straw or wood and waste incineration plants.

fuel_type	fuel_id	fuel_gr_abbr	nfr_id	snap_id	PCDD/F, ng per GJ
			1A4c i	0203	10
	303A	LPG	1A1a	0101 and 0102	0.025
			1A2a-g	03	0.025
			1A4a i	0201	2
			1A4b i	0202	2
			1A4c i	0203	2
	308A	REFINERY GAS	1A1b	0103	0.025
GAS	301A	NATURAL GAS	1A1a	Not engines	0.025
				Engines	0.57
			1A1b	0103	0.025
			1A1c	010504	0.025
			1A2 a-g	03, Not engines	0.025
				Engines	0.57
			1A4a i	0201	2
				020105	0.57
			1A4b i	0202	2
				020204	0.57
			1A4c i	0203	2
				020304	0.57
WASTE	114A	WASTE	1A1a	0101 and 0102	5
			1A4a i	0201	5
	115A	INDUSTRIAL WASTE	1A2f	0316	5
BIOMASS	111A	WOOD	1A1a	0101	14
				0102	1
			1A2 a-g	03	1
			1A4a i	0201	400
			1A4b i	0202	304
			1A4c i	0203	400
	117A	STRAW	1A1a	0101	19
				0102	22
			1A4b i	0202	500
			1A4c i	0203	400
	215A	BIO OIL	1A1a	0101 and 0102	0.882
			1A2 a-g	03	0.882
			1A4b i	0202	10
	309A	BIOGAS	1A1a	Engines	0.96
				Not engines	0.025
			1A2a-g	Not engines	0.025
				Engines	0.96
			1A4a i	Not engines	2
				Engines	0.96
			1A4b	Not engines	2
			1A4c i	Not engines	2
				Engines	0.96
	310A	BIO GASIF GAS	1A1a	010105	1.7
				010101	0.025
	315A	BIONATGAS	1A1a	0101 and 0102	0.025
			1A2a-g	03	0.025
			1A4a	0201	2
			1A4b	0202	2
			1A4c	0203	2

7.15 HCB emission factors

The HCB emission inventory is documented in Nielsen et al. (2014b).

Table 81 shows the emission factors and references for the Danish emission factors.

Table 81 Emission factors for HCB in stationary combustion.

Fuel	NFR (SNAP)	Emission factor, ng/GJ	Reference
Coal	1A1, 1A2	6,700	Grochowalski & Konieczyński (2008); EEA (2013)
Coal	1A4b	1,200,000	Syc et al. (2011)
Coal	1A4a and 1A4c	23,000	Syc et al. (2011)
Other solid fuels	1A1, 1A2	6,700	Assumed equal to coal.
Other solid fuels	1A4	1,200,000	Assumed equal to coal.
Liquid fuels[1)]	1A1, 1A2, 1A4	220	Nielsen et al. (2010a)
Gaseous fuels	1A1, 1A2, 1A4	-	Negligible
Waste	1A1, 1A2, 1A4	4300	Nielsen et al. (2010a). A time series have been estimated. The emission factor for 1990 (190,000 ng/GJ) refer to Pacyna et al. (2003).
Wood	1A1, 1A2	5,000	EEA (2013)
Wood	1A4	5,000	EEA (2013)
Straw	1A1, 1A2	113	Nielsen et al. (2010a)
Straw	1A4	5,000	EEA (2013)
Biogas	1A1, 1A2, 1A4	190	Nielsen et al. (2010a)
Producer gas	1A1, 1A2, 1A4	800	Nielsen et al. (2010a)

1) The emission factor for LPG and refinery gas is negligible.

For coal, the emission factor from Grochowalski & Konieczyński (2008) is applied for energy industries and for industrial plants. This emission factor is also applied in the EEA Guidebook (EEA, 2013).

For residential plants, the emission factor 1,200,000 ng/GJ is applied referring to Syc et al. (2011). For commercial/institutional plants and for plants in agriculture/forestry the lower end of the value in Syc et al. (2011) (23,000 ng/GJ) is applied.

The emission factor for gas oil fuelled CHP engines (220 ng/GJ) referring to Nielsen et al. (2010a) is applied for all liquid fuels except for LPG and refinery gas.

For gaseous fuels, LPG and refinery gas no data are available and the emission is negligible.

For waste combustion, emission data from Danish plants are available and these data are applied (Nielsen et al., 2010a). The emission factor 4,300 ng/GJ is applied for 2005 onwards. The HCB emission factor for 1990 refers to Pacyna et al. (2003). The emission of HCB is related to emission of PCDD/F and the decline rate between 1990 and 2005 is based on the decline rate for PCDD/F.

Recent emission measurements from Polish industrial waste incineration plants confirms the emission factor level for waste incineration considering that the PCDD/F emission level is 15 times the PCDD/F emission level for Danish plants.

For wood combustion, the emission factors from EEA (2013) are applied for both energy industries, industrial plants and for non-industrial plants. For residential wood combustion, it would be relevant to estimate a time series. However, the currently available data are considered insufficient for this estimate.

The Cl content in straw is higher than in wood (Villeneuve et al., 2013) and thus the emission from straw combustion might potentially be higher. However, the emission factor for CHP plants combusting straw reported in Nielsen et al. (2010a) is lower than the emission factor applied for wood.

The emission factor for energy industries and industrial combustion refer to Nielsen et al. (2010a). For non-industrial plants, the EEA (2013) emission factor is applied.

The emission factors for biogas and producer gas both refer to Nielsen et al (2010a).

7.16 PCB emission factors

The PCB emission inventory has been documented in Nielsen et al. (2014b).

PCB emission is strongly related to the Cl content of the fuel (Syc et al., 2011) and to the emission level for PCDD/F (Hedman et al., 2006; Syc et al., 2011; Pandelova et al., 2009).

The Cl content of straw, bark and manure is higher than for wood (Villeneuve et al., 2012). Villeneuve et al. (2012) states the Cl contents 50-60 mg/kg wood, 100-370 mg/kg bark, 1000-7000 mg/kg straw.

Different references for PCB emissions are not directly comparable because some PCB emission data are reported for individual PCB congeners, some as a sum of a specified list of PCB congeners and some PCB emission data are reported as toxic equivalence (teq) based on toxicity equivalence factors (TEF) for 12 dioxin-like PCB congeners. The emission measurements reported by Thistlethwaite (2001a and 2001b) show that the emission of non-dioxin-like PCBs is high compared to the emission of dioxin-like PCBs.

Furthermore, teq values based on TEF are reported as WHO_{2005}-teq or WHO_{1998}-teq. This difference is however typically less than 50%[33].

Table 82 shows the emission factors that have been selected for the Danish PCB emission inventory and reference for each emission factor. All emission factors are dioxin-like PCBs (but not teq values). PCB emission factors have been added for all fuels except LPG, refinery gas and natural gas. The emission from these three fuels is considered negligible.

[33] Data have been compared for a few datasets in which each dioxin-like PCB congener was specified.

Table 82 Emission factors for ∑dl-PCB in stationary combustion, 2015.

Fuel	NFR (SNAP)	Emission factor, ∑ dl-PCB, ng/GJ	Emission factor, PCB, ng WHO_{1998}-teq/GJ	Reference
Coal	1A1	839	3.16	Grochowalski & Konieczyński (2008)
Coal	1A2	5,700	53	Thistlethwaite (2001a)
Coal	1A4	7,403	66	Syc et al. (2011)
Other solid fuels	1A1	839	3.16	Assumed equal to coal.
Other solid fuels	1A2	5,700	53	Assumed equal to coal.
Other solid fuels	1A4	7,403	66	Assumed equal to coal.
Residual oil and orimulsion	1A1, 1A2, 1A4	839	3.2	The teq value refers to Dyke et al. (2003). The TEQ value is equal to the emission factor for coal combustion in power plants and the sum of dioxin-like PCB congeners has been assumed equal to the corresponding factor for coal.
Gas oil	1A1, 1A2, 1A4	93	0.11	Nielsen et al. (2010a)
Other liquid fuels[1)]	1A1, 1A2, 1A4	93	0.11	Assumed equal to gas oil.
Gaseous fuels	1A1, 1A2, 1A4	-	-	Negligible
Waste	1A1, 1A2, 1A4	109 (time series)	0.28 (time series)	Nielsen et al. (2010a). A time series have been estimated. The emission factor for 1990 (46,000 ng/GJ or 117 ng WHO1998teq/GJ) have been estimated based on the assumption that the PCB emission factor time series follow the PCDD/F time series.
Wood	1A1, 1A2, 1A4a/c	2,800	21	Thistlethwaite (2001a)
Wood	1A4b	2,752 (time series)	20.6)	Hedman et al. (2006). A time series have been estimated based on time series for technologies applied in Denmark.
Straw	1A1, 1A2	3,110	31.2	Assumed equal to residential plants.
Straw	1A4	3,110	31.2	Syc et al. (2011)
Biogas	1A1, 1A2, 1A4	90	0.13	Nielsen et al. (2010a)
Producer gas	1A1, 1A2, 1A4	144	0.17	Nielsen et al. (2010a)

1. Except LPG and refinery gas.

The emission factor for waste incineration refers to recent Danish field measurements. Historical data are not available, but a time series have been estimated based on the assumption that the dl-PCB emission factor follows the PCDD/-F emission factor. The estimated emission factor for 1990 is 45,671 ng/GJ or 117 ng WHO-teq/GJ. This emission level is confirmed by other references (Kakareka & Kukharchyk, 2005; Andrijewski et al., 2004). The emission factor time series is shown in Table 83.

For residential wood combustion, technology specific emission factors in toxicological equivalence are available from Hedman et al. (2006). However, sums of dioxin-like PCBs are not included in the reference. The emission factors for dioxin-like PCBs have been estimated based on the data for toxicological equivalence and the sum of dioxin-like PCBs in Thistlethwaite (2001a). Thus, the teq factors referring to Hedman (2006) have been multiplied by 2800/21. This assumption is highly uncertain, but the resulting emission factors seem to be in agreement with other references for residential wood combustion. A technology distribution time series for residential wood combustion in Denmark is available and have been applied for estimating the time series for the aggregated emission factor shown in Table 83.

Emission factor time series for waste incineration and for residential wood combustion are shown in Table 83.

Table 83 Emission factor time series for waste incineration and for residential wood combustion.

Year	Waste incineration ∑dl-PCB, ng/GJ	Residential wood combustion ∑dl-PCB, ng/GJ
1990	45671	6648
1991	38063	6622
1992	30433	6588
1993	22825	6559
1994	19773	6510
1995	16721	6445
1996	13690	6327
1997	10638	6231
1998	7586	6101
1999	5515	5708
2000	3423	5390
2001	3423	4834
2002	3423	4609
2003	3423	4548
2004	1766	4477
2005	109	4267
2006	109	4028
2007	109	4050
2008	109	3801
2009	109	3496
2010	109	3309
2011	109	3138
2012	109	2974
2013	109	2710
2014	109	2362
2015	109	2308

7.17 Implied emission factors

A considerable part of the emission data for waste incineration plants and large power plants are plant-specific. Thus, the area source emission factors do not necessarily represent average values for these plant categories. To attain a set of emission factors that expresses the average emission for power plants combusting coal and for waste incineration plants, implied emission factors have been calculated for these two plant categories. The implied emission factors are presented in Annex 10. The implied emission factors are calculated as total emission divided by total fuel consumption.

8. Uncertainty

Uncertainty estimates include uncertainty with regard to the total emission inventory as well as uncertainty with regard to trends. Uncertainties are reported annually for both greenhouse gases and for other pollutants.

8.1 Greenhouse gases

8.1.1 Methodology

The uncertainty for greenhouse gas emissions have been estimated according to the IPCC Guidelines (IPCC, 2006). This year the uncertainty has been estimated only by the tier 1 approach.

The tier 1 approach is based on a normal distribution and a confidence interval of 95 %.

The input data for the tier 1 approach are:

- Emission data for the base year and the latest year
- Uncertainties for emission factors
- Uncertainty for fuel consumption rates

The emission source categories applied are listed in Table 84.

Source categories

Due to large differences in data uncertainty, some emission source categories have been further disaggregated than suggested in the IPCC Guidelines (2006):

- For five different fuels, CO_2 emissions based on ETS data and on non-ETS data have been considered two different emission sources.
- CH_4 emission from natural gas fuelled engines
- CH_4 emission from biogas fuelled engines
- CH_4 emission from residential wood combustion
- CH_4 emission from residential and agricultural combustion of straw
- N_2O emission from residential wood combustion
- N_2O emission from residential and agricultural combustion of straw

The separate uncertainty estimation for gas engine CH_4 emission and CH_4 emission from other plants is applied, because in Denmark, the CH_4 emission from gas engines is much larger than the emission from other stationary combustion plants, and the CH_4 emission factor for gas engines is estimated with a much smaller uncertainty level than for other stationary combustion plants.

The 2015 uncertainty levels have been applied in the tier 1 approach.

Fuel

The applied uncertainty rates for fuel consumption are shown below.

Table 84 Uncertainties for fuel consumption 2015.

IPCC Source category	2015	Reference
1A1, 1A2, 1A4 St. comb. Coal, ETS data, CO_2	0.5%	ETS data
1A1, 1A2, 1A4 St. comb. Coal, no ETS data, CO_2	0.9%	Estimated based on IPCC (2006) values
1A1, 1A2, 1A4 St. comb., BKB, CO_2	2.9%	Estimated based on IPCC (2006) values
1A1, 1A2, 1A4 St. comb., Coke oven coke, CO_2	1.8%	Estimated based on IPCC (2006) values
1A1, 1A2, 1A4 St. comb., Fossil waste, ETS data, CO_2	2%	DCE assumption
1A1, 1A2, 1A4 St. comb., Fossil waste, no ETS data, CO_2	5%	DCE assumption
1A1, 1A2, 1A4 St. comb., Petroleum coke, ETS data, CO_2	0.5%	ETS data
1A1, 1A2, 1A4 St. comb., Petroleum coke, no ETS data, CO_2	1.9%	Estimated based on IPCC (2006) values
1A1, 1A2, 1A4 St. comb., Residual oil, ETS data, CO_2	0.5%	ETS data
1A1, 1A2, 1A4 St. comb., Residual oil, no ETS data, CO_2	1.6%	Estimated based on IPCC (2006) values
1A1, 1A2, 1A4 St. comb., Gas oil, CO_2	2.6%	Estimated based on IPCC (2006) values
1A1, 1A2, 1A4 St. comb., Kerosene, CO_2	1.7%	Estimated based on IPCC (2006) values
1A1, 1A2, 1A4 St. comb., LPG, CO_2	2.6%	Estimated based on IPCC (2006) values
1A1b,St. comb., Refinery gas, CO_2	1.0%	Estimated based on IPCC (2006) values
1A1, 1A2, 1A4, Stationary combustion, Natural gas, onshore, CO_2	1.3%	Estimated based on IPCC (2006) values. Offshore gas turbines not included in this category
1A1c Offshore gas turbines, Natural gas, CO_2	0.5%	ETS data for 2015, IPCC (2006) for 1990
1A1, Stationary Combustion, SOLID, CH_4	1.0%	IPCC (2006), less than 1%
1A1, Stationary Combustion, LIQUID, CH_4	1.0%	IPCC (2006), less than 1%
1A1, Stationary Combustion, not engines, GAS, CH_4	1.0%	IPCC (2006), less than 1%
1A1, Stationary Combustion, WASTE, CH_4	3.0%	DCE assumption. The uncertainty for the total consumption of waste is lower than the uncertainty for the fossil part
1A1, Stationary Combustion, not engines, BIOMASS, CH_4	3.0%	DCE assumption
1A2, Stationary Combustion, SOLID, CH_4	2.0%	IPCC (2006)
1A2, Stationary Combustion, LIQUID, CH_4	2.0%	IPCC (2006)
1A2, Stationary Combustion, not engines, GAS, CH_4	2.0%	IPCC (2006)
1A2, Stationary Combustion, WASTE, CH_4	3.0%	DCE assumption. The uncertainty for the total consumption of waste is lower than the uncertainty for the fossil part
1A2, Stationary Combustion, not engines, BIOMASS, CH_4	10.0%	IPCC (2006)
1A4, Stationary Combustion, SOLID, CH_4	3.0%	IPCC (2006)
1A4, Stationary Combustion, LIQUID, CH_4	3.0%	IPCC (2006)
1A4, Stationary Combustion, not engines, GAS, CH_4	3.0%	IPCC (2006)
1A4, Stationary Combustion, WASTE, CH_4	3.0%	DCE assumption. The uncertainty for the total consumption of waste is lower than the uncertainty for the fossil part
1A4, Stationary Combustion, not engines, not residential wood and not residential/agricultural straw, BIOMASS, CH_4	10.0%	IPCC (2006)
1A4, Stationary Combustion, Residential wood combustion, CH_4	20.0%	DCE assumption
1A4, Stationary Combustion, Residential and agricultural straw combustion, CH_4	15.0%	DCE assumption
1A1, 1A2, 1A4 Natural gas fuelled engines, GAS, CH_4	1.0%	Lindgren (2010)
1A1, 1A2, 1A4 Biogas fuelled engines, GAS, CH_4	3.0%	DCE assumption
1A1, Stationary Combustion, SOLID, N_2O	1.0%	IPCC (2006), less than 1%
1A1, Stationary Combustion, LIQUID, N_2O	1.0%	IPCC (2006), less than 1%
1A1, Stationary Combustion, GAS, N_2O	1.0%	IPCC (2006), less than 1%
1A1, Stationary Combustion, WASTE, N_2O	3.0%	DCE assumption
1A1, Stationary Combustion, BIOMASS, N_2O	3.0%	DCE assumption
1A2, Stationary Combustion, SOLID, N_2O	2.0%	IPCC (2006)
1A2, Stationary Combustion, LIQUID, N_2O	2.0%	IPCC (2006)
1A2, Stationary Combustion, GAS, N_2O	2.0%	IPCC (2006)
1A2, Stationary Combustion, WASTE, N_2O	3.0%	DCE assumption
1A2, Stationary Combustion, BIOMASS, N_2O	10.0%	IPCC (2006)
1A4, Stationary Combustion, SOLID, N_2O	3.0%	IPCC (2006)
1A4, Stationary Combustion, LIQUID, N_2O	3.0%	IPCC (2006)
1A4, Stationary Combustion, GAS, N_2O	3.0%	IPCC (2006)
1A4, Stationary Combustion, WASTE, N_2O	3.0%	DCE assumption
1A4, Stationary Combustion, not residential wood and not residential/agricultural straw, BIOMASS, N_2O	10.0%	IPCC (2006)
1A4b, Stationary Combustion, Residential wood combustion, N_2O	20.0%	DCE assumption
1A4b/c, Stationary Combustion, Residential and agricultural straw combustion, N_2O	15.0%	DCE assumption

Emission factors

Uncertainties for emission factors are shown in Table 85.

Table 85 Uncertainties for emission factors, 2015.

IPCC Source category	2015	Reference
1A1, 1A2, 1A4 St. comb. Coal, ETS data, CO_2	0.3%	ETS data, 2015 estimate
1A1, 1A2, 1A4 St. comb. Coal, no ETS data, CO_2	1.0%	DCE assumption
1A1, 1A2, 1A4 St. comb., BKB, CO_2	5.0%	IPCC (2000), chapter 2.1.1.6
1A1, 1A2, 1A4 St. comb., Coke oven coke, CO_2	5.0%	IPCC (2000), chapter 2.1.1.6
1A1, 1A2, 1A4 St. comb., Fossil waste, ETS data, CO_2	5.0%	ETS data, DCE estimate based on Astrup et al. (2012)
1A1, 1A2, 1A4 St. comb., Fossil waste, no ETS data, CO_2	10.0%	Non-ETS data, DCE estimate based on Astrup et al. (2012)
1A1, 1A2, 1A4 St. comb., Petroleum coke, ETS data, CO_2	0.5%	ETS data, 2015 estimate
1A1, 1A2, 1A4 St. comb., Petroleum coke, no ETS data, CO_2	5.0%	IPCC (2000), chapter 2.1.1.6
1A1, 1A2, 1A4 St. comb., Residual oil, ETS data, CO_2	0.5%	ETS data, 2015 estimate
1A1, 1A2, 1A4 St. comb., Residual oil, no ETS data, CO_2	2.0%	Jensen & Lindroth (2002)
1A1, 1A2, 1A4 St. comb., Gas oil, CO_2	1.5%	Based on interval in IPCC (2006)
1A1, 1A2, 1A4 St. comb., Kerosene, CO_2	3.0%	Based on interval in IPCC (2006)
1A1, 1A2, 1A4 St. comb., LPG, CO_2	4.0%	Based on interval in IPCC (2006)
1A1b,St. comb., Refinery gas, CO_2	2.0%	1990: IPCC (2000), chapter 2.1.1.6. 2015: DCE assumption based on the fact that data are based on EU ETS data
1A1, 1A2, 1A4, Stationary combustion, Natural gas, onshore, CO_2	0.4%	Lindgren (2010). Personal communication.
1A1c Offshore gas turbines, Natural gas, CO_2	0.5%	ETS data for 2015, but not for 1990
1A1, Stationary Combustion, SOLID, CH_4	100%	Based on interval in IPCC (2006), table 2.12
1A1, Stationary Combustion, LIQUID, CH_4	100%	Based on interval in IPCC (2006), table 2.12
1A1, Stationary Combustion, not engines, GAS, CH_4	100%	Based on interval in IPCC (2006), table 2.12
1A1, Stationary Combustion, WASTE, CH_4	100%	Based on interval in IPCC (2006), table 2.12
1A1, Stationary Combustion, not engines, BIOMASS, CH_4	100%	Based on interval in IPCC (2006), table 2.12
1A2, Stationary Combustion, SOLID, CH_4	100%	Based on interval in IPCC (2006), table 2.12
1A2, Stationary Combustion, LIQUID, CH_4	100%	Based on interval in IPCC (2006), table 2.12
1A2, Stationary Combustion, not engines, GAS, CH_4	100%	Based on interval in IPCC (2006), table 2.12
1A2, Stationary Combustion, WASTE, CH_4	100%	Based on interval in IPCC (2006), table 2.12
1A2, Stationary Combustion, not engines, BIOMASS, CH_4	100%	Based on interval in IPCC (2006), table 2.12
1A4, Stationary Combustion, SOLID, CH_4	100%	Based on interval in IPCC (2006), table 2.12
1A4, Stationary Combustion, LIQUID, CH_4	100%	Based on interval in IPCC (2006), table 2.12
1A4, Stationary Combustion, not engines, GAS, CH_4	100%	Based on interval in IPCC (2006), table 2.12
1A4, Stationary Combustion, WASTE, CH_4	100%	Based on interval in IPCC (2006), table 2.12
1A4, Stationary Combustion, not engines, not residential wood and not residential/agricultural straw, BIOMASS, CH_4	100%	Based on interval in IPCC (2006), table 2.12
1A4, Stationary Combustion, Residential wood combustion, CH_4	150%	Upper value in IPCC (2006), table 2.12
1A4, Stationary Combustion, Residential and agricultural straw combustion, CH_4	150%	Upper value in IPCC (2006), table 2.12
1A1, 1A2, 1A4 Natural gas fuelled engines, GAS, CH_4	2%	1990: DCE estimate based on Nielsen et al. (2010a). 2015: Jørgensen et al. (2010). Uncertainty data for NMVOC + CH_4
1A1, 1A2, 1A4 Biogas fuelled engines, GAS, CH_4	10%	DCE estimate based on Nielsen et al. (2010a)
1A1, Stationary Combustion, SOLID, N_2O	400%	DCE, rough estimate based on a default value of 400 % when the emission factor is based on emission measurements from plants in Denmark
1A1, Stationary Combustion, LIQUID, N_2O	1000 %	IPCC (2000)
1A1, Stationary Combustion, GAS, N_2O	750%	DCE, rough estimate based on a default value of 400 % when the emission factor is based on emission measurements from plants in Denmark and 1000 % if not
1A1, Stationary Combustion, WASTE, N_2O	400%	DCE, rough estimate based on a default value of 400 % when the emission factor is based on emission measurements from plants in Denmark
1A1, Stationary Combustion, BIOMASS, N_2O	400%	DCE, rough estimate based on a default value of 400 % when the emission factor is based on emission measurements from plants in Denmark
1A2, Stationary Combustion, SOLID, N_2O	400%	DCE, rough estimate based on a default value of 400 % when the emission factor is based on emission measurements from plants in Denmark
1A2, Stationary Combustion, LIQUID, N_2O	1000 %	IPCC (2000)

IPCC Source category	2015	Reference
1A2, Stationary Combustion, GAS, N_2O	750%	DCE, rough estimate based on a default value of 400 % when the emission factor is based on emission measurements from plants in Denmark and 1000 % if not
1A2, Stationary Combustion, WASTE, N_2O	400%	DCE, rough estimate based on a default value of 400 % when the emission factor is based on emission measurements from plants in Denmark
1A2, Stationary Combustion, BIOMASS, N_2O	400%	DCE, rough estimate based on a default value of 400 % when the emission factor is based on emission measurements from plants in Denmark.
1A4, Stationary Combustion, SOLID, N_2O	400%	DCE, rough estimate based on a default value of 400 % when the emission factor is based on emission measurements from plants in Denmark
1A4, Stationary Combustion, LIQUID, N_2O	1000 %	IPCC (2000)
1A4, Stationary Combustion, GAS, N_2O	750%	DCE, rough estimate based on a default value of 400 % when the emission factor is based on emission measurements from plants in Denmark and 1000 % if not
1A4, Stationary Combustion, WASTE, N_2O	400%	DCE, rough estimate based on a default value of 400 % when the emission factor is based on emission measurements from plants in Denmark
1A4, Stationary Combustion, not residential wood and not residential/agricultural straw, BIOMASS, N_2O	400%	DCE, rough estimate based on a default value of 400 % when the emission factor is based on emission measurements from plants in Denmark
1A4b, Stationary Combustion, Residential wood combustion, N_2O	500%	DCE estimate
1A4b/c, Stationary Combustion, Residential and agricultural straw combustion, N_2O	500%	DCE estimate

8.1.2 Results

The tier 1 uncertainty estimates for stationary combustion emission inventories are shown in Table 86. Detailed calculation sheets are provided in Annex 7.

The tier 1 uncertainty interval for greenhouse gas is estimated to be ±2.2 % and trend in greenhouse gas emission is -50.5 % ± 1.0 %-age points. The main sources of uncertainty for greenhouse gas emission 2015 are the CO_2 emission from waste incineration without EU ETS data, N_2O and CH_4 emissions from residential wood combustion, and N_2O emission from biomass and gaseous fuels applied in energy industries (1A1). The main sources of uncertainty in the trend in greenhouse gas emission are the CO_2 emission from waste incineration (the part without EU ETS data), N_2O emission from residential wood combustion and N_2O emissions from biomass in energy industries (1A1).

Table 86 Danish GHG uncertainty estimates for tier 1 approach, 2015.

Pollutant	Uncertainty Total emission, %	Trend 1990-2015, %	Uncertainty trend, %-age points
GHG	±2.2	-50.5	±1.0
CO_2	±1.1	-51.2	±0.6
CH_4	±59	+43	±52
N_2O	±182	+1.5	±203

8.2 Other pollutants

8.2.1 Methodology

The Danish uncertainty estimates for non-GHGs are based on the simple Tier 1 approach.

The uncertainty estimates are based on emission data for the base year and year 2015 as well as on uncertainties for fuel consumption and emission factors for each of the NFR source categories. Residential plants have however been split in two parts: Residential wood combustion and other residential plants.

The base year for all pollutants is 1990.

The uncertainty for fuel consumption in stationary combustion plants is based on EEA (2013). The uncertainties are shown in Table 87.

The applied uncertainties for activity rates and emission factors are based on EEA (2013). The uncertainty for emission factors that are based on recent Danish emission measurements are however estimated lower than suggested in the Guidebook. The applied uncertainties for emission factors are listed in Table 88.

Table 87 Uncertainty rates for fuel consumption, %.

Sector	%
1A1a Public electricity and heat production	1
1A1b Petroleum refining	1
1A1c_ii Oil and gas extraction	1
1A2 Manufacturing industries and construction	2
1A4a_i Commercial / institutional	3
1A4b_i Residential (excluding wood)	3
1A4b_i Residential wood	20
1A4c_i Agriculture / forestry / fishing	3

Table 88 Uncertainty rates for emission factors, %.

Sector	SO_2	NO_x	NMVOC	CO	PM	HM	PAH	HCB	Dioxin	NH_3	PCB	BC
1A1a Public electricity and heat production	10	15	50	20	20	50	100	1000	200	1000	1000	1000
1A1b Petroleum refining	10	20	50	20	50	100	100	1000	1000	1000	1000	1000
1A1c_ii Oil and gas extraction	10	20	50	20	50	100	100	1000	1000	1000	1000	1000
1A2 Manufacturing industries and construction	10	20	50	20	30	100	100	1000	1000	1000	1000	1000
1A4a_i Commercial/ institutional	20	50	50	50	50	300	1000	1000	1000	1000	1000	1000
1A4b_i Residential (excluding wood)	20	30	50	50	50	300	1000	1000	1000	1000	1000	1000
1A4b_i Residential wood	20	50	100	100	200	1000	1000	500	600	100	1000	1000
1A4c_i Agriculture/ forestry/fishing	20	50	50	50	50	300	1000	1000	1000	1000	1000	1000

8.2.2 Results

The uncertainty estimates for stationary combustion emission inventories are shown in Table 89. Detailed calculation sheets are provided in Annex 7.

The total emission uncertainty is 6.0 % for SO_2 and 10 % for NO_x.

Table 89 Uncertainty estimates, tier 1 approach, 2015.

Pollutant	Uncertainty Total emission, %	Trend 1990-2015, %	Uncertainty Trend, %-age points
SO_2	±6.0	-95	±0.3
NO_x	±10	-77	±2
NMVOC	±72	-3	±32
CO	±70	-20	±32
NH_3	±102	130	±111
TSP	±171	20	±51
PM_{10}	±173	21	±50
$PM_{2.5}$	±176	24	±50
BC	±871	85	±327
As	±54	-82	±8
Cd	±513	-41	±260
Cr	±303	-79	±62
Cu	±398	-84	±61
Hg	±41	-91	±3
Ni	±74	-90	±5
Pb	±192	-86	±26
Se	±40	-83	±3
Zn	±180	-23	±117
HCB	±747	-80	±34
PCDD/F	±456	-67	±125
Benzo(b)fluoranthene	±778	56	±290
Benzo(k)fluoranthene	±791	64	±180
Benzo(a)pyrene	±828	43	±242
Indeno(1,2,3-c,d)pyrene	±789	8	±362
PCB	±645	-67	±79

9. QA/QC and verification

An updated quality manual for the Danish emission inventories has been published in 2013 (Nielsen et al., 2013a). The quality manual describes the concepts of quality work and definitions of sufficient quality, critical control points and a list of Point for Measuring (PM).

Documentation concerning verification of the Danish GHG emission inventories has been published by (Fauser et al., 2013). In addition, the IPCC reference approach for CO_2 emission is an important verification of the CO_2 emission from the energy sector. The reference approach for the energy sector is shown in Chapter 9.1. Finally, a verification based on Eurostat data has been reported to EU in recent years. This estimate is included in Chapter 11.

Information on the Danish QA / QC plan is included in Nielsen et al. (2013a). Source specific QA / QC and PM's are shown Chapter 9.3.

9.1 Verification, reference approach

In addition to the sector specific CO_2 emission inventories (the national approach), the CO_2 emission is also estimated using the reference approach described in the IPCC Guidelines (IPCC, 2006). The reference approach is based on data for fuel production, import, export and stock change. The CO_2 emission inventory based on the reference approach is reported to the Climate Convention and used for verification of the sectoral 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 Agency (DEA) and published on their home page (DEA, 2016a). The fraction of carbon oxidised has been assumed 1.00.

The applied carbon emission factors are equal to the emission factors also applied in the sectoral approach and thus include nationally referenced emission factors. This is in agreement with the 2006 IPCC Guidelines.

The Climate Convention reporting tables (CRF) include a comparison of the national approach and the reference approach estimates.

The consumption for non-energy purposes is subtracted in the reference approach, because non-energy use of fuels is included in other sectors (Industrial processes and Solvent use) in the Danish national approach. Three fuels are used for non-energy purposes: lubricants, bitumen and white spirit. The total consumption for non-energy purposes is relatively low – 10.5 PJ in 2015.

The CO_2 emission from oxidation of lube oil during use was 31.7 Gg in 2015 and this emission is reported in the sector industrial processes and product use (sector 2.D). The reported emission corresponds to 20 % of the CO_2 emission from lube oil consumption assuming full oxidation. This is in agreement with the methodology for lube oil emissions in the 2006 IPCC Guidelines (IPCC, 2006). Methodology and emission data for lube oil are shown in Nielsen et al. (2017a).

For white spirit, the CO_2 emission is indirect as the emissions occur as NMVOC emissions from the use of white spirit as a solvent. The indirect CO_2 emission from solvent use was 60.6 Gg in 2015. The methodology and emission data for white spirit are included in Nielsen et al. (2017a).

The CO_2 emission from bitumen is included in sector 2.D.3, Road paving with asphalt and Asphalt roofing. The total CO_2 emissions for these sectors are 0.17 Gg in 2015. Methodology and emission data for non-energy use of bitumen are shown in Nielsen et al. (2017a).

The national approach and the reference approach have been compared and the differences between the two approaches are shown in Table 90 below.

Table 90 Difference between national approach and reference approach.

Year	Difference Energy consumption [%]	Difference CO_2 emission [%]
1990	0.28	-0.31
1991	-0.55	-0.95
1992	-0.02	-0.62
1993	-0.40	-0.99
1994	-0.31	-0.88
1995	-0.56	-0.92
1996	-0.49	-0.74
1997	-0.03	-0.11
1998	1.49	1.33
1999	-0.58	-0.87
2000	0.26	0.07
2001	0.75	0.65
2002	0.05	-0.12
2003	0.10	-0.05
2004	-0.01	-0.15
2005	-0.89	-0.90
2006	-0.64	-0.82
2007	-0.91	-1.00
2008	-0.17	-0.32
2009	-1.63	-1.69
2010	0.12	-0.16
2011	-0.96	-1.00
2012	-1.37	-1.62
2013	-0.72	-1.00
2014	-1.33	-1.46
2015	-1.94	-2.16

The comparison of the national approach and the reference approach is illustrated in Figure 71. In 2015, the fuel consumption rates in the two approaches differ by 1.94 % and the CO_2 emission differs by 2.16 %. In the years 1990-2014, both the fuel consumption and the CO_2 emission differ by less than 1.7 %.

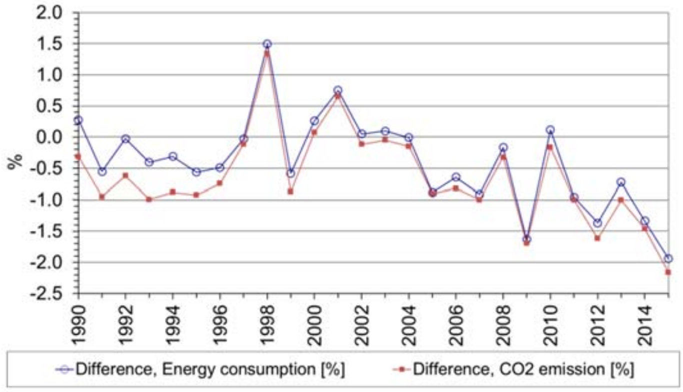


Figure 71 Comparison of the reference approach and the national approach.

The fluctuations in Figure 71 follow the fluctuations of the statistical difference in the Danish energy statistics shown in Figure 72. The large differences in certain years, e.g. in 1998, 2009, 2012 and 2015 are due to high statistical differences in the Danish energy statistics in these years.

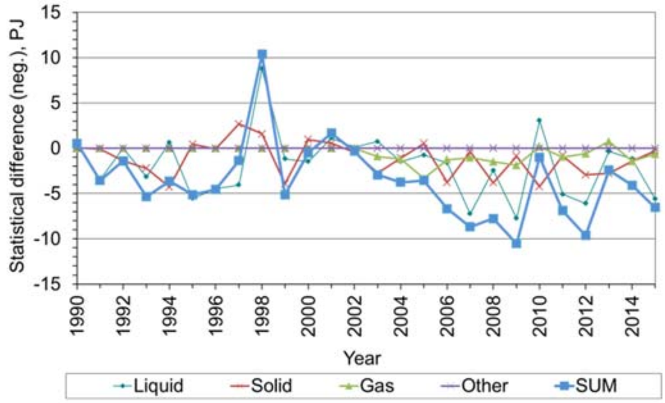


Figure 72 Statistical difference in the Danish energy statistics (DEA, 2016a).

The large difference in 2015 is related to fuel consumption, mainly for liquid fuels. The difference for liquid fuels is 2.65 % or 6.4 PJ. The statistical difference for liquid fuels in the Danish energy statistics is 5.6 PJ for 2015. This difference mainly relate to crude oil (3.4 PJ) and to gas / diesel oil (1.9 PJ). In addition to the statistical difference of the energy statistics, the Danish emission inventory includes more residual oil than the energy statistics because plant and ferry specific fuel consumption data add up to a total that exceeds the total consumption in the energy statistics.

The differences mentioned above will be part of the ongoing dialogue with the Danish Energy Agency and data will be improved if possible. The Danish energy statistics is always updated for the latest 3 years and thus the large statistical difference in 2015 energy data is likely to decrease in the annual update of the energy statistics published in 2017.

Finally, for gaseous fuels the Danish emission inventory includes higher fuel consumption for offshore gas turbines than included in the energy statistics. The fuel consumption applied in the inventory is based on EU ETS data that are not in agreement with the energy statistics (0.7 PJ higher than the energy statistics in 2015). This will be part of the ongoing dialogue with the Danish Energy Agency.

9.2 National external review

The 2004, 2006, 2009 and 2014 updates of the sector report for stationary combustion has been reviewed by external experts (Nielsen & Illerup, 2004; Nielsen & Illerup, 2006; Nielsen et al., 2009, Nielsen et al., 2014). The national external review forms a vital part of the QA activities for stationary combustion.

The 2004, 2006, 2009 and 2014 updates of this report were reviewed by Jan Erik Johnsson from the Technical University of Denmark, Bo Sander from Elsam Engineering, Annemette Geertinger from FORCE Technology and Vibeke Vestergaard Nielsen, AU DCE.

9.3 QA/QC for GHG inventory

9.3.1 Data storage, level 1

Table 91 lists the sector specific PM's for data storage level 1.

Table 91 List of PM for data storage level 1.

Level	CCP	Id	Description	Sectoral/general	Stationary combustion
Data Storage level 1	1. Accuracy	DS.1.1.1	General level of uncertainty for every data set including the reasoning for the specific values.	Sectoral	Uncertainties are estimated and references given in Chapter 7.
	2. Comparability	DS1.2.1	Comparability of the emission factors / calculation parameters with data from international guidelines, and evaluation of major discrepancies.	Sectoral	In general, if national referenced emission factors differ considerably from IPCC Guideline/EEA Guidebook values this is discussed in Chapter 7. This documentation is improved annually based on reviews. At CRF level, a project has been carried out comparing the Danish inventories with those of other countries (Fauser et al., 2013).
	3.Completeness	DS.1.3.1	Ensuring that the best possible national data for all sources are included, by setting down the reasoning behind the selection of datasets.	Sectoral	A list of external data are shown and discussed below.
	4.Consistency	DS.1.4.1	The original external data has to be archived with proper reference.	Sectoral	It is ensured that all external data are archived at DCE. Subsequent data processing takes place in other spreadsheets or databases. The datasets are archived annually in order to ensure that the basic data for a given report are always available in their original form.
	6.Robustness	DS.1.6.1	Explicit agreements between the external institution holding the data and DCE about the conditions of delivery	Sectoral	For stationary combustion, a data delivery agreement is made with the DEA. DCE and DEA have renewed the data delivery agreement in 2015. Most of the other external data sources are available due to legislation. See Table 92.
	7.Transparency	DS.1.7.1	Listing of all archived datasets and external contacts.	Sectoral	A list of external datasets and external contacts is shown in Table 92 below.

Table 92 List of external data sources.

Dataset	Description	Activity data or emission factor	Reference	Contact(s)	Data agreement/ Comment
Energipro-ducenttællingen.xls	Data set for all electricity and heat producing plants.	Activity data	The Danish Energy Agency (DEA)	Kaj Stærkind	Data agreement 2015.
Gas consumption for gas engines and gas turbines 1990-1994	Historical data set for gas engines and gas turbines.	Activity data	The Danish Energy Agency (DEA)	Kaj Stærkind	No data agreement. Historical data
Basic data (Grunddata.xls)	The Danish energy statistics. Data set applied for both the reference approach and the national approach.	Activity data	The Danish Energy Agency (DEA)	Jane Rusbjerg	Data agreement 2015. However, the data set is also published as part of national energy statistics.
Energy statistics for industrial subsectors	Disaggregation of the industrial fuel consumption.	Activity data	The Danish Energy Agency (DEA)	Jane Rusbjerg	Included in data delivery agreement 2015.
SO_2 & NO_x data, plants>25 MW_e	Annual emission data for all power plants > 25 MW_e. Includes information on methodology: measurements or emission factor.	Emissions	Energinet.dk	Christian F.B. Nielsen	No data agreement.
Emission factors	Emission factors refer to a large number of sources.	Emission factors	See Chapter 7		Some of the annually updated CO_2 emission factors are based on EU ETS data, see below. For other emission factors no formal data delivery agreement.
Annual environmental reports / environmental data	Emissions from plants defined as large point sources	Emissions	Various plants		No data agreement. Some plants are obligated by law to report data (DEPA, 2010b) and data are published on the Danish EPA homepage.
EU ETS data	Plant specific CO_2 emission factors	Emission factors and fuel consumption	The Danish Energy Agency (DEA)	Dorte Maimann Helen Falster	Plants are obligated by law. The availability of detailed information is part of the data agreement with DEA (2015 update).

Energiproducenttaellingen - statistic on fuel consumption from district heating and power plants (DEA)

The data set includes all plants producing power or district heating. The spreadsheet from DEA is listing fuel consumption of all plants included as large point sources in the emission inventory. The statistic on fuel consumption from district heating and power plants is regarded as complete and with no significant uncertainty since the plants are bound by law to report their fuel consumption and other information.

Gas consumption for gas engines and gas turbines 1990-1994 (DEA)

For the years 1990-1994, DEA has estimated consumption of natural gas and biogas in gas engines and gas turbines (DEA, 2003). Estimated fuel consumption data for 1990-1993 was based on engine specific data for year of installation and for fuel consumption in 1994. DCE assesses that the DEA estimate is the best available data.

Basic data (DEA)

The spreadsheet from the Danish energy statistics (DEA) is used for the CO_2 emission calculation in accordance with the IPCC reference approach and is also the first data set applied in the national approach. The data set is included in the data delivery agreement with DEA, but it is also published annually on DEA's homepage.

Energy statistics for industrial subsectors (DEA)

The data includes disaggregation of the fuel consumption for industrial plants. The data set is estimated for the reporting to Eurostat. The data are included in the 2015 update of the agreement with DEA.

SO_2 and NO_x emission data from electricity producing plants > 25MW_e (Energinet.dk)

Energinet.dk collects SO_2 and NO_x emission data for plants larger than 25 MW_e. Energinet.dk forwards data for implementation in the emission inventory. Data are on production unit level. DCE's QC of the data consists of a comparison with data from previous years and with data from the plants' annual environmental reports.

Emission factors

For specific references, see the Chapter 7 regarding emission factors. Some of the annually updated CO_2 emission factors are based on EU ETS data, see below.

Annual environmental reports (DEPA)

A large number of plants are obligated by law to report annual environmental data including emission data. DCE compares the data with those from previous years and large discrepancies are checked.

EU ETS data (DEA)

EU ETS data includes information on fuel consumption, heating values, carbon content of fuel, oxidation factor and CO_2 emissions. DCE receives the verified reports for all plants, which utilises a detailed estimation methodology. DCE's QC of the received data consists of comparing to calculation using standard emission factors as well as comparing reported values with those for previous years. The data set is included in the 2015 update of the agreement with DEA.

9.3.2 Data processing level 1

Table 93 lists the sector specific PM's for data processing level 1.

Table 93 List of PM for data processing level 1.

Level	CCP	Id	Description	Sectoral/ general	Stationary combustion
Data Processing level 1	1. Accuracy	DP.1.1.1	Uncertainty assessment for every data source not part of DS.1.1.1 as input to Data Storage level 2 in relation to type and scale of variability.	Sectoral	Uncertainties are estimated and references given in chapter 8.
	2.Comparability	DP.1.2.1	The methodologies have to follow the international guidelines suggested by UNFCCC and IPCC.	Sectoral	The methodological approach is consistent with international guidelines. An overview of tiers is given in NIR Chapter 3.2.5
	3.Completeness	DP.1.3.1	Identification of data gaps with regard to data sources that could improve quantitative knowledge.	Sectoral	The energy statistics is considered complete.
	4.Consistency	DP.1.4.1	Documentation and reasoning of methodological changes during the time series and the qualitative assessment of the impact on time series consistency.	Sectoral	The two main methodological changes in the time series; implementation of Energiproducenttaellingen (plant specific fuel consumption data) from 1994 onwards and implementation of EU ETS data from 2006 onwards is discussed in NIR chapter 3.2.5.
	5.Correctness	DP.1.5.2	Verification of calculation results using time series	Sectoral	Time series for activity data on SNAP and CRF source category level are used to identify possible errors. Time series for emission factors and the emission from CRF subcategories are also examined.
		DP.1.5.3	Verification of calculation results using other measures	Sectoral	The IPCC reference approach validates the fuel consumption rates and CO_2 emission. Both differ less than 2.0 % in 1990-2014. However, the difference in 2015 was 2.16 % for CO_2. The reference approach is further discussed in NIR Chapter 3.4.
	7.Transparency	DP.1.7.1	The calculation principle, the equations used and the assumptions made must be described.	Sectoral	This is included in NIR Chapter 3.2.5.
		DP.1.7.2	Clear reference to dataset at Data Storage level 1	Sectoral	This is included in NIR Chapter 3.2.5.
		DP.1.7.3	A manual log to collect information about recalculations.	Sectoral	-

9.3.3 Data storage level 2

Table 94 lists the sector specific PM's for data storage level 2.

Table 94 List of PM, data storage level 2.

Level	**CCP**	**Id**	**Description**	**Sectoral/ general**	**Stationary combustion**
Data Storage level 2	5.Correctness	DS.2.5.1	Check if a correct data import to level 2 has been made	Sectoral	To ensure a correct connection between data on level 2 and level 1, different controls are in place, e.g. control of sums and random tests.

9.3.4 Data storage level 4

Table 95 lists the sector specific PM's for data storage level 4.

Table 95 List of PM for data storage level 4.

Level	CCP	Id	Description	Sectoral / general	Stationary combustion
Data Storage level 4	4. Consistency	DS.4.4.3	The IEFs from the CRF are checked regarding both level and trend. The level is compared to relevant emission factors to ensure correctness. Large dips/jumps in the time series are explained.	Sectoral	Large dips/jumps in time series are discussed and explained in NIR Chapter 3.2.3 and 3.2.4.

9.3.5 Other QC procedures

Some automated checks have been prepared for the emission databases:

- Check of units for fuel rate, emission factors and plant-specific emissions
- Check of emission factors for large point sources. Emission factors for pollutants that are not plant-specific should be the same as those defined for area sources
- Additional checks on database consistency
- Emission factor references are included in this report (Chapter 7)
- Annual environmental reports are kept for subsequent control of plant-specific emission data
- QC checks of the country-specific emission factors have not been performed, but most factors are based on input from companies that have implemented some QA / QC work. The major power plant owner / operator in Denmark, DONG Energy has obtained the ISO 14001 certification for an environmental management system. The Danish Gas Technology Centre and Force Technology both run accredited laboratories for emission measurements
- The emission from each large point source is compared with the emission reported the previous year

10. Source specific recalculations and improvements

10.1 Recalculations for GHGs

Table 96 shows recalculations of the CO_2, CH_4 and N_2O emissions. Emissions reported this year have been compared to emissions reported last year.

Sector specific recalculations for 2014 are shown in Table 97.

The main recalculations are discussed below.

Table 96 Recalculations for emissions reported this year compared to emissions reported last year.

Pollutant	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
							%						
CO_2	100.55	100.52	100.63	100.65	100.61	100.81	100.91	100.71	100.90	101.10	101.40	101.40	101.61
CH_4	99.96	100.01	99.98	100.02	100.01	100.01	100.01	100.01	100.01	100.02	100.03	101.25	102.15
N_2O	100.16	100.15	100.11	100.20	100.15	100.15	100.27	100.16	100.25	100.30	100.42	100.84	101.35

Table 97 Recalculations for stationary combustion, 2014.

	CO_2 , Gg CO_2	CH_4, Gg CO_2 eqv.	N_2O Gg CO_2 eqv.	CO_2 %	CH_4, %	N_2O %
1A1 Energy industries	-61.4	0.1	0.0	-0.4%	0.1%	0.0%
1A1a Public electricity and heat production	-61.4	0.1	0.0	-0.5%	0.1%	0.0%
1A1b Petroleum refining	0.0	0.0	0.0	0.0%	0.0%	0.0%
1A1c Oil and gas extraction	0.0	0.0	0.0	0.0%	0.0%	0.0%
1A2 Industry	8.8	0.9	0.4	0.3%	10.4%	1.3%
1A2a Iron and steel	3.9	0.0	0.0	4.7%	4.3%	6.2%
1A2b Non-ferrous metals	0.0	0.0	0.0	-100.0%	-100.0%	-100.0%
1A2c Chemicals	62.0	0.9	0.4	18.5%	540.3%	18.1%
1A2d Pulp, paper and print	-58.5	-0.4	-1.9	-40.9%	-81.5%	-74.8%
1A2e Food processing, beverages and tobacco	-114.5	-0.2	-0.5	-9.7%	-6.7%	-6.0%
1A2f Non-metallic minerals	91.7	0.1	0.6	8.7%	2.4%	7.9%
1A2gviii Other manufacturing industry	24.2	0.5	2.0	6.6%	26.7%	14.5%
1A4 Other sectors	385.0	4.2	1.9	17.6%	3.2%	3.5%
1A4ai Commercial/institutional: Stationary	387.6	-0.5	0.4	68.1%	-4.8%	8.2%
1A4bi Residential: Stationary	-2.5	4.8	1.6	-0.2%	5.0%	3.3%
1A4ci Agriculture/Forestry/Fishing: Stationary	0.0	0.0	0.0	0.0%	-0.1%	0.0%
Stationary combustion	332.5	5.2	2.4	1.6%	2.2%	1.3%

For stationary combustion plants, the emission estimates for the years 1990-2014 have been updated according to the latest energy statistics published by the Danish Energy Agency. The update included both end use and transformation sectors as well as a source category update. The changes in the energy statistics are largest for the years 2012, 2013 and 2014.

The reported CO_2 emission is higher for all years due to the recalculation of the CO_2 emission factor for residual oil.

The increased CO_2 emission in 2014 from sector *1A4a i Commercial / institutional: Stationary* is related to an improved disaggregation between transport and stationary combustion for gas / diesel oil. However, the disaggregation between 1A4a and 1A4b is not correct and will be improved in future inventories (see page 84).

The CH_4 emission is higher mainly for 2013 and 2014 than reported last year. This is related to a higher emission from residential plants. This occurs due to a recalculation of the residential wood consumption in the Danish energy statistics (+1.0 PJ in 2013 and + 1.3 PJ in 2014).

The increased N_2O emission reported for 2014 is also related to the improved data for residential wood combustion in the energy statistics.

In the reporting last year, a very small emission was included in subsector 1A2b Non-ferrous metals. This is now reported not occurring and this is in agreement with the updated energy statistics. The update of the disaggregation between industrial subsectors is also reflected in other of the industrial subsectors.

The fossil carbon content of waste applied in the reference approach is now the implied emission factor from the national approach in CRF rather than based on the default emission factor for waste. Thus, plant specific data are implemented in the emission factor applied in the reference approach.

10.1.1 Improvements related to reviews

"ERT recommends that Denmark continue its investigations on how EU-ETS can inform country-specific emission factors. Focusing on residual fuel oil (small combustion activities outside of EU-ETS) and waste incineration with energy recovery. Noting that application of country-specific emission factor for waste incineration will be most challenging across time series."

The improved CO_2 emission factors for residual oil were initiated based on the 2016 review.

For waste incineration, EU ETS data have been implemented for 2015. Data are only available for a few years, but DCE will in future years analyse data and at some point implement the collected EU ETS data in an improved country specific emission factor and - if possible - a time series.

10.2 Recalculations for non-GHGs

For stationary combustion plants, the emission estimates for the years 1990-2014 have been updated according to the latest energy statistics published by the Danish Energy Agency. The update included both end use and transformation sectors as well as a source category update. The changes in the energy statistics are largest for the years 2012, 2013 and 2014.

In addition, the disaggregation of fuels applied for manufacturing industries and construction have been updated according to the latest reporting from DEA. The consumption and emissions for the sector *1A2b Stationary combustion in manufacturing industries and construction: Non-ferrous metals* is now reported not occurring (NO) which is in agreement with the updated DEA data.

Recalculations for stationary combustion as a whole are shown in Table 98.

The largest recalculations are related to a recalculation of the consumption of wood in residential plants in 2013-2014 in the energy statistics.

SO_2 emission measurements for 2014 have been implemented for a number of plants for which the data were not available prior to the reporting in 2016. In addition, the emission factor for one plant has been improved based on measurements from former years.

Table 98 Recalculations for stationary combustion, emissions reported in 2017 compared to emissions reported in 2016.

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
SO_2	100.1%	100.1%	100.3%	100.4%	100.3%	100.5%	100.6%	100.7%	100.9%	101.0%	99.9%	99.5%	96.9%
NO_x	100.2%	100.2%	100.3%	100.3%	100.4%	100.3%	100.4%	100.5%	100.5%	100.1%	100.2%	100.4%	100.5%
NMVOC	100.1%	100.1%	100.1%	100.1%	100.1%	100.2%	100.2%	100.1%	100.2%	100.3%	100.4%	103.6%	104.7%
CO	100.0%	100.1%	100.1%	100.1%	100.1%	100.1%	100.1%	100.1%	100.1%	100.1%	100.2%	103.2%	104.5%
TSP	New	New	100.1%	100.1%	100.1%	100.1%	100.1%	100.1%	100.1%	100.1%	100.1%	104.0%	105.8%
PM_{10}	New	New	100.1%	100.1%	100.1%	100.1%	100.1%	100.1%	100.1%	100.1%	100.1%	104.0%	105.9%
$PM_{2.5}$	New	New	100.1%	100.1%	100.1%	100.1%	100.1%	100.1%	100.1%	100.1%	100.1%	104.1%	106.0%
BC	New	New	100.5%	100.3%	100.4%	100.1%	100.2%	100.3%	100.2%	100.1%	100.0%	104.0%	106.6%
NH_3	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	101.2%	102.0%	107.1%	109.6%
As	100.0%	100.0%	100.0%	100.0%	100.0%	99.9%	100.0%	100.0%	100.0%	100.0%	100.1%	99.8%	100.2%
Cd	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	102.7%	103.6%
Cr	100.0%	100.0%	100.1%	100.0%	100.1%	100.1%	100.1%	100.1%	100.1%	100.1%	100.2%	102.2%	103.2%
Cu	100.0%	100.0%	100.0%	100.0%	100.1%	100.0%	100.1%	100.1%	100.1%	100.1%	100.3%	100.9%	101.6%
Hg	100.0%	100.0%	100.0%	100.1%	100.1%	100.1%	100.1%	100.1%	100.1%	100.1%	100.4%	100.3%	100.5%
Ni	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.9%
Pb	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.4%	101.2%	101.8%
Se	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.2%	100.0%	100.1%
Zn	100.0%	100.0%	100.0%	100.0%	100.0%	99.9%	100.0%	100.0%	100.0%	100.0%	100.1%	102.8%	103.8%
HCB	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.1%	100.1%	100.2%	100.6%
PCDD/F	100.0%	100.0%	100.1%	100.1%	100.1%	100.1%	100.2%	100.1%	100.2%	100.2%	100.4%	103.3%	104.5%
Benzo(a)pyrene	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.2%	103.6%	105.1%
Benzo(b)fluoranthene	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.2%	103.2%	104.4%
Benzo(k)fluoranthene	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.1%	103.4%	104.8%
Indeno(123cd)pyrene	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.6%	103.3%	104.8%
PCB	100.0%	100.0%	100.1%	100.1%	100.1%	100.1%	100.1%	100.1%	100.1%	100.1%	100.2%	100.6%	101.3%

10.3 Source specific planned improvements

10.3.1 Planned improvements for GHGs

Biogas distributed in the town gas grid will be included in the fuel category biogas in the next emission inventory.

The disaggregation of the gas oil consumption between the sectors 1A4a and 1A4b will be corrected for 2014.

The difference between national approach and national approach was above 2 % for 2015. This will be part of the ongoing dialogue with the Danish Energy Agency, and if possible, data will be improved.

10.3.2 Planned improvements for non-GHGs

Improvements related to the NEC review 2017 will be implemented.

NH_3 emission from biomass combustion in 1A4 and 1A2 will be included in the inventory.

11. Emission inventories based on Eurostat data and comparison to national approach

The data reported in CRF have been compared to the data aggregated from the fuel data available from Eurostat. The comparison includes both the sectoral approach and the reference approach.

The comparison has been performed in accordance with the Commission implementing regulation (EU) No 749/2014 of 30 June 2014 and with the IPCC Guidelines (2006). The comparison is performed for verification of the reported CRF data.

In Denmark, the emission inventory is based on the official energy statistics published by the Danish Energy Agency (DEA). DEA is also responsible for the reporting to Eurostat.

11.1 Reference approach

11.1.1 Methodology

The Danish reference approach for 2015 has been compared to a reference approach estimate based on Eurostat data (Eurostat, 2017). The correspondence lists for activity and fuel are shown in Table 99 and Table 100 below.

Table 99 Correspondence list for activity, Reference Approach.

Eurostat code	Eurostat nomenclature	CRF_RA
B_100100	Primary production	Production in CRF table 1A(b)
B_100300	Imports	Imports in CRF table 1A(b)
B_100400	Stock changes	Stock changes in CRF table 1A(b)
B_100500	Exports	Exports in CRF table 1A(b)
B_100800	Bunkers	International bunkers in CRF table 1A(b)
B_101931	International aviation	International bunkers in CRF table 1A(b)

Table 100 Correspondence list for fuel, Reference Approach.

Eurostat fuel codes	Eurostat nomenclature	RA fuel
2112	Patent Fuel	BKB and Patent Fuel
2115	Anthracite	Anthracite
2116	Coking Coal	Coking Coal
2117	Other Bituminous Coal	Other Bituminous Coal
2118	Sub-bituminous Coal	Sub-bituminous Coal
2120	Coke (derived product)	Coke Oven/Gas Coke
2121	Coke Oven Coke	Coke Oven/Gas Coke
2122	Gas Coke	Coke Oven/Gas Coke
2130	Coal Tar	Other Solid Fossil
2210	Lignite/Brown Coal	Lignite
2230	BKB/PB	BKB and Patent Fuel
2310	Peat	Peat
3105	Crude Oil without NGL	Crude oil
3106	Natural Gas Liquids (NGL)	Natural Gas Liquids
3191	Refinery Feedstocks	Refinery Feedstocks
3214	Refinery Gas (not. Liquid)	Other Oil
3215	Ethane	Ethane
3220	LPG	Liquefied Petroleum Gas
3234	Motor gasoline (without biogasoline) (derived product)	Gasoline
3235	Aviation Gasoline	Gasoline
3240	Kerosenes & Jet fuels (derived product)	Jet kerosene
3244	Other Kerosene	Jet kerosene
3246	Gasoline Type Jet Fuel	Jet kerosene
3247	Kerosene Type Jet Fuel	Jet kerosene
3250	Naphta	Naphta
3260	Gas/Diesel Oil (without bio-diesel) (derived product)	Gas / Diesel Oil
3265	Transport Diesel (derived product)	Gas / Diesel Oil
3266	Heating and other Gasoil	Gas / Diesel Oil
3270A	Residual Fuel Oil	Residual Fuel Oil
3281	White Spirit and SBP	Other Oil
3282	Lubricants	Lubricants
3283	Bitumen	Bitumen
3285	Petroleum Coke	Petroleum Coke
3286	Paraffin Waxes	Other Oil
3295	Other Oil Products	Other Oil
4100	Natural gas in TJ (GCV)	Natural Gas
5541	Wood & Wood Waste	Solid Biomass
5542	Biogas (derived product)	Gas Biomass
55421	Landfill Gas	Gas Biomass
55422	Sewage Sludge Gas	Gas Biomass
55423	Other Biogas	Gas Biomass
55431	Municipal wastes (renewable)	Waste biomass
5544	Charcoal	Solid Biomass
5545	Liquid biofuels (derived product)	Liquid Biomass
5546	Biogasoline (derived product)	Liquid Biomass
5547	Biodiesels (derived product)	Liquid Biomass
5548	Other liquid biofuels	Liquid Biomass
55432	Municipal wastes (non-renewable)	Waste fossil
7100	Industrial wastes	Waste fossil

DEA publish all data reported to Eurostat on their homepage, www.ens.dk.

Default emission factors for CO_2 referring to IPCC (2006) have been applied in the reference approach estimate based on Eurostat data. For some fuels, the default CO_2 emission factors differ from the national referenced emission factors.

11.1.2 Results

The reference approach estimated based on Eurostat data is shown in Table 101. The CRF data for reference approach have been compared to reference approach data aggregated from the Eurostat data. The results for fuel consumption are shown in Table 102 and the results for CO_2 emission is shown in Table 103.

Fuel consumption for transport between mainland Denmark and Greenland and the Faroe Islands is not included in the reporting to the IEA and Eurostat. In the Danish emission inventory, the transport between Denmark, Greenland and the Faroe Islands is considered domestic. This causes a difference for liquid fuels used for aviation and navigation.

For some minor fuel categories, e.g. BKB the difference is caused by the fact that the Eurostat data are rounded off to the nearest 1000 tonnes.

The calorific value for crude oil applied by Eurostat is not in agreement with the Danish energy statistics and the data reported by the Danish Energy Agency to Eurostat. DEA (2016c) states the NCV 43 GJ/tonnes whereas the Eurostat values are based on the NCV 41.671 GJ/tonnes. This 3 % difference is reflected in the all data (production, import, export etc.) for crude oil. The DEA have confirmed that Eurostat applies a lower NCV than reported in the international energy reportings from Denmark. The reference for the NCV applied by Eurostat is Eurostat (2017b).

For coal, the international reporting states the NCV 22.89 GJ/tonnes and the GCV 24.1 GJ/tonnes. However, in the Danish statistics the NCV is 24.1 GJ/tonnes. This cause the 5 % difference. The average NCV of the EU ETS data for coal was 24.0 GJ/tonnes for 2015. The DEA will correct the reported GCV next year.

The apparent fossil fuel consumption based on the Eurostat data differs 3 % from the apparent fossil fuel consumption stated in CRF. This is mainly related to the data inaccuracies mentioned above. The differences are 5 % for solid fuels, 4 % for liquid fuels, 0 % for gaseous fuels and 0 % for fossil waste.

The comparison of CO_2 emission data is similar to the comparison of fuel consumption. In addition to the differences caused by fuel consumption data the country specific emission factors applied for gasoline, natural gas, gaseous biomass and the biomass fraction of waste differ considerably from the IPCC default emission factors applied for the Eurostat data estimate.

Table 101 Reference Approach based on Eurostat data, 2015.

FUEL TYPES			Unit	Production	Imports	Exports	International bunkers	Stock change	Apparent consumption	Conversion factor (TJ/Unit)	NCV/GCV (2)	Apparent consumption (TJ)	Carbon emission factor (t C/TJ)	Carbon content (kt)	Carbon stored [C excluded] (kt C)	Net carbon emissions ((kt) C)	Fraction of carbon oxidized	Actual CO_2 emissions ((kt) CO2)
Liquid fossil	Primary fuels	Crude oil	TJ	320453.00	173561.00	188521.00		3084.00	302409.00	1.00	NCV	302409.00	19.99	6045.43	NO	6045.43	1.00	22166.58
		Orimulsion	TJ	NO	NO	NO		NO	NO	1.00	NCV	NO	21.00	NO	NO	NO	1.00	NO
		Natural gas liquids	TJ	NO	NO	NO		NO	NO	1.00	NCV	NO	17.51	NO	NO	NO	1.00	NO
	Secondary fuels	Gasoline	TJ		29346.00	58605.00	0.00	1007.00	-30266.00	1.00	NCV	-30266.00	18.90	-572.03	NO	-572.03	1.00	-2097.43
		Jet kerosene	TJ		39106.00	2740.00	36975.00	3610.00	-4219.00	1.00	NCV	-4219.00	19.50	-82.27	NO	-82.27	1.00	-301.66
		Other kerosene	TJ		NO	NO	NO	NO	NO	1.00	NCV	NO	19.61	NO	NO	NO	1.00	NO
		Shale oil	TJ		NO	NO		NO	NO	1.00	NCV	NO	19.99	NO	NO	NO	1.00	NO
		Gas/diesel oil	TJ		158716.00	109782.00	18574.00	18703.00	11657.00	1.00	NCV	11657.00	20.21	235.58	NO	235.58	1.00	863.78
		Residual fuel oil	TJ		155000.00	182120.00	13400.00	11400.00	-51920.00	1.00	NCV	-51920.00	21.11	-1095.98	NO	-1095.98	1.00	-4018.61
		Liquefied petroleum gases (LPG)	TJ		1150.00	4324.00		92.00	-3266.00	1.00	NCV	-3266.00	17.21	-56.20	NO	-56.20	1.00	-206.08
		Ethane	TJ		NO	NO		NO	NO	1.00	NCV	NO	16.80	NO	NO	NO	1.00	NO
		Naphtha	TJ		NO	NO		NO	NO	1.00	NCV	NO	19.99	NO	NO	NO	1.00	NO
		Bitumen	TJ		7960.00	0.00		-119.00	8079.00	1.00	NCV	8079.00	22.01	177.81	177.81	0.00	1.00	0.00
		Lubricants	TJ		2304.00	84.00	84.00	NO	2136.00	1.00	NCV	2136.00	19.99	42.70	42.70	0.00	1.00	0.00
		Petroleum coke	TJ		5526.00	94.00		-1099.00	6531.00	1.00	NCV	6531.00	26.59	173.67	NO	173.67	1.00	636.77
		Refinery feedstocks	TJ		4782.00	14006.00		-1708.00	-7516.00	1.00	NCV	-7516.00	19.99	-150.25	NO	-150.25	1.00	-550.92
		Other oil	TJ		NO	NO		NO	NO	1.00	NCV	NO	19.99	NO	NO	NO	1.00	NO
Other liquid fossil												348.00		6.96	6.96	0.00		0.00
		White Spirit										348.00	19.99	6.96	6.96	0.00		0.00
Liquid fossil totals												**233973.00**		**4725.40**	**227.47**	**4497.93**		**16492.43**
Solid fossil	Primary fuels	Anthracite(3)	TJ	NO	NO	NO		NO	NO	1.00	NCV	NO	26.81	NO	NO	NO	1.00	NO
		Coking coal	TJ	NO	NO	NO		NO	NO	1.00	NCV	NO	25.80	NO	NO	NO	1.00	NO
		Other bituminous coal	TJ	NO	63131.00	2106.00	NO	-10781.00	71806.00	1.00	NCV	71806.00	25.80	1852.59	NO	1852.59	1.00	6792.85
		Sub-bituminous coal	TJ	NO	NO	NO	NO	NO	NO	1.00	NCV	NO	26.21	NO	NO	NO	1.00	NO
		Lignite	TJ	NO	NO	NO		NO	NO	1.00	NCV	NO	27.55	NO	NO	NO	1.00	NO
		Oil shale and tar sand	TJ	NO	NO	NO		NO	NO	1.00	NCV	NO	29.18	NO	NO	NO	1.00	NO
	Secondary fuels	BKB(4) and patent fuel	TJ		0.00	0.00		NO	0.00	1.00	NCV	0.00	26.59	0.00	NO	0.00	1.00	0.00
		Coke oven/gas coke	TJ		428.00	NO		-57.00	485.00	1.00	NCV	485.00	29.18	14.15	NO	14.15	1.00	51.90
		Coal tar	TJ		NO	NO		NO	NO	1.00	NCV	NO	NO	NO	NO	NO	1.00	NO
Other solid fossil																		
Solid fossil totals												**72291.00**		**1866.75**	**NO**	**1866.75**		**6844.74**
Gaseous fossil		Natural gas (dry)	TJ	173510.00	24744.00	82349.00		-3521.00	119426.00	1.00	NCV	119426.00	15.30	1827.22	NO	1827.22	1.00	6699.80
Other gaseous fossil																		
Gaseous fossil totals												**119426.00**		**1827.22**	**NO**	**1827.22**		**6699.80**
Waste (non-biomass fraction)			TJ	15995.00	1866.00	NO	NO	NO	17861.00	1.00	NCV	17861.00	25.01	446.69	NO	446.69	1.00	1637.85
Other fossil fuels																		
Peat(5,6)			TJ	NO	NO	NO	NO	NO	NO	1.00	NCV	NO	28.91	NO	NO	NO	1.00	NO
Total												**425690.00**		**8419.37**	**227.47**	**8191.90**		**30036.97**
Biomass total												144698.00		4130.90	NO	4130.90		15146.63
		Solid biomass	TJ	66581.00	39423.00	NO		NO	106004.00	1.00	NCV	106004.00	30.55	3237.94	NO	3237.94	1.00	11872.45
		Liquid biomass	TJ	562.00	11039.00	1084.00		1.00	10516.00	1.00	NCV	10516.00	19.31	203.05	NO	203.05	1.00	744.53
		Gas biomass	TJ	6347.00	NO	NO		NO	6347.00	1.00	NCV	6347.00	14.89	94.51	NO	94.51	1.00	346.55
		Other non-fossil fuels (biogenic waste)	TJ	19550.00	2281.00	NO		NO	21831.00	1.00	NCV	21831.00	27.27	595.39	NO	595.39	1.00	2183.10

Table 102 Compared fuel consumption data, Reference Approach, 2015.

FUEL TYPES		Apparent consumption reported in GHG inventory (TJ)	Apparent consumption using Eurostat data[1)] (TJ)	Absolute difference (TJ)	Relative difference %	Explanations for differences
Liquid fossil	Crude oil	312045	302409	9636	3%	The calorific value for crude oil applied by Eurostat is not in agreement with the Danish energy statistics and the data reported by the Danish Energy Agency to Eurostat. DEA (2016c) states the NCV 43 GJ/tonnes whereas the Eurostat values are based on the NCV 41.671 GJ/tonnes. This 3 % difference is reflected in the all data (production, import, export etc.) for crude oil. This question will be included in the annual meetings with the DEA energy statistics experts.
	Orimulsion	NO	NO	0	0%	
	Natural gas liquids	NO	NO	0	0%	
	Gasoline	-30307	-30266	-41	0%	
	Jet kerosene	-3733	-4219	486	-13%	Fuel consumption for transport between mainland Denmark and Greenland and the Faroe Islands is not included in the reporting to the IEA and Eurostat. In the Danish emission inventory, the transport between Denmark, Greenland and the Faroe Islands is considered domestic. This causes a difference for liquid fuels used for aviation and navigation. For Jet kerosene, the fuel consumption to/from Greenland or Faroe Islands was 508 TJ in 2015 and thus close to the absolute difference (486 TJ). In addition, data for international bunkers will differ between the energy statistics and the CRF for the latest year. However, the data applied in CRF are adopted for the energy statistics the following year.
	Other kerosene	NO	NO	0	0%	
	Shale oil	NO	NO	0	0%	
	Gas/diesel oil	11729	11657	72	1%	Fuel consumption for transport between mainland Denmark and Greenland and the Faroe Islands is not included in the reporting to the IEA and Eurostat. In the Danish emission inventory, the transport between Denmark, Greenland and the Faroe Islands is considered domestic. This causes a difference for liquid fuels used for aviation and navigation. For diesel oil, the fuel consumption to/from Greenland or Faroe Islands was 170 TJ in 2015.
	Residual fuel oil	-51208	-51920	712	-1%	Fuel consumption for transport between mainland Denmark and Greenland and the Faroe Islands is not included in the reporting to the IEA and Eurostat. In the Danish emission inventory, the transport between Denmark, Greenland and the Faroe Islands is considered domestic. This causes a difference for liquid fuels used for aviation and navigation. For residual fuel oil, the fuel consumption to/from Greenland or Faroe Islands was 1519 TJ in 2015.
	Liquefied petroleum gases (LPG)	-3243	-3266	23	-1%	
	Ethane	NO	NO	0	0%	
	Naphtha	NO	NO	0	0%	
	Bitumen	8066	8079	-13	0%	
	Lubricants	2150	2136	14	1%	
	Petroleum coke	6578	6531	47	1%	
	Refinery feedstocks	-7505	-7516	11	0%	
	Other oil	NO	NO	0	0%	
	White Spirit	326	348	-22	-7%	Eurostat data are rounded off and due to the low consumption of White Spirit this cause the large relative difference.

FUEL TYPES		Apparent consumption reported in GHG inventory (TJ)	Apparent consumption using Eurostat data[1)] (TJ)	Absolute difference (TJ)	Relative difference %	Explanations for differences
Liquid fossil totals		244899	233973	10926	4%	Primarily related to the difference for crude oil.
Solid fossil	Anthracite	NO	NO	0	0%	
	Coking coal	NO	NO	0	0%	
	Other bituminous coal	75597	71806	3791	5%	The international reporting states the NCV 22.89 GJ/tonnes and the GCV 24.1 GJ/tonnes. However, in the Danish statistics the NCV is 24.1 GJ/tonnes (DEA, 2016c). This cause the 5 % difference. The average NCV of the EU ETS data for coal was 24.0 GJ/tonnes for 2015. This question will be included in the annual meetings with the DEA energy statistics experts.
	Sub-bituminous coal	NO	NO	0	0%	
	Lignite	NO	NO	0	0%	
	Oil shale and tar sand	NO	NO	0	0%	
	BKB(4) and patent fuel	-1	0	-1	100%	Eurostat data are rounded off and due to the low consumption of BKB this cause the large relative difference.
	Coke oven/gas coke	504	485	19	4%	The difference is caused by the low consumption of coke oven coke and the rounding off of the Eurostat data.
	Coal tar	NO	NO	0	0%	
Solid fossil totals		76101	72291	3810	5%	The difference is related to the difference for other bituminous coal.
Gaseous fossil	Natural gas (dry)	119425	119426	-1	0%	
Gaseous fossil totals		119425	119426	-1	0%	
Waste (non-biomass fraction)		17861	17861	0	0%	
Peat(5,6)		NO	NO	0	0%	
Total		**458286**	**443551**	**14735**	**3%**	
Biomass total		141532	144698	-3166	-2%	
	Solid biomass	103501	106004	-2503	-2%	
	Liquid biomass	9853	10516	-663	-7%	The CRF includes the three DEA fuel categories: Biodiesel (37.5 GJ/tonnes), Bioethanol (26.7 GJ/tonnes) and biogasoline (37.2 GJ/tonnes). The NCV for the three fuels are not the same and the CRF data are based on individual NCVs. The Eurostat data are based on NCV for biodiesel. In addition, the rounding off of the Eurostat data causes a difference.
	Gas biomass	6348	6347	1	0%	
	Other non-fossil fuels (biogenic waste)	21830	21831	-1	0%	The difference in fuel consumption data is low but the default CO_2 emission factor applied for the Eurostat data differ 37 % from the Danish emission factor. This cause the large difference in the estimated CO_2 emission.

1) Apparent consumption using data reported pursuant to Regulation (EC) No 1099\2008 (TJ).

Table 103 Compared CO_2 emission data, Reference Approach, 2015.

FUEL TYPES		CO_2 emission reported in GHG inventory (Gg)	CO_2 emission based on Eurostat data (Gg)	Absolute difference (Gg)	Relative difference %	Explanations for differences
Liquid fossil	Crude oil	22873	22167	706	3%	The difference is related to fuel consumption.
	Orimulsion	NO	NO	0	0%	
	Natural gas liquids	NO	NO	0	0%	
	Gasoline	-2212	-2097	-115	5%	The emission factor applied for Denmark differs from the IPCC default factor.
	Jet kerosene	-269	-302	33	-12%	The difference is related to fuel consumption.
	Other kerosene	NO	NO	0	0%	
	Shale oil	NO	NO	0	0%	
	Gas/diesel oil	868	864	4	0%	
	Residual fuel oil	-4025	-4019	-6	0%	
	Liquefied petroleum gases (LPG)	-205	-206	1	-1%	The difference is related to fuel consumption.
	Ethane	NO	NO	0	0%	
	Naphtha	NO	NO	0	0%	
	Bitumen	0	0	0	100%	Fuels for non-energy use have been included in other sectors and subtracted in the Danish reference approach.
	Lubricants	0	0	0	100%	Fuels for non-energy use have been included in other sectors and subtracted in the Danish reference approach.
	Petroleum coke	612	637	-25	-4%	The national referenced emission factor applied in CRF is lower than the IPCC default emission factor for petroleum coke.
	Refinery feedstocks	-550	-551	1	0%	
	Other oil	NO	NO	0	0%	
	White Spirit	0	0	0	131%	Fuels for non-energy use have been included in other sectors and subtracted in the Danish reference approach.
Liquid fossil totals		17092	16492	600	4%	Mainly related to crude oil.
Solid fossil	Anthracite(3)	NO	NO	0	0%	
	Coking coal	NO	NO	0	0%	
	Other bituminous coal	7141	6793	348	5%	The difference is related to fuel consumption.
	Sub-bituminous coal	NO	NO	0	0%	
	Lignite	NO	NO	0	0%	
	Oil shale and tar sand	NO	NO	0	0%	

FUEL TYPES		CO_2 emission reported in GHG inventory (Gg)	CO_2 emission based on Eurostat data (Gg)	Absolute difference (Gg)	Relative difference %	Explanations for differences
	BKB(4) and patent fuel	0	0	0	100%	The difference is related to fuel consumption.
	Coke oven/gas coke	54	52	2	4%	The difference is related to fuel consumption.
	Coal tar	NO	NO	0	0%	
	Other solid fossil		0	0	0%	
Solid fossil totals		7195	6845	350	5%	Mainly related to Other bituminous coal.
Gaseous fossil	Natural gas (dry)	6814	6700	115	2%	The emission factor applied for Denmark differs from the IPCC default factor.
	Other gaseous fossil		0	0	0%	
Gaseous fossil totals		6814	6700	115	2%	Related to natural gas.
Waste (non-biomass fraction)		1649	1638	11	1%	
Peat(5,6)		NO	NO	0	0%	
Total		**32751**	**30037**	**2714**	**8%**	**Mainly related to the fuel consumption of coal and crude oil.**
Biomass total		15804	15147	658	4%	Mainly related to the emission factor applied for incineration of biomass waste.
	Solid biomass	11592	11872	-280	-2%	The difference is related to fuel consumption.
	Liquid biomass	698	745	-47	-7%	The difference is related to fuel consumption.
	Gas biomass	534	347	187	35%	The emission factor applied for Denmark differs from the IPCC default factor.
	Other non-fossil fuels (biogenic waste)	2981	2183	798	27%	The emission factor applied for Denmark differs from the IPCC default factor.

11.2 Sectoral approach

11.2.1 Methodology

The Danish sectoral approach for 2015 has been compared to a sectoral approach estimate based on Eurostat data (Eurostat, 2017). The correspondence lists for activity and fuels are shown in Table 104 and Table 105 respectively.

Table 104 Correspondence list for activity, sectoral approach.

INDIC_NRG	INDIC_NRG(L)/TIME	CRF_SA
B_100800	International Marine Bunkers	International
B_101031	Transformation input in Main Activity Producer Electricity Plants	1A1a
B_101032	Transformation input in Main Activity Producer CHP Plants	1A1a
B_101034	Transformation input in Autoproducer Electricity Plants	1A1a
B_101035	Transformation input in Autoproducer CHP Plants	1A1a (1A1b for refinery gas)
B_101038	Transformation input in Main Activity Producer Heat Plants	1A1a
B_101039	Transformation input in Autoproducer Heat Plants	1A1a
B_101301	Own Use in Electricity, CHP and Heat Plants	1A1a
B_101305	Consumption in Oil and gas extraction	1A1c
B_101307	Consumption in Petroleum Refineries	1A1b
B_101315	Consumption in Blast Furnaces	1A2a
B_101805	Iron and Steel	1A2a
B_101810	Non-Ferrous Metals	1A2b
B_101815	Chemical and Petrochemical	1A2c
B_101820	Non-Metallic Minerals	1A2f
B_101825	Mining and Quarrying	1A2g
B_101830	Food and Tobacco	1A2e
B_101835	Textile and Leather	1A2g
B_101840	Paper, Pulp and Print	1A2d
B_101846	Transport Equipment	1A2g
B_101847	Machinery	1A2g
B_101851	Wood and Wood Products	1A2g
B_101852	Construction	1A2g
B_101853	Non-specified (Industry)	1A2g
B_101910	Rail	1A3c
B_101920	Road	1A3b
B_101931	International aviation	International
B_101932	Domestic aviation	1A3a
B_101940	Domestic Navigation	1A3d
B_101945	Consumption in Pipeline transport	1A3e
B_101950	Non-specified (Transport)	1A3e
B_102010	Residential	1A4b
B_102020	Fishing	1A4c
B_102030	Agriculture/Forestry	1A4c
B_102035	Services	1A4a
B_102040	Non-specified (Other)	1A5

Table 105 Correspondence list for fuels, sectoral approach.

Eurostat fuel codes	Eurostat nomenclature	Sectoral approach fuel group	Sectoral approach fuel
2117	Other Bituminous Coal	Solid	Other Bituminous Coal
2121	Coke Oven Coke	Solid	Coke oven coke
2230	BKB (brown coal briquettes)	Solid	BKB
3214	Refinery gas	Liquid	Refinery gas
3220	Liquefied petroleum gas (LPG)	Liquid	LPG
3234	Gasoline (without bio components)	Liquid	Motor gasoline
3235	Aviation gasoline	Liquid	Aviation gasoline
3244	Other kerosene	Liquid	Jet kerosene
3246	Gasoline type jet fuel	Liquid	Jet kerosene
3247	Kerosene type jet fuel (without bio components)	Liquid	Jet kerosene
3260	Gas/diesel oil (without bio components)	Liquid	Gas/diesel oil
3270A	Total fuel oil	Liquid	Fuel oil
3281	White Spirit and SBP	Liquid	Naphtha
3282	Lubricants	Liquid	Lubricants
3283	Bitumen	Liquid	Bitumen
3285	Petroleum coke	Liquid	Petroleum coke
4100	Natural gas	Gaseous	Natural gas
4210	Coke Oven Gas	Gaseous	Coke Oven Gas
4230	Gas Works Gas	Gaseous	Gas Works Gas
5541	Solid biofuels (excluding charcoal)	Biomass	Biomass solid
5542	Biogas	Biomass	Biogas
55431	Municipal waste (renewable)	Biomass	Waste biomass
55432	Municipal waste (non-renewable)	Fossil waste	Waste fossil
5546	Biogasoline	Biomass	Biogasoline
5547	Biodiesels	Biomass	Biodiesels
5548	Other liquid biofuels	Biomass	Other liquid biofuels

11.2.2 Results

Table 106 shows the total fuel consumption in the sectoral approach based on CRF and Eurostat respectively.

For coal, the international reporting states the NCV 22.89 GJ/tonnes and the GCV 24.1 GJ/tonnes. However, in the Danish statistics the NCV is 24.1 GJ/tonnes. This difference in applied NCVs causes the 5 % difference. The average NCV of the EU ETS data for coal was 24.0 GJ/tonnes for 2015. As mentioned above, this question will also be included in the annual meetings with the DEA energy statistics experts.

For liquid fuels, the consumption based on Eurostat is higher than in CRF. The fuel consumption for transport between mainland Denmark and Greenland and the Faroe Islands is included in international bunkers in the reporting to Eurostat. In the Danish emission inventory, the transport between Denmark, Greenland and the Faroe Islands is considered domestic. This causes a difference for liquid fuels used for aviation and navigation.

For fossil waste, the bottom up approach applied in the Danish emission inventory adds up to higher consumption than stated in the energy statistics for 2015.

For gaseous fuels, the consumption for offshore gas turbines is higher in CRF than in the Eurostat data. CRF data for offshore gas turbines is based on EU ETS data that are not in agreement with the energy statistics due to application of an inaccurate NCV in the energy statistics.

Table 106 Total fuel consumption, sectoral approach, 2015.

	Fuel CRF, TJ	Fuel Eurostat, TJ	Fuel Eurostat / Fuel CRF, %
Solid	76458	72831	95%
Liquid	240745	227214	94%
Gaseous	121003	119863	99%
Fossil waste	18406	17862	97%
Biomass	142980	144359	101%

Table 107 Fuel consumption and CO_2 emission, sectoral approach, 2015.

Sector	Fuel group	Fuel				CO_2				Comments
		CRF	Eurostat	Difference	Eurostat / CRF	CRF	Eurostat	Difference	Eurostat / CRF	
		TJ	TJ	TJ	%	Gg	Gg	Gg	%	
1A1a	Solid	71623	67892	-3731	95%	6771	6423	-349	95%	The international reporting states the NCV 22.89 GJ/tonnes and the GCV 24.1 GJ/tonnes. However, in the Danish statistics the NCV is 24.1 GJ/tonnes. This cause the 5 % difference. The average NCV of the EU ETS data for coal was 24.0 GJ/tonnes for 2015. This question will be implemented in the annual meetings with the DEA energy statistics experts.
1A1a	Liquid	2011	2668	657	133%	154	203	49	132%	Part of the consumption of liquid fuels in autoproducer CHP and autoproducer district heating plants are applied in different industrial subsectors and included in these sectors in CRF. In the data based on Eurostat data, these consumption rates have been included in sector 1A1a.
1A1a	Gaseous	30728	34431	3703	112%	1753	1932	179	110%	Part of the consumption of gaseous fuels in autoproducer CHP and autoproducer district heating plants are applied in different industrial subsectors and included in these sectors in CRF. In the data based on Eurostat data, these consumption rates have been included in sector 1A1a.
1A1a	Fossil waste	16885	17003	118	101%	1576	1559	-16	99%	
1A1a	Biomass	81576	84321	2745	103%	9359	8885	-474	95%	
1A1a Total		202823	206315	3492	102%	19613	19001	-612	97%	
1A1b	Solid	NO	NO	0	100%	NO	0	0	NO	
1A1b	Liquid	16797	17136	339	102%	978	999	21	102%	The CRF data refer to the EU ETS data from the two refineries in Denmark. The EU ETS data are not in agreement with the energy statistics due to application of an inaccurate NCV in the energy statistics.
1A1b	Gaseous	NO	NO	0	100%	NO	0	0	NO	
1A1b	Fossil waste	NO	NO	0	100%	NO	0	0	NO	
1A1b	Biomass	NO	NO	0	100%	NO	0	0	NO	
1A1b Total		16797	17136	339	102%	978	999	21	102%	
1A1c	Solid	NO	NO	0	100%	NO	0	0	NO	
1A1c	Liquid	0	NO	0	0%	0	0	0	0%	
1A1c	Gaseous	24921	24082	-839	97%	1436	1351	-85	94%	The CRF data refer to the EU ETS data from the offshore sector in Denmark. The EU ETS data are not in agreement with the energy statistics due to application of an inaccurate NCV in the energy statistics.

Sector	Fuel group	Fuel				CO_2				Comments
		CRF	Eurostat	Difference	Eurostat / CRF	CRF	Eurostat	Difference	Eurostat / CRF	
		TJ	TJ	TJ	%	Gg	Gg	Gg	%	
1A1c	Fossil waste	NO	NO	0	100%	NO	0	0	NO	
1A1c	Biomass	NO	NO	0	100%	NO	0	0	NO	
1A1c Total		24921	24082	-839	97%	1436	1351	-85	94%	
1A2a	Solid	NO	NO	0	100%	NO	0	0	NO	
1A2a	Liquid	13	89	76	684%	1	6	5	690%	
1A2a	Gaseous	1539	1651	112	107%	88	93	5	105%	
1A2a	Fossil waste	NO	NO	0	100%	NO	0	0	NO	
1A2a	Biomass	0	1	1	2115%	0	0	0	2115%	
1A2a Total		1552	1741	189	112%	89	99	10	111%	
1A2b	Solid	NO	NO	0	100%	NO	0	0	NO	
1A2b	Liquid	NO	NO	0	100%	NO	0	0	NO	
1A2b	Gaseous	NO	NO	0	100%	NO	0	0	NO	
1A2b	Fossil waste	NO	NO	0	100%	NO	0	0	NO	
1A2b	Biomass	NO	NO	0	100%	NO	0	0	NO	
1A2b Total		NO	NO	0	100%	NO	0	0	NO	
1A2c	Solid	804	504	-300	63%	76	48	-28	63%	
1A2c	Liquid	227	248	21	109%	17	19	1	107%	
1A2c	Gaseous	5167	4694	-473	91%	295	261	-34	89%	
1A2c	Fossil waste	NO	NO	0	100%	NO	0	0	NO	
1A2c	Biomass	223	NO	-223	0%	20	0	-20	0%	
1A2c Total		6421	5446	-975	85%	408	328	-80	80%	
1A2d	Solid	NO	NO	0	100%	NO	0	0	NO	
1A2d	Liquid	5	131	126	2603%	0	9	9	2797%	
1A2d	Gaseous	1184	1459	275	123%	68	82	14	121%	
1A2d	Fossil waste	NO	6	6	NO in CRF	NO	1	1	NO	
1A2d	Biomass	225	124	-101	55%	25	14	-11	55%	
1A2d Total		1414	1720	306	122%	93	105	12	113%	

Sector	Fuel group	Fuel				CO_2				Comments
		CRF	Eurostat	Difference	Eurostat / CRF	CRF	Eurostat	Difference	Eurostat / CRF	
		TJ	TJ	TJ	%	Gg	Gg	Gg	%	
1A2e	Solid	1347	1213	-134	90%	128	116	-12	91%	
1A2e	Liquid	2193	2068	-125	94%	173	154	-19	89%	
1A2e	Gaseous	12396	11157	-1239	90%	707	625	-82	88%	
1A2e	Fossil waste	NO	19	19	NO in CRF	NO	2	2	NO	
1A2e	Biomass	341	554	213	162%	27	31	4	115%	
1A2e Total		16277	15011	-1266	92%	1036	929	-107	90%	
1A2f	Solid	1511	2361	850	156%	145	228	82	157%	
1A2f	Liquid	6788	7209	421	106%	632	686	55	109%	
1A2f	Gaseous	4572	4226	-346	92%	261	237	-24	91%	
1A2f	Fossil waste	1452	643	-809	44%	124	59	-65	48%	
1A2f	Biomass	1113	857	-256	77%	82	87	5	106%	
1A2f Total		15436	15296	-140	99%	1243	1297	53	104%	
1A2g	Solid	561	114	-447	20%	59	11	-48	18%	
1A2g	Liquid	10023	6766	-3257	68%	730	497	-233	68%	
1A2g	Gaseous	5713	4291	-1422	75%	326	241	-85	74%	
1A2g	Fossil waste	NO	5	5	NO in CRF	NO	0	0	NO	
1A2g	Biomass	0	4372	4372	NO in CRF	0	489	489	NO	
1A2g Total		16297	15548	-749	95%	1115	1238	123	111%	
1A3a	Solid	NO	NO	0	100%	NO	0	0	NO	
1A3a	Liquid	1771	1262	-509	71%	128	90	-37	71%	
1A3a	Gaseous	NO	NO	0	100%	NO	0	0	NO	
1A3a	Fossil waste	NO	NO	0	100%	NO	0	0	NO	
1A3a	Biomass	NO	NO	0	100%	NO	0	0	NO	
1A3a Total		1771	1262	-509	71%	128	90	-37	71%	
1A3b	Solid	NO	NO	0	100%	NO	0	0	NO	
1A3b	Liquid	155237	147419	-7818	95%	11436	10659	-777	93%	
1A3b	Gaseous	117	NO	-117	0%	7	0	-7	0%	
1A3b	Fossil waste	NO	NO	0	100%	NO	0	0	NO	

Sector	Fuel group	Fuel				CO_2				Comments
		CRF	Eurostat	Difference	Eurostat / CRF	CRF	Eurostat	Difference	Eurostat / CRF	
		TJ	TJ	TJ	%	Gg	Gg	Gg	%	
1A3b	Biomass	8969	9713	744	108%	660	688	28	104%	
1A3b Total		164323	157132	-7191	96%	12102	11347	-756	94%	
1A3c	Solid	NO	NO	0	100%	NO	0	0	NO	
1A3c	Liquid	3356	3373	17	101%	248	250	2	101%	
1A3c	Gaseous	NO	NO	0	100%	NO	0	0	NO	
1A3c	Fossil waste	NO	NO	0	100%	NO	0	0	NO	
1A3c	Biomass	NO	NO	0	100%	NO	0	0	NO	
1A3c Total		3356	3373	17	101%	248	250	2	101%	
1A3d	Solid	NO	NO	0	100%	NO	0	0	NO	
1A3d	Liquid	4880	5634	754	115%	370	418	48	113%	
1A3d	Gaseous	69	NO	-69	0%	4	0	-4	0%	
1A3d	Fossil waste	NO	NO	0	100%	NO	0	0	NO	
1A3d	Biomass	NO	NO	0	100%	NO	0	0	NO	
1A3d Total		4949	5634	685	114%	374	418	44	112%	
1A3e	Solid	NO	NO	0	100%	NO	0	0	NO	
1A3e	Liquid	NO	1338	1338	NO in CRF	NO	97	97	NO	
1A3e	Gaseous	NO	NO	0	100%	NO	0	0	NO	
1A3e	Fossil waste	NO	NO	0	100%	NO	0	0	NO	
1A3e	Biomass	NO	NO	0	100%	NO	0	0	NO	
1A3e Total		0	1338	1338	NO in CRF	0	97	97	NO	
1A4a	Solid	NO	NO	0	100%	NO	0	0	NO	
1A4a	Liquid	4968	2628	-2340	53%	361	191	-170	53%	
1A4a	Gaseous	7752	7342	-410	95%	442	412	-31	93%	
1A4a	Fossil waste	69	186	117	271%	NO	17	17	NO	
1A4a	Biomass	2233	1624	-609	73%	222	165	-57	74%	
1A4a Total		15022	11780	-3242	78%	1025	785	-241	77%	
1A4b	Solid	NO	NO	0	100%	NO	0	0	NO	

Sector	Fuel group	Fuel				CO_2				Comments
		CRF	Eurostat	Difference	Eurostat / CRF	CRF	Eurostat	Difference	Eurostat / CRF	
		TJ	TJ	TJ	%	Gg	Gg	Gg	%	
1A4b	Liquid	7735	10024	2289	130%	563	730	167	130%	
1A4b	Gaseous	25098	24776	-322	99%	1432	1386	-46	97%	
1A4b	Fossil waste	NO	NO	0	100%	NO	0	0	NO	
1A4b	Biomass	40497	40492	-5	100%	4485	4520	35	101%	
1A4b Total		73330	75292	1962	103%	6481	6636	156	102%	
1A4c	Solid	612	747	135	122%	58	71	13	122%	
1A4c	Liquid	22062	19221	-2841	87%	1632	1422	-209	87%	
1A4c	Gaseous	1747	1479	-268	85%	100	83	-17	83%	
1A4c	Fossil waste	NO	NO	0	100%	NO	0	0	NO	
1A4c	Biomass	2889	2301	-588	80%	280	250	-30	89%	
1A4c Total		27310	23748	-3562	87%	2069	1826	-243	88%	
1A5	Solid	NO	NO	0	100%	NO	0	0	NO	
1A5	Liquid	2680	NO	-2680	0%	197	0	-197	0%	
1A5	Gaseous	NO	275	275	NO in CRF	NO	15	15	NO	
1A5	Fossil waste	NO	NO	0	100%	NO	0	0	NO	
1A5	Biomass	NO	NO	0	100%	NO	0	0	NO	
1A5 Total		2680	275	-2405	10%	197	15	-181	8%	
International	Solid	NO	NO	0	100%	NO	0	0	NO	
International	Liquid	67060	69033	1973	103%	4938	5063	126	103%	
International	Gaseous	NO	NO	0	100%	NO	0	0	NO	
International	Fossil waste	NO	NO	0	100%	NO	0	0	NO	
International	Biomass	NO	NO	0	100%	NO	0	0	NO	
International Total		67060	69033	1973	103%	4938	5063	126	103%	

12. Total EU ETS data compared to CRF data

The annual reporting of GHGs to EU includes a comparison of the CRF data and the total ETS data. The comparison has been made regarding the verified emissions reported under the (EU ETS Directive 2003/87/EC) and the emissions reported in the CRF tables.

12.1 The allocation of the verified emissions reported under EU ETS to CRF categories

The verification is based on the database for all EU ETS data from the Danish Energy Agency.

CRF emission categories have been added to all EU ETS data[34].

For fuel combustion, all plants in the EU ETS databased have a plant id that can be linked to another plant specific database from DEA that includes all plants that supply power or district heating to the public grid (Energiproducenttællingen). This database includes SNAP sector codes and thus CRF sector codes can be linked based on the correspondence list between SNAP and CRF sector codes. The emissions from combustion from the remaining plants (offshore gas turbines, refineries and a large number of different industrial plants) have been allocated to the relevant CRF sector manually.

For process emissions, the CRF categories are added manually for each emission source included in the EU ETS database.

12.2 Consistency of data reported under EU ETS with the CRF inventory

In the Danish inventory, the data reported under the EU ETS are used directly in the inventory for plants using higher tier methods. For plants reporting using a lower tier method, the data are not used in the inventory. However, the data reported is checked in terms of overall sum checks of individual categories to ensure that the emissions reported under EU ETS for a source category do not exceed the emissions in the inventory.

The comparison of CRF data and EU ETS data is shown on the next pages. It shows that the emission reported under category 1A1c in the ETS exceeds the emissions reported in the inventory. The consumption of gas oil reported in 1A1c in the energy statistics is not in agreement with the consumption in the ETS reports. This problem is however related to disaggregation of the gas oil consumption and do not affect the total CO_2 emission reported.

[34] CRF categories are now a part of the data included in the EU ETS data sheet from DEA.

Implementing Regulation Article 10: Reporting on consistency of reported emissions with data from the emissions trading system

1. Member States shall report the information referred to in Article 7(1)(k) of Regulation (EU) No 525/2013 in accordance with the tabular format set out in Annex V to this regulation.
2. Member States shall report textual information on the results of the checks performed pursuant to Article 7(1)(l) of Regulation (EU) No 525/2013.

Allocation of verified emissions reported by installations and operators under Directive 2003/87/EC to source categories of the national greenhouse gas inventory	
Member State:	Denmark
Reporting year:	2015
Basis for data: verified ETS emissions and greenhouse gas emissions as reported in inventory submission for the year X-2	

Total emissions (CO2 -eq)					
Category[1]	Gas	Greenhouse gas inventory emissions [kt CO2eq][3]	Verified emissions under Directive 2003/87/EC [kt CO2eq][3]	Ratio in % (Verified emissions/ inventory emissions)[3]	Comment[2]
Greenhouse gas emissions (total emissions without LULUCF for GHG inventory and without emissions from 1A3a Civil aviation, total emissions from installations under Article 3h of Directive 2003/87/EC)	Total GHG	50814.44	15795.9	31.1%	
CO2 emissions (total CO2 emissions without LULUCF for GHG inventory and without emissions from 1A3a Civil aviation, total emissions from installations under Article 3h of Directive 2003/87/EC)	Total GHG	35018.96	15795.9	45.1%	

CO2 emissions					
Category[1]		Greenhouse gas inventory emissions [kt CO2eq][3]	Verified emissions under Directive 2003/87/EC [kt CO2eq][3]	Ratio in % (Verified emissions/ inventory emissions)[3]	Comment[2]
1.A Fuel combustion activities, total	CO_2	33474.8	14539.2	43.4%	
1.A Fuel combustion activities, stationary combustion [4]	CO_2	18505.2	14539.2	78.6%	
1.A.1 Energy industries	CO_2	12668.0	12210.1	96.4%	
1.A.1.a Public electricity and heat production	CO_2	10254.1	9771.8	95.3%	
1.A.1.b Petroleum refining	CO_2	978.1	978.1	100.0%	
1.A.1.c Manufacture of solid fuels and other energy industries	CO_2	1435.8	1460.2	101.7%	The energy statistics do not include consumption of gas oil in oil and gas extraction. The gas oil consumption is however included in other sectors.
Iron and steel total (1.A.2, 1.B, 2.C.1) [5]	CO_2	88.7	88.4	99.7%	
1.A.2. Manufacturing industries and construction	CO_2	3830.4	2302.1	60.1%	
1.A.2.a Iron and steel	CO_2	88.7	88.4	99.7%	
1.A.2.b Non-ferrous metals	CO_2	NO	0.0	NO	

1.A.2.c Chemicals	CO_2	388.4	109.2	28.1%	
1.A.2.d Pulp, paper and print	CO_2	67.9	48.7	71.7%	
1.A.2.e Food processing, beverages and tobacco	CO_2	1008.8	788.2	78.1%	
1.A.2.f Non-metallic minerals	CO_2	1161.7	955.2	82.2%	
1.A.2.g Other	CO_2	1114.9	312.4	28.0%	
1.A.3. Transport	CO_2	12191.7	0.0	0.0%	
1.A.3.e Other transportation (pipeline transport)	CO_2	NO	0.0	NO	
1.A.4 Other sectors	CO_2	4588.2	27.0	0.6%	
1.A.4.a Commercial / Institutional	CO_2	803.3	4.6	0.6%	
1.A.4.c Agriculture/ Forestry / Fisheries	CO_2	1789.4	22.5	1.3%	
1.B Fugitive emissions from Fuels	CO_2	247.1	245.7	99.4%	
1.C CO2 Transport and storage	CO_2	NO	NO	NO	
1.C.1 Transport of CO2	CO_2	NO	NO	NO	
1.C.2 Injection and storage	CO_2	NO	NO	NO	
1.C:3 Other 2.A Mineral products	CO_2	NO	NO	NO	
2.A Mineral products	CO_2	1051.8	1011.0	96.1%	
2.A.1 Cement Production	CO_2	931.5	931.5	100.0%	
2.A.2. Lime production	CO_2	50.6	23.7	46.8%	
2.A.3. Glass production	CO_2	8.9	8.9	100.0%	
2.A.4. Other process uses of carbonates	CO_2	60.8	47.0	77.2%	
2.B Chemical industry	CO_2	1.6	0.0	0.0%	
2.B.1. Ammonia production	CO_2	NO	NO	NO	
2.B.3. Adipic acid production (CO2)	CO_2	NO	NO	NO	
2.B.4. Caprolactam, glyoxal and glyoxylic acid production	CO_2	NO	NO	NO	
2.B.5. Carbide production	CO_2	NO	NO	NO	
2.B.6 Titanium dioxide production	CO_2	NO	NO	NO	
2.B.7 Soda ash production	CO_2	NO	NO	NO	
2.B.8 Petrochemical and carbon black production	CO_2	NO	NO	NO	
2.C Metal production	CO_2	0.2	0.0	0.0%	
2.C.1. Iron and steel production	CO_2	NO	NO	NO	
2.C.2 Ferroalloys production	CO_2	NO	NO	NO	
2.C.3 Aluminium production	CO_2	NO	NO	NO	
2.C.4 Magnesium production	CO_2	NO	NO	NO	
2.C.5 Lead production	CO_2	0.2	0.0	0.0%	
2.C.6 Zinc production	CO_2	NO	NO	NO	
2.C.7 Other metal production	CO_2	NO	NO	NO	

N2O emissions					
Category[1]	Gas	Greenhouse gas inventory emissions [kt CO2eq][3]	Verified emissions under Directive 2003/87/EC [kt CO2eq][3]	Ratio in % (Verified emissions/ inventory emissions)[3]	Comment[2]
2.B.2. Nitric acid production	N_2O	NO	NO	NO	
2.B.3. Adipic acid production	N_2O	NO	NO	NO	
2.B.4. Caprolactam, glyoxal and glyoxylic acid production	N_2O	NO	NO	NO	

PFC emissions					
Category[1]	Gas	Greenhouse gas inventory emissions [kt CO_2eq][3]	Verified emissions under Directive 2003/87/EC [kt CO_2eq][3]	Ratio in % (Verified emissions/ inventory emissions)[3]	Comment[2]
2.C.3 Aluminium production	PFC	NO	NO	NO	

[1] The allocation of verified emissions to disaggregated inventory categories at four-digit level must be reported where such allocation of verified emissions is possible and emissions occur. The following notation keys should be used: NO = not occurring IE = included elsewhere C = confidential negligible = small amount of verified emissions may occur in respective CRF category, but amount is < 5% of the category.
[2] The column comment should be used to give a brief summary of the checks performed and if a Member State wants to provide additional explanations with regard to the allocation reported. Member States should add a short explanation when using IE or other notation keys to ensure transparency.
[3] Data to be reported up to one decimal point for kt and % values.
[4] 1.A Fuel combustion, stationary combustion should include the sum total of the relevant rows below for 1.A (without double counting) plus the addition of other stationary combustion emissions not explicitly included in any of the rows below.
[5] To be filled on the basis of combined CRF categories pertaining to 'Iron and Steel', to be determined individually by each Member State; e.g. (1.A.2.a+ 2.C.1 + 1.A.1.c and other relevant CRF categories that include emissions from iron and steel (e.g. 1A1a, 1B1))
Notation: x = reporting year.

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Annexes

Annex 1 Correspondence list between SNAP and CRF source categories

Table 1.1 Correspondence list between SNAP and CRF source categories for stationary combustion.

snap_id	snap_name	CRF id	CRF name
010100	Public power	1A1a	Public electricity and heat production
010101	Combustion plants >= 300 MW (boilers)	1A1a	Public electricity and heat production
010102	Combustion plants >= 50 and < 300 MW (boilers)	1A1a	Public electricity and heat production
010103	Combustion plants < 50 MW (boilers)	1A1a	Public electricity and heat production
010104	Gas turbines	1A1a	Public electricity and heat production
010105	Stationary engines	1A1a	Public electricity and heat production
010200	District heating plants	1A1a	Public electricity and heat production
010201	Combustion plants >= 300 MW (boilers)	1A1a	Public electricity and heat production
010202	Combustion plants >= 50 and < 300 MW (boilers)	1A1a	Public electricity and heat production
010203	Combustion plants < 50 MW (boilers)	1A1a	Public electricity and heat production
010204	Gas turbines	1A1a	Public electricity and heat production
010205	Stationary engines	1A1a	Public electricity and heat production
010300	Petroleum refining plants	1A1b	Petroleum refining
010301	Combustion plants >= 300 MW (boilers)	1A1b	Petroleum refining
010302	Combustion plants >= 50 and < 300 MW (boilers)	1A1b	Petroleum refining
010303	Combustion plants < 50 MW (boilers)	1A1b	Petroleum refining
010304	Gas turbines	1A1b	Petroleum refining
010305	Stationary engines	1A1b	Petroleum refining
010306	Process furnaces	1A1b	Petroleum refining
010400	Solid fuel transformation plants	1A1c	Oil and gas extraction
010401	Combustion plants >= 300 MW (boilers)	1A1c	Oil and gas extraction
010402	Combustion plants >= 50 and < 300 MW (boilers)	1A1c	Oil and gas extraction
010403	Combustion plants < 50 MW (boilers)	1A1c	Oil and gas extraction
010404	Gas turbines	1A1c	Oil and gas extraction
010405	Stationary engines	1A1c	Oil and gas extraction
010406	Coke oven furnaces	1A1c	Oil and gas extraction
010407	Other (coal gasification, liquefaction)	1A1c	Oil and gas extraction
010500	Coal mining, oil / gas extraction, pipeline compressors	1A1c	Oil and gas extraction
010501	Combustion plants >= 300 MW (boilers)	1A1c	Oil and gas extraction
010502	Combustion plants >= 50 and < 300 MW (boilers)	1A1c	Oil and gas extraction
010503	Combustion plants < 50 MW (boilers)	1A1c	Oil and gas extraction
010504	Gas turbines	1A1c	Oil and gas extraction
010505	Stationary engines	1A1c	Oil and gas extraction
010506	Pipeline compressors	1A3e i	Pipeline transport
020100	Commercial and institutional plants	1A4a i	Commercial/institutional: Stationary
020101	Combustion plants >= 300 MW (boilers)	1A4a i	Commercial/institutional: Stationary
020102	Combustion plants >= 50 and < 300 MW (boilers)	1A4a i	Commercial/institutional: Stationary
020103	Combustion plants < 50 MW (boilers)	1A4a i	Commercial/institutional: Stationary
020104	Stationary gas turbines	1A4a i	Commercial/institutional: Stationary
020105	Stationary engines	1A4a i	Commercial/institutional: Stationary
020106	Other stationary equipments	1A4a i	Commercial/institutional: Stationary
020200	Residential plants	1A4b i	Residential: Stationary
020201	Combustion plants >= 50 MW (boilers)	1A4b i	Residential: Stationary
020202	Combustion plants < 50 MW (boilers)	1A4b i	Residential: Stationary
020203	Gas turbines	1A4b i	Residential: Stationary
020204	Stationary engines	1A4b i	Residential: Stationary
020205	Other equipments (stoves, fireplaces, cooking)	1A4b i	Residential: Stationary
020300	Plants in agriculture, forestry and aquaculture	1A4c i	Agriculture/Forestry/Fishing: Stationary
020301	Combustion plants >= 50 MW (boilers)	1A4c i	Agriculture/Forestry/Fishing: Stationary
020302	Combustion plants < 50 MW (boilers)	1A4c i	Agriculture/Forestry/Fishing: Stationary
020303	Stationary gas turbines	1A4c i	Agriculture/Forestry/Fishing: Stationary
020304	Stationary engines	1A4c i	Agriculture/Forestry/Fishing: Stationary
020305	Other stationary equipments	1A4c i	Agriculture/Forestry/Fishing: Stationary
030100	Comb. in boilers, gas turbines and stationary	1A2g viii	Other manufacturing industry
030101	Combustion plants >= 300 MW (boilers)	1A2g viii	Other manufacturing industry
030102	Combustion plants >= 50 and < 300 MW (boilers)	1A2g viii	Other manufacturing industry
030103	Combustion plants < 50 MW (boilers)	1A2g viii	Other manufacturing industry
030104	Gas turbines	1A2g viii	Other manufacturing industry
030105	Stationary engines	1A2g viii	Other manufacturing industry
030106	Other stationary equipments	1A2g viii	Other manufacturing industry
030200	Process furnaces without contact (a)	1A2g viii	Other manufacturing industry
030203	Blast furnace cowpers	1A2a	Iron and steel
030204	Plaster furnaces	1A2g viii	Other manufacturing industry
030205	Other furnaces	1A2g viii	Other manufacturing industry
030400	Iron and Steel	1A2a	Iron and steel

snap_id	snap_name	CRF id	CRF name
030401	Combustion plants >= 300 MW (boilers)	1A2a	Iron and steel
030402	Combustion plants >= 50 and < 300 MW (boilers)	1A2a	Iron and steel
030403	Combustion plants < 50 MW (boilers)	1A2a	Iron and steel
030404	Gas turbines	1A2a	Iron and steel
030405	Stationary engines	1A2a	Iron and steel
030406	Other stationary equipments	1A2a	Iron and steel
030500	Non-Ferrous Metals	1A2b	Non-ferrous metals
030501	Combustion plants >= 300 MW (boilers)	1A2b	Non-ferrous metals
030502	Combustion plants >= 50 and < 300 MW (boilers)	1A2b	Non-ferrous metals
030503	Combustion plants < 50 MW (boilers)	1A2b	Non-ferrous metals
030504	Gas turbines	1A2b	Non-ferrous metals
030505	Stationary engines	1A2b	Non-ferrous metals
030506	Other stationary equipments	1A2b	Non-ferrous metals
030600	Chemical and Petrochemical	1A2c	Chemicals
030601	Combustion plants >= 300 MW (boilers)	1A2c	Chemicals
030602	Combustion plants >= 50 and < 300 MW (boilers)	1A2c	Chemicals
030603	Combustion plants < 50 MW (boilers)	1A2c	Chemicals
030604	Gas turbines	1A2c	Chemicals
030605	Stationary engines	1A2c	Chemicals
030606	Other stationary equipments	1A2c	Chemicals
030700	Non-Metallic Minerals	1A2f	Non-metallic minerals
030701	Combustion plants >= 300 MW (boilers)	1A2f	Non-metallic minerals
030702	Combustion plants >= 50 and < 300 MW (boilers)	1A2f	Non-metallic minerals
030703	Combustion plants < 50 MW (boilers)	1A2f	Non-metallic minerals
030704	Gas turbines	1A2f	Non-metallic minerals
030705	Stationary engines	1A2f	Non-metallic minerals
030706	Other stationary equipments	1A2f	Non-metallic minerals
030800	Mining and Quarrying	1A2g viii	Other manufacturing industry
030801	Combustion plants >= 300 MW (boilers)	1A2g viii	Other manufacturing industry
030802	Combustion plants >= 50 and < 300 MW (boilers)	1A2g viii	Other manufacturing industry
030803	Combustion plants < 50 MW (boilers)	1A2g viii	Other manufacturing industry
030804	Gas turbines	1A2g viii	Other manufacturing industry
030805	Stationary engines	1A2g viii	Other manufacturing industry
030806	Other stationary equipments	1A2g viii	Other manufacturing industry
030900	Food and Tobacco	1A2e	Food processing, beverages and tobacco
030901	Combustion plants >= 300 MW (boilers)	1A2e	Food processing, beverages and tobacco
030902	Combustion plants >= 50 and < 300 MW (boilers)	1A2e	Food processing, beverages and tobacco
030903	Combustion plants < 50 MW (boilers)	1A2e	Food processing, beverages and tobacco
030904	Gas turbines	1A2e	Food processing, beverages and tobacco
030905	Stationary engines	1A2e	Food processing, beverages and tobacco
030906	Other stationary equipments	1A2e	Food processing, beverages and tobacco
031000	Textile and Leather	1A2g viii	Other manufacturing industry
031001	Combustion plants >= 300 MW (boilers)	1A2g viii	Other manufacturing industry
031002	Combustion plants >= 50 and < 300 MW (boilers)	1A2g viii	Other manufacturing industry
031003	Combustion plants < 50 MW (boilers)	1A2g viii	Other manufacturing industry
031004	Gas turbines	1A2g viii	Other manufacturing industry
031005	Stationary engines	1A2g viii	Other manufacturing industry
031006	Other stationary equipments	1A2g viii	Other manufacturing industry
031100	Paper, Pulp and Print	1A2d	Pulp, Paper and Print
031101	Combustion plants >= 300 MW (boilers)	1A2d	Pulp, Paper and Print
031102	Combustion plants >= 50 and < 300 MW (boilers)	1A2d	Pulp, Paper and Print
031103	Combustion plants < 50 MW (boilers)	1A2d	Pulp, Paper and Print
031104	Gas turbines	1A2d	Pulp, Paper and Print
031105	Stationary engines	1A2d	Pulp, Paper and Print
031106	Other stationary equipments	1A2d	Pulp, Paper and Print
031200	Transport Equipment	1A2g viii	Other manufacturing industry
031201	Combustion plants >= 300 MW (boilers)	1A2g viii	Other manufacturing industry
031202	Combustion plants >= 50 and < 300 MW (boilers)	1A2g viii	Other manufacturing industry
031203	Combustion plants < 50 MW (boilers)	1A2g viii	Other manufacturing industry
031204	Gas turbines	1A2g viii	Other manufacturing industry
031205	Stationary engines	1A2g viii	Other manufacturing industry
031206	Other stationary equipments	1A2g viii	Other manufacturing industry
031300	Machinery	1A2g viii	Other manufacturing industry
031301	Combustion plants >= 300 MW (boilers)	1A2g viii	Other manufacturing industry
031302	Combustion plants >= 50 and < 300 MW (boilers)	1A2g viii	Other manufacturing industry
031303	Combustion plants < 50 MW (boilers)	1A2g viii	Other manufacturing industry
031304	Gas turbines	1A2g viii	Other manufacturing industry
031306	Other stationary equipments	1A2g viii	Other manufacturing industry
031400	Wood and Wood Products	1A2g viii	Other manufacturing industry

snap_id	snap_name	CRF id	CRF name
031401	Combustion plants >= 300 MW (boilers)	1A2g viii	Other manufacturing industry
031402	Combustion plants >= 50 and < 300 MW (boilers)	1A2g viii	Other manufacturing industry
031403	Combustion plants < 50 MW (boilers)	1A2g viii	Other manufacturing industry
031404	Gas turbines	1A2g viii	Other manufacturing industry
031405	Stationary engines	1A2g viii	Other manufacturing industry
031406	Other stationary equipments	1A2g viii	Other manufacturing industry
031500	Construction	1A2g viii	Other manufacturing industry
031501	Combustion plants >= 300 MW (boilers)	1A2g viii	Other manufacturing industry
031502	Combustion plants >= 50 and < 300 MW (boilers)	1A2g viii	Other manufacturing industry
031503	Combustion plants < 50 MW (boilers)	1A2g viii	Other manufacturing industry
031504	Gas turbines	1A2g viii	Other manufacturing industry
031505	Stationary engines	1A2g viii	Other manufacturing industry
031506	Other stationary equipments	1A2g viii	Other manufacturing industry
031600	Cement production	1A2f	Non-metallic minerals
031601	Combustion plants >= 300 MW (boilers)	1A2f	Non-metallic minerals
031602	Combustion plants >= 50 and < 300 MW (boilers)	1A2f	Non-metallic minerals
031603	Combustion plants < 50 MW (boilers)	1A2f	Non-metallic minerals
031604	Gas turbines	1A2f	Non-metallic minerals
031605	Stationary engines	1A2f	Non-metallic minerals
031606	Other stationary equipments	1A2f	Non-metallic minerals
032000	Non-specified (Industry)	1A2g viii	Other manufacturing industry
032001	Combustion plants >= 300 MW (boilers)	1A2g viii	Other manufacturing industry
032002	Combustion plants >= 50 and < 300 MW (boilers)	1A2g viii	Other manufacturing industry
032003	Combustion plants < 50 MW (boilers)	1A2g viii	Other manufacturing industry
032004	Gas turbines	1A2g viii	Other manufacturing industry
032005	Stationary engines	1A2g viii	Other manufacturing industry
032006	Other stationary equipments	1A2g viii	Other manufacturing industry

Annex 2 Fuel rate

Table 2.1 Fuel consumption rate for stationary combustion plants 1990-2015, PJ.

Sum of Fuel_rate_PJ			Year									
fuel_type	**fuel_id**	**fuel_gr_abbr**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
SOLID	101A	ANODIC CARBON										
	102A	COAL	253.4	344.3	286.8	300.8	323.4	270.3	371.9	276.3	234.3	196.5
	103A	SUB-BITUMINOUS										
	106A	BROWN COAL BRI.	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
	107A	COKE OVEN COKE	1.3	1.4	1.2	1.2	1.2	1.3	1.2	1.3	1.3	1.4
LIQUID	110A	PETROLEUM COKE	4.5	4.4	4.3	5.7	7.5	5.3	5.9	6.0	5.3	6.8
	203A	RESIDUAL OIL	32.1	38.3	38.5	32.8	46.2	33.0	37.8	26.6	30.0	23.7
	204A	GAS OIL	63.8	67.4	58.6	64.6	56.5	56.3	60.8	53.9	51.3	50.4
	206A	KEROSENE	5.1	1.0	0.8	0.8	0.7	0.6	0.5	0.4	0.4	0.3
	225A	ORIMULSION						19.9	36.8	40.5	32.6	34.2
	303A	LPG	3.0	2.8	2.4	2.5	2.6	2.7	3.0	2.6	2.8	2.5
	308A	REFINERY GAS	14.2	14.5	14.9	15.4	16.4	20.8	21.4	16.9	15.2	15.7
GAS	301A	NATURAL GAS	76.1	86.1	90.5	102.5	114.6	132.7	156.3	164.5	178.7	187.9
WASTE	114A	WASTE	15.5	16.7	17.8	19.4	20.3	22.9	25.0	26.8	26.6	29.1
	115A	INDUSTR. WASTES										
BIOMASS	111A	WOOD	18.2	20.0	21.0	22.2	21.9	21.8	23.4	23.4	22.9	24.4
	117A	STRAW	12.5	13.3	13.9	13.4	12.7	13.1	13.5	13.9	13.9	13.7
	215A	BIO OIL	0.7	0.7	0.7	0.8	0.2	0.3	0.1	0.0	0.0	0.0
	309A	BIOGAS	0.8	0.9	0.9	1.1	1.3	1.8	2.0	2.4	2.7	2.7
	310A	BIO GASIF GAS					0.1	0.0	0.0	0.0	0.0	0.0
	315A	BIONATGAS										
Total			**501.3**	**612.1**	**552.4**	**583.2**	**625.6**	**602.9**	**759.6**	**655.5**	**618.1**	**589.4**

Continued

Sum of Fuel_rate_PJ			Year									
fuel_type	**fuel_id**	**fuel_gr_abbr**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
SOLID	101A	ANODIC CARBON										0.0
	102A	COAL	164.7	174.3	174.7	239.0	182.5	154.0	232.0	194.1	170.5	167.7
	103A	SUB-BITUMINOUS										
	106A	BROWN COAL BRI.	0.0	0.0	0.0	0.0					0.0	0.0
	107A	COKE OVEN COKE	1.2	1.1	1.1	1.0	1.1	1.0	1.0	1.1	1.0	0.8
LIQUID	110A	PETROLEUM COKE	6.8	7.8	7.8	8.0	8.4	8.1	8.5	9.2	6.9	5.9
	203A	RESIDUAL OIL	18.8	21.1	26.2	28.6	24.5	21.9	26.1	19.8	15.8	14.7
	204A	GAS OIL	44.1	46.3	41.2	41.4	38.2	34.2	29.5	25.3	25.0	27.4
	206A	KEROSENE	0.2	0.3	0.3	0.3	0.2	0.3	0.2	0.1	0.1	0.1
	225A	ORIMULSION	34.1	30.2	23.8	1.9	0.0					
	303A	LPG	2.4	2.2	2.0	2.1	2.2	2.2	2.3	1.9	1.7	1.5
	308A	REFINERY GAS	15.6	15.8	15.2	16.6	15.9	15.3	16.1	15.9	14.1	15.0
GAS	301A	NATURAL GAS	186.1	193.8	193.6	195.9	195.1	187.4	191.1	171.0	173.0	165.7
WASTE	114A	WASTE	29.8	31.3	33.3	35.1	35.3	35.8	36.9	38.1	39.6	37.6
	115A	INDUSTR. WASTES	0.5	1.4	1.9	1.5	2.0	2.0	1.5	1.6	2.0	1.7
BIOMASS	111A	WOOD	27.5	30.8	31.6	38.9	43.9	49.7	52.1	60.3	63.6	66.0
	117A	STRAW	12.2	13.7	15.7	16.9	17.9	18.5	18.5	18.8	15.9	17.4
	215A	BIO OIL	0.0	0.2	0.1	0.4	0.6	0.8	1.1	1.2	1.8	1.7
	309A	BIOGAS	2.9	3.0	3.4	3.6	3.7	3.8	3.9	3.9	3.9	4.2
	310A	BIO GASIF GAS	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3
	315A	BIONATGAS										
Total			**547.1**	**573.4**	**571.7**	**631.2**	**571.6**	**535.1**	**621.0**	**562.4**	**535.1**	**527.7**

Continued

Sum of Fuel_rate_PJ			Year					
fuel_type	**fuel_id**	**fuel_gr_abbr**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
SOLID	101A	ANODIC CARBON	0.0	0.0	0.0	0.0		
	102A	COAL	163.0	135.5	105.6	135.0	107.0	75.9
	103A	SUB-BITUMINOUS		0.0	0.1	0.1	0.0	0.0
	106A	BROWN COAL BRI.	0.0	0.0	0.0	0.0	0.0	
	107A	COKE OVEN COKE	0.7	0.7	0.6	0.6	0.6	0.5
LIQUID	110A	PETROLEUM COKE	5.1	6.5	6.7	6.1	6.6	6.6
	203A	RESIDUAL OIL	13.0	8.0	7.3	5.7	4.5	4.1
	204A	GAS OIL	27.0	20.9	17.3	15.4	8.2	9.4
	206A	KEROSENE	0.1	0.0	0.0	0.0	0.0	0.0
	225A	ORIMULSION						
	303A	LPG	1.5	1.4	1.5	1.3	0.9	1.4

Continued

	308A	REFINERY GAS	14.3	13.7	14.8	14.8	15.4	16.2
GAS	301A	NATURAL GAS	186.0	157.5	147.3	139.5	119.5	120.8
WASTE	114A	WASTE	36.8	36.7	35.9	35.7	36.9	37.7
	115A	INDUSTR. WASTES	1.4	1.7	1.5	1.8	1.8	2.5
BIOMASS	111A	WOOD	81.3	78.8	81.8	81.3	80.2	85.7
	117A	STRAW	23.3	20.2	18.3	20.3	18.4	19.2
	215A	BIO OIL	2.0	0.8	1.1	0.9	0.7	0.6
	309A	BIOGAS	4.3	4.1	4.4	4.6	5.1	5.2
	310A	BIO GASIF GAS	0.2	0.3	0.4	0.4	0.4	0.5
	315A	BIONATGAS					0.3	1.0
Total			**560.0**	**486.9**	**444.6**	**463.3**	**406.7**	**387.4**

Table 2.2 Detailed fuel consumption data for stationary combustion plants, 1990-2015, PJ.

This table is available at: http://envs.au.dk/videnudveksling/luft/emissioner/supporting-documentation/greenhouse-gases-nir/

Annex 3 Default Lower Calorific Value (LCV) of fuels and fuel correspondence list

Table 3.1 Time series for calorific values of fuels (DEA 2016a).

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Crude Oil, Average	GJ per tonne	42.40	42.40	42.40	42.70	42.70	42.70	42.70	43.00	43.00	43.00
Crude Oil, Golf	GJ per tonne	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 per tonne	42.70	42.70	42.70	42.70	42.70	42.70	42.70	43.00	43.00	43.00
Refinery Feedstocks	GJ per tonne	41.60	41.60	41.60	41.60	41.60	41.60	41.60	42.70	42.70	42.70
Refinery Gas	GJ per tonne	52.00	52.00	52.00	52.00	52.00	52.00	52.00	52.00	52.00	52.00
LPG	GJ per tonne	46.00	46.00	46.00	46.00	46.00	46.00	46.00	46.00	46.00	46.00
Naphtha (LVN)	GJ per tonne	44.50	44.50	44.50	44.50	44.50	44.50	44.50	44.50	44.50	44.50
Motor Gasoline	GJ per tonne	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80
Aviation Gasoline	GJ per tonne	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80
JP4	GJ per tonne	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80
Other Kerosene	GJ per tonne	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50
JP1	GJ per tonne	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50
Gas/Diesel Oil	GJ per tonne	42.70	42.70	42.70	42.70	42.70	42.70	42.70	42.70	42.70	42.70
Fuel Oil	GJ per tonne	40.40	40.40	40.40	40.40	40.40	40.40	40.70	40.65	40.65	40.65
Orimulsion	GJ per tonne	27.60	27.60	27.60	27.60	27.60	28.13	28.02	27.72	27.84	27.58
Petroleum Coke	GJ per tonne	31.40	31.40	31.40	31.40	31.40	31.40	31.40	31.40	31.40	31.40
Waste Oil	GJ per tonne	41.90	41.90	41.90	41.90	41.90	41.90	41.90	41.90	41.90	41.90
White Spirit	GJ per tonne	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50
Bitumen	GJ per tonne	39.80	39.80	39.80	39.80	39.80	39.80	39.80	39.80	39.80	39.80
Lubricants	GJ per tonne	41.90	41.90	41.90	41.90	41.90	41.90	41.90	41.90	41.90	41.90
Natural Gas	GJ per 1000 Nm^3	39.00	39.00	39.00	39.30	39.30	39.30	39.30	39.60	39.90	40.00
Town Gas	GJ per 1000 m^3							17.00	17.00	17.00	17.00
Electricity Plant Coal	GJ per tonne	25.30	25.40	25.80	25.20	24.50	24.50	24.70	24.96	25.00	25.00
Other Hard Coal	GJ per tonne	26.10	26.50	26.50	26.50	26.50	26.50	26.50	26.50	26.50	26.50
Coke	GJ per tonne	31.80	29.30	29.30	29.30	29.30	29.30	29.30	29.30	29.30	29.30
Brown Coal Briquettes	GJ per tonne	18.30	18.30	18.30	18.30	18.30	18.30	18.30	18.30	18.30	18.30
Straw	GJ per tonne	14.50	14.50	14.50	14.50	14.50	14.50	14.50	14.50	14.50	14.50
Wood Chips	GJ per m^3	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80
Wood Chips	GJ per m^3	9.30	9.30	9.30	9.30	9.30	9.30	9.30	9.30	9.30	9.30
Firewood, Hardwood	GJ per m^3	10.40	10.40	10.40	10.40	10.40	10.40	10.40	10.40	10.40	10.40
Firewood, Conifer	GJ per tonne	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60
Wood Pellets	GJ per tonne	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50
Wood Waste	GJ per m^3	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
Wood Waste	GJ per 1000 m^3	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20
Biogas	GJ per tonne								23.00	23.00	23.00
Wastes	GJ per tonne	8.20	8.20	9.00	9.40	9.40	10.00	10.50	10.50	10.50	10.50
Bioethanol	GJ per tonne	26.70	26.70	26.70	26.70	26.70	26.70	26.70	26.70	26.70	26.70
Liquid Biofuels	GJ per tonne	37.60	37.60	37.60	37.60	37.60	37.60	37.60	37.60	37.60	37.60
Bio Oil	GJ per tonne	37.20	37.20	37.20	37.20	37.20	37.20	37.20	37.20	37.20	37.20

Continued		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Crude Oil, Average	GJ per tonne	43.00	43.00	43.00	43.00	43.00	43.00	43.00	43.00	43.00	43.00
Crude Oil, Golf	GJ per tonne	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 per tonne	43.00	43.00	43.00	43.00	43.00	43.00	43.00	43.00	43.00	43.00
Refinery Feedstocks	GJ per tonne	42.70	42.70	42.70	42.70	42.70	42.70	42.70	42.70	42.70	42.70
Refinery Gas	GJ per tonne	52.00	52.00	52.00	52.00	52.00	52.00	52.00	52.00	52.00	52.00
LPG	GJ per tonne	46.00	46.00	46.00	46.00	46.00	46.00	46.00	46.00	46.00	46.00
Naphtha (LVN)	GJ per tonne	44.50	44.50	44.50	44.50	44.50	44.50	44.50	44.50	44.50	44.50
Motor Gasoline	GJ per tonne	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80
Aviation Gasoline	GJ per tonne	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80
JP4	GJ per tonne	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80	43.80
Other Kerosene	GJ per tonne	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50
JP1	GJ per tonne	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50
Gas/Diesel Oil	GJ per tonne	42.70	42.70	42.70	42.70	42.70	42.70	42.70	42.70	42.70	42.70
Fuel Oil	GJ per tonne	40.65	40.65	40.65	40.65	40.65	40.65	40.65	40.65	40.65	40.65
Orimulsion	GJ per tonne	27.62	27.64	27.71	27.65	27.65	27.65	27.65	27.65	27.65	27.65
Petroleum Coke	GJ per tonne	31.40	31.40	31.40	31.40	31.40	31.40	31.40	31.40	31.40	31.40
Waste Oil	GJ per tonne	41.90	41.90	41.90	41.90	41.90	41.90	41.90	41.90	41.90	41.90
White Spirit	GJ per tonne	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50	43.50
Bitumen	GJ per tonne	39.80	39.80	39.80	39.80	39.80	39.80	39.80	39.80	39.80	39.80
Lubricants	GJ per tonne	41.90	41.90	41.90	41.90	41.90	41.90	41.90	41.90	41.90	41.90
Natural Gas	GJ per 1000 Nm^3	40.15	39.99	40.06	39.94	39.77	39.67	39.54	39.59	39.48	39.46
Town Gas	GJ per 1000 m^3	17.01	16.88	17.39	16.88	17.58	17.51	17.20	17.14	15.50	21.29
Electricity Plant Coal	GJ per tonne	24.80	24.90	25.15	24.73	24.60	24.40	24.80	24.40	24.30	24.60
Other Hard Coal	GJ per tonne	26.50	26.50	26.50	26.50	26.50	26.50	26.50	26.50	25.81	25.13
Coke	GJ per tonne	29.30	29.30	29.30	29.30	29.30	29.30	29.30	29.30	29.30	29.30
Brown Coal Briquettes	GJ per tonne	18.30	18.30	18.30	18.30	18.30	18.30	18.30	18.30	18.30	18.30
Straw	GJ per tonne	14.50	14.50	14.50	14.50	14.50	14.50	14.50	14.50	14.50	14.50
Wood Chips	GJ per m^3	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80
Wood Chips	GJ per m^3	9.30	9.30	9.30	9.30	9.30	9.30	9.30	9.30	9.30	9.30
Firewood, Hardwood	GJ per m^3	10.40	10.40	10.40	10.40	10.40	10.40	10.40	10.40	10.40	10.40
Firewood, Conifer	GJ per tonne	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60
Wood Pellets	GJ per tonne	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50
Wood Waste	GJ per m^3	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
Wood Waste	GJ per 1000 m^3	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20
Biogas	GJ per tonne	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00
Wastes	GJ per tonne	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50
Bioethanol	GJ per tonne	26.70	26.70	26.70	26.70	26.70	26.70	26.70	26.70	26.70	26.70
Liquid Biofuels	GJ per tonne	37.60	37.60	37.60	37.60	37.60	37.60	37.60	37.60	37.50	37.50
Bio Oil	GJ per tonne	37.20	37.20	37.20	37.20	37.20	37.20	37.20	37.20	37.20	37.20

Continued		2010	2011	2012	2013	2014	2015
Crude Oil, Average	GJ per tonne	43.00	43.00	43.00	43.00	43.00	43.00
Crude Oil, Golf	GJ per tonne	41.80	41.80	41.80	41.80	41.80	41.80
Crude Oil, North Sea	GJ per tonne	43.00	43.00	43.00	43.00	43.00	43.00
Refinery Feedstocks	GJ per tonne	42.70	42.70	42.70	42.70	42.70	42.70
Refinery Gas	GJ per tonne	52.00	52.00	52.00	52.00	52.00	52.00
LPG	GJ per tonne	46.00	46.00	46.00	46.00	46.00	46.00
Naphtha (LVN)	GJ per tonne	44.50	44.50	44.50	44.50	44.50	44.50
Motor Gasoline	GJ per tonne	43.80	43.80	43.80	43.80	43.80	43.80
Aviation Gasoline	GJ per tonne	43.80	43.80	43.80	43.80	43.80	43.80
JP4	GJ per tonne	43.80	43.80	43.80	43.80	43.80	43.80
Other Kerosene	GJ per tonne	43.50	43.50	43.50	43.50	43.50	43.50
JP1	GJ per tonne	43.50	43.50	43.50	43.50	43.50	43.50
Gas/Diesel Oil	GJ per tonne	42.70	42.70	42.70	42.70	42.70	42.70
Fuel Oil	GJ per tonne	40.65	40.65	40.65	40.65	40.65	40.65
Orimulsion	GJ per tonne	27.65	27.65	27.65	27.65	27.65	27.65
Petroleum Coke	GJ per tonne	31.40	31.40	31.40	31.40	31.40	31.40
Waste Oil	GJ per tonne	41.90	41.90	41.90	41.90	41.90	41.90
White Spirit	GJ per tonne	43.50	43.50	43.50	43.50	43.50	43.50
Bitumen	GJ per tonne	39.80	39.80	39.80	39.80	39.80	39.80
Lubricants	GJ per tonne	41.90	41.90	41.90	41.90	41.90	41.90
Natural Gas	GJ per 1000 Nm^3	39.46	39.51	39.55	38.99	39.53	39.64
Town Gas	GJ per 1000 m^3	21.35	21.37	19.30	19.31	20.10	20.31
Electricity Plant Coal	GJ per tonne	24.44	24.38	24.23	24.49	24.70	24.10
Other Hard Coal	GJ per tonne	24.44	24.38	24.23	24.49	24.70	24.10
Coke	GJ per tonne	29.30	29.30	29.30	29.30	29.30	29.30
Brown Coal Briquettes	GJ per tonne	18.30	18.30	18.30	18.30	18.30	18.30
Straw	GJ per tonne	14.50	14.50	14.50	14.50	14.50	14.50
Wood Chips	GJ per m^3	2.80	2.80	2.80	2.80	2.80	2.80
Wood Chips	GJ per m3	9.30	9.30	9.30	9.30	9.30	9.30
Firewood, Hardwood	GJ per m3	10.40	10.40	10.40	10.40	10.40	10.40
Firewood, Conifer	GJ per tonne	7.60	7.60	7.60	7.60	7.60	7.60
Wood Pellets	GJ per tonne	17.50	17.50	17.50	17.50	17.50	17.50
Wood Waste	GJ per m^3	14.70	14.70	14.70	14.70	14.70	14.70
Wood Waste	GJ per 1000 m^3	3.20	3.20	3.20	3.20	3.20	3.20
Biogas	GJ per tonne	23.00	23.00	23.00	23.00	23.00	23.00
Wastes	GJ per tonne	10.50	10.50	10.50	10.60	10.60	10.60
Bioethanol	GJ per tonne	26.70	26.70	26.70	26.70	26.70	26.70
Liquid Biofuels	GJ per tonne	37.50	37.50	37.50	37.50	37.50	37.50
Bio Oil	GJ per tonne	37.20	37.20	37.20	37.20	37.20	37.20

Table 3.2 Fuel category correspondence list from DEA, DCE and Climate Convention reporting (CRF).

Danish Energy Agency	DCE 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
-	Anode carbon	Solid
-	Fly ash	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 similar	Biomass
Wood Pellets	Wood and similar	Biomass
Wood Chips	Wood and similar	Biomass
Firewood, Hardwood & Conifer	Wood and similar	Biomass
Waste Combustion (biomass)	Municipal wastes	Biomass
Bio fuels	Liquid biofuels	Biomass
Biogas	Biogas	Biomass
Biogas, other	Biogas	Biomass
Biogas, landfill	Biogas	Biomass
Biogas, sewage sludge	Biogas	Biomass
(Wood applied in gas engines)	Biomass gasif. gas	Biomass
Biogas upgraded for distribution in the natural gas grid	Bio-natural gas	Biomass
Waste Combustion (fossil)	Fossil waste	Other fuel

Annex 4 Emission factors

Table 4.1 CO_2 emission factors, 2015.

Fuel	Emission factor kg per GJ		Reference type	IPCC fuel category
	Biomass	Fossil fuel		
Coal, source category 1A1a Public electricity and heat production		94.46 [1)]	Country specific	Solid
Coal, Other source categories		94.6[3)]	IPCC (2006)	Solid
Brown coal briquettes		97.5	IPCC (2006)	Solid
Coke oven coke		107 [3)]	IPCC (2006)	Solid
Other solid fossil fuels [6)]		118[1)]	Country specific	Solid
Fly ash fossil (from coal)		95.4	Country specific	Solid
Petroleum coke		93 [3)]	Country-specific	Liquid
Residual oil, source category 1A1a Public electricity and heat production		79.17 [1)]	Country-specific	Liquid
Residual oil, other source categories		78.6 [3)]	Country-specific	Liquid
Gas oil		74 [1)]	EEA (2007)	Liquid
Kerosene		71.9	IPCC (2006)	Liquid
Orimulsion		80 [2)]	Country-specific	Liquid
LPG		63.1	IPCC (2006)	Liquid
Refinery gas		57.508	Country-specific	Liquid
Natural gas, off shore gas turbines		57.615	Country-specific	Gas
Natural gas, other		56.06	Country-specific	Gas
Waste	75.1 [3)4)]	+ 37[3)4)]	Country-specific	Biomass and Other fuels
Straw	100		IPCC (2006)	Biomass
Wood	112		IPCC (2006)	Biomass
Bio oil	70.8		IPCC (2006)	Biomass
Biogas	84.1		Country-specific	Biomass
Biomass gasification gas	142.9[5)]		Country-specific	Biomass
Bio-natural gas	55.55		Country-specific	Biomass

1) Plant specific data from EU ETS incorporated for individual plants.
2) Not applied in 2015. Orimulsion was applied in Denmark in 1995 – 2004.
3) Plant specific data from EU ETS incorporated for cement industry and sugar, lime and mineral wool production.
4) The emission factor for waste is (37+75.1) kg CO_2 per GJ waste. The fuel consumption and the CO_2 emission have been disaggregated to the two IPCC fuel categories *Biomass* and *Other fossil fuels* in CRF. The corresponding IEF for CO_2, Other fuels is 82.22 kg CO_2 per GJ fossil waste (not including plant specific data).
5) Includes a high content of CO_2 in the gas.
6) Anodic carbon. Not applied in Denmark in 2015.

Table 4.2 CO_2 emission factors time series.

Year	Coal, sector 1A1a, kg per GJ	Residual oil, sector 1A1a, kg per GJ	Refinery gas, kg per GJ	Natural gas, off shore gas turbines, kg per GJ	Natural gas, other, kg per GJ	Industrial waste, biomass part
1990	94	78.6	57.6	57.469	56.9	86.7
1991	94	78.6	57.6	57.469	56.9	86.7
1992	94	78.6	57.6	57.469	56.9	84.2
1993	94	78.6	57.6	57.469	56.9	83.0
1994	94	78.6	57.6	57.469	56.9	83.0
1995	94	78.6	57.6	57.469	56.9	81.1
1996	94	78.6	57.6	57.469	56.9	79.6
1997	94	78.6	57.6	57.469	56.9	79.6
1998	94	78.6	57.6	57.469	56.9	79.6
1999	94	78.6	57.6	57.469	56.9	79.6
2000	94	78.6	57.6	57.469	57.1	79.6
2001	94	78.6	57.6	57.469	57.25	79.6
2002	94	78.6	57.6	57.469	57.28	79.6
2003	94	78.6	57.6	57.469	57.19	79.6
2004	94	78.6	57.6	57.469	57.12	79.6
2005	94	78.6	57.6	57.469	56.96	79.6
2006	94.4	78.6	57.812	57.879	56.78	79.6
2007	94.3	78.5	57.848	57.784	56.78	79.6
2008	94.0	78.5	57.948	56.959	56.77	79.6
2009	93.6	78.9	56.817	57.254	56.69	79.6
2010	93.6	79.2	57.134	57.314	56.74	79.6
2011	94.73	79.25	57.861	57.379	56.97	79.6
2012	94.25	79.21	58.108	57.423	57.03	79.6
2013	93.95	79.28	58.274	57.295	56.79	79.6
2014	94.17	79.49	57.620	57.381	56.95	79.6
2015	94.46	79.17	57.508	57.615	57.06	79.6

Table 4.3 CH_4 emission factors and references, 2015.

Fuel group	Fuel	CRF source category	CRF source category	SNAP	Emission factor, g per GJ	Reference
SOLID	COAL	1A1a	Public electricity and heat production	0101 0102	0.9	IPCC (2006), Tier 3, Table 2-6, Utility Boiler, Pulverised bituminous coal combustion, Wet bottom.
		1A2 a-g	Industry	03	10	IPCC (2006), Tier 1, Table 2-3, Manufacturing industries.
		1A4b i	Residential	0202	300	IPCC (2006), Tier 1, Table 2.5, Residential, Bituminous coal.
		1A4c i	Agriculture/ Forestry	0203	10	IPCC (2006), Tier 1, Table 2-4, Commercial, coal.[1)]
	BROWN COAL BRI.	1A4b i	Residential	0202	300	IPCC (2006), Tier 1, Table 2-5, Residential, brown coal briquettes.
	COKE OVEN COKE	1A2 a-g	Industry	03	10	IPCC (2006), Tier 1, Table 2-4, Commercial, coke oven coke.
		1A4b i	Residential	0202	300	IPCC (2006), Tier 1, Table 2-5, Residential, coke oven coke.
	ANODIC CARBON	1A2 a-g	Industry	03	10	IPCC (2006), Tier 1, Table 2-3, Manufacturing industries.
	FOSSIL FLY ASH	1A1a	Public electricity and heat production	0101	0.9	IPCC (2006), Tier 3, Table 2-6, Utility Boiler, Pulverised bituminous coal combustion, Wet bottom.
LIQUID	PETROLEUM COKE	1A2 a-g	Industry	03	3	IPCC (2006), Tier 1, Table 2-3, Industry, petroleum coke.
		1A4a	Commercial/ Institutional	0201	10	IPCC (2006), Tier 1, Table 2-4, Commercial, Petroleum coke.
		1A4b	Residential	0202	10	IPCC (2006), Tier 1, Table 2-5, Residential / agricultural, Petroleum coke.
		1A4c	Agriculture/ Forestry	0203	10	IPCC (2006), Tier 1, Table 2-5, Residential / agricultural, Petroleum coke.
	RESIDUAL OIL	1A1a	Public electricity and heat production	010101	0.8	IPCC (2006), Tier 3, Table 2-6, Utility Boiler, Residual fuel oil.
				010102 010103	1.3	Nielsen et al. (2010).
				010104	3	IPCC (2006), Tier 1, Table 2-2, Energy industries, residual oil.
				010105	4	IPCC (2006), Tier 3, Table 2-6, Utility, Large diesel engines.
				010203	0.8	IPCC (2006), Tier 3, Table 2-6, Utility Boiler, Residual fuel oil.
		1A1b	Petroleum refining	010306	3	IPCC (2006), Tier 1, Table 2-2, Energy industries, residual fuel oil.
		1A2 a-g	Industry	03	1.3	Nielsen et al. (2010).
				Engines	4	IPCC (2006), Tier 3, Table 2-6, Utility, Large diesel engines.
		1A4a	Commercial/ Institutional	0201	1.4	IPCC (2006), Tier 3, Table 2-10, Commercial, residual fuel oil boilers.
		1A4b	Residential	0202	1.4	IPCC (2006), Tier 3, Table 2-9, Residential, residual fuel oil.
		1A4c	Agriculture/ Forestry	0203	1.4	IPCC (2006), Tier 3, Table 2-10, Commercial, residual fuel oil boilers.[1)].
	GAS OIL	1A1a	Public electricity and heat production	010101 010102 010103	0.9	IPCC (2006), Tier 3, Table 2-6, Utility, gas oil, boilers.
				010104	3	IPCC (2006), Tier 1, Table 2-2, Energy industries, gas oil.
				010105	24	Nielsen et al. (2010)..
				010202 010203	0.9	IPCC (2006), Tier 3, Table 2-6, Utility, gas oil, boilers.

Fuel group	Fuel	CRF source category	CRF source category	SNAP	Emission factor, g per GJ	Reference
		1A1b	Petroleum refining	010306	3	IPCC (2006), Tier 1, Table 2-2, Energy industries, gas oil.
		1A1c	Oil and gas extraction	010504	3	IPCC (2006), Tier 1, Table 2-2, Energy industries, gas oil.
		1A2 a-g	Industry	03	0.2	IPCC (2006), Tier 3, Table 2-7, Industry, gas oil, boilers.
				Tur-bines	3	IPCC (2006), Tier 1, Table 2-3, Industry, gas oil.
				Engines	24	Nielsen et al. (2010)
		1A4a	Commercial/ Institu-tional	0201	0.7	IPCC (2006), Tier 3, Table 2-10, Commercial, gas oil.
				020105	24	Nielsen et al. (2010).
		1A4b i	Residential	0202	0.7	IPCC (2006), Tier 3, Table 2.9, Residential, gas oil.
		1A4c	Agriculture/ Forestry	0203	0.7	IPCC (2006), Tier 3, Table 2-10, Commercial, gas oil[1)].
				020304	24	Nielsen et al. (2010).
	KEROSENE	1A2 a-g	Industry	all	3	IPCC (2006), Tier 1, Table 2-3, Industry, other kerosene.
		1A4a	Commercial/ Institu-tional	0201	10	IPCC (2006), Tier 1, Table 2-4, Commercial, other kerosene.
		1A4b i	Residential	0202	10	IPCC (2006), Tier 1, Table 2-5, Residential/agricultural, other kerosene.
		1A4c i	Agriculture/ Forestry	0203	10	IPCC (2006), Tier 1, Table 2-5, Residential/agricultural, other kerosene.
	LPG	1A1a	Public electricity and heat production	0101 0102	1	IPCC (2006), Tier 1, Table 2-2, Energy Industries, LPG.
		1A1b	Petroleum refining	0103	1	IPCC (2006), Tier 1, Table 2-2, Energy Industries, LPG.
		1A2 a-g	Industry	03	1	IPCC (2006), Tier 1, Table 2-3, Industry, LPG.
		1A4a	Commercial/ Institu-tional	0201	5	IPCC (2006), Tier 1, Table 2-4, Commercial, LPG.
		1A4b i	Residential	0202	5	IPCC (2006), Tier 1, Table 2-5, Residential / agricultural, LPG.
		1A4c i	Agriculture/ Forestry	0203	5	IPCC (2006), Tier 1, Table 2-5, Residential / agricultural, LPG.
	REFINERY GAS	1A1b	Petroleum refining	010304	1.7	Assumed equal to natural gas fuelled gas turbines. Nielsen et al. (2010).
				010306	1	IPCC (2006), Tier 1, Table 2-2, refinery gas.
GAS	NATURAL GAS	1A1a	Public electricity and heat production	010101 010102 010103	1	IPCC (2006), Tier 3, Table 2-6, Utility, natural gas, boilers.
				010104	1.7	Nielsen et al. (2010).
				010105	481	Nielsen et al. (2010).
				010202 010203	1	IPCC (2006), Tier 3, Table 2-6, Utility, natural gas, boilers.
		1A1b	Petroleum refining	010306	1	Assumed equal to industrial boilers.
		1A1c	Oil and gas extraction	010503	1	Assumed equal to industrial boilers.
				010504	1.7	Nielsen et al. (2010).
		1A2 a-g	Industry	Other	1	IPCC (2006), Tier 3, Table 2-7, Industry, natural gas boilers.
				Gas tur-bines	1.7	Nielsen et al. (2010).
				Engines	481	Nielsen et al. (2010).
		1A4a	Commercial/ Institu-tional	0201	1	IPCC (2006), Tier 3, Table 2-10, Commer-cial, natural gas boilers.
				020105	481	Nielsen et al. (2010).

Fuel group	Fuel	CRF source category	CRF source category	SNAP	Emission factor, g per GJ	Reference
		1A4b i	Residential	0202	1	IPCC (2006), Tier 3, Table 2-9. Residential, natural gas boilers.
				020204	481	Nielsen et al. (2010).
		1A4c i	Agriculture/ Forestry	0203	1	IPCC (2006), Tier 3, Table 2-10, Commercial, natural gas boilers[1)].
				020304	481	Nielsen et al. (2010).
WASTE	WASTE	1A1a	Public electricity and heat production	0101 0102	0.34	Nielsen et al. (2010).
		1A2 a-g	Industry	03	30	IPCC (2006), Tier 1, Table 2-3, Industry, municipal wastes.
		1A4a	Commercial/ Institutional	0201	30	IPCC (2006), Tier 1, Table 2-3, Industry, municipal wastes [2)].
	INDUSTRIAL WASTE	1A2f	Industry	0316	30	IPCC (2006), Tier 1, Table 2-3, Industry, industrial wastes.
BIO-MASS	WOOD	1A1a	Public electricity and heat production	0101	3.1	Nielsen et al. (2010).
				0102	11	IPCC (2006), Tier 3, Table 2-6, Utility boilers, wood.
		1A2 a-g	Industry	03	11	IPCC (2006), Tier 3, Table 2-7, Industry, wood, boilers.
		1A4a	Commercial/ Institutional	0201	11	IPCC (2006), Tier 3, Table 2-10, Commercial, wood.
		1A4b i	Residential	0202	93.19	DCE estimate based on technology distribution [3)].
		1A4c i	Agriculture/ Forestry	0203	11	IPCC (2006), Tier 3, Table 2-10, Commercial, wood.[1)].
	STRAW	1A1a	Public electricity and heat production	0101	0.47	Nielsen et al. (2010).
				0102	30	IPCC (2006), Tier 1, Table 2-2, Energy industries, other primary solid biomass.
		1A4b i	Residential	0202	300	IPCC (2006), Tier 1, Table 2-5, Residential, other primary solid biomass.
		1A4c i	Agriculture/ Forestry	020300	300	IPCC (2006), Tier 1, Table 2-5, Agriculture, other primary solid biomass.
				020302	30	IPCC (2006), Tier 1, Table 2-2, Energy industries, other primary solid biomass (large agricultural plants considered equal to this plant category).
	BIO OIL	1A1a	Public electricity and heat production	010102	3	IPCC (2006), Tier 1, Table 2-2, Energy industries, biodiesels.
				010105	24	Nielsen et al. (2010) assumed same emission factor as for gas oil fuelled engines.
				0102	3	IPCC (2006), Tier 1, Table 2-2, Energy industries, biodiesels.
		1A2 a-g	Industry	03	3	IPCC (2006), Tier 1, Table 2-3, Industry, biodiesels.
				030902	0.2	-
		1A4b i	Residential	0202	10	IPCC (2006), Tier 1, Table 2-5, Residential, biodiesels.
	BIOGAS	1A1a	Public electricity and heat production	0101	1	IPCC (2006), Tier 1, Table 2-2, Energy industries, other biogas.
				010105	434	Nielsen et al. (2010).
				0102	1	IPCC (2006), Tier 1, Table 2-2, Energy industries, other biogas.
		1A2 a-g	Industry	03	1	IPCC (2006), Tier 1, Table 2-3, Industry, other biogas.
				Engines	434	Nielsen et al. (2010).

Fuel group	Fuel	CRF source category	CRF source category	SNAP	Emission factor, g per GJ	Reference
		1A4a	Commercial/ Institutional	0201	5	IPCC (2006), Tier 1, Table 2-4, Commercial, other biogas.
				020105	434	Nielsen et al. (2010).
		1A4b	Residential	0202	1	Assumed equal to natural gas.
		1A4c i	Agriculture/ Forestry	0203	5	IPCC (2006), Tier 1, Table 2-5, Agriculture, other biogas.
				020304	434	Nielsen et al. (2010).
	BIO GASIF GAS	1A1a	Public electricity and heat production	010101	1	Assumed equal to biogas.
				010105	13	Nielsen et al. (2010).
		1A4a	Commercial/Institutional	020105	13	Nielsen et al. (2010).
	BIONATGAS	1A1a	Public electricity and heat production	0101	1	Assumed equal to natural gas.
		1A2 a-g	Industry	03	1	Assumed equal to natural gas.
		1A4a	Commercial/ Institutional	0201	1	Assumed equal to natural gas.
		1A4b	Residential	0202	1	Assumed equal to natural gas.
		1A4c	Agriculture/ Forestry	0203	1	Assumed equal to natural gas.

2) Assumed same emission factors as for commercial plants. Plant capacity and technology are similar for Danish plants.

3) Assumed same emission factor as for industrial plants. Plant capacity and technology is similar to industrial plants rather than to residential plants.

4) Aggregated emission factor based on the technology distribution in the sector (DEPA, 2013) and technology specific emission factors that refer to: Paulrud et al. (2005), Johansson et al. (2004) and Olsson & Kjällstrand (2005). The emission factor is below the IPCC (2006) interval for residential wood combustion (100-900 g/GJ).

Table 4.4 Technology specific CH_4 emission factors for residential wood combustion.

Technology	**Emission factor, g per GJ**	**Reference**
Old stove	430	Methane emissions from residential biomass combustion, Paulrud et al. (2005) (SMED report, Sweden).
New stove	215	Assumed ½ the emission factor for old stoves.
Modern stove (2008-2015)	125	Estimated based on the emission factor for new stoves and the emission factors for NMVOC.
Modern stove (2015-2017)	125	Same as modern stove (2008-2015).
Modern stove (2017-)	125	Same as modern stove (2008-2015).
Eco labelled stove / new advanced stove (-2015)	2	Low emissions from wood burning in an ecolabelled residential boiler. Olsson & Kjällstrand (2005).
Eco labelled stove / new advanced stove (2015-)	2	Same as advanced / ecolabelled stoves.
Other stove	430	Assumed equal to old stove.
Old boilers with hot water storage	211	Methane emissions from residential biomass combustion, Paulrud et al., 2005 (SMED report, Sweden).
Old boilers without hot water storage	256	Methane emissions from residential biomass combustion, Paulrud et al., 2005 (SMED report, Sweden).
New boilers with hot water storage	50	Emission characteristics of modern and old-type residential boilers fired with wood logs and wood pellets. Johansson et al. (2004).
New boilers without hot water storage	50	Emission characteristics of modern and old-type residential boilers fired with wood logs and wood pellets. Johansson et al. (2004).
Pellet boilers/stoves	3	Methane emissions from residential biomass combustion, Paulrud et al., 2005 (SMED report, Sweden).

Table 4.5 CH_4 emission factors time series.

Year	Natural gas fuelled engines Emission factor, g per GJ	Biogas fuelled engines Emission factor, g per GJ	Residential wood combustion, g per GJ	Waste incineration g per GJ	Natural gas fuelled gas turbines, g per GJ
1990	266	239	318	0.59	1.5
1991	309	251	312	0.59	1.5
1992	359	264	306	0.59	1.5
1993	562	276	300	0.59	1.5
1994	623	289	293	0.59	1.5
1995	632	301	286	0.59	1.5
1996	616	305	276	0.59	1.5
1997	551	310	267	0.59	1.5
1998	542	314	257	0.59	1.5
1999	541	318	237	0.59	1.5
2000	537	323	222	0.59	1.5
2001	522	342	198	0.59	1.5
2002	508	360	189	0.59	1.6
2003	494	379	187	0.59	1.6
2004	479	397	184	0.51	1.7
2005	465	416	175	0.42	1.7
2006	473	434	165	0.34	1.7
2007	481	434	166	0.34	1.7
2008	481	434	157	0.34	1.7
2009	481	434	144	0.34	1.7
2010	481	434	137	0.34	1.7
2011	481	434	129	0.34	1.7
2012	481	434	123	0.34	1.7
2013	481	434	111	0.34	1.7
2014	481	434	95	0.34	1.7
2015	481	434	93	0.34	1.7

Table 4.6 N_2O emission factors and references, 2015.

Fuel group	Fuel	CRF source category	CRF source category	SNAP	Emission factor, g per GJ	Reference
SOLID	COAL	1A1a	Public electricity and heat production	0101	0.8	Elsam (2005).
				0102	1.4	IPCC (2006), Tier 3, Table 2.6, Utility source, pulverised bituminous coal, wet bottom boiler.
		1A2 a-g	Industry	03	1.5	IPCC (2006), Tier 1, Table 2-3, Manufacturing industries, coal.
		1A4b i	Residential	0202	1.5	IPCC (2006), Tier 1, Table 2-5, Residential, coal.
		1A4c i	Agriculture/ Forestry	0203	1.5	IPCC (2006), Tier 1, Table 2-4, Commercial, coal[1)].
	BROWN COAL BRI.	1A4b i	Residential	0202	1.5	IPCC (2006), Tier 1, Table 2-5, Residential, brown coal briquettes.
	COKE OVEN COKE	1A2 a-g	Industry	03	1.5	IPCC (2006), Tier 1, Table 2-3, Industry, coke oven coke.
		1A4b i	Residential	020200	1.5	IPCC (2006), Tier 1, Table 2-5, Residential, coke oven coke.
	ANODIC CARBON	1A2 a-g	Industry	03	1.5	IPCC (2006), Tier 1, Table 2-3, manufacturing industries, other bituminous coal.
	FOSSIL FLY ASH	1A1a	Public electricity and heat production	0101	0.8	Assumed equal to coal.
LIQUID	PETROLEUM COKE	1A2 a-g	Industry – other	03	0.6	IPCC (2006), Tier 1, Table 2-3, Industry, petroleum coke.
		1A4a	Commercial/ Institutional	0201	0.6	IPCC (2006), Tier 1, Table 2-4, Commercial, petroleum coke.
		1A4b i	Residential	0202	0.6	IPCC (2006), Tier 1, Table 2-5, Residential, petroleum coke.
		1A4c i	Agriculture/ Forestry	0203	0.6	IPCC (2006), Tier 1, Table 2-5, Residential/Agricultural, petroleum coke.
	RESIDUAL OIL	1A1a	Public electricity and heat production	010101	0.3	IPCC (2006), Tier 3, Table 2-6, Utility, residual fuel oil.
				010102 010103	5	Nielsen et al. (2010).
				010104	0.6	IPCC (2006), Tier 1, Table 2-2, Energy industries, residual fuel oil.
				010203	0.3	IPCC (2006), Tier 3, Table 2-6, Utility, residual fuel oil.
		1A1b	Petroleum refining	010306	0.6	IPCC (2006), Tier 1, Table 2-2, Energy industries, residual fuel oil.
		1A2 a-g	Industry	03	5	Nielsen et al. (2010).
				Engines	0.6	IPCC (2006), Tier 1, Table 2-3, manufacturing industries and construction, residual fuel oil.
		1A4a	Commercial/ Institutional	0201	0.3	IPCC (2006), Tier 3, Table 2-10, Commercial, fuel oil boilers.
		1A4b i	Residential	0202	0.6	IPCC (2006), Tier 1, Table 2-5, Residential, residual fuel oil.
		1A4c i	Agriculture/ Forestry	0203	0.3	IPCC (2006), Tier 3, Table 2-10, Commercial, fuel oil boilers[1)].
	GAS OIL	1A1a	Public electricity and heat production	010101 010102 010103	0.4	IPCC (2006), Tier 3, Table 2-6, Utility, gas oil boilers.
				010104	0.6	IPCC (2006), Tier 1, Table 2-2, Energy industries, gas oil.
				010105	2.1	Nielsen et al. (2010).
				0102	0.4	IPCC (2006), Tier 3, Table 2-6, Utility, gas oil boilers.

Fuel group	Fuel	CRF source category	CRF source category	SNAP	Emission factor, g per GJ	Reference
		1A1b	Petroleum refining	010306	0.6	IPCC (2006), Tier 1, Table 2-2, Energy industries, gas oil.
		1A1c	Oil and gas extraction	010504	0.6	IPCC (2006), Tier 1, Table 2-2, Energy industries, gas oil.
		1A2 a-g	Industry	03	0.4	IPCC (2006), Tier 3, Table 2-7, Industry, gas oil boilers.
				Tur-bines	0.6	IPCC (2006), Tier 1, Table 2-3, Industry, gas oil.
				Engines	2.1	Nielsen et al. (2010)
		1A4a	Commercial/ Institutional	0201	0.4	IPCC (2006), Tier 3, Table 2-10, Commercial, gas oil boilers.
				Engines	2.1	Nielsen et al. (2010).
		1A4b i	Residential	0202	0.6	IPCC (2006), Tier 1, Table 2-5, Residen-tial, gas oil.
		1A4c	Agriculture/ Forestry	0203	0.4	IPCC (2006), Tier 3, Table 2-10, Commercial, gas oil boilers[1)].
				020304	2.1	Nielsen et al. (2010).
	KEROSENE	1A2 a-g	Industry	03	0.6	IPCC (2006), Tier 1, Table 2-3, Industry, other kerosene.
		1A4a	Commercial/ Institutional	0201	0.6	IPCC (2006), Tier 1, Table 2-4, Commercial, other kerosene.
		1A4b i	Residential	0202	0.6	IPCC (2006), Tier 1, Table 2-5, Residential, other kerosene.
		1A4c i	Agriculture/ Forestry	0203	0.6	IPCC (2006), Tier 1, Table 2-4, Commercial, other kerosene [1)].
	LPG	1A1a	Public electricity and heat production	0101 0102	0.1	IPCC (2006), Tier 1, Table 2-2, Energy industries, LPG.
		1A1b	Petroleum refining	010306	0.1	IPCC (2006), Tier 1, Table 2-2, Energy industries, LPG.
		1A2 a-g	Industry	03	0.1	IPCC (2006), Tier 1, Table 2-3, Industry, LPG.
		1A4a	Commercial/ Institutional	0201	0.1	IPCC (2006), Tier 1, Table 2-4, Commercial, LPG.
		1A4b i	Residential	0202	0.1	IPCC (2006), Tier 1, Table 2-5, Residential, LPG.
		1A4c i	Agriculture/ Forestry	0203	0.1	IPCC (2006), Tier 1, Table 2-5, Residential/Agricultural, LPG.
	REFINERY GAS	1A1b	Petroleum refining	010304	1	Assumed equal to natural gas fuelled tur-bines. Based on Nielsen et al. (2010).
				010306	0.1	IPCC (2006), Tier 1, Table 2-2, Energy industries, refinery gas.
GAS	NATURAL GAS	1A1a	Public electricity and heat production	010101 010102 010103	1	IPCC (2006), Tier 3, Table 2-6, Natural gas, Utility, boiler.
				010104	1	Nielsen et al. (2010).
				010105	0.58	Nielsen et al. (2010).
				0102	1	IPCC (2006), Tier 3, Table 2-6, Natural gas, Utility, boiler.
		1A4b	Petroleum refining	010306	1	IPCC (2006), Tier 3, Table 2-6, Natural gas, Utility, boiler.
		1A1c	Oil and gas extraction	010504	1	Nielsen et al. (2010).
		1A2 a-g	Industry	03	1	IPCC (2006), Tier 3, Table 2-7, Industry, natural gas boilers.
				Gas tur-bines	1	Nielsen et al. (2010).
				Engines	0.58	Nielsen et al. (2010).
		1A4a	Commercial/ Institutional	020100 020103	1	IPCC (2006), Tier 3, Table 2-10, Commercial, natural gas boilers.
				Engines	0.58	Nielsen et al. (2010).

Fuel group	Fuel	CRF source category	CRF source category	SNAP	Emission factor, g per GJ	Reference
		1A4b i	Residential	0202	1	IPCC (2006), Tier 3, Table 2-9, Residential, natural gas boilers.
				Engines	0.58	Nielsen et al. (2010)
		1A4c i	Agriculture/ Forestry	0203	1	IPCC (2006), Tier 3, Table 2-10, Commercial, natural gas boilers. [1)]
				Engines	0.58	Nielsen et al. (2010).
WASTE	WASTE	1A1a	Public electricity and heat production	0101 0102	1.2	Nielsen et al. (2010).
		1A2 a-g	Industry	03	4	IPCC (2006), Tier 1, Table 2-3, Industry, wastes.
		1A4a	Commercial/ Institutional	0201	4	IPCC (2006), Tier 1, Table 2-4, Commercial, municipal wastes.
	INDUSTR. WASTE	1A2 a-g	Industry	03	4	IPCC (2006), Tier 1, Table 2-3, Industry, industrial wastes.
BIO-MASS	WOOD	1A1a	Public electricity and heat production	0101	0.8	Nielsen et al. (2010).
				0102	4	IPCC (2006), Tier 1, Table 2-2, Energy industries, wood.
		1A2 a-g	Industry	03	4	IPCC (2006), Tier 1, Table 2-3, Industry, wood.
		1A4a	Commercial/ Institutional	0201	4	IPCC (2006), Tier 1, Table 2-4, Commercial, wood.
		1A4b i	Residential	0202	4	IPCC (2006), Tier 1, Table 2-5, Residential, wood.
		1A4c i	Agriculture/ Forestry	0203	4	IPCC (2006), Tier 1, Table 2-5, Agriculture, wood.
	STRAW	1A1a	Public electricity and heat production	0101	1.1	Nielsen et al. (2010).
				0102	4	IPCC (2006), Tier 1, Table 2-2, Energy industries, other primary solid bio-mass.
		1A4b i	Residential	0202	4	IPCC (2006), Tier 1, Table 2-5, Residential, other primary solid biomass.
		1A4c i	Agriculture/ Forestry	0203	4	IPCC (2006), Tier 1, Table 2-5, Agriculture, other primary solid biomass.
	BIO OIL	1A1a	Public electricity and heat production	0101 0102	0.6	IPCC (2006), Tier 3, Table 2-2, Utility, biodiesels.
				Engines	2.1	Assumed equal to gas oil. Based on Nielsen et al. (2010).
		1A2 a-g	Industry	03	0.6	IPCC (2006), Tier 1, Table 2-3, Industry, biodiesels.
				030902	0.4	-
		1A4b i	Residential	0202	0.6	IPCC (2006), Tier 1, Table 2-5, Residential, biodiesels.
	BIOGAS	1A1a	Public electricity and heat production	0101 0102	0.1	IPCC (2006), Tier 1, Table 2-2, Energy industries, other biogas.
				Engines	1.6	Nielsen et al. (2010).
		1A2 a-g	Industry	03	0.1	IPCC (2006), Tier 1, Table 2-3, Industry, other biogas.
				Engines	1.6	Nielsen et al. (2010)
		1A4a	Commercial/ Institutional	0201	0.1	IPCC (2006), Tier 1, Table 2,4, Commercial, other biogas.
				Engines	1.6	Nielsen et al. (2010).
		1A4b	Residential	0202	1	Assumed equal to natural gas.
		1A4c i	Agriculture/ Forestry	0203	0.1	IPCC (2006), Tier 1, Table 2-5, Agriculture, other biogas.
				Engines	1.6	Nielsen et al. (2010).
	BIO GASIF GAS	1A1a	Public electricity and heat production	010101	0.1	Assumed equal to biogas.

Fuel group	Fuel	CRF source category	CRF source category	SNAP	Emission factor, g per GJ	Reference
				010105	2.7	Nielsen et al. (2010).
		1A4a	Commercial/ Institutional	020105	2.7	Nielsen et al. (2010).
	BIONATGAS	1A1a	Public electricity and heat production	0101 or 0102	1	Assumed equal to natural gas.
		1A2 a-g	Industry	03	1	Assumed equal to natural gas.
		1A4a	Commercial/ Institutional	0201	1	Assumed equal to natural gas.
		1A4b	Residential	0202	1	Assumed equal to natural gas.
		1A4c	Agriculture/ Forestry	020,3	1	Assumed equal to natural gas.

[1)] In Denmark, plants in Agriculture/Forestry are similar to Commercial plants.

Table 4.7 N_2O emission factors time series.

Year	Natural gas fuelled gas turbines. Emission factor, g per GJ	Refinery gas fuelled gas turbines. Emission factor, g per GJ
1990	2.2	2.2
1991	2.2	2.2
1992	2.2	2.2
1993	2.2	2.2
1994	2.2	2.2
1995	2.2	2.2
1996	2.2	2.2
1997	2.2	2.2
1998	2.2	2.2
1999	2.2	2.2
2000	2.2	2.2
2001	2.0	2.0
2002	1.9	1.9
2003	1.7	1.7
2004	1.5	1.5
2005	1.4	1.4
2006	1.2	1.2
2007	1.0	1.0
2008	1.0	1.0
2009	1.0	1.0
2010	1.0	1.0
2011	1.0	1.0
2012	1.0	1.0
2013	1.0	1.0
2014	1.0	1.0
2015	1.0	1.0

Table 4.8 SO_2 emission factors and references, 2015.

Fuel type	Fuel	NFR	NFR_name	SNAP	SO_2 emission factor, g/GJ	Reference
SOLID	ANODIC CARBON	1A2g	Industry - other	032002	855	DCE estimate based on plant specific data.
	COAL	1A1a	Public electricity and heat production	0101	10	DCE estimate based on data reported by plant owners and EU ETS (2016).
				0102	467	DCE estimate based on country specific coal data from Dong Energy (Jensen, 2017) and coal import data from DEA (2016c).
		1A2a-g	Industry	03 except 0309 and 0316	467	DCE estimate based on country specific coal data from Dong Energy (Jensen, 2017) and coal import data from DEA (2016c).
		1A2e	Industry, food, beverages and tobacco	0309	231	DCE estimate based on plant specific data for 2010.
		1A2f	Cement industry	0316	67	DCE estimate based on plant specific data for 2011-2015.
		1A2g	Mineral wool production	Mineral wool 032002	861	DCE estimate based on plant specific data for 2010-2015.
		1A4b i	Residential	020200	467	DCE estimate based on country specific coal data from Dong Energy (Jensen, 2017) and coal import data from DEA (2016c).
		1A4c i	Agriculture/ Forestry	0203	467	DCE estimate based on country specific coal data from Dong Energy (Jensen, 2017) and coal import data from DEA (2016c).
	FLY ASH FOSSIL	1A1a	Public electricity and heat production	010104	10	Assumed equal to coal.
	BROWN COAL BRI.	1A4b	Residential	0202	467	Assumed equal to coal. DCE assumption.
	COKE OVEN COKE	1A2a-g	Industry	03	467	Assumed equal to coal. DCE assumption.
		1A2g	Mineral wool production	Mineral wool 032002	837	DCE estimate based on plant specific data for 2010-2015.
		1A4b	Residential	0202	467	Assumed equal to coal. DCE assumption.
LIQUID	PETROLEUM COKE	1A2a-g	Industry	03	605	DCE calculation based on DEPA (2001b), DEPA (2014), DEA (2016a) and EMEP (2006).
		1A2g	Cement industry	0316	67	DCE estimate based on plant specific data for 2011-2015.
		1A4a	Commercial/ Institutional	0201	605	DCE calculation based on DEPA (2001b), DEPA (2014), DEA (2016a) and EMEP (2006).
		1A4b	Residential	0202	605	DCE calculation based on DEPA (2001b), DEPA (2014), DEA (2016a) and EMEP (2006).
		1A4c	Agriculture/ Forestry	0203	605	DCE calculation based on DEPA (2001b), DEPA (2014), DEA (2016a) and EMEP (2006).
	RESIDUAL OIL	1A1a	Electricity and heat production	0101	100	DCE estimate based on plant specific data for 2008 and 2009.
				0102	344	DCE estimate based on EOF (2017) and DEA (2016a).
		1A1b	Petroleum refining	010306	286	DCE estimate based on plant specific data for year 2015.
		1A2a-g	Industry	03	344	DCE estimate based on EOF (2017) and DEA (2016a).

Fuel type	Fuel	NFR	NFR_name	SNAP	SO_2 emission factor, g/GJ	Reference
		1A4a	Commercial/ Institutional	0201	344	DCE estimate based on EOF (2017) and DEA (2016a).
		1A4b	Residential	0202	344	DCE estimate based on EOF (2017) and DEA (2016a).
		1A4c i	Agriculture/ Forestry	0203	344	DCE estimate based on EOF (2017) and DEA (2016a).
	GAS OIL	1A1a	Public electricity and heat production	0101 0102	23	DCE estimate based on DEPA (1998), Miljø- og planlægn-ingsudvalget (1998) and DEA (2016a). Confirmed in Q8 (2017), Shell (2013) and Circle K (2017).
		1A1b	Petroleum refining	010306	23	DCE estimate based on DEPA (1998), Miljø- og planlægn-ingsudvalget (1998) and DEA (2016a). Confirmed in Q8 (2017), Shell (2013) and Circle K (2017).
		1A1c	Oil and gas extraction	0105	23	DCE estimate based on DEPA (1998), Miljø- og planlægn-ingsudvalget (1998) and DEA (2016a). Confirmed in Q8 (2017), Shell (2013) and Circle K (2017).
		1A2a-g	Industry	03	23	DCE estimate based on DEPA (1998), Miljø- og planlægn-ingsudvalget (1998) and DEA (2016a). Confirmed in Q8 (2017), Shell (2013) and Circle K (2017).
		1A4a	Commercial/ Institutional	0201	23	DCE estimate based on DEPA (1998), Miljø- og planlægn-ingsudvalget (1998) and DEA (2016a). Confirmed in Q8 (2017), Shell (2013) and Circle K (2017).
		1A4b i	Residential	0202	23	DCE estimate based on DEPA (1998), Miljø- og planlægn-ingsudvalget (1998) and DEA (2016a). Confirmed in Q8 (2017), Shell (2013) and Circle K (2017).
		1A4c	Agriculture/Forestry	0203	23	DCE estimate based on DEPA (1998), Miljø- og planlægn-ingsudvalget (1998) and DEA (2016a). Confirmed in Q8 (2017), Shell (2013) and Circle K (2017).
	KEROSENE	1A2g	Industry - other	03	5	DCE estimate based on Tønder (2004) and Shell (2013).
		1A4a	Commercial/ Institutional	0201	5	DCE estimate based on Tønder (2004) and Shell (2013).
		1A4b i	Residential	0202	5	DCE estimate based on Tønder (2004) and Shell (2013).
		1A4c i	Agriculture/ Forestry	0203	5	DCE estimate based on Tønder (2004) and Shell (2013).
	LPG	1A1a	Public electricity and heat production	All	0.13	DCE estimate based on Augustesen (2003), Krebs (2003) and DEA (2016a).
		1A2a-g	Industry	03	0.13	DCE estimate based on Augustesen (2003), Krebs (2003) and DEA (2016a).
		1A4a	Commercial/ Institutional	0201	0.13	DCE estimate based on Augustesen (2003), Krebs (2003) and DEA (2016a).
		1A4b i	Residential	0202	0.13	DCE estimate based on Augustesen (2003), Krebs (2003) and DEA (2016a).
		1A4c i	Agriculture/ Forestry	0203	0.13	DCE estimate based on Augustesen (2003), Krebs (2003) and DEA (2016a).
	REFINERY GAS	1A1b	Petroleum refining	0103	1	DCE estimate based on plant specific data for one plant, average value for 1995-2002.
GAS	NATURAL GAS	1A1a	Public electricity and heat production	0101, 0102, except engines	0.43	DCE estimate based on data from Energinet.dk (2017) and Energinet.dk (2013).

Fuel type	Fuel	NFR	NFR_name	SNAP	SO_2 emission factor, g/GJ	Reference
				010105, engines	0.5	Kristensen (2003).
		1A1b	Petroleum refining	0103	0.43	DCE estimate based on data from Energinet.dk (2017) and Energinet.dk (2013).
		1A1c	Oil and gas extraction	0105	0.43	DCE estimate based on data from Energinet.dk (2017) and Energinet.dk (2013).
		1A2a-g	Industry	03 except engines	0.43	DCE estimate based on data from Energinet.dk (2017) and Energinet.dk (2013).
				Engines	0.5	Kristensen (2003).
		1A4a	Commercial/ Institutional	0201 except engines	0.43	DCE estimate based on data from Energinet.dk (2017) and Energinet.dk (2013).
				Engines	0.5	Kristensen (2003).
		1A4b i	Residential	0202 except engines	0.43	DCE estimate based on data from Energinet.dk (2017) and Energinet.dk (2013).
				Engines	0.5	Kristensen (2003).
		1A4c i	Agriculture/ Forestry	0203 except engines	0.43	DCE estimate based on data from Energinet.dk (2017) and Energinet.dk (2013).
				Engines	0.5	Kristensen (2003).
WASTE	WASTE	1A1a	Public electricity and heat production	0101	8.3	Nielsen et al. (2010a).
				0102	14	DCE estimate based on plant specific data for four plants, 2009 data.
		1A2a-g	Industry	03	14	Assumed equal to district heating plants (DCE assumption).
		1A4a	Commercial/ Institutional	0201	14	Assumed equal to district heating plants (DCE assumption).
	INDU-STRIAL WASTE	1A2f	Industry – non-metallic minerals	031600	14	Assumed equal to waste. DCE assumption.
BIO-MASS	WOOD	1A1a	Public electricity and heat production	0101	1.9	Nielsen et al. (2010a).
				0102	11	EEA (2016).
		1A2a-g	Industry	03	11	EEA (2016).
		1A4a	Commercial/ Institutional	0201	11	EEA (2016).
		1A4b i	Residential	0202	11	EEA (2016).
		1A4c i	Agriculture/ Forestry	0203	11	EEA (2016).
	STRAW	1A1a	Public electricity and heat production	0101	49	Nielsen et al. (2010a).
				0102	115	Assumed equal to farmhouse boilers.
		1A4b i	Residential	0202	115	Jensen et al. (2017).
		1A4c i	Agriculture/ Forestry	0203	115	Jensen et al. (2017).

Fuel type	Fuel	NFR	NFR_name	SNAP	SO_2 emission factor, g/GJ	Reference
	BIO OIL	1A1a	Public electricity and heat production	0101	0.3	DCE estimate based on Folkecenter for Vedvarende Energi (2000) and DEA (2016a).
				0102	0.3	DCE estimate based on Folkecenter for Vedvarende Energi (2000) and DEA (2016a).
		1A2a-g	Industry	03	0.3	DCE estimate based on Folkecenter for Vedvarende Energi (2000) and DEA (2016a).
		1A4b i	Residential	0202	0.3	DCE estimate based on Folkecenter for Vedvarende Energi (2000) and DEA (2016a).
	BIOGAS	1A1a	Public electricity and heat production	0101, except engines	25	DCE estimate based on Christiansen (2003), Hjort-Gregersen (1999) and DEA (2016a).
				Engines	19.2	Nielsen & Illerup (2003)
				0102	25	DCE estimate based on Christiansen (2003), Hjort-Gregersen (1999) and DEA (2016a).
		1A2a-g	Industry	03, ex-cept en-gines	25	DCE estimate based on Christiansen (2003), Hjort-Gregersen (1999) and DEA (2016a).
				03, en-gines	19.2	Nielsen & Illerup (2003).
		1A4a	Commercial/ Institutional	0201, except engines	25	DCE estimate based on Christiansen (2003), Hjort-Gregersen (1999) and DEA (2016a).
				020105	19.2	Nielsen & Illerup (2003).
		1A4b	Residential	0202	25	DCE estimate based on Christiansen (2003), Hjort-Gregersen (1999) and DEA (2016a).
		1A4c i	Agriculture/ Forestry	0203, except engines	25	DCE estimate based on Christiansen (2003), Hjort-Gregersen (1999) and DEA (2016a).
				020304	19.2	Nielsen & Illerup (2003).
	BIO GASIF GAS	1A1a	Public electricity and heat production	010105	7	Kristensen (2017a) and Kristensen (2017b).
	BIONATGAS	1A1a	Public electricity and heat production	0101	0.43	Assumed equal to natural gas.
		1A2a-g	Industry	03	0.43	Assumed equal to natural gas.
		1A4a	Commercial/ Institutional	0201	0.43	Assumed equal to natural gas.
		1A4b	Residential	0202	0.43	Assumed equal to natural gas.
		1A4c	Agriculture/ Forestry	0203	0.43	Assumed equal to natural gas.

Table 4.9 SO_2 emission factors time series, g per GJ for the years 1990 to 2015.

This table is available at:

http://envs.au.dk/videnudveksling/luft/emissioner/supporting-documentation/air-pollution-iir/

Table 4.10 NO_x emission factors and references, 2015.

Fuel type	Fuel	NFR	NFR_name	SNAP	NOx emission factor, g/GJ	Reference
SOLID	ANODIC CARBON	1A2g	Industry - other	032000	183	Assumed equal to coal. DCE assumption.
	COAL	1A1a	Public electricity and heat production	0101	29	DCE estimate based on plant specific emission data and EU ETS (2016).
				0102	95	DEPA (2001a).
		1A2a-g	Industry	03 except cement produc-tion	183	DCE estimate based on plant specific data for four plants in 2015.
		1A2f	Industry, cement production	0316	179	DCE estimate based on plant specific data for 2015.
		1A4b i	Residential	020200	95	DEPA (2001a).
		1A4c i	Agriculture/ Forestry	0203	95	DEPA (2001a).
	FLY ASH FOSSIL	1A1a	Public electricity and heat production	0101	29	Assumed equal to the emission factor for coal.
	BROWN COAL BRI.	1A4b	Residential	0202	95	Assumed equal to coal. DCE assumption.
	COKE OVEN COKE	1A2a-g	Industry	03	183	Assumed equal to coal. DCE assumption.
		1A4b	Residential	0202	95	Assumed equal to coal. DCE assumption.
LIQUID	PETROLEUM COKE	1A2a-g	Industry	03	138	Assumed equal to residual oil. DCE assumption.
			Industry, non-metallic minerals	0316	179	DCE estimate based on plant specific data for 2015.
		1A4a	Commercial/ Institutional	0201	51	EEA (2016). Tier 1, Small combustion, liquid fuels applied in residential plants.
		1A4b	Residential	0202	51	EEA (2016). Tier 1, Small combustion, liquid fuels applied in residential plants.
		1A4c	Agriculture/ Forestry	0203	51	EEA (2016). Tier 1, Small combustion, liquid fuels applied in residential plants.
	RESIDUAL OIL	1A1a	Public electricity and heat production	0101	138	DCE estimate based on plant specific data for 2008, 2009 and 2010. Plant specific data refer to: Energinet.dk (2009); Energinet.dk (2010); Energinet.dk (2011): EU ETS (2009-2011).
				0102	142	DEPA (2001a).
		1A1b	Petroleum refining	010306	142	EEA(2016).
		1A2a-g	Industry	03	129	DCE estimate based on plant specific data for 2015.
				0316	179	DCE estimate based on plant specific data for 2015.
		1A4a	Commercial/ Institutional	0201	142	DEPA (2001a).
		1A4b	Residential	0202	142	DEPA (2001a).
		1A4c i	Agriculture/ Forestry	0203	142	DEPA (2001a).

Fuel type	Fuel	NFR	NFR_name	SNAP	NOx emission factor, g/GJ	Reference
	GAS OIL	1A1a	Public electricity and heat production	010101, 010102, 010103	114	DCE estimate based on plant specific data for 2011.
				0102	130	DEPA (2016), DEPA (2012b), DEPA (2003b) and DEPA (1990).
				010104	230	DCE estimate based on plant specific data year 2015.
				010105	942	Nielsen et al. (2010a).
		1A1b	Petroleum refining	010306	65	EEA (2016).
		1A1c	Oil and gas extraction	010504	230	Assumed equal to gas turbines applied in CHP plants. DCE assumption.
		1A2a-g	Industry	03 except engines	130	DEPA (2016), DEPA (2012b), DEPA (2003b) and DEPA (1990).
		1A2a-g	Industry	Engines	942	Nielsen et al. (2010a).
		1A4a	Commercial/ Institutional	0201	52	DEPA (2001a).
				Engines	942	Nielsen et al. (2010a).
		1A4b i	Residential	0202	52	DEPA (2001a).
				Engines	942	Nielsen et al. (2010a).
		1A4c	Agriculture/Forestry	0203	52	DEPA (2001a).
				Engines	942	Nielsen et al. (2010a).
	KEROSENE	1A2g	Industry - other	03	50	EEA (2016). The emission factor is for liquid fuels combusted in residential plants.
		1A4a	Commercial/ Institutional	0201	50	EEA (2016). The emission factor is for liquid fuels combusted in residential plants.
		1A4b i	Residential	0202	50	EEA (2016). The emission factor is for liquid fuels combusted in residential plants.
		1A4c i	Agriculture/ Forestry	0203	50	EEA (2016). The emission factor is for liquid fuels combusted in residential plants.
	LPG	1A1a	Public electricity and heat production	All	96	IPCC (1997).
		1A2a-g	Industry	03	96	IPCC (1997).
		1A4a	Commercial/ Institutional	0201	71	IPCC (1997).
		1A4b i	Residential	0202	47	IPCC (1997)
		1A4c i	Agriculture/ Forestry	0203	71	IPCC (1997)
	REFINERY GAS	1A1b	Petroleum refining	010304	170	DCE estimate based on plant specific data for a gas turbine in year 2000.
				010306	56	DCE estimate based on plant specific data for year 2015.
GAS	NATURAL GAS	1A1a	Public electricity and heat production	010101, 010102	55	DEPA (2003b), DEPA (2012), DEPA (2015) and DEPA (2016).
				010103	33.04	Schweitzer & Kristensen (2015).
				010104	48	Nielsen et al. (2010a).
				010105	135	Nielsen et al. (2010a).
				0102	33.04	Schweitzer & Kristensen (2015).
		1A1b	Petroleum refining	0103	33.04	Schweitzer & Kristensen (2015).

Fuel type	Fuel	NFR	NFR_name	SNAP	NOx emission factor, g/GJ	Reference
		1A1c	Oil and gas extraction	010504	199	Estimate based on plant specific data. Malinovsky (2016a; Malinovsky, 2016b).
		1A2a-g	Industry	03	33.04	Schweitzer & Kristensen (2015).
				Engines	135	Nielsen et al. (2010a).
				Turbines	48	Nielsen et al. (2010a).
		1A2f		030700	87	DCE estimate based on plant specific data for 11 clay production plants, EU ETS (2011-2012); DEPA (2012).
		1A4a	Commercial/ Institutional	0201	33.04	Schweitzer & Kristensen (2015).
				Engines	135	Nielsen et al. (2010a).
		1A4b i	Residential	0202	24.30	Schweitzer & Kristensen (2014).
				Engines	135	Nielsen et al. (2010a).
		1A4c i	Agriculture/ Forestry	0203	33.04	Schweitzer & Kristensen (2015).
				Engines	135	Nielsen et al. (2010a).
WASTE	WASTE	1A1a	Public electricity and heat production	0101	75	DCE estimate based on plant specific data for year 2015.
				0102	164	DCE estimate based on plant specific data for year 2000.
		1A2a-g	Industry	03	164	DCE estimate based on plant specific data for district heating plants in year 2000.
		1A4a	Commercial/ Institutional	0201	164	DCE estimate based on plant specific data for district heating plants in year 2000.
	INDUSTRIAL WASTE	1A2f	Industry – non-metallic minerals	031600	179	DCE estimate based on plant specific data for 2015.
BIO-MASS	WOOD	1A1a	Public electricity and heat production	0101	81	Nielsen et al. (2010a).
				0102	90	Serup et al. (1999).
		1A2a-g	Industry	03	90	Serup et al. (1999).
		1A4a	Commercial/ Institutional	0201	90	Serup et al. (1999)
		1A4b i	Residential	0202	76.76	DCE estimate based on DEA (2016a), DEPA (2013) and EEA (2013). The methodology for estimating this emission factor is included in Chapter 6.5.
		1A4c i	Agriculture/ Forestry	0203	90	Serup et al. (1999).
	STRAW	1A1a	Public electricity and heat production	0101	125	Nielsen et al. (2010a).
				0102	90	Nikolaisen et al. (1998).
		1A4b i	Residential	0202	154	Jensen et al. (2017).
		1A4c i	Agriculture/ Forestry	0203	154	Jensen et al. (2017).
	BIO OIL	1A1a	Public electricity and heat production	0101	114	Assumed equal to gas oil. DCE assumption.
				0102	130	Assumed equal to gas oil. DCE assumption.
		1A2a-g	Industry	03	130	Assumed equal to gas oil. DCE assumption.
				Engines	942	Assumed equal to gas oil. DCE assumption.
		1A4b i	Residential	0202	52	Assumed equal to gas oil. DCE assumption.
	BIOGAS	1A1a	Public electricity and heat production	0101, not engines	55	Assumed equal to large natural gas fuelled boilers.
				Engines	202	Nielsen et al. (2010a).
				0102	28	DEPA (2001a).

Fuel type	Fuel	NFR	NFR_name	SNAP	NOx emission factor, g/GJ	Reference
		1A2a-g	Industry	03, not engines	55	Assumed equal to large natural gas fuelled boilers.
				03, engines	202	Nielsen et al. (2010a).
				030902	55	Assumed equal to large natural gas fuelled boilers.
		1A4a	Commercial/ Institutional	0201, not engines	28	DEPA (2001a).
				020105	202	Nielsen et al. (2010a).
		1A4b	Residential	0202	24.30	Assumed equal to natural gas (upgraded biogas).
		1A4c i	Agriculture/ Forestry	0203, not engines	28	DEPA (2001a).
				020304	202	Nielsen et al. (2010a).
	BIO GASIF GAS	1A1a	Public electricity and heat production	010105	173	Nielsen et al. (2010a).
	BIONATGAS	1A1a	Public electricity and heat production	0101	55	Assumed equal to natural gas. DCE assumption.
				0102	33.04	Assumed equal to natural gas. DCE assumption.
		1A2a-g	Industry	03	33.04	Assumed equal to natural gas. DCE assumption.
		1A4a	Commercial/ Institutional	0201	33.04	Assumed equal to natural gas. DCE assumption.
		1A4b	Residential	0202	24.30	Assumed equal to natural gas. DCE assumption.
		1A4c	Agriculture/ Forestry	0203	33.04	Assumed equal to natural gas. DCE assumption.

Table 4.11 NO_x emission factors time series, g per GJ for the years 1990 to 2015.

This table is available at:

http://envs.au.dk/videnudveksling/luft/emissioner/supporting-documentation/air-pollution-iir/

Table 4.12 NMVOC emission factors and references, 2015.

Fuel type	Fuel	NFR	NFR_name	SNAP	NMVOC, g/GJ	Reference
SOLID	ANODIC CARBON	1A2g	Industry - other	0320	10	Assumed equal to coal. DCE assumption.
	COAL	1A1a	Public electricity and heat production	0101 0102	1.0	EEA (2016), Tier 1, Energy Industries Table 3-2.
		1A2a-g	Industry	03	10	EEA (2016), Tier 1, Industry Table 3-2, assumed lower interval.
		1A4c i	Agriculture/ Forestry	0203	88.8	EEA (2016), Tier 1, Small combustion Table 3-7.
	FLY ASH FOSSIL	1A1a	Public electricity and heat production	0101	1.0	Assumed equal to coal. DCE assumption.
	BROWN COAL BRI.	1A4b i	Residential	0202	484	EEA (2016), Tier 1, Small combustion Table 3-3.
	COKE OVEN COKE	1A2a-g	Industry	03	10	EEA (2016), Tier 1, Industry Table 3-2, assumed lower interval.
		1A4b	Residential	0202	484	EEA (2016), Tier 1, Small combustion Table 3-3 (and Table 3-2).
LIQUID	PETROLEUM COKE	1A2a-g	Industry	03	25	EEA (2016) Tier 1, Industry Table 3-4.
		1A4a	Commercial/ Institutional	0201	20	EEA (2016), Tier 1, Small combustion Table 3-9.
		1A4b	Residential	0202	20	EEA (2016), Tier 1 for 1A4a/1A4c have been applied (DCE assumption). Small combustion Table 3-9.
		1A4c	Agriculture/ Forestry	0203	20	EEA (2016), Tier 1, Small combustion Table 3-9
	RESIDUAL OIL	1A1a	Public electricity and heat production	010101 010102 010103	0.8	Nielsen et al. (2010a).
				010104	2.3	EEA (2016), Tier 1, Energy Industries Table 3-5.
				010105	2.3	EEA (2016), Tier 1, Energy Industries Table 3-5.
				010203	2.3	EEA (2016), Tier 1, Energy Industries Table 3-5.
		1A1b	Petroleum refining	010306	2.3	EEA (2016), Tier 1, Energy Industries Table 3-5 (and Table 4.1).
		1A2a-g	Industry	03 except engines	0.8	Nielsen et al. (2010a).
				Engines	25	EEA (2016), Tier 1, Industry Table 3-4.
		1A4a	Commercial/ Institutional	0201	20	EEA (2016), Tier 1, Small combustion Table 3-9.
		1A4b	Residential	0202	20	EEA (2016), Tier 1, Small combustion Table 3-9, assumed equal to 1A4a/1A4c.
		1A4c i	Agriculture/ Forestry	0203	20	EEA (2016), Small combustion Tier 1, Table 3-9.
	GAS OIL	1A1a	Public electricity and heat production	010101 010102 010103	0.8	EEA (2016), Tier 1, Energy Industries Table 3-6.
				010104	0.19	EEA (2016), Tier 2, Energy Industries Table 3-18.
				010105	37.1	EEA (2016), Tier 2, Energy Industries Table 3-19.
				0102	0.8	EEA (2016), Tier 1, Energy Industries Table 3-6.

Fuel type	Fuel	NFR	NFR_name	SNAP	NMVOC, g/GJ	Reference
		1A1b	Petroleum refining	010306	0.8	EEA (2016), Tier 1, Energy Industries Table 3-6 (and Table 4.1).
		1A1c	Oil and gas extraction	010504	0.19	EEA (2016), Tier 2, Energy Industries Table 3-18.
		1A2a-g	Industry	03 boilers > 50 MW	0.8	EEA (2016), Tier 1, Energy Industries Table 3-6.
				Gas turbines	0.19	EEA (2016), Tier 2, Energy Industries Table 3-18.
				Engines	37.1	EEA (2016), Tier 2, Energy Industries Table 3-19.
		1A4a	Commercial/ Institutional	0201 except engines	20	EEA (2016), Tier 1, Small Combustion Table 3-9.
				Engines	37.1	EEA (2016), Tier 2, Energy Industries Table 3-19.
		1A4b i	Residential	0202	20	EEA (2016), Tier 1, Small Combustion Table 3-9.
		1A4c	Agriculture/Forestry	020302	20	EEA (2016), Tier 1, Small Combustion Table 3-9.
	KEROSENE	1A2a-g	Industry	03	0.8	EEA (2016), Tier 1, Energy Industries Table 3-6.
		1A4a	Commercial/ Institutional	0201	20	EEA (2016), Tier 1, Small Combustion Table 3-9.
		1A4b i	Residential	0202	20	EEA (2016), Tier 1, Small Combustion Table 3-9.
		1A4c i	Agriculture/ Forestry	0203	20	EEA (2016), Tier 1, Small Combustion Table 3-9.
	LPG	1A1a	Public electricity and heat production	0101 0102	0.8	EEA (2016), Tier 1, Energy Industries Table 3-6.
		1A2a-g	Iron and steel	03	0.8	EEA (2016), Tier 1, Energy Industries Table 3-6.
		1A4a	Commercial/ Institutional	0201	20	EEA (2016), Tier 1, Small Combustion Table 3-9.
		1A4b i	Residential	0202	20	EEA (2016), Tier 1, Small Combustion Table 3-9.
		1A4c i	Agriculture/ Forestry	0203	20	EEA (2016), Tier 1, Small Combustion Table 3-9.
	REFINERY GAS	1A1b	Petroleum refining	0103	1.4	Assumed equal to natural gas fuelled gas turbines. DCE assumption.
GAS	NATURAL GAS	1A1a	Public electricity and heat production	010101 010102 010103	2	Danish Gas Technology Centre (2001).
				010104	1.6	Nielsen et al. (2010a).
				010105	92	Nielsen et al. (2010a).
				0102	2	Danish Gas Technology Centre (2001).
		1A1b	Petroleum refining	0103	2	Danish Gas Technology Centre (2001).
		1A1c	Oil and gas extraction	0105	1.6	Nielsen et al. (2010a).
		1A2a-g	Industry	03 except engines and turbines	2	Danish Gas Technology Centre (2001).
				Turbines	1.6	Nielsen et al. (2010a).
				Engines	92	Nielsen et al. (2010a).
		1A4a	Commercial/ Institutional	0201 except engines	2	Danish Gas Technology Centre (2001).
				Engines	92	Nielsen et al. (2010a).
		1A4b i	Residential	0202 except engines	4	Gruijthuijsen & Jensen (2000).
				Engines	92	Nielsen et al. (2010a).
		1A4c i	Agriculture/ Forestry	0203 except engines	2	Danish Gas Technology Centre (2001).

Fuel type	Fuel	NFR	NFR_name	SNAP	NMVOC, g/GJ	Reference
				Engines	92	Nielsen et al. (2010a).
WASTE	WASTE	1A1a	Public electricity and heat production	0101	0.56	Nielsen et al. (2010a).
				0102	0.56	Nielsen et al. (2010a). The CHP emission factor has been applied for other plant categories.
		1A2a-g	Industry	03	0.56	Nielsen et al. (2010a). The CHP emission factor has been applied for other plant categories.
		1A4a	Commercial/ Institutional	0201	0.56	Nielsen et al. (2010a). The CHP emission factor has been applied for other plant categories.
	INDISTRIAL WASTE	1A2f	Industry	0316	0.56	Nielsen et al. (2010a). The CHP emission factor has been applied for other plant categories.
BIO-MASS	WOOD	1A1a	Public electricity and heat production	0101	5.1	Nielsen et al. (2010a).
				0102	7.3	EEA (2016), Tier 1, Energy Industries Table 3-7.
		1A2a-g	Industry	03	95	Estimate based on country specific data, see (1).
		1A4a	Commercial/ Institutional	0201	58	Estimate based on country specific data, see (1).
		1A4b i	Residential	0202	293	DCE estimate based on DEA (2016a), DEPA (2013) and EEA (2013). The methodology for estimating this emission factor is included in Chapter 6.5.
		1A4c i	Agriculture/ Forestry	0203	58	Estimate based on country specific data, see (1).
	STRAW	1A1a	Public electricity and heat production	0101	0.78	Nielsen et al. (2010a).
				0102	7.3	EEA (2016), Tier 1, Energy Industries Table 3-7.
		1A4b i	Residential	0202	600	EEA (2016), Tier 1, Small Combustion Table 3-6.
		1A4c i	Agriculture/ Forestry	0203	600	EEA (2016). Plants are assumed equal to residential plants.
				020302	12	EEA (2016), Tier 2, Small Combustion Table 3-45.
	BIO OIL	1A1a	Public electricity and heat production	010102	0.8	EEA (2016), Tier 1, Energy Industries Table 3-6 (gas oil).
				010105	37	EEA (2016), Tier 2, Energy Industries Table 3-19 (gas oil, large stationary CI reciprocating engines).
				0102	0.8	EEA (2016), Tier 1, Energy Industries Table 3-6 (gas oil).
		1A2a-g	Industry	03, not engines	0.8	EEA (2016), Tier 1, Energy Industries Table 3-6 (gas oil).
				010105	37	EEA (2016), Tier 2, Energy Industries Table 3-19 (gas oil, large stationary CI reciprocating engines).
		1A4b i	Residential	0202	20	EEA (2016), Tier 1, Small combustion Table 3-9 (liquid fuels).
	BIOGAS	1A1a	Public electricity and heat production	0101	2	Assumed equal to natural gas. DCE assumption.
				010105	10	Nielsen et al. (2010a).

Fuel type	Fuel	NFR	NFR_name	SNAP	NMVOC, g/GJ	Reference
				0102	2	Assumed equal to natural gas. DCE assumption.
		1A2a-g	Industry	03 except engines	2	Assumed equal to natural gas. DCE assumption.
				Engines	10	Nielsen et al. (2010a).
		1A4a	Commercial/ Institutional	0201 except engines	2	Assumed equal to natural gas. DCE assumption.
				Engines	10	Nielsen et al. (2010a).
		1A4b	Residential	0202	4	Assumed equal to natural gas. DCE assumption.
		1A4c i	Agriculture/ Forestry	0203 except engines	2	Assumed equal to natural gas. DCE assumption.
				Engines	10	Nielsen et al. (2010a).
	BIO GASIF GAS	1A1a	Public electricity and heat production	010105	2	Nielsen et al. (2010a).
				0101 except engines	2	Assumed equal to natural gas. DCE assumption.
	BIONATGAS	1A1a	Public electricity and heat production	0101 and 0102	2	Assumed equal to natural gas. DCE assumption.
		1A2a-g	Industry	03	2	Assumed equal to natural gas. DCE assumption.
		1A4a	Commercial/ Institutional	0201	2	Assumed equal to natural gas. DCE assumption.
		1A4b	Residential	0202	4	Assumed equal to natural gas. DCE assumption.
		1A4c	Agriculture/ Forestry	0203	2	Assumed equal to natural gas. DCE assumption.

Table 4.13 NMVOC emission factors time series, g per GJ for the years 1990 to 2015.
This table is available at:
http://envs.au.dk/videnudveksling/luft/emissioner/supporting-documentation/air-pollution-iir/

Table 4.14 CO emission factors and references, 2015.

Fuel type	Fuel	NFR	NFR_name	SNAP	CO emission factor g/GJ	Reference
SOLID	ANODIC CARBON	1A2a-g	Industry	03	10	Assumed the same emission factor as for coal. DCE assumption.
	COAL	1A1a	Public electricity and heat production	0101 and 0102	10	Sander (2002).
		1A2a-g	Industry	03	10	Assumed equal to boilers in public electricity and heat production. DCE assumption.
		1A4c i	Agriculture/ Forestry	0203	931	EEA (2016), Tier 2, Small Combustion Table 3.15, residential boilers, solid fuels.
	FLY ASH FOSSIL	1A1a	Public electricity and heat production	0101	10	EEA (2016), Tier 1, Small Combustion Table 3.7.
	BROWN COAL BRI.	1A4b i	Residential	0202	4787	Assumed equal to coal. DCE assumption.
	COKE OVEN COKE	1A2a-g	Industry	03	10	EEA (2016), Tier 2, Small Combustion Table 3.15, residential boilers, solid fuels.
		1A4b	Residential	0202	4787	Assumed the same emission factor as for coal. DCE assumption.
LIQUID	PETROLEUM COKE	1A2a-g	Industry	03	66	EEA (2016), Tier 2, Small Combustion Table 3.15, residential boilers, solid fuels.
		1A4a	Commercial/Institutional	0201	93	EEA (2016), Tier 1, Manufacturing industries and construction Table 3.4 for liquid fuels.
		1A4b	Residential	0202	93	EEA (2016), Tier 1, Manufacturing industries and construction Table 3.4 for liquid fuels.
		1A4c	Agriculture/ Forestry	0203	93	EEA (2016), Tier 1, Small Combustion Table 3.9
	RESIDUAL OIL	1A1a	Electricity and heat production	010101 010104 010105	15	EEA (2016), Tier 1, Small Combustion Table 3.9 (assumed equal to the emission factor for 1A4a/1A4c).
				010102 010103	2.8	EEA (2016), Tier 1, Small Combustion Table 3.9.
				0102	15.1	Sander (2002).
		1A1b	Petroleum refining	010306	6	Nielsen et al. (2010a).
		1A2a-g	Industry	03 except engines	2.8	EEA (2016), Tier 1, Energy Industries Table 3.5.
				Engines	130	EEA (2016), Tier 2, Energy Industries Table 4.4.
		1A4a	Commercial/Institutional	0201	40	Nielsen et al. (2010a).
		1A4b	Residential	0202	57	EEA (2016). Tier 2 emission factor for gas oil fuelled engines in Energy Industries. Refers to Nielsen et al. (2010a).
		1A4c i	Agriculture/ Forestry	0203	40	EEA (2016). Tier 2, Small Combustion Table 3.25.
	GAS OIL	1A1a	Public electricity and heat production	0101 except engines	15	EEA (2016), Tier 1, Small Combustion Table 3.5.
				Engines	130	EEA (2016). Tier 2, Small Combustion Table 3.25.
				0102	16.2	Sander (2002).

Fuel type	Fuel	NFR	NFR_name	SNAP	CO emission factor g/GJ	Reference
		1A1b	Petroleum refining	010306	16.2	Nielsen et al. (2010a)
		1A1c	Oil and gas extraction	0105	15	EEA (2016), Tier 1, Energy Industries Table 3.6.
		1A2a-g	Industry	03 except gas turbines and engines	66	EEA (2016), Tier 1, Energy Industries Table 4.5.
				Gas turbines	15	Sander (2002).
				Engines	130	EEA (2016), Tier 1, Manufacturing industries and construction Table 3.4 for liquid fuels.
		1A4a	Commercial/ Institutional	0201 except engines	40	Sander (2002).
				Engines	130	Nielsen et al. (2010a).
		1A4b i	Residential	0202	3.7	EEA (2016). Tier 2, Small Combustion Table 3.24.
		1A4c	Agriculture/Forestry	0203	40	Nielsen et al. (2010a).
	KEROSENE	1A2a-g	Industry	03	66	EEA (2016). Tier 2, Small Combustion Table 3.18. Gas oil applied in small residential boilers.
		1A4a	Commercial/ Institutional	0201	40	EEA (2016). Tier 2, Small Combustion Table 3.24.
		1A4b i	Residential	0202	3.7	EEA (2016), Tier 1, Manufacturing industries and construction Table 3.4 for liquid fuels.
		1A4c i	Agriculture/ Forestry	0203	40	EEA (2016). Tier 2, Small Combustion Table 3.24.
	LPG	1A1a	Public electricity and heat production	0101 and 0102	16.2	EEA (2016). Tier 2, Small Combustion Table 3.18. Gas oil applied in small residential boilers.
		1A2a-g	Industry	03	66	EEA (2016). Tier 2, Small Combustion Table 3.24.
		1A4a	Commercial/ Institutional	0201	40	EEA (2016), Tier 1, Energy Industries Table 3.6
		1A4b i	Residential	0202	3.7	EEA (2016), Tier 1, Manufacturing industries and construction Table 3.4 for liquid fuels.
		1A4c i	Agriculture/ Forestry	0203	40	EEA (2016). Tier 2, Small Combustion Table 3.24.
	REFINERY GAS	1A1b	Petroleum refining	0103	12.1	EEA (2016). Tier 2, Small Combustion Table 3.18. Gas oil applied in small residential boilers.
GAS	NATURAL GAS	1A1a	Public electricity and heat production	010101 and 010102	15	EEA (2016). Tier 2, Small Combustion Table 3.24.
				010103	28	EEA (2016). Tier 1, Energy Industries Table 4.2 for refinery gas applied in petroleum refining.
				010104	4.8	Sander (2002).
				010105	58	DEPA (2001a).
				0102	28	Nielsen et al. (2010a).
		1A1b	Petroleum refining	0103	28	Nielsen et al. (2010a).
		1A1c	Oil and gas extraction	0105	4.8	DEPA (2001a).
		1A2a-g	Industry	03 except gas turbines and engines	28	Assumed equal to district heating plants.
				Gas turbines	4.8	Nielsen et al. (2010a).
				Engines	58	DEPA (2001a).

Fuel type	Fuel	NFR	NFR_name	SNAP	CO emission factor g/GJ	Reference
		1A4a	Commercial/ Institutional	0201 except engines	28	Nielsen et al. (2010a).
				Engines	58	Nielsen et al. (2010a).
		1A4b i	Residential	0202 except engines	20	DEPA (2001a).
				Engines	58	Nielsen et al. (2010a).
		1A4c i	Agriculture/ Forestry	0203 except engines	28	Gruijthuijsen & Jensen (2000).
				Engines	58	Nielsen et al. (2010a).
WASTE	WASTE	1A1a	Public electricity and heat production	0101	3.9	DEPA (2001a).
				0102	10	Nielsen et al. (2010a).
		1A2a-g	Industry	03	10	Nielsen et al. (2010a).
		1A4a	Commercial/ Institutional	0201	10	DCE calculation based on annual environmental reports for Danish plants year 2000.
	INDISTRIAL WASTE	1A2f	Industry	0316	10	Assumed equal to district heating plants. DCE assumption.
BIO-MASS	WOOD	1A1a	Public electricity and heat production	0101	90	Assumed equal to district heating plants. DCE assumption.
				010203	240	Assumed equal to waste, district heating plants. DCE assumption.
		1A2a-g	Industry	03	240	Nielsen et al. (2010a).
		1A4a	Commercial/ Institutional	020100	240	DEPA (2001a).
		1A4b i	Residential	0202	2158	DEPA (2001a).
		1A4c i	Agriculture/ Forestry	020300	240	DEPA (2001a).
	STRAW	1A1a	Public electricity and heat production	0101	67	DCE estimate based on DEA (2016a), DEPA (2013) and EEA (2013). The methodology for estimating this emission factor is included in Chapter 6.5.
				0102	325	DEPA (2001a).
		1A4b i	Residential	0202	2000	Nielsen et al. (2010a).
		1A4c i	Agriculture/ Forestry	0203	2000	DEPA (2001a); Nikolaisen et al (1998).
				020302	325	EEA (2007); Jensen & Nielsen (1990) and Bjerrum (2002), Kristensen & Kristensen (2004). Time series.
	BIO OIL	1A1a	Public electricity and heat production	0101 and 0102	15	EEA (2007); Jensen & Nielsen (1990) and Bjerrum (2002), Kristensen & Kristensen (2004). Time series.
		1A2a-g	Industry	03	66	DEPA (2001a); Nikolaisen et al (1998).
		1A4b i	Residential	0202	3.7	Assumed same emission factor as for gas oil. DCE assumption.
	BIOGAS	1A1a	Public electricity and heat production	0101 except engines	36	Assumed same emission factor as for gas oil. DCE assumption.
				Engines	310	Assumed same emission factor as for gas oil. DCE assumption.

Fuel type	Fuel	NFR	NFR_name	SNAP	CO emission factor g/GJ	Reference
				0102	36	Assumed same emission factor as for gas oil. DCE assumption.
		1A2a-g	Industry	03 except engines	36	Assumed same emission factor as for gas oil. DCE assumption.
				Engines	310	DEPA (2001a).
		1A4a	Commercial/ Institutional	0201 except engines	36	Nielsen et al. (2010a).
				Engines	310	DEPA (2001a).
		1A4b	Residential	0202	20	DEPA (2001a).
		1A4c i	Agriculture/ Forestry	0203 except engines	36	Nielsen et al. (2010a).
				Engines	310	DEPA (2001a).
	BIO GASIF GAS	1A1a	Public electricity and heat production	010105	586	Nielsen et al. (2010a).
				010101	36	Assumed equal to natural gas. DCE assumption.
	BIONATGAS	1A1a	Public electricity and heat production	0101	15	DEPA (2001a).
				0102	28	Nielsen et al. (2010a).
		1A2a-g	Industry	03	28	Nielsen et al. (2010a).
		1A4a	Commercial/ Institutional	0201	28	DEPA (2001a).
		1A4b i	Residential	0202	20	Assumed equal to natural gas. DCE assumption.
		1A4c i	Agriculture/ Forestry	0203	28	Assumed equal to natural gas. DCE assumption.

Table 4.15 CO emission factors time series, g per GJ for the years 1990 to 2015.
This table is available at:
http://envs.au.dk/videnudveksling/luft/emissioner/supporting-documentation/air-pollution-iir/

Table 4.16 NH_3 emission factors and references 2015.

Fuel	NFR (SNAP)	Emission factor, g/GJ	Reference
Coal	1A4b	0.3	EEA (2016), Tier 1, Small combustion Table 3-3.
BKB	1A4b	0.3	EEA (2016), Tier 1, Small combustion Table 3-3.
Coke oven coke	1A4b	0.3	EEA (2016), Tier 1, Small combustion Table 3-3.
Wood	1A4b	37.4	DCE estimate based on DEA (2016a), DEPA (2013) and EEA (2013). The methodology for estimating this emission factor is included in Chapter 6.5.
Wood	1A4a, 1A4c, 1A2	37	EEA (2016), Tier 1, Small Combustion Table 3-10.
Waste	1A1a	0.29	Nielsen et al. (2010a).
Straw	1A4b, 1A4c	70	EEA (2016), Tier 1, Small Combustion Table 3-6.
Straw	1A4a, 1A2	37	EEA (2016), Tier 1, Small Combustion Table 3-10.

Table 4.17 NH_3 emission factors time series, g per GJ, 1990 to 2015.
This table is available at:
http://envs.au.dk/videnudveksling/luft/emissioner/supporting-documentation/air-pollution-iir/

Table 4.18 PM emission factors (in g per GJ) and references, 2015.

fuel_type	fuel_id	fuel_gr_abbr	nfr_id_EA	snap_id	TSP, g/GJ	Reference for TSP	PM_{10}, g/GJ	$PM_{2.5}$, g/GJ	Reference for PM_{10} and $PM_{2.5}$ emission factors or for the PM_{10} and the $PM_{2.5}$ fraction
SOLID	101A	ANODIC CARBON	1A2g iii	0320	17	DEPA (1990), DEPA (1995)	12	7	TNO (2001)
	102A	COAL	1A1a	0101	3	Livbjerg et al. (2001)	2.6	2.1	Livbjerg et al. (2001)
				0102	6	TNO (2001)	6	5	TNO (2001)
			1A2 a-g	03	17	DEPA (1990), DEPA (1995)	12	7	TNO (2001)
			1A4c i	0203	17	DEPA (1990), DEPA (1995)	12	7	TNO (2001)
	103A	FLY ASH FOSSIL	1A1a	0101	3	Livbjerg et al. (2001)	2.6	2.1	Livbjerg et al. (2001)
	106A	BROWN COAL BRI.	1A4b i	0202	17	Same emission factor as for coal is assumed (DCE assumption)	12	7	Same emission factor as for coal is assumed (DCE assumption)
	107A	COKE OVEN COKE	1A2 a-g	03	17	Same emission factor as for coal is assumed (DCE assumption)	12	7	Same emission factor as for coal is assumed (DCE assumption)
			1A4b	0202	17	Same emission factor as for coal is assumed (DCE assumption)	12	7	Same emission factor as for coal is assumed (DCE assumption)
LIQUID	110A	PETROLEUM COKE	1A2a-g	03	10	TNO (2001)	7	3	TNO (2001)
			1A4a	0201	100	TNO (2001)	60	30	TNO (2001)
			1A4b	0202	100	TNO (2001)	60	30	TNO (2001)
			1A4c	0203	100	TNO (2001)	60	30	TNO (2001)
	203A	RESIDUAL OIL	1A1a	010101	3	Nielsen & Illerup (2003)	3	2.5	Nielsen & Illerup (2003)
				010102	9.5	Nielsen et al. (2010a)	9.5	7.9	TNO (2001)
				010103	9.5	Nielsen et al. (2010a)	9.5	7.9	TNO (2001)
				010104	3	TNO (2001)	3	2.5	TNO (2001)
				010105	3	TNO (2001)	3	2.5	TNO (2001)
				0102	3	TNO (2001)	3	2.5	TNO (2001)
			1A1b	010306	50	TNO (2001)	40	35	TNO (2001)
			1A2 a-g	03	9.5	Nielsen et al. (2010a)	7.1	4.8	TNO (2001)
			1A4a	0201	14	DEPA (1990), DEPA (1995)	10.5	7	TNO (2001)
			1A4b	0202	14	DEPA (1990), DEPA (1995)	10.5	7	TNO (2001)
			1A4c i	0203	14	DEPA (1990), DEPA (1995)	10.5	7	TNO (2001)
	204A	GAS OIL	1A1a	0101	5	TNO (2001)	5	5	TNO (2001)
				0102	5	TNO (2001)	5	5	TNO (2001)
			1A1b	010306	5	TNO (2001)	5	5	TNO (2001)
			1A1c	0105	5	TNO (2001)	5	5	TNO (2001)
			1A2a-g	03	5	TNO (2001)	5	5	TNO (2001)
			1A4a i	0201	5	TNO (2001)	5	5	TNO (2001)
			1A4b i	0202	5	TNO (2001)	5	5	TNO (2001)
			1A4c i	0203	5	TNO (2001)	5	5	TNO (2001)
	206A	KEROSENE	1A2 a-g	all	5	TNO (2001)	5	5	TNO (2001)
			1A4a i	0201	5	TNO (2001)	5	5	TNO (2001)
			1A4b i	0202	5	TNO (2001)	5	5	TNO (2001)

fuel_type	fuel_id	fuel_gr_abbr	nfr_id_EA	snap_id	TSP, g/GJ	Reference for TSP	PM_{10}, g/GJ	$PM_{2.5}$, g/GJ	Reference for PM_{10} and $PM_{2.5}$ emission factors or for the PM_{10} and the $PM_{2.5}$ fraction
			1A4c i	0203	5	TNO (2001)	5	5	TNO (2001)
	303A	LPG	1A1a	0101, 0102	0.2	TNO (2001)	0.2	0.2	TNO (2001)
			1A2 a-g	03	0.2	TNO (2001)	0.2	0.2	TNO (2001)
			1A4a i	0201	0.2	TNO (2001)	0.2	0.2	TNO (2001)
			1A4b i	0202	0.2	TNO (2001)	0.2	0.2	TNO (2001)
			1A4c i	0203	0.2	TNO (2001)	0.2	0.2	TNO (2001)
	308A	REFINERY GAS	1A1b	0103	5	TNO (2001)	5	5	TNO (2001)
GAS	301A	NATURAL GAS	1A1a	0101	0.1	TNO (2001)	0.1	0.1	TNO (2001)
				Gas turbines	0.1	Nielsen & Illerup (2003)	0.061	0.051	Nielsen & Illerup (2003)
				Engines	0.76	Nielsen & Illerup (2003)	0.189	0.161	Nielsen & Illerup (2003)
				0102	0.1	TNO (2001)	0.1	0.1	TNO (2001)
			1A1b	0103	0.1	TNO (2001)	0.1	0.1	TNO (2001)
			1A1c	0105	0.1	Nielsen & Illerup (2003)	0.061	0.051	Nielsen & Illerup (2003)
			1A2a-g	Engines	0.76	Nielsen & Illerup (2003)	0.189	0.161	Nielsen & Illerup (2003)
				Turbines	0.1	Nielsen & Illerup (2003)	0.061	0.051	Nielsen & Illerup (2003)
				Other	0.1	TNO (2001)	0.1	0.1	TNO (2001)
			1A4a i	0201	0.1	TNO (2001)	0.1	0.1	TNO (2001)
				Engines	0.76	Nielsen & Illerup (2003)	0.189	0.161	Nielsen & Illerup (2003)
			1A4b i	0202	0.1	TNO (2001)	0.1	0.1	TNO (2001)
				Engines	0.76	Nielsen & Illerup (2003)	0.189	0.161	Nielsen & Illerup (2003)
			1A4c i	0203	0.1	TNO (2001)	0.1	0.1	TNO (2001)
				Engines	0.76	Nielsen & Illerup (2003)	0.189	0.161	Nielsen & Illerup (2003)
WASTE	114A	WASTE	1A1a	0101	0.29	Nielsen et al. (2010a)	0.29	0.29	Nielsen & Illerup (2003)
				0102	4.2	The emission factor have been estimated by DCE based on plant specific data from MSW incineration plants, district heating, 2008	3.2	2.1	The emission factor have been estimated by DCE based on plant specific data from MSW incineration plants, district heating, 2008
			1A2 a-g	03	4.2	The emission factor have been estimated by DCE based on plant specific data from MSW incineration plants, district heating, 2008	3.2	2.1	The emission factor have been estimated by DCE based on plant specific data from MSW incineration plants, district heating, 2008
			1A4a i	0201	4.2	The emission factor have been estimated by DCE based on plant specific data from MSW incineration plants, district heating, 2008	3.2	2.1	The emission factor have been estimated by DCE based on plant specific data from MSW incineration plants, district heating, 2008

fuel_type	fuel_id	fuel_gr_abbr	nfr_id_EA	snap_id	TSP, g/GJ	Reference for TSP	PM_{10}, g/GJ	$PM_{2.5}$, g/GJ	Reference for PM_{10} and $PM_{2.5}$ emission factors or for the PM_{10} and the $PM_{2.5}$ fraction
	115A	INDUSTRIAL WASTE	1A2f	0316	4.2	The emission factor have been estimated by DCE based on plant specific data from MSW incineration plants, district heating, 2008	3.2	2.1	The emission factor have been estimated by DCE based on plant specific data from MSW incineration plants, district heating, 2008
BIOMASS	111A	WOOD	1A1a	0101	10	Nielsen et al. (2010a)	7.45	4.82	Estimated based on the TSP emission factor
				0102	19	DEPA (2001a)	13	10	DEPA (2001), TNO (2001)
			1A2 a-g	03	19	DEPA (2001a)	13	10	DEPA (2001), TNO (2001)
			1A4a i	0201	143	DEPA (2001a)	143	135	TNO (2001)
			1A4b i	0202	367	DCE estimate based on DEA (2016a), DEPA (2013), Glasius et al. (2005), EEA (2013), Illerup et al. (2007), Nordic Ecolabelling (2012). See Chapter 6.5.	348	340	DCE estimate based on DEA (2016a), DEPA (2013), Glasius et al. (2005), EEA (2013), Illerup et al. (2007), Nordic Ecolabelling (2012). See Chapter 6.5.
			1A4c i	0203	143	DEPA (2001a)	143	135	TNO (2001)
	117A	STRAW	1A1a i	0101	2.3	Nielsen et al. (2010a)	1.71	1.11	Nielsen & Illerup (2003)
				0102	21	DEPA (2001a)	15	12	TNO (2001)
			1A4b i	0202	433	Kristensen (2017c)	433	433	Zefeng (2011)
			1A4c i	0203	433	Kristensen (2017c)	433	433	Zefeng (2011)
				020302	21	DEPA (2001a)	15	12	TNO (2001)
	215A	BIO OIL	1A1a	0101	5	Assuming same emission factors as for gas oil (DCE assumption)	5	5	Assuming same emission factors as for gas oil (DCE assumption)
				0102	5	Assuming same emission factors as for gas oil (DCE assumption)	5	5	Assuming same emission factors as for gas oil (DCE assumption)
			1A2a-g	03	5	Assuming same emission factors as for gas oil (DCE assumption)	5	5	Assuming same emission factors as for gas oil (DCE assumption)
			1A4b i	0202	5	Assuming same emission factors as for gas oil (DCE assumption)	5	5	Assuming same emission factors as for gas oil (DCE assumption)
	309A	BIOGAS	1A1a	0101, not engines	1.5	DEPA (1990), DEPA (1995)	1.5	1.5	All TSP emission is assumed to be <2,5µm (DCE assumption)
				010105	2.63	Nielsen & Illerup (2003)	0.451	0.206	Nielsen & Illerup (2003)
				0102	1.5	DEPA (1990), DEPA (1995)	1.5	1.5	All TSP emission is assumed to be <2,5µm (DCE assumption)
			1A2a-g	Engines	2.63	Nielsen & Illerup (2003)	0.451	0.206	Nielsen & Illerup (2003)
				Other	1.5	DEPA (1990), DEPA (1995)	1.5	1.5	All TSP emission is assumed to be <2,5µm (DCE assumption)
			1A4a i	0201	1.5	DEPA (1990), DEPA (1995)	1.5	1.5	All TSP emission is assumed to be <2,5µm (DCE assumption)
				Engines	2.63	Nielsen & Illerup (2003)	0.451	0.206	Nielsen & Illerup (2003)

fuel_type	fuel_id	fuel_gr_abbr	nfr_id_EA	snap_id	TSP, g/GJ	Reference for TSP	PM_{10}, g/GJ	$PM_{2.5}$, g/GJ	Reference for PM_{10} and $PM_{2.5}$ emission factors or for the PM_{10} and the $PM_{2.5}$ fraction
			1A4b	0202	0.1	Biogas upgraded for the town gas grid. Assumed equal to natural gas	0.1	0.1	Biogas upgraded for the town gas grid. Assumed equal to natural gas
			1A4c i	0203	1.5	DEPA (1990), DEPA (1995)	1.5	1.5	All TSP emission is assumed to be <2,5µm (DCE assumption)
				Engines	2.63	Nielsen & Illerup (2003)	0.451	0.206	Nielsen & Illerup (2003)
	310A	BIO GASIF GAS	1A1a	010105	2.63	Same emission factor as for biogas assumed (DCE assumption)	0.451	0.206	Same emission factor as for biogas assumed (DCE assumption)
				010101	0.2	Assumed equal to LPG	0.2	0.2	Assumed equal to LPG
	315A	BIONATGAS	1A1a	0101 and 0102	0.1	Assumed equal to natural gas	0.1	0.1	Assumed equal to natural gas
			1A2a-g	03	0.1	Assumed equal to natural gas	0.1	0.1	Assumed equal to natural gas
			1A4a	0201	0.1	Assumed equal to natural gas	0.1	0.1	Assumed equal to natural gas
			1A4b	0202	0.1	Assumed equal to natural gas	0.1	0.1	Assumed equal to natural gas
			1A4c	0203	0.1	Assumed equal to natural gas	0.1	0.1	Assumed equal to natural gas

Table 4.19 TSP emission factors time series for the years 2000 to 2015.
This table is available at:
http://envs.au.dk/videnudveksling/luft/emissioner/supporting-documentation/air-pollution-iir/

Table 4.20 PM10 emission factors time series for the years 2000 to 2015.
This table is available at:
http://envs.au.dk/videnudveksling/luft/emissioner/supporting-documentation/air-pollution-iir/

Table 4.21 PM2.5 emission factors time series for the years 2000 to 2015.
This table is available at:
http://envs.au.dk/videnudveksling/luft/emissioner/supporting-documentation/air-pollution-iir/

Table 4.22 BC emission factors time series for the years 2000 to 2015.
This table is available at:
http://envs.au.dk/videnudveksling/luft/emissioner/supporting-documentation/air-pollution-iir/

Table 4.23 BC fraction of $PM_{2.5}$, 2015.

Fuel_id	Fuel	NFR	SNAP	BC_%	Reference: EEA Guidebook 2013.
101A	Anodic carbon	1A2	03	2.2%	Energy Industries, Table 3-2
102A	Coal	1A1a	0101, 0102	2.2%	Energy Industries, Table 3-2
102A	Coal	1A4a	0201	6.4%	Small Combustion, Table 3-7
102A	Coal	1A4b	0202	6.4%	Small Combustion, Table 3-3
102A	Coal	1A4c	0203	6.4%	Small Combustion, Table 3-7
102A	Coal	1A2	03	6.4%	Manufacturing Industries, Table 3-2
103A	Fly ash fossil	1A1a	010104	2.2%	Assumed equal to coal. DCE assumption.
106A	Brown coal bri.	1A4a	0201	6.4%	Small Combustion, Table 3-7
106A	Brown coal bri.	1A4b	0202	6.4%	Small Combustion, Table 3-3
106A	Brown coal bri.	1A4c	0203	6.4%	Small Combustion, Table 3-7
106A	Brown coal bri.	1A2	03	6.4%	Manufacturing Industries, Table 3-2
107A	Coke oven coke	1A4b	0202	6.4%	Small Combustion, Table 3-3
107A	Coke oven coke	1A2	0301	6.4%	Manufacturing Industries, Table 3-2
110A	Petroleum coke	1A1a	0101	5.6%	Energy Industries, table 3-5
110A	Petroleum coke	1A4a	0201	56.0%	Small Combustion, Table 3-5
110A	Petroleum coke	1A4b	0202	8.5%	Small Combustion, Table 3-5
110A	Petroleum coke	1A4c	0203	56.0%	Small Combustion, Table 3-5
110A	Petroleum coke	1A2	03	56.0%	Manufacturing Industries, Table 3-4
111A	Wood	1A1a	0101, 0102	3.3%	Energy Industries, Table 3-7
111A	Wood	1A4a	0201	28.0%	Small Combustion, Table 3-10
111A	Wood	1A4b	0202	14.4%	See residential wood combustion, Chapter 6.5
111A	Wood	1A4c	0203	28.0%	Small Combustion, Table 3-10
111A	Wood	1A2	0301	28.0%	Manufacturing Industries, Table 3-5
114A	Waste	1A1a	0101, 0102	3.5%	Municipal waste Incineration, Table 3-1
114A	Waste	1A4a	0201	3.5%	Municipal waste Incineration, Table 3-1
114A	Waste	1A2	03	3.5%	Municipal waste Incineration, Table 3-1
117A	Straw	1A1a	0101, 0102	3.3%	Energy Industries, Table 3-7
117A	Straw	1A4a	020103	28.0%	Small Combustion, Table 3-10
117A	Straw	1A4b	0202	28.0%	Small Combustion, Table 3-10 (Assumed equal to agricultural plants)
117A	Straw	1A4c	020300	28.0%	Small Combustion, Table 3-10
117A	Straw	1A2	03	28.0%	Manufacturing Industries, Table 3-5
203A	Residual oil	1A1a	0101, 0102	5.6%	Energy Industries, Table 3-5
203A	Residual oil	1A1b	010306	5.6%	Energy Industries, Table 4-4
203A	Residual oil	1A4a	0201	56.0%	Small Combustion, Table 3-9
203A	Residual oil	1A4b	0202	8.5%	Small Combustion, Table 3-5
203A	Residual oil	1A4c	0203	56.0%	Small Combustion, Table 3-9
203A	Residual oil	1A2	03	56.0%	Manufacturing Industries, Table 3-4
204A	Gas oil	1A1a	0101, 0102	33.5%	Energy Industries, Table 3-6
204A	Gas oil	1A1a	010104	33.5%	Energy Industries, Table 3-18
204A	Gas oil	1A1a	010105	78.0%	Energy Industries, Table 3-19
204A	Gas oil	1A1a	010204	33.5%	Energy Industries, Table 3-18
204A	Gas oil	1A1a	010205	78.0%	Energy Industries, Table 3-19
204A	Gas oil	1A1b	010306	33.5%	Energy Industries, Table 4-5
204A	Gas oil	1A1c	010504	33.5%	Energy Industries, Table 3-18
204A	Gas oil	1A1c	010505	78.0%	Energy Industries, Table 3-19
204A	Gas oil	1A4a	0201	56.0%	Small Combustion, Table 3-9
204A	Gas oil	1A4a	020105	78.0%	Energy Industries, Table 3-37
204A	Gas oil	1A4b	0202	3.9%	Small Combustion, Table 3-21
204A	Gas oil	1A4b	020204	78.0%	Energy Industries, Table 3-19
204A	Gas oil	1A4c	0203	56.0%	Small Combustion, Table 3-9
204A	Gas oil	1A4c	020304	78.0%	Energy Industries, Table 3-37
204A	Gas oil	1A2	03	56.0%	Manufacturing Industries, Table 3-4
204A	Gas oil	1A2	03xx04	33.5%	Energy Industries, Table 3-18
204A	Gas oil	1A2	03xx05	78.0%	Energy Industries, Table 3-19
206A	Kerosene	1A4a	0201	56.0%	Small Combustion, Table 3-9
206A	Kerosene	1A4b	0202	8.5%	Small Combustion, Table 3-5
206A	Kerosene	1A4c	0203	56.0%	Small Combustion, Table 3-9
206A	Kerosene	1A2	03	56.0%	Manufacturing Industries, Table 3-4
215A	Bio oil	1A1a	0101	33.5%	Assumed equal to gas oil. DCE assumption.
215A	Bio oil	1A1a	010105	78.0%	Assumed equal to gas oil. DCE assumption.

Fuel_id	Fuel	NFR	SNAP	BC_%	Reference: EEA Guidebook 2013.
215A	Bio oil	1A1a	0102	33.5%	Assumed equal to gas oil. DCE assumption.
215A	Bio oil	1A1a	020105	78.0%	Assumed equal to gas oil. DCE assumption.
215A	Bio oil	1A4b	020200	3.9%	Assumed equal to gas oil. DCE assumption.
215A	Bio oil	1A4b	020304	78.0%	Assumed equal to gas oil. DCE assumption.
215A	Bio oil	1A2	03	56.0%	Manufacturing Industries, Table 3-4
215A	Bio oil	1A2	03xx05	78.0%	Assumed equal to gas oil. DCE assumption.
225A	Orimulsion	1A1a	010101	2.2%	Assumed equal to coal. DCE assumption.
301A	Natural gas	1A1a	0101	2.5%	Energy Industries, Table 3-4
301A	Natural gas	1A1a	010104	2.5%	Energy Industries, Table 3-17
301A	Natural gas	1A1a	010105	2.5%	Energy Industries, Table 3-20
301A	Natural gas	1A1a	010200	2.5%	Energy Industries, Table 3-4
301A	Natural gas	1A1c	0105	2.5%	Energy Industries, Table 3-4
301A	Natural gas	1A1c	010504	2.5%	Energy Industries, Table 3-17
301A	Natural gas	1A1c	010505	2.5%	Energy Industries, Table 3-20
301A	Natural gas	A14a	0201	4.0%	Small Combustion, Table 3-8
301A	Natural gas	1A4a	020104	2.5%	Small Combustion, Table 3-34
301A	Natural gas	1A4a	020105	2.5%	Energy Industries, Table 3-36
301A	Natural gas	1A4b	0202	5.4%	Small Combustion, Table 3-19
301A	Natural gas	1A4b	020204	2.5%	Energy Industries, Table 3-20
301A	Natural gas	1A4c	020300	4.0%	Small Combustion, Table 3-8
301A	Natural gas	1A4c	020303	2.5%	Energy Industries, Table 3-17
301A	Natural gas	1A4c	020304	2.5%	Energy Industries, Table 3-36
301A	Natural gas	1A2	03	4.0%	Manufacturing Industries, Table 3-3
301A	Natural gas	1A2	03xx04	2.5%	Energy Industries, Table 3-17
301A	Natural gas	1A2	03xx05	2.5%	Energy Industries, Table 3-20
303A	LPG	1A1a	0101	2.5%	Assumed equal to natural gas. DCE assumption.
303A	LPG	1A1a	010104	2.5%	Assumed equal to natural gas. DCE assumption.
303A	LPG	1A1a	0102	2.5%	Assumed equal to natural gas. DCE assumption.
303A	LPG	1A2b	010306	2.5%	Assumed equal to natural gas. DCE assumption.
303A	LPG	1A4a	020100	4.0%	Assumed equal to natural gas. DCE assumption.
303A	LPG	1A4a	020105	4.0%	Assumed equal to natural gas. DCE assumption.
303A	LPG	1A4b	0202	5.4%	Assumed equal to natural gas. DCE assumption.
303A	LPG	1A4c	0203	4.0%	Assumed equal to natural gas. DCE assumption.
303A	LPG	1A2	03	4.0%	Assumed equal to natural gas. DCE assumption.
308A	Refinery gas	1A1a	010101	18.4%	Energy Industries, Table 4-2
308A	Refinery gas	1A1a	010203	18.4%	Energy Industries, Table 4-2
308A	Refinery gas	1A1b	0103	18.4%	Energy Industries, Table 4-2
308A	Refinery gas	1A2	03	18.4%	Energy Industries, Table 4-2
309A	Biogas	1A1a	0101	3.3%	Assumed % equal to wood. DCE assumption
309A	Biogas	1A1a	0102	3.3%	Assumed % equal to wood. DCE assumption
309A	Biogas	1A1c	010505	3.3%	Assumed % equal to wood. DCE assumption
309A	Biogas	1A4a	0201	28.0%	Assumed % equal to wood. DCE assumption
309A	Biogas	1A4c	0203	28.0%	Assumed % equal to wood. DCE assumption
309A	Biogas	1A2	03	28.0%	Assumed % equal to wood. DCE assumption
310A	Bio gasif. gas	1A1a	010105	3.3%	Assumed % equal to wood. DCE assumption
310A	Bio gasif. gas	1A4a	020105	3.3%	Assumed % equal to wood. DCE assumption
310A	Bio gasif. gas	1A4c	020304	28.0%	Assumed % equal to wood. DCE assumption
310A	Bio gasif. gas	1A2	03xx05	28.0%	Assumed % equal to wood. DCE assumption
315A	Bio natural gas	1A1a	0101	2.5%	Assumed equal to natural gas. DCE assumption.
315A	Bio natural gas	1A1a	0102	2.5%	Assumed equal to natural gas. DCE assumption.
315A	Bio natural gas	1A4a	0201	4.0%	Assumed equal to natural gas. DCE assumption.
315A	Bio natural gas	1A4b	0202	5.4%	Assumed equal to natural gas. DCE assumption.
315A	Bio natural gas	1A4c	0203	4.0%	Assumed equal to natural gas. DCE assumption.
315A	Bio natural gas	1A2	03	4.0%	Assumed equal to natural gas. DCE assumption.

Table 4.24 HM emission factors and references, 2015.

fuel_type	fuel_gr_abbr	nfr	nfr_name	snap	As mg/GJ	Cd mg/GJ	Cr mg/GJ	Cu mg/GJ	Hg mg/GJ	Ni mg/GJ	Pb mg/GJ	Se mg/GJ	Zn mg/GJ	Reference
SOLID	ANODIC CARBON	1A2g	Industry	all	4	1.8	13.5	17.5	7.9	13	134	1.8	200	EEA (2016), Tier 1, Industry Table 3-2.
	COAL	1A1a	Public electricity and heat production	all	0.51	0.07	0.86	0.48	1.3	0.97	0.62	5.9	1.9	Implied emission factor 2008 estimated by DCE based on plant specific emission data for power plants.
		All other	All other	All	4	1.8	13.5	17.5	7.9	13	134	23	200	EEA (2016), Tier 1, Industry Table 3-2. For Se: Tier 1, Energy Industries Table 3-2. See also Nielsen et al. (2013c).
	FLY ASH FOSSIL	1A1a	Public electricity and heat production	0101	0.51	0.07	0.86	0.48	1.3	0.97	0.62	5.9	1.9	Implied emission factor 2008 estimated by DCE based on plant specific emission data for power plants.
	BROWN COAL BRI.	1A4b i	Residential	0202	2.5	1.5	11.2	22.3	5.1	12.7	130	1.8	220	EEA (2016), Tier 1, Small Combustion Table 3-3. For Se Tier 1, Small Combustion Table 3-7 (for 1A4a/c).
	COKE OVEN COKE	1A2 a-g	Industry	all	4	1.8	13.5	17.5	7.9	13	134	1.8	200	EEA (2016), Tier 1, Industry Table 3-2.
		1A4b	Residential	0202	2.5	1.5	11.2	22.3	5.1	12.7	130	1.8	220	EEA (2016), Tier 1, Small Combustion Table 3-3. For Se Tier 1, Small Combustion Table 3-7 (for 1A4a/c).
LIQUID	PETROLEUM COKE	all	All	all	3.98	1.2	2.55	5.31	0.341	255	4.56	2.06	87.8	EEA (2016), Tier 1, Energy Industries Table 3-5 (for heavy fuel oil).
	RESIDUAL OIL	1A1a	Public electricity and heat production	all	2.1	0.53	2.6	2.4	0.21	362	2.6	1.2	7.4	Implied emission factor 2008 estimated by DCE based on plant specific emission data for power plants.
		All other	All other	all	3.98	1.2	2.55	5.31	0.341	255	4.56	2.06	87.8	EEA (2016), Tier 1, Energy Industries Table 3-5 (for heavy fuel oil).
	GAS OIL	-	Engines (reciprocating)	all	0.055	0.011	0.2	0.3	0.11	0.013	0.15	0.22	58	Nielsen et al. (2010a).
		-	All other	all	0.002	0.001	0.2	0.13	0.12	0.005	0.012	0.002	0.42	Gon & Kuenen (2009).
	KEROSENE	All	All	all	0.002	0.001	0.2	0.13	0.12	0.005	0.012	0.002	0.42	Assumed equal to gas oil. DCE assumption.

fuel_type	fuel_gr_abbr	nfr	nfr_name	snap	As mg/GJ	Cd mg/GJ	Cr mg/GJ	Cu mg/GJ	Hg mg/GJ	Ni mg/GJ	Pb mg/GJ	Se mg/GJ	Zn mg/GJ	Reference
	LPG	All	All	all	0.002	0.001	0.2	0.13	0.12	0.005	0.012	0.002	0.42	EEA (2016), Tier 1, Small Combustion Table 3-5 (for 1A4b, other liquid fuels).
	REFINERY GAS	1A1b	Petroleum refining	all	0.343	0.712	2.74	2.22	0.086	3.6	1.79	0.42	25.5	EEA (2016), Tier 1, Energy Industries Table 4-2 (for refinery gas, 1A1b).
GAS	NATURAL GAS	-	Engines (reciprocating)	all	0.05	0.003	0.05	0.01	0.1	0.05	0.04	0.01	2.9	Nielsen et al. (2010a).
		-	All other	all	0.119	0.00025	0.00076	0.000076	0.1	0.00051	0.0015	0.0112	0.0015	Gruijthuijsen (2001). For Hg: Nielsen et al. (2010a), also applied in EEA (2016), Tier 1, Energy Industries Table 3-4. For Se: EEA (2016), Tier 1, Energy Industries Table 3-4.
WASTE	WASTE	-	All	all	0.59	0.44	1.56	1.3	1.79	2.06	5.52	1.11	2.33	Nielsen et al. (2010a).
	INDUSTRIAL WASTE	1A2f	Industry - Other	all	0.59	0.44	1.56	1.3	1.79	2.06	5.52	1.11	2.33	Nielsen et al. (2010a).
BIOMASS	WOOD	-	All non-residential	all	0.19	0.27	2.34	2.6	0.4	2.34	3.62	0.5	2.3	For Cd, Hg and Zn: Nielsen et al. (2010a). For Cr, Cu, Ni and Pb: Nielsen & Illerup (2003). For As and Se: EEA (2016), Tier 1, Small Combustion Table 3-10 (for solid biomass applied in 1A4a/c). Reference for As: Struschka et al. (2008). Reference for Se: Hedberg et al. (2002).
		1A4b i	Residential	all	0.19	13	23	6	0.56	2	27	0.5	512	EEA (2016).
	STRAW	1A1a	Public electricity and heat production	all	0.19	0.32	1.6	1.7	0.31	1.7	6.2	0.5	0.41	For Cd, Hg and Zn: Nielsen et al. (2010a). For Cr, Cu, Ni and Pb: Nielsen & Illerup (2003). For As and Se: EEA (2016), Tier 1, Small Combustion Table 3-10.
		1A4b i	Residential	0202	0.19	13	23	6	0.56	2	27	0.5	512	EEA (2016), Tier 1, Small Combustion Table 3-6.
		1A4c i	Agriculture/ Forestry	0203	0.19	13	23	6	0.56	2	27	0.5	512	EEA (2016), Tier 1, Small Combustion Table 3-6 (for 1A4b).
	BIO OIL	-	Engines	engines	0.055	0.011	0.2	0.3	0.11	0.013	0.15	0.22	58	Assumed equal to gas oil. DCE assumption.

fuel_type	fuel_gr_abbr	nfr	nfr_name	snap	As mg/GJ	Cd mg/GJ	Cr mg/GJ	Cu mg/GJ	Hg mg/GJ	Ni mg/GJ	Pb mg/GJ	Se mg/GJ	Zn mg/GJ	Reference
		-	All other	-	0.002	0.001	0.2	0.13	0.12	0.005	0.012	0.002	0.42	Assumed equal to gas oil. DCE assumption.
	BIOGAS	-	All non-residential	all	0.04	0.002	0.18	0.31	0.12	0.23	0.005	0.21	3.95	Nielsen et al. (2010a).
		1A4b	Residential	all	0.119	0.00025	0.00076	0.000076	0.1	0.00051	0.0015	0.0112	0.0015	Assumed equal to natural gas (biogas upgraded for distribution in the town gas grid).
	BIO GASIF GAS	1A1a	Public electricity and heat production	010105	0.12	0.009	0.029	0.045	0.54	0.014	0.022	0.18	0.058	Nielsen et al. (2010a).
				010101	0.002	0.001	0.2	0.13	0.12	0.005	0.012	0.002	0.42	Assumed equal to gas oil. DCE assumption.
	BIONATGAS	-	All	all	0.119	0.00025	0.00076	0.000076	0.1	0.00051	0.0015	0.0112	0.0015	Assumed equal to natural gas.

Table 4.25 As emission factors time series, mg per GJ, for the years 1990 to 2015. This table is available at:
http://envs.au.dk/videnudveksling/luft/emissioner/supporting-documentation/air-pollution-iir/

Table 4.26 Cd emission factors time series, mg per GJ, for the years 1990 to 2015. This table is available at:
http://envs.au.dk/videnudveksling/luft/emissioner/supporting-documentation/air-pollution-iir/

Table 4.27 Cr emission factors time series, mg per GJ, for the years 1990 to 2015. This table is available at:
http://envs.au.dk/videnudveksling/luft/emissioner/supporting-documentation/air-pollution-iir/

Table 4.28 Cu emission factors time series, mg per GJ, for the years 1990 to 2015. This table is available at:
http://envs.au.dk/videnudveksling/luft/emissioner/supporting-documentation/air-pollution-iir/

Table 4.29 Hg emission factors time series, mg per GJ, for the years 1990 to 2015. This table is available at:
http://envs.au.dk/videnudveksling/luft/emissioner/supporting-documentation/air-pollution-iir/

Table 4.30 Ni emission factors time series, mg per GJ, for the years 1990 to 2015. This table is available at:
http://envs.au.dk/videnudveksling/luft/emissioner/supporting-documentation/air-pollution-iir/

Table 4.31 emission factors time series, mg per GJ, for the years 1990 to 2015. This table is available at:
http://envs.au.dk/videnudveksling/luft/emissioner/supporting-documentation/air-pollution-iir/

Table 4.32 Se emission factors time series, mg per GJ, for the years 1990 to 2015. This table is available at:
http://envs.au.dk/videnudveksling/luft/emissioner/supporting-documentation/air-pollution-iir/

Table 4.33 Zn emission factors time series, mg per GJ, for the years 1990 to 2015. This table is available at:
http://envs.au.dk/videnudveksling/luft/emissioner/supporting-documentation/air-pollution-iir/

Table 4.34 PAH emission factors 2015.

fuel_type	fuel_id	fuel_gr_abbr	nfr_id	snap_id	Benzo(a)-pyrene µg per GJ	Benzo(b)-fluoranthene µg per GJ	Benzo(k)-fluoranthene µg per GJ	Indeno-(1,2,3-c,d)-pyrene µg per GJ	Reference
SOLID	102A	ANODIC CARBON	1A2g	0320	23	929	929	698	Finstad et al. (2001)
		COAL	1A1a	All	0.7	37	29	1.1	EEA (2016). Tier 1, Energy Industries Table 3-2
			1A2 a-g	All	23	929	929	698	Finstad et al. (2001)
			1A4c i	0203	59524	63492	1984	119048	Finstad et al. (2001)
	103A	FLY ASH FOSSIL	1A1a	0101	0.7	37	29	1.1	EEA (2016). Tier 1, Energy Industries Table 3-2
	106A	BROWN COAL BRI.	1A4b i	0202	59524	63492	1984	119048	Finstad et al. (2001) (Same emission factor as for coal is assumed. DCE assumption)
	107A	COKE OVEN COKE	1A2 a-g	all	23	929	929	698	Finstad et al. (2001)
			1A4b	0202	59524	63492	1984	119048	Finstad et al. (2001)
LIQUID	110A	PETROLEUM COKE	1A2 a-g	all	80	42	66	160	Finstad et al. (2001). Assumed equal to residual oil
			1A4a i	all	80	42	66	160	Finstad et al. (2001). Assumed equal to residual oil
			1A4b i	all	80	42	66	160	Finstad et al. (2001). Assumed equal to residual oil
			1A4c i	all	80	42	66	160	Finstad et al. (2001). Assumed equal to residual oil
	203A	RESIDUAL OIL	1A1a	All	109.6	475.41	93.21	177.28	Finstad et al. (2001)
			1A1b	010306	109.6	475.41	93.21	177.28	Finstad et al. (2001)
			1A2 a-g	all	80	42	66	160	Finstad et al. (2001)
			1A4a i	all	80	42	66	160	Finstad et al. (2001)
			1A4b i	all	80	42	66	160	Finstad et al. (2001)
			1A4c i	all	80	42	66	160	Finstad et al. (2001)
	204A	GAS OIL	1A1a	Not engines	109.6	475.41	93.21	177.28	Finstad et al. (2001)
				Engines	1.9	15	1.7	1.5	Nielsen et al. (2010a)
			1A1b	010306	109.6	475.41	93.21	177.28	Finstad et al. (2001)
			1A1c	010504	109.6	475.41	93.21	177.28	Finstad et al. (2001)
			1A2 a-g	Not engines	80	42	66	160	Finstad et al. (2001)
				Engines	1.9	15	1.7	1.5	Nielsen et al. (2010a)
			1A4a i	Not engines	80	42	66	160	Finstad et al. (2001)
				Engines	1.9	15	1.7	1.5	Nielsen et al. (2010a)
			1A4b i	0202	80	42	66	160	Finstad et al. (2001)
			1A4c i	0203	80	42	66	160	Finstad et al. (2001)
GAS	301A	NATURAL GAS	1A1a	010104	1	1	2	3	Nielsen & Illerup (2003)

fuel_type	fuel_id	fuel_gr_abbr	nfr_id	snap_id	Benzo(a)-pyrene	Benzo(b)-fluoranthene	Benzo(k)-flu-oranthene	Indeno-(1,2,3-c,d)-pyrene	Reference
				010105	1.2	9	1.7	1.8	Nielsen et al. (2010a)
			1A1c	010504	1	1	2	3	Nielsen & Illerup (2003)
			1A2 a-g	Turbines	1	1	2	3	Nielsen & Illerup (2003)
				Engines	1.2	9	1.7	1.8	Nielsen et al. (2010a)
			1A4a i	020105	1.2	9	1.7	1.8	Nielsen et al. (2010a)
			1A4b i	020202	0.133	0.663	0.265	2.653	Jensen (2001)
				020204	1.2	9	1.7	1.8	Nielsen et al. (2010a)
			1A4c i	020304	1.2	9	1.7	1.8	Nielsen et al. (2010a)
WASTE	114A	WASTE	1A1a	all	0.8	1.7	0.9	1.1	Nielsen et al. (2010a)
			1A4a i	0201	0.8	1.7	0.9	1.1	Nielsen et al. (2010a)
	115A	INDUSTRIAL WASTE	1A2f	0316	0.8	1.7	0.9	1.1	Nielsen et al. (2010a)
BIOMASS	111A	WOOD	1A1a	0101	11	15	5	10	Nielsen et al. (2010a)
				0102	6.46	1292.52	1292.52	11.56	Finstad et al. (2001)
			1A2 a-g	all	6.46	1292.52	1292.52	11.56	Finstad et al. (2001)
			1A4a i	0201	168707	221769	73469	119728	Finstad et al. (2001)
			1A4b i	All	44471	45593	16511	24782	Aggregated emission factor based on the technology distribution in the sector and guidebook (EEA, 2013) emission factors. Technology distribution based on: DEPA (2013)
			1A4c i	all	168707	221769	73469	119728	Finstad et al. (2001)
	117A	STRAW	1A1a	0101	0.5	0.5	0.5	0.5	Nielsen et al. (2010a)
				0102	1529	3452	1400	1029	Berdowski et al. (1995)
			1A4b i	0202	12956	12828	6912	4222	Berdowski et al. (1995)
			1A4c i	0203	12956	12828	6912	4222	Berdowski et al. (1995)
	215A	BIO OIL	1A1a	all	109.6	475.41	93.21	177.28	Same emission factors as for gas oil is assumed (DCE assumption).
			1A2 a-g	all	80	42	66	160	Same emission factors as for gas oil is assumed (DCE assumption)
			1A4b i	0202	80	42	66	160	Same emission factors as for gas oil is assumed (DCE assumption)
	309A	BIOGAS	Engines	All	1.3	1.2	1.2	0.6	Nielsen et al. (2010a)
	310A	BIO GASIF GAS	Engines	010105	2	2	2	2	Nielsen et al. (2010a)

Table 4.35 PAH emission factors time series, µg pr GJ for the years 1990 to 2015. This table is available at: http://envs.au.dk/videnudveksling/luft/emissioner/supporting-documentation/air-pollution-iir/

Table 4.36 Emission factors for PCDD/F, 2015.

fuel_type	fuel_id	fuel_gr_abbr	nfr_id	snap_id	PCDD/F, ng per GJ
SOLID	102A	ANODIC CARBON	1A2g	0320	1.32
		COAL	1A1a	0101 and 0102	1.32
			1A2 a-g	03	1.32
			1A4c i	0203	300
	103A	FLY ASH FOSSIL	1A1a	0101	1.32
	106A	BROWN COAL BRI.	1A4b i	0202	800
	107A	COKE OVEN COKE	1A2 a-g	03	1.32
			1A4c	0203	800
LIQUID	110A	PETROLEUM COKE	1A2 a-g	03	1.32
			1A4a i	0201	300
			1A4b i	0202	300
			1A4c i	0203	300
	203A	RESIDUAL OIL	1A1a	All	0.882
			1A1b	010306	0.882
			1A2 a-g	03	0.882
			1A4a i	0201	10
			1A4b i	0202	10
			1A4c i	0203	10
	204A	GAS OIL	1A1a	Not engines	0.882
				Engines	0.99
			1A1b	010306	0.882
			1A1c	010504	0.882
			1A2 a-g	Not engines	0.882
				Engines	0.99
			1A4a i	Not engines	10
				Engines	0.99
			1A4b i	0202	10
			1A4c i	0203	10
	206A	KEROSENE	1A2a-g	03	0.882
			1A4a i	0201	10
			1A4b i	0202	10
			1A4c i	0203	10
	303A	LPG	1A1a	0101 and 0102	0.025
			1A2a-g	03	0.025
			1A4a i	0201	2
			1A4b i	0202	2
			1A4c i	0203	2
	308A	REFINERY GAS	1A1b	0103	0.025
GAS	301A	NATURAL GAS	1A1a	Not engines	0.025
				Engines	0.57
			1A1b	0103	0.025
			1A1c	010504	0.025
			1A2 a-g	03, Not engines	0.025
				Engines	0.57
			1A4a i	0201	2
				020105	0.57
			1A4b i	0202	2
				020204	0.57

fuel_type	fuel_id	fuel_gr_abbr	nfr_id	snap_id	PCDD/F, ng per GJ
			1A4c i	0203	2
				020304	0.57
WASTE	114A	WASTE	1A1a	0101 and 0102	5
			1A4a i	0201	5
	115A	INDUSTRIAL WASTE	1A2f	0316	5
BIOMASS	111A	WOOD	1A1a	0101	14
				0102	1
			1A2 a-g	03	1
			1A4a i	0201	400
			1A4b i	0202	304
			1A4c i	0203	400
	117A	STRAW	1A1a	0101	19
				0102	22
			1A4b i	0202	500
			1A4c i	0203	400
	215A	BIO OIL	1A1a	0101 and 0102	0.882
			1A2 a-g	03	0.882
			1A4b i	0202	10
	309A	BIOGAS	1A1a	Engines	0.96
				Not engines	0.025
			1A2a-g	Not engines	0.025
				Engines	0.96
			1A4a i	Not engines	2
				Engines	0.96
			1A4b	Not engines	2
			1A4c i	Not engines	2
				Engines	0.96
	310A	BIO GASIF GAS	1A1a	010105	1.7
				010101	0.025
	315A	BIONATGAS	1A1a	0101 and 0102	0.025
			1A2a-g	03	0.025
			1A4a	0201	2
			1A4b	0202	2
			1A4c	0203	2

Table 4.37 Emission factor time series for PCDD/F.
This table is available at:
http://envs.au.dk/videnudveksling/luft/emissioner/supporting-documentation/air-pollution-iir/

Table 4.38 Emission factors for HCB, 2015.

Fuel	NFR (SNAP)	Emission factor, ng/GJ	Reference
Coal	1A1, 1A2	6,700	Grochowalski & Konieczyński (2008); EEA (2013).
Coal	1A4b	1,200,000	Syc et al. (2011).
Coal	1A4a and 1A4c	23,000	Syc et al. (2011).
Other solid fuels	1A1, 1A2	6,700	Assumed equal to coal.
Other solid fuels	1A4	1,200,000	Assumed equal to coal.
Liquid fuels[1)]	1A1, 1A2, 1A4	220	Nielsen et al. (2010a).
Gaseous fuels	1A1, 1A2, 1A4	-	Negligible.
Waste	1A1, 1A2, 1A4	4300	Nielsen et al. (2010a). A time series have been estimated. The emission factor for 1990 (190,000 ng/GJ) refer to Pacyna et al. (2003).
Wood	1A1, 1A2	5,000	EEA (2013).
Wood	1A4	5,000	EEA (2013).
Straw	1A1, 1A2	113	Nielsen et al. (2010a).
Straw	1A4	5,000	EEA (2013).
Biogas	1A1, 1A2, 1A4	190	Nielsen et al. (2010a).
Producer gas	1A1, 1A2, 1A4	800	Nielsen et al. (2010a).

Table 4.39 Emission factor time series for HCB from waste incineration.
This table is available at:
http://envs.au.dk/videnudveksling/luft/emissioner/supporting-documentation/air-pollution-iir/

Table 4.40 Emission factors for PCB, 2015.

Fuel	NFR (SNAP)	Emission factor, ∑ dl-PCB, ng/GJ	Emission factor, PCB, ng WHO_{1998}-teq/GJ	Reference
Coal	1A1	839	3.16	Grochowalski & Konieczyński (2008).
Coal	1A2	5,700	53	Thistlethwaite (2001a).
Coal	1A4	7,403	66	Syc et al. (2011).
Other solid fuels	1A1	839	3.16	Assumed equal to coal.
Other solid fuels	1A2	5,700	53	Assumed equal to coal.
Other solid fuels	1A4	7,403	66	Assumed equal to coal.
Residual oil and orimulsion	1A1, 1A2, 1A4	839	3.2	The teq value refers to Dyke et al. (2003). The TEQ value is equal to the emission factor for coal combustion in power plants and the sum of dioxin-like PCB congeners has been assumed equal to the corresponding factor for coal.
Gas oil	1A1, 1A2, 1A4	93	0.11	Nielsen et al. (2010a).
Other liquid fuels[1)]	1A1, 1A2, 1A4	93	0.11	Assumed equal to gas oil.
Gaseous fuels	1A1, 1A2, 1A4	-	-	Negligible.
Waste	1A1, 1A2, 1A4	109 (time series)	0.28 (time series)	Nielsen et al. (2010a). A time series have been estimated. The emission factor for 1990 (46,000 ng/GJ or 117 ng WHO1998teq/GJ) have been estimated based on the assumption that the PCB emission factor time series follow the PCDD/F time series.
Wood	1A1, 1A2, 1A4a/c	2,800	21	Thistlethwaite (2001a).
Wood	1A4b	2,752 (time series)	20.6)	Hedman et al. (2006). A time series have been estimated based on time series for technologies applied in Denmark.
Straw	1A1, 1A2	3,110	31.2	Assumed equal to residential plants.
Straw	1A4	3,110	31.2	Syc et al. (2011).
Biogas	1A1, 1A2, 1A4	90	0.13	Nielsen et al. (2010a).
Producer gas	1A1, 1A2, 1A4	144	0.17	Nielsen et al. (2010a).

[1.] Except LPG and refinery gas.

Table 4.41 PCB emission factor time series for waste incineration and for residential wood combustion.
This table is available at:
http://envs.au.dk/videnudveksling/luft/emissioner/supporting-documentation/air-pollution-iir/

Table 4.42 Technology specific PCB emission factors for residential wood combustion.

Technology	dl-PCB emission factor, ng WHO-teq/GJ	∑dl-PCB emission factor, ng/GJ	Reference and assumptions
Old stove	53	7049	Hedman (2006), old boiler
New stove	53	7049	Hedman (2006), old boiler
Modern stove (2008-2015)	7	931	Hedman (2006), modern boiler
Modern stove (2015-2017)	7	931	Hedman (2006), modern boiler
Modern stove (2017-)	7	931	Hedman (2006), modern boiler
Eco labelled stove / new advanced stove (-2015)	3.5	466	Hedman (2006), assumed ½ modern boiler
Eco labelled stove / new advanced stove (2015-)	3.5	466	Hedman (2006), assumed ½ modern boiler
Other stove	53	7049	Hedman (2006), old boiler
Old boiler with acc. tank	53	7049	Hedman (2006), old boiler
Old boiler without acc. tank	53	7049	Hedman (2006), old boiler
New boiler with acc. tank	7	931	Hedman (2006), modern boiler
New boiler without acc. tank	7	931	Hedman (2006), modern boiler
Pellet boilers/stoves	3.5	466	Hedman (2006), assumed ½ modern boiler

Annex 5 Large point sources

Table 5.1 Large point sources, 2015 (stationary combustion).

Large point sources
AffaldPlus+, Naestved Forbraendingsanlaeg
AffaldPlus+, Naestved Kraftvarmevaerk
Affaldplus+, Slagelse Forbr. and DONG Slagelse KVV
Affaldscenter aarhus - Forbraendsanlaegget
Affaldsforbraendingsanlaeg I/S REFA
Amagerforbraending
Amagervaerket
Ardagh Glass Holmegaard A/S
Asnaesvaerket
Avedoerevaerket
AVV Forbraendingsanlaeg
Bofa I/S
Centralkommunernes Transmissionsselskab F_berg
Cheminova
DanSteel
DTU
Esbjergvaerket
Faxe Kalk
Fjernvarme Fyn, Centrum Varmecentral
Frederikshavn Affaldskraftvarmevaerk
Frederikshavn Kraftvarmevaerk
Fynsvaerket
Grenaa Forbraending
Grenaa Kraftvarmevaerk
H.C.Oerstedsvaerket
Haldor Topsoee
Hammel Fjernvarmeselskab
Helsingoer Kraftvarmevaerk
Herningvaerket
Hilleroed Kraftvarmevaerk
Hjoerring Varmeforsyning
Horsens Kraftvarmevaerk
I/S Faelles Forbraending
I/S Kara Affaldsforbraendingsanlaeg
I/S Kraftvarmevaerk Thisted
I/S Nordforbraending
I/S Reno Nord
I/S Reno Syd
I/S Vestforbraending
Koege Kraftvarmevaerk
Kolding Forbraendingsanlaeg TAS
Kommunekemi
Koppers
Kyndbyvaerket
L90 Affaldsforbraending
Maricogen
Masnedoevaerket
Maabjergvaerket
Nordic Sugar Nakskov
Nordic Sugar Nykoebing
Nordjyllandsvaerket
Nybro Gasbehandlingsanlaeg
Odense Kraftvarmevaerk
Oestkraft
Rensningsanlaegget Lynetten
Rockwool A/S D oense
Rockwool A/S Vamdrup
Saint-Gobain Isover A/S
Shell Raffinaderi
Silkeborg Kraftvarmevaerk
Skaerbaekvaerket
Skagen Forbraending
Soenderborg Kraftvarmevaerk
Special Waste System

Large point sources
Statoil Raffinaderi
Studstrupvaerket
Svanemoellevaerket
Svendborg Kraftvarmevaerk
Viborg Kraftvarme
Vordingborg Kraftvarme
Aalborg Portland
AarhusKarlshamn Denmark A/S
Danisco Grindsted Dupont
Randersvaerket Verdo
Dalum Kraftvarmevaerk
Duferco Danish Steel

Table 5.2 Large point sources, aggregated fuel consumption in 2015.

nfr_id_EA	fuel_id	fuel_gr_abbr	Sum of Fuel_TJ
1A1a	102A	COAL	71487
	103A	SUB-BITUMINOUS	49
	111A	WOOD	30136
	114A	WASTE	37522
	117A	STRAW	7419
	203A	RESIDUAL OIL	1029
	204A	GAS OIL	433
	215A	BIO OIL	21
	301A	NATURAL GAS	14959
	303A	LPG	10
	309A	BIOGAS	116
	310A	BIO GASIF GAS	0
1A1a Total			163180
1A1b	203A	RESIDUAL OIL	624
	204A	GAS OIL	7
	301A	NATURAL GAS	0
	303A	LPG	0
	308A	REFINERY GAS	16166
1A1b Total			16797
1A1c	204A	GAS OIL	0
	301A	NATURAL GAS	116
1A1c Total			117
1A2a	204A	GAS OIL	0
	301A	NATURAL GAS	1539
	303A	LPG	9
1A2a Total			1548
1A2c	203A	RESIDUAL OIL	204
	204A	GAS OIL	22
	301A	NATURAL GAS	1479
	303A	LPG	0
1A2c Total			1706
1A2e	102A	COAL	880
	107A	COKE OVEN COKE	97
	111A	WOOD	22
	203A	RESIDUAL OIL	2152
	204A	GAS OIL	13
	215A	BIO OIL	157
	301A	NATURAL GAS	79
	309A	BIOGAS	95
1A2e Total			3495
1A2f	102A	COAL	1466
	110A	PETROLEUM COKE	6331
	115A	INDUSTR. WASTES	2488
	203A	RESIDUAL OIL	94
	204A	GAS OIL	99
	215A	BIO OIL	0
	301A	NATURAL GAS	4
1A2f Total			10482
1A2g viii	101A	ANODIC CARBON	0
	102A	COAL	184
	107A	COKE OVEN COKE	376
	204A	GAS OIL	1
	301A	NATURAL GAS	1266
	303A	LPG	1
1A2g viii Total			1828
1A4a i	114A	WASTE	153
	309A	BIOGAS	0
1A4a i Total			153
Grand Total			199305

Table 5.3 Large point sources, plant specific emissions[1].

Year	2015																				
nfr_id	lps_name	SO_2	NO_x	NMVOC	CO	NH_3	TSP	PM_{10}[2]	$PM_{2.5}$[2]	BC[2]	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn	PCDD/F
1A1a	AffaldPlus+, Naestved Forbraend-ingsanlaeg	x	x	x	x	x	x	x	x	x					x					
1A1a	Affaldplus+, Slagelse Forbr. and DONG Slagelse KVV	x	x		x		x	x	x	x										
1A1a	Affaldscenter aarhus - Forbraend-sanlaegget	x	x	x			x	x	x	x					x					x
1A1a	Affaldsforbraendingsanlaeg I/S REFA	x	x																	
1A1a	Amagerforbraending	x	x	x	x	x	x	x	x	x					x					x
1A1a	Amagervaerket	x	x				x	x	x	x	x	x	x	x	x	x	x	x	x	
1A1a	Asnaesvaerket	x	x				x	x	x	x	x	x	x	x	x	x	x	x	x	
1A1a	Avedoerevaerket	x	x		x		x	x	x	x	x	x	x	x	x	x	x	x	x	
1A1a	AVV Forbraendingsanlaeg	x	x		x															x
1A1a	Bofa I/S	x	x		x						x	x	x	x	x	x	x			x
1A1a	Centralkommunernes Transmis-sionsselskab F_berg	x	x																	
1A1a	Esbjergvaerket	x	x				x	x	x	x	x	x	x	x	x	x	x	x	x	
1A1a	Fjernvarme Fyn, Centrum Varme-central		x																	
1A1a	Frederikshavn Affaldskraft-varmevaerk	x	x		x		x	x	x	x	x	x	x	x	x	x	x			x
1A1a	Frederikshavn Kraftvarmevaerk	x	x				x	x	x	x										
1A1a	Fynsvaerket	x	x				x	x	x	x	x	x	x	x	x	x	x	x	x	
1A1a	Grenaa Kraftvarmevaerk	x	x		x		x	x	x	x										
1A1a	H.C.Oerstedsvaerket		x		x															
1A1a	Helsingoer Kraftvarmevaerk		x																	
1A1a	Herningvaerket	x	x		x		x	x	x	x	x	x	x	x	x	x	x	x	x	
1A1a	Hilleroed Kraftvarmevaerk		x																	
1A1a	Horsens Kraftvarmevaerk	x	x		x		x	x	x	x										x
1A1a	I/S Faelles Forbraending	x	x		x		x	x	x	x										
1A1a	I/S Kara Affaldsforbraendingsan-laeg	x	x		x		x	x	x	x					x					x
1A1a	I/S Nordforbraending	x	x																	
1A1a	I/S Reno Nord	x	x	x	x		x	x	x	x										
1A1a	I/S Reno Syd	x	x	x	x		x	x	x	x					x					x
1A1a	I/S Vestforbraending	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x			x
1A1a	Koege Kraftvarmevaerk		x																	
1A1a	Kolding Forbraendingsanlaeg TAS	x	x	x	x	x	x	x	x	x					x					x

1A1a	Kommunekemi	x	x	x	x		x	x	x	x										
1A1a	Kyndbyvaerket	x	x		x						x	x	x	x	x	x	x	x	x	
1A1a	L90 Affaldsforbraending	x	x		x		x	x	x	x					x					x
1A1a	Masnedoevaerket		x																	
1A1a	Maabjergvaerket	x	x		x															
1A1a	Nordjyllandsvaerket	x	x				x	x	x	x	x	x	x	x	x	x	x	x	x	
1A1a	Odense Kraftvarmevaerk		x																	
1A1a	Oestkraft	x	x				x													
1A1a	Silkeborg Kraftvarmevaerk		x																	
1A1a	Skaerbaekvaerket	x	x				x	x	x	x	x	x	x	x	x	x	x	x	x	
1A1a	Skagen Forbraending	x	x														x			x
1A1a	Soenderborg Kraftvarmevaerk	x	x	x	x		x	x	x	x	x				x					x
1A1a	Special Waste System	x	x		x															
1A1a	Studstrupvaerket	x	x				x	x	x	x	x	x	x	x	x	x	x	x	x	
1A1a	Svanemoellevaerket		x		x															
1A1a	Svendborg Kraftvarmevaerk	x	x		x		x	x	x	x		x	x	x	x	x	x			x
1A1a	Viborg Kraftvarme		x																	
1A1a	Vordingborg Kraftvarme	x	x																	
1A1a	Dalum Kraftvarmevaerk	x	x																	
1A1a	Randersvaerket Verdo	x	x				x	x	x	x										
1A1a	I/S Kraftvarmevaerk Thisted	x	x												x					x
1A1a	Hammel Fjernvarmeselskab	x	x		x		x	x	x	x					x					x
1A1b	Shell Raffinaderi	x	x																	
1A1b	Statoil Raffinaderi	x	x																	
1A1c	Nybro Gasbehandlingsanlaeg		x																	
1A2a	DanSteel		x																	
1A2c	Haldor Topsoee		x																	
1A2c	Koppers	x	x	x																
1A2e	Maricogen		x																	
1A2e	Nordic Sugar Nakskov	x	x																	
1A2e	Nordic Sugar Nykoebing	x	x				x	x	x	x										
1A2e	AarhusKarlshamn Denmark A/S	x	x				x	x	x	x										
1A2e	Danisco Grindsted Dupont		x																	
1A2f	Faxe Kalk	x	x																	
1A2f	Aalborg Portland	x	x		x	x	x	x	x	x					x					
1A2g viii	Ardagh Glass Holmegaard A/S		x																	
1A2g viii	Rockwool A/S Doense	x	x																	
1A2g viii	Rockwool A/S Vamdrup	x	x																	
1A2g viii	Saint-Gobain Isover A/S		x																	
1A4a i	Rensningsanlaegget Lynetten	x	x		x		x	x	x	x		x			x		x			
Total		3180	10535	14	3477	46	280	225	156	7	26	5	33	26	125	62	34	388	203	148
Total emission from stationary combustion		7024	25922	13848	103464	1231	14154	13259	12722	1877	213	567	1133	564	252	1620	2144	686	21284	15574

Share of total emission from stationary combustion based on plant specific data, %	45%	41%	0.10%	3%	3.8%	2%	2%	1%	0.4%	12%	1%	3%	5%	50%	4%	2%	57%	1%	1%

[1)] Emissions of the pollutants marked with "x" are plant specific. Emission of other pollutants is estimated based on emission factors. The total shown *in this table* only includes plant specific data.

[2)] Based on particle size distribution and BC fractions.

Annex 6 Adjustment of CO_2 emission

Table 6.1 Adjustment of CO_2 emission (DEA, 2016a).

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Actual Degree Days	Degree days	2857	3284	3022	3434	3148	3297	3837	3236	3217	3056
Normal Degree Days	Degree days	3379	3380	3359	3365	3366	3378	3395	3389	3375	3339
Net electricity import	PJ	25.4	-7.1	13.5	4.3	-17.4	-2.9	-55.4	-26.1	-15.6	-8.3
Actual CO_2 emission	1 000 000 tonnes	38.3	48.0	42.2	44.4	48.0	44.9	58.2	48.3	44.5	41.3
Adjusted CO_2 emission	1 000 000 tonnes	44.5	46.4	45.1	45.5	44.3	44.3	45.2	42.4	40.9	39.4
Continued		**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Actual Degree Days	Degree days	2902	3279	3011	3150	3113	3068	2908	2807	2853	3061
Normal Degree Days	Degree days	3304	3289.4	3273.2	3271.3	3260.9	3224.2	3188	3136	3120	3127
Net electricity import	PJ	2.4	-2.1	-7.5	-30.8	-10.3	4.9	-25.0	-3.4	5.2	1.2
Actual CO_2 emission	1 000 000 tonnes	37.4	39.0	38.5	43.3	37.2	33.5	41.2	35.7	32.9	32.0
Adjusted CO_2 emission	1 000 000 tonnes	38.0	38.6	36.9	36.5	35.0	34.6	35.6	34.9	34.0	32.3
Continued		**2010**	**2011**	**2012**	**2013**	**2014**	**2015**				
Actual Degree Days	Degree days	3742	2970	3234	3207	2664	2921				
Normal Degree Days	Degree days	3171	3156	3166	3155	3131	3112				
Net electricity import	PJ	-4.1	4.7	18.8	3.9	10.3	21.3				
Actual CO_2 emission	1 000 000 tonnes	32.5	27.6	23.8	25.8	21.5	18.9				
Adjusted CO_2 emission	1 000 000 tonnes	31.6	28.7	28.0	26.5	23.2	22.5				

Annex 7 Uncertainty estimates

Table 7.1 Uncertainty estimation, approach 1, GHG.

This table is available at: http://envs.au.dk/videnudveksling/luft/emissioner/supporting-documentation/greenhouse-gases-nir/

Table 7.2 Uncertainty estimation, approach 1, CO_2.

This table is available at: http://envs.au.dk/videnudveksling/luft/emissioner/supporting-documentation/greenhouse-gases-nir/

Table 7.3 Uncertainty estimation, approach 1, CH_4.

This table is available at: http://envs.au.dk/videnudveksling/luft/emissioner/supporting-documentation/greenhouse-gases-nir/

Table 7.4 Uncertainty estimation, approach 1, N_2O.

This table is available at: http://envs.au.dk/videnudveksling/luft/emissioner/supporting-documentation/greenhouse-gases-nir/

Table 7.5 Uncertainty estimate for non-GHGs.

This table is available at: http://envs.au.dk/videnudveksling/luft/emissioner/supporting-documentation/air-pollution-iir/

Annex 8 Emission inventory 2015 based on SNAP sectors

Table 8.1 Emission inventory 2015 based on SNAP sectors.

db	2015			
Sum of Emission		**pol_id**	**pol_abbr**	**uni_abbr**
		CO_2	**CH_4**	**N_2O**
nfr_id_EA	**snap_id**	**Gg**	**Mg**	**Mg**
1A1a	010100	0.000	0.162	0.162
	010101	7310.694	90.915	71.891
	010102	996.755	42.955	39.963
	010103	468.218	7.495	15.245
	010104	434.747	50.840	21.120
	010105	188.324	2819.730	7.870
	010200	0.000	0.163	0.163
	010201	0.000	0.000	0.000
	010202	45.821	1.174	0.773
	010203	809.549	338.101	89.502
	010205	0.000	0.000	0.000
1A1a Total		**10254.108**	**3351.536**	**246.689**
1A1b	010304	115.138	3.442	2.025
	010306	862.960	16.033	1.792
1A1b Total		**978.098**	**19.475**	**3.817**
1A1c	010503	6.633	0.116	0.116
	010504	1429.141	42.169	24.805
	010505	0.000	0.000	0.000
1A1c Total		**1435.774**	**42.285**	**24.921**
1A2a	030400	0.286	0.005	0.018
	030402	88.405	1.548	1.540
1A2a Total		**88.691**	**1.554**	**1.558**
1A2b	030500	0.000	0.000	0.000
1A2b Total		**0.000**	**0.000**	**0.000**
1A2c	030600	286.505	12.261	5.067
	030602	41.182	0.699	0.703
	030603	20.280	0.344	1.100
	030604	40.384	1.205	0.706
	030605	0.000	43.525	0.160
1A2c Total		**388.351**	**58.034**	**7.737**
1A2d	031100	57.696	3.260	1.827
	031102	0.000	0.000	0.000
	031103	0.000	0.224	0.081
	031104	10.195	0.304	0.179
1A2d Total		**67.891**	**3.787**	**2.087**
1A2e	030900	632.768	14.300	11.030
	030902	171.713	9.540	7.452
	030903	118.713	3.852	5.396
	030904	71.109	2.119	1.246
	030905	14.489	122.135	0.147
1A2e Total		**1008.791**	**151.947**	**25.272**
1A2f	030700	288.286	6.602	5.082
	030703	23.924	2.510	0.380
	030705	0.436	3.679	0.004
	031600	849.062	105.924	21.780
	031604	0.000	0.000	0.000
	031605	0.000	0.000	0.000
1A2f Total		**1161.708**	**118.714**	**27.246**
1A2g viii	030104	0.000	0.000	0.000
	030105	0.000	0.000	0.000
	030106	6.360	0.111	0.111
	030800	36.799	10.920	4.375
	031000	15.887	0.444	0.344
	031005	0.009	0.076	0.000
	031200	13.238	0.482	0.329
	031205	0.000	0.000	0.000
	031300	144.791	6.167	3.809
	031305	7.626	64.287	0.078
	031400	8.608	20.197	7.530
	031403	0.000	3.707	1.348
	031405	0.058	0.492	0.001
	031500	28.454	0.496	0.433
	032000	59.207	13.261	5.660
	032002	73.748	5.863	25.740
	032004	0.029	0.001	0.001

db	2015			
Sum of Emission		**pol_id**	**pol_abbr**	**uni_abbr**
		CO_2	**CH_4**	**N_2O**
nfr_id_EA	**snap_id**	**Gg**	**Mg**	**Mg**
	032005	2.360	33.235	0.080
1A2g viii Total		**397.177**	**159.739**	**49.838**
1A4a i	020100	618.305	24.632	13.179
	020103	1.704	5.064	0.650
	020105	11.866	370.985	1.166
1A4a i Total		**631.875**	**400.681**	**14.995**
1A4b i	020200	1915.523	4391.971	189.715
	020202	9.688	0.533	0.185
	020204	8.363	70.510	0.085
1A4b i Total		**1933.575**	**4463.014**	**189.985**
1A4c i	020300	143.807	600.264	11.102
	020302	0.015	0.625	0.083
	020303	0.000	0.000	0.000
	020304	15.353	375.318	1.065
1A4c i Total		**159.175**	**976.207**	**12.251**
Grand Total		**18505.214**	**9746.973**	**606.398**

Table 8.2 Emission inventory 2015 based on SNAP sectors, non-GHGs.

This table is available at:

http://envs.au.dk/videnudveksling/luft/emissioner/supporting-documentation/air-pollution-iir/

Annex 9 EU ETS data for coal

EU ETS data are available for the years 2006-2015. Corresponding values for lower calorific value (LCV) and implied emission factor (IEF) for CO_2 for 2006-2009 are shown in Figure 9.1. The IEF factors include the oxidation factors.

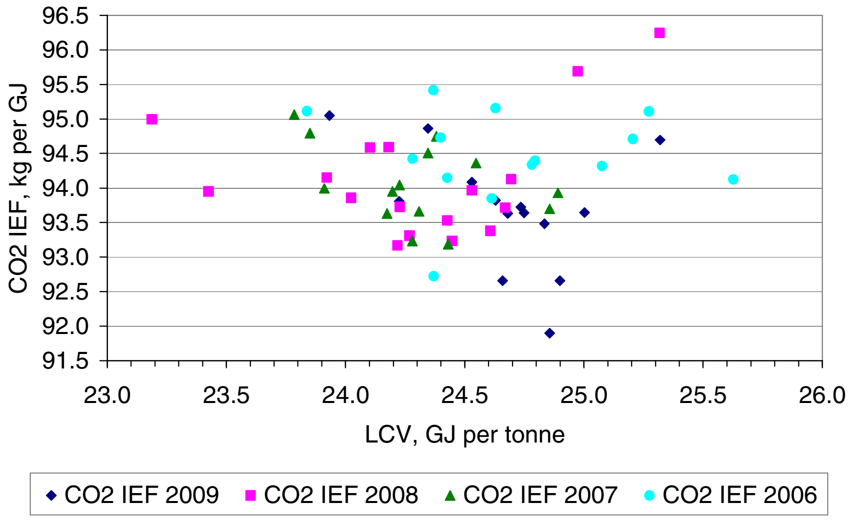


Figure 9.1 EU ETS data for LCV and CO_2 IEF (including oxidation factor) for coal. Data for the years 2006-2009.

Annex 10 Implied emission factors for power plants and municipal waste incineration plants

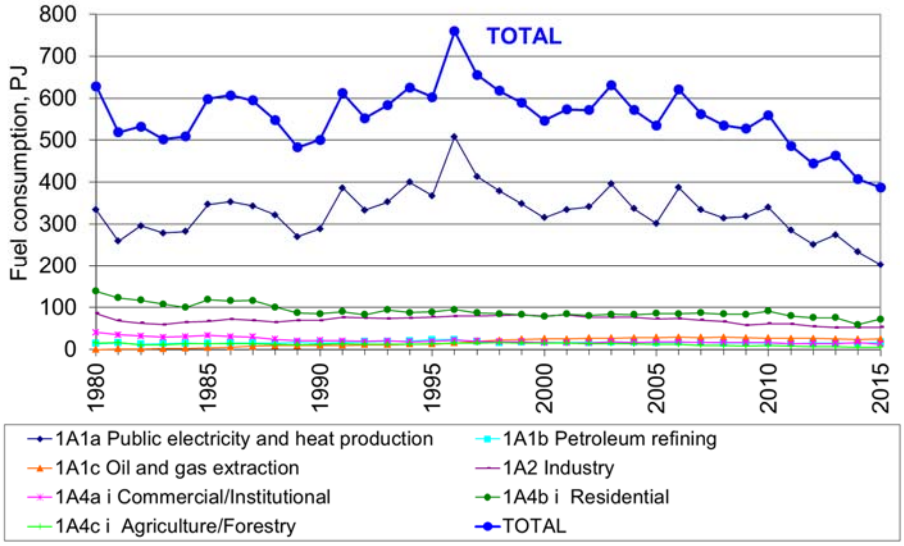
Table 10.1 Implied emission factors for municipal waste incineration plants 2015.

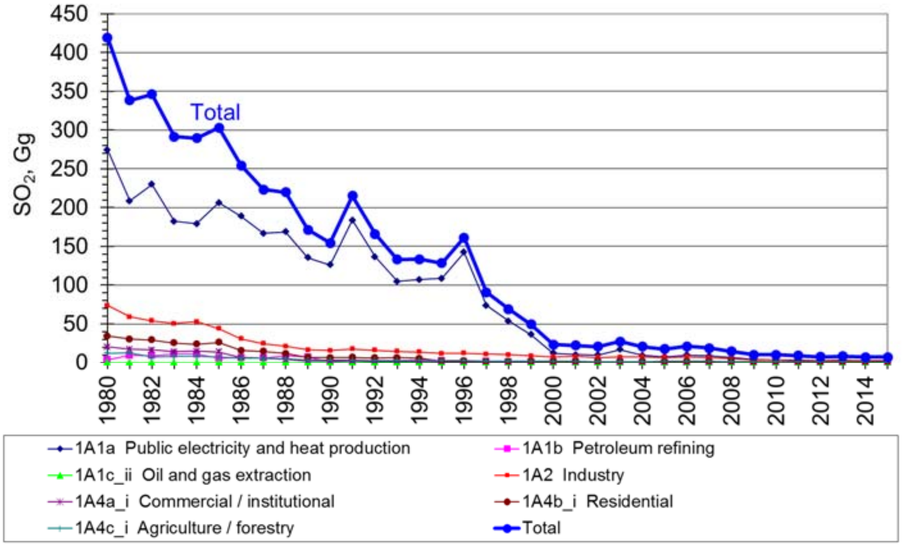
Pollutant	Implied emission factor	Unit
SO_2	6.9	g /GJ
NO_x	75	g / GJ
TSP	0.65	g / GJ
PM_{10}	0.55	g / GJ
$PM_{2.5}$	0.47	g / GJ
As	0.57	mg / GJ
Cd	0.39	mg / GJ
Cr	1.52	mg / GJ
Cu	1.37	mg / GJ
Hg	1.64	mg / GJ
Ni	2.77	mg / GJ
Pb	4.79	mg / GJ
Se	1.16	mg / GJ
Zn	2.52	mg / GJ

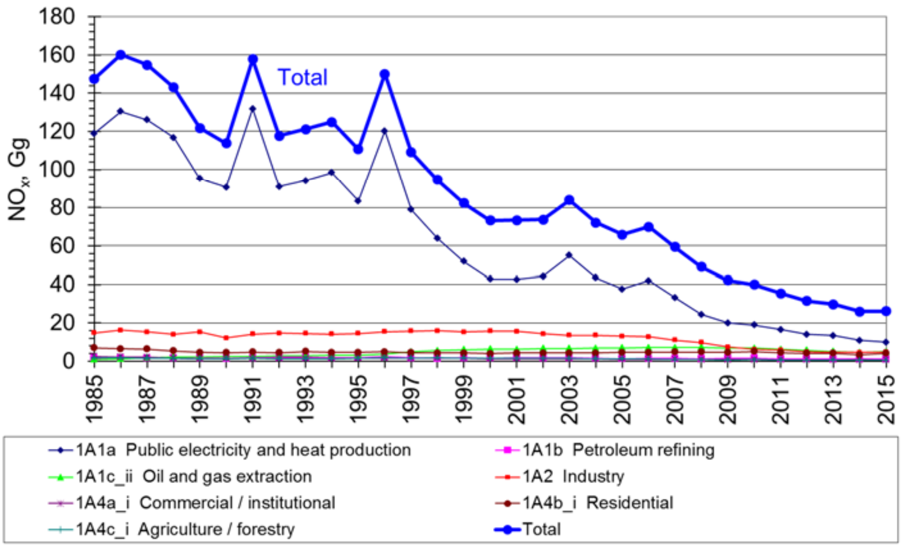
Table 10.2 Implied emission factors for power plants combusting coal, 2015.

Pollutant	Implied emission factor	Unit
SO_2	9.6	g / GJ
NO_x	29	g / GJ
TSP	1.7	g / GJ
PM_{10}	1.4	g / GJ
$PM_{2.5}$	1.2	g / GJ
As	0.30	mg / GJ
Cd	0.023	mg / GJ
Cr	0.27	mg / GJ
Cu	0.20	mg / GJ
Hg	0.86	mg / GJ
Ni	0.47	mg / GJ
Pb	0.22	mg / GJ
Se	6.8	mg / GJ
Zn	0.85	mg / GJ

Annex 11 Time-series 1980/1985 – 2015







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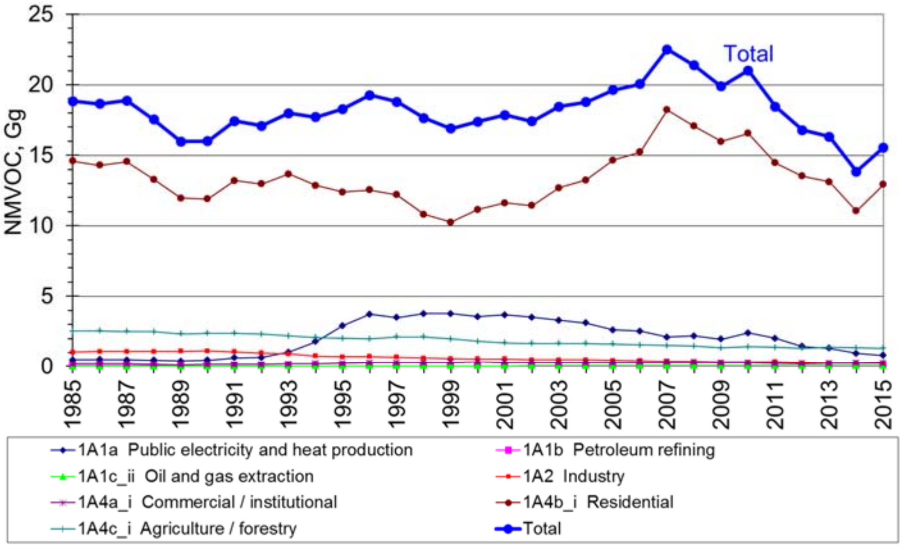

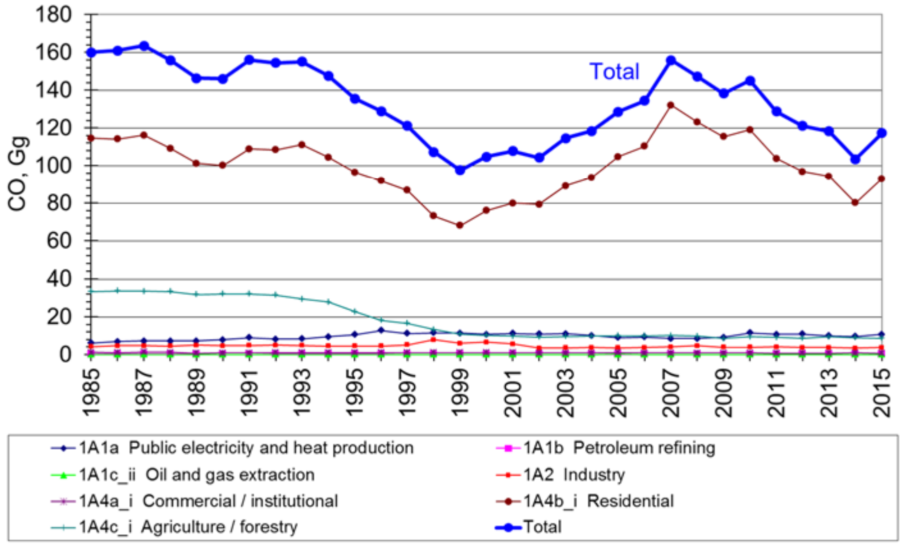

Figure 11.1 Time-series for fuel consumption and emissions, 1980/1985 - 2015.

DANISH EMISSION INVENTORIES FOR STATIONARY COMBUSTION PLANTS

Inventories until 2015

Emission inventories for stationary combustion plants are presented and the methodologies and assumptions used for the inventories are described. The pollutants considered are SO_2, NOx, NMVOC, CH_4, CO, CO_2, N_2O, NH_3, particulate matter, black carbon, heavy metals, PCDD/F, HCB, PCBs and PAH. The CO_2 emission from stationary combustion was 51.2 % lower in 2015 than in 1990 and the total greenhouse gas emission was 50.5 % lower than in 1990. However, fluctuations in the emission level for CO_2 are large as a result of electricity import/export. A considerable decrease of the SO_2, NOx and heavy metal emissions is mainly a result of decreased emissions from large power plants and waste incineration plants. The combustion of wood in residential plants has increased considerably in 1990-2007 resulting in increased emission of PAH, particulate matter and black carbon. The emissions have decreased after 2007 due to installation of modern stoves and boilers. The PCDD/F emission decreased since 1990 due to flue gas cleaning on waste incineration plants.

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