DANISH EMISSION INVENTORIES FOR STATIONARY COMBUSTION PLANTS

Inventories until 2023

Scientific Report from DCE – Danish Centre for Environment and Energy No. 700 2026

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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 CO_2, CH_4, N_2O, SO_2, NO_x, NMVOCs, CO, NH_3, particulate matter, black carbon, heavy metals, PCDD/Fs, HCB, PCBs and PAHs. The CO_2 emission from stationary combustion was 73.2 % lower in 2023 than in 1990 and the total greenhouse gas emission was 72.5 % 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 PM emissions increased until 2007 and decreased after 2007. The increase until 2007 was caused by the increased wood combustion in residential plants. The decrease after 2007 is caused by installation of modern stoves and boilers with lower emissions. The PCDD/F emission decreased until 1999 due to improved flue gas cleaning on waste incineration plants. In recent years, residential wood combustion is the largest emission source.

Keywords: Emission, combustion, emission inventory, stationary combustion, power plants, district heating, CHP, co-generation, boiler, engine, incineration, MSW, residential, combustion, stoves, 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, GHG

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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
CO_2 eq	Carbon dioxide equivalents
CORINAIR	CORe INventory on AIR emissions
Cr	Chromium
CRF	Common Reporting Format, former reporting format applied for greenhouse gas emissions
CRT	Common Reporting Template, reporting format applied for greenhouse gas emissions
Cu	Copper
DEA	Danish Energy Agency
DEPA	Danish Environmental Protection Agency
dl-PCB	dioxin like - polychlorinated biphenyl
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
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
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
NID	National Inventory Document
NMVOCs	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	Particulate Matter
PM_{10}	Particulate Matter < 10 µm
$PM_{2.5}$	Particulate Matter < 2.5 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 Environment and Gender Equality and the Ministry of Climate, Energy and Utilities, 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.

A draft version of this report has not been available for comments by the ministries, and no steering group or external partners have been writing or commenting on the report. However, the report has been externally reviewed, see below.

This report forms part of the documentation for the emission inventories for stationary combustion plants in Denmark. The report includes both methodology and emission data. The results of inventories up to 2023 are included. The report updates the eight reports published in 2004, 2006, 2007, 2009, 2010, 2014, 2018 and 2021.

In addition to the national approach emission data for stationary combustion, this report also includes three data sets for greenhouse gases (GHG) that are reported to EU:

- The reference approach.
- Verification based on Eurostat data.
- Comparison of the sum of EU ETS data and the national approach data.

The sector reports are reviewed by external national experts. The external national reviews form a vital part of the QA activities for the emission inventories for stationary combustion required in IPCC Guidelines (IPCC, 2006). This year, Peter Louring Nielsen from the Danish Energy Agency has reviewed the report, mainly the chapters related to EU ETS data and CO_2 emission factors.

The 2004, 2006, 2009, 2014, 2018 and 2021 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, Vibeke Vestergaard Nielsen, DCE - Danish Centre for Environment and Energy, Aarhus University, energy experts from the Danish Energy Agency and Jytte Boll Illerup from The Danish Environmental Protection Agency.

Summary

Danish emission inventories for greenhouse gases (GHG) are prepared on an annual basis and are reported to the United Nations Framework Convention on Climate Change (UNFCCC or Climate Convention). Danish emission inventories for non-GHGs are prepared on an annual basis and are reported to the Convention on Long-Range Transboundary Air Pollution (LRTAP).

The pollutants reported to the LRTAP Convention are also reported to the European Commission's National Emissions Ceiling Directive (NECD).

This report provides detailed background information on the methodology, and references for the input data in the inventory. In addition, the resulting emission time series are presented.

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 (NMVOCs), carbon monoxide (CO), particulate matter (PM) which include TSP, PM_{10} and $PM_{2.5}$, black carbon (BC), ammonia (NH_3), heavy metals (As, Cd, Cr, Cu, Hg, Ni, Pb, Se and Zn), polychlorinated dibenzodioxins and –furans (PCDD/Fs), polycyclic aromatic hydrocarbons (PAHs: Benzo(a)-pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and Indeno(1,2,3-c,d)pyrene), polychlorinated biphenyls (PCBs) 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.

The emission factors are based either on national references or on international guidebooks (EEA, 2023[1]; 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 plants. 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 (EU ETS).

In the emission inventory for 2023, 71 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 52 % of the overall fuel consumption in stationary combustion plants.

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 2023, the total fuel consumption was 37 % lower than in 1990 and the fossil fuel consumption was 70 % lower than in 1990. The use of coal and oil has decreased whereas the use of waste and biomass has increased.

[1] Or former updates of the Guidebook.

In 2023, stationary combustion accounted for 28.1 % of the total Danish emission of GHGs (including LULUCF) and 42 % of the CO_2 emission.

Stationary combustion plants account for more than 50 % of the national emission (2023) for the following pollutants: SO_2, $PM_{2.5}$, BC, the heavy metals As, Cd, Hg and Se, PCDD/Fs, PCBs and PAHs. Furthermore, the emission from stationary combustion plants accounts for more than 10 % of the national emission for the following pollutants: CO_2, NO_x, NMVOC, CO, PM_{10}, HCB and the heavy metals Cr, Ni, Pb and Zn. Stationary combustion plants account for less than 10 % of the national emission of CH_4, N_2O, NH_3, TSP and the heavy metal Cu.

Public electricity and heat production is the largest subsector in stationary combustion for CO_2, CH_4, N_2O, SO_2, NO_x, Hg, Se, HCB and PCBs.

Residential plants is the largest subsector for NMVOCs, CO, NH_3, particulate matter, BC, Cd, Cr, Cu, Pb, Zn, PAHs and PCDD/Fs. Wood combustion in residential plants is the predominant emission source.

Industrial plants are the main emission sources for As and Ni.

CO_2 is the most important greenhouse gas accounting for 96.7 % 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 greenhouse gas emission are lower in 2023 than in 1990, CO_2 is 73.2 % lower and greenhouse gas emissions are 72.5 % lower. However, fluctuations in the GHG emission level are large. The fluctuations in the time series are mainly caused by electricity import/export but are also a result of outdoor temperature variations from year to year that leads to fluctuations in the fuel consumption for space heating.

The CH_4 emission from stationary combustion was 4 % higher in 2023 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 after 2004 is due to structural changes in the Danish electricity market, which resulted in fewer profitable operational hours each year for the gas engines.

The N_2O emission from stationary combustion has decreased by 14 % from 1990 to 2023. However, fluctuations in emission level due to electricity import/export are considerable.

SO_2 emission from stationary combustion plants has decreased by 97 % since 1990. The considerable emission decrease is mainly a result of the reduced emission from public electricity and heat production plants but the emission from other source categories also decreased considerably. The lower emissions have been achieved by 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 80 % 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 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 2023, the wood consumption (excluding wood pellets) in residential plants was 79 % higher than in 1990. The consumption increased from 1990 to 2007 and decreased after 2007. Residential wood combustion is a major emission source for NMVOCs, CO, NH_3, PM, BC, dioxins (PCDD/Fs), some heavy metals and PAHs. A change of technology (installation of modern stoves and boilers) has caused decreasing emission factors[2].

The NMVOC emissions from stationary combustion plants has decreased by 44 % from 1990. The emission increased until 2007 and decreased after 2007. 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 after 2007 is a result of lower emission from residential wood combustion and the low number of operation hours for the lean burn gas engines.

The CO emission from stationary combustion has decreased 55 % since 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 decreased emission in 2007-2023 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 time series for PM emission from stationary combustion plants follows the time series for PM emission from residential plants. The emission of TSP, PM_{10} and $PM_{2.5}$ was 38 %, 41 % and 40 %, respectively, lower in 2023 than in 1990. The PM emissions increased until 2007 and decreased after 2007. 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 after 2007 and decreased emission factor for residential wood combustion has resulted in a decrease of PM emission from stationary combustion after 2007.

Residential plants are the largest emission source for BC, mainly residential combustion of straw, wood and wood pellets The emission in 2023 was 27 % lower than in 1990.

The emission of PAHs has decreased since 1990, mainly after 2007. This is also a result of the time series for combustion of wood in residential plants.

Emissions of all heavy metals have decreased considerably (45 % - 94 %) since 1990. 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

[2] Except for dioxins.

improved flue gas cleaning was initiated due to lower emission limit values in Danish legislation (DEPA, 2011).

The total PCDD/F emission has decreased 57 % 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, both wood consumption and emission of PCDD/F have decreased since 2016 for residential plants. The dioxin emission factors for residential wood combustion are dependent on the wood origin but independent of stove technology. Thus, the dioxin emission from residential wood combustion has not decreased similar to the PM and PAH emissions due to implementation of new improved stoves and boilers.

The HCB emission has decreased 84 % since 1990 mainly due to improved flue gas cleaning in waste incineration plants.

The dl-PCB emissions have decreased 74 % 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 interval for the Danish greenhouse gas emission from stationary combustion is estimated to be ±2.6 % and the trend in greenhouse gas emissions is -72.5 % ± 0.7 %-age points.

In addition to the sector specific CO_2 emission inventories (the sectoral approach - SA), the CO_2 emission from the energy sector[3] is also estimated using the reference approach (RA) described in the IPCC Guidelines (IPCC, 2006). In 2023, the fuel consumption rates in the two approaches differ by 2.23 % and the CO_2 emission differs by 2.66 %. Both the fuel consumption and the CO_2 emission differ by less than 2 % for all years except 2016, 2022 and 2023. The high difference for some years is mainly caused by statistical differences in the Danish energy statistics.

As part of the EU review of the reported GHG emission data, EU performs for each member state a comparison of Eurostat energy data (in TJ) with energy data provided in the CRT. 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. In addition, the calorific value (NCV) for coal applied in the Eurostat data are not in agreement with the average NCV for coal applied in the Danish energy statistics.

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 36 % of the total CO_2 emission reported in the Danish emission inventory.

[3] Including energy consumption in mobile sources.

Sammenfatning

Opgørelser over de samlede danske luftemissioner rapporteres årligt til klimakonventionen (United Nation Framework Convention on Climate Change, UNFCCC) og til UNECE-konventionen om langtransporteret grænseoverskridende luftforurening (UNECE Convention on Long-Range Transboundary Air Pollution, der forkortes LRTAP Convention). Der udarbejdes også opgørelser til rapportering til Europakommissionens NEC (National Emissions Ceiling) direktiv.

Denne rapport giver detaljeret baggrundsinformation om den anvendte metode samt referencer for de data der ligger til grund for opgørelsen – energistatistikken og emissionsfaktorerne. Endvidere vises de estimerede emissioner og tidsserierne herfor.

Emissionsopgørelserne omfatter følgende stoffer af relevans for stationær forbrænding: kuldioxid (CO_2), metan (CH_4), lattergas (N_2O), svovldioxid (SO_2), kvælstofoxid (NO_x), NMVOC, karbonmonoxid (CO), partikler (PM der inkluderer total partikelemission (TSP), PM_{10} og $PM_{2,5}$), black carbon (BC), ammoniak (NH_3), tungmetaller (As, Cd, Cr, Cu, Hg, Ni, Pb, Se og Zn), dioxiner (PCDD/F), fire polycykliske aromatiske hydrocarboner (PAH: Benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene og indeno(1,2,3-c,d)pyrene), polyklorerede bifenyler (PCB) og hexachlorbenzen (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, er indarbejdet i opgørelserne.

Emissionsfaktorerne stammer enten fra danske referencer eller fra internationale guidebøger (EEA, 2023[4] og IPCC, 2006) udarbejdet til brug for denne type emissionsopgørelser. Hovedparten af de emissionsfaktorer, der er udarbejdet specielt for danske forhold, er baseret på miljølovgivning, danske rapporter eller 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 2023 er 71 stationære forbrændingsanlæg defineret som punktkilder. Punktkilderne omfatter: Kraftværker, decentrale kraftvarmeværker, affaldsforbrændingsanlæg, industrielle forbrændingsanlæg samt raffinaderier. Brændselsforbruget for disse anlæg udgør 52 % 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 2023 var det samlede brændselsforbrug 37 % lavere end i 1990, mens det fossile brændselsforbrug var 70 % lavere end i 1990. Forbruget af kul og olie er faldet, mens forbruget af affald og biobrændsler er steget.

[4] Samt tidligere opdateringer af EEA Guidebook.

I 2023 stammede 28,1 % af den samlede danske emission af drivhusgasser fra stationær forbrænding. For CO_2 var andelen fra stationær forbrænding 42 %.

For følgende stoffer udgør emissionen fra stationær forbrænding over 50 % af den nationale emission: SO_2, $PM_{2,5}$, BC, tungmetallerne As, Cd, Hg og Se, dioxin, PCB og PAH. Endvidere udgør emissionen over 10 % for CO_2, NO_x, NMVOC, CO, PM_{10}, HCB, Cr, Ni, Pb og Zn. Stationær forbrænding bidrager med mindre end 10 % af den nationale emission af CH_4, N_2O, NH_3, TSP og Cu.

For stationær forbrænding er el- og varmeproducerende værker den betydeligste emissionskilde for CO_2, CH_4, N_2O, SO_2, NO_x, Hg, Se, HCB og PCB.

Emissioner fra beboelse (kedler, brændeovne mv.) er den betydeligste emissionskilde for NMVOC, CO, NH_3, partikler, BC, Cd, Cr, Cu, Pb, Zn, dioxin og PAH. Det er især forbrænding af træ, som bidrager til disse emissioner.

Industrielle anlæg er den største emissionskilde for As og Ni.

CO_2 udgjorde i 2023 96,7 % 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 2023 end i 1990. CO_2 emissionen var 73,2 % lavere og drivhusgasemissionen var 72,5 % 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 4 % højere i 2023 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. Efter 2004 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 af N_2O var 14 % lavere i 2023 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 97 % siden 1990. Den store reduktion er primært fra el- og fjernvarmeproducerende anlæg, men emissionen fra andre anlæg er ligeledes faldet. Den lavere emission er opnået ved installering af afsvovlingsanlæg samt ved 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 for flere anlægstyper.

NO_x-emissionen fra stationær forbrænding er faldet med 80 % 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 (træpiller ikke inkluderet) forbrændt i villakedler og brændeovne var i 2023 79 % højere end i 1990. Forbruget steg fra 1990 til 2007, hvorefter forbruget er faldet. Dette har stor betydning for tidsserierne for en række emissionskomponenter, for hvilke netop træ anvendt i villakedler/brændeovne, er en væsentlig emissionskilde: NMVOC, CO, NH_3, partikler, BC, dioxin, nogle metaller og PAH. Emissionen fra nyere brændeovne/-kedler er lavere end for de ældre[5], idet forbrændingsteknologien er forbedret, og stigningen i emissioner er således lavere end stigningen i brændselsforbruget.

Emissionen af NMVOC fra stationær forbrænding er faldet 44 % siden 1990. Emissionen steg indtil 2007 og faldt derefter. Stigningen frem til 2007 skyldes primært øget brændeforbrug i brændeovne og øget anvendelse af gasmotorer på decentrale kraftvarmeværker. Faldet i emission efter 2007 er et resultat af forbedret forbrændingsteknologi i brændeovnene samt færre driftstimer for gasmotorerne.

CO-emissionen fra stationær forbrænding er faldet 55 % siden 1990. Tidsserien for emissionen af CO fra stationær forbrænding følger tidsserien for CO fra husholdninger. Det øgede forbrug af træ i brændeovne og –kedler i 1999 – 2007 reflekteres i tidsserien for CO-emission. Faldet i CO-emission fra 2007 til 2023 er et resultat af bedre teknologi i nyere brændeovne samt at brændeforbruget ikke stiger fra 2007 og frem.

Tidsserierne for emissionen af partikler følger tidsserierne for partikelemissionen fra træ anvendt i husholdninger (brændeovne og –kedler). Emissionen af TSP, PM_{10} og $PM_{2,5}$ er faldet henholdsvis 38 %, 41 % og 40 % siden år 1990. Emissionen steg indtil 2007 og faldt derefter. Stigningen indtil 2007 hænger sammen med det øgede forbrug af træ i husholdninger frem til 2007. Emissionsfaktorerne er dog faldet i forbindelse med udskiftning til nyere anlæg. Efter 2007 er emissionen faldet igen som følge af installering af flere nyere brændeovne og kedler. Emissionsgrænseværdien i Brændeovnsbekendtgørelsen og grænseværdien for Svanemærkede brændeovne er sat ned flere gange.

Emissionen af BC var i 2023 27 % lavere end i 1990. Forbrænding af træ, træpiller og halm i husholdninger er den primære emissionskilde for BC.

Emissionen af de forskellige PAH'er er faldet siden 1990, primært efter 2007. Dette er ligeledes et resultat af tidsserien for forbrænding af træ i husholdninger.

Tungmetalemissionerne er faldet 45 % - 94 % siden 1990. Emissionen er faldet trods en øget forbrænding af affald. Reduktionen er et resultat af den forbedrede røggasrensning på affaldsforbrændingsanlæg og på kraftværker.

Emissionen af dioxiner var 57 % lavere i 2023 end i 1990. Dette fald skyldes primært installering af dioxinrensningsanlæg på affaldsforbrændingsanlæg, som alle affaldsforbrændingsanlæg iht. Forbrændingsbekendtgørelsen[6] skulle idriftsætte senest i 2005. Emissionen fra husholdninger er steget siden 1990 på grund af det øgede forbrug af træ i husholdninger. Både træforbruget of dioxinemissionen er faldet siden 2016 for husholdninger.

[5] Dioxin er dog uafhængig af teknologiforbedringerne.
[6] Bekendtgørelse om anlæg der forbrænder affald, Bekendtgørelse 162 af 11. marts 2003.

HCB-emissionen er faldet 84 % siden 1990, primært på grund af forbedret røggasrensning på affaldsforbrændingsanlæg.

PCB-emissionen er faldet 74 % siden 1990. Faldet er et resultat af forbedret dioxinrensning på affaldsforbrændingsanlæggene.

Emissionen af drivhusgasser er bestemt med en usikkerhed på ±2,6 %. Drivhusgasemissionen er siden 1990 faldet 72,5 % ± 0,7 %-point.

Ud over den sektoropdelte emissionsopgørelse for forbrænding i stationære og mobile kilder omfatter rapporteringen af drivhusgasser også brændselsforbrug og CO_2 beregnet ved referencemetoden. Referencemetoden er baseret på data for brændselsproduktion, import, eksport og lagerændringer. De to opgørelsesmetoder sammenlignes og for den danske opgørelse ligger forskellen lavere end 2 % for alle andre år end 2016, 2022 og 2023. Forskellen imellem de to metoder er primært de statistiske afvigelser i energistatistikkens data. Sammenligningen udgør en verifikation af den sektorspecifikke opgørelse.

Som en del af et EU review af de danske emissionsopgørelser, foretages en sammenligning af de rapporterede data (CRT-data) og data baseret på Eurostats data. Denne sammenligning er vist i rapporten og de væsentligste forskelle er forklaret. En af de væsentligste forskelle er, at 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 den danske emissionsopgørelse.

Summen af CO_2-kvotedata rapporteret under EU-direktiv 2003/87/EC er blevet sammenholdt med de danske emissionsopgørelser for drivhusgasser på sektorniveau. Samlet set udgør kvotedata 36 % af den samlede danske CO_2-emission.

1 Introduction

1.1 Definition of stationary combustion and subsectors

In the Danish emission database, all activity rates and emissions are defined in SNAP sector categories (Selected Nomenclature for Air Pollution) according to the CORINAIR system[7]. 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 CRT/NFR sector codes is based on a correspondence list between SNAP and CRT/NFR enclosed in Annex 1. Stationary combustion is defined as combustion activities in the SNAP sectors 01-03, not including SNAP 0303.

Emissions from industrial processes e.g., calcination are not included in stationary combustion. Fugitive emissions from fuels are not included in stationary combustion.

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
  - 1A1c i Agriculture/forestry

The emission and fuel consumption data included in tables and figures in this report only include data for stationary combustion plants of a given CRT sector.

The consumption of fuel for military use in stationary combustion plants has been included in commercial/institutional plants.

All pipeline compressors on the natural gas grid are electric compressors. Hence fuel consumption and emissions are not occurring in the sector 1A3e i Pipeline transport even though the activity occur, therefore it is reported as

[7] Including some additional SNAP added for industrial combustion.

not applicable (NA) in the reporting tables. The fuel consumption in the Danish gas treatment plant is included in sector 1A1cii Oil and gas extraction.

1.2 Emission share from stationary combustion

Table 1 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 1 Emission share from stationary combustion compared to national total, 2023.

Pollutant	Emission share
GHG total	28.1 %
CO_2	42 %
CH_4	2.4 %
N_2O	3.2 %
SO_2	56 %
NO_x	29 %
NMVOC	10 %
CO	40 %
NH_3	1.5 %
TSP	9 %
PM_{10}	34 %
$PM_{2.5}$	63 %
BC	64 %
As	54 %
Cd	83 %
Cr	44 %
Cu	0.7 %
Hg	80 %
Ni	20 %
Pb	11 %
Se	72 %
Zn	30 %
HCB	44 %
PCDD/F	81 %
Benzo(a)pyrene	88 %
Benzo(b)fluoranthene	85 %
Benzo(k)fluoranthene	81 %
Indeno(123cd)pyrene	79 %
PCB	77 %

1.3 Key Categories for GHGs

Key Category Analysis (KCA) approach 1 and approach 2 for the years 1990 and 2023 and for the trend 1990-2023 for Denmark has been carried out in accordance with the IPCC Guidelines (IPCC, 2006).

Table 2 shows the 25 stationary combustion key categories. The table is based on the analysis including LULUCF. Detailed key category analysis is shown in the National Inventory Document, Chapter 1.5, and Annex 1 (Nielsen et al., 2025a).

The CO_2 emissions from stationary combustion are key categories for all the major fuels. Due to the relatively high uncertainty for N_2O emission factors, the N_2O emission from several emission sources are key categories in the approach 2 analysis. CH_4 from residential wood combustion and from combustion of straw in residential/agricultural plants are also key categories.

Table 2   Key categories[8], stationary combustion.

		Approach 1			Approach 2		
		1990	2023	1990-2023	1990	2023	1990-2023
1A Stationary combustion, Coal, ETS data, CO_2	CO_2		Level	Trend			
1A Stationary combustion, Coal, no ETS data, CO_2	CO_2	Level		Trend	Level		Trend
1A Stationary combustion, Fossil waste, ETS data, CO_2	CO_2		Level	Trend		Level	Trend
1A Stationary combustion, Fossil waste, no ETS data, CO_2	CO_2	Level	Level				
1A Stationary combustion, Petroleum coke, ETS data, CO_2	CO_2		Level	Trend			
1A Stationary combustion, Petroleum coke, no ETS data, CO_2	CO_2	Level		Trend			
1A Stationary combustion, Residual oil, ETS data, CO_2	CO_2			Trend			
1A Stationary combustion, Residual oil, no ETS data, CO_2	CO_2	Level		Trend			Trend
1A Stationary combustion, Gas oil, CO_2	CO_2	Level	Level	Trend	Level		Trend
1A Stationary combustion, Kerosene, CO_2	CO_2	Level		Trend			
1A Stationary combustion, LPG, CO_2	CO_2		Level	Trend			
1A1b Stationary combustion, Petroleum refining, Refinery gas, CO_2	CO_2	Level	Level	Trend			
1A Stationary combustion, Natural gas, onshore, CO_2	CO_2	Level	Level	Trend			
1A1c_ii Stationary combustion, Oil and gas extraction, Offshore gas turbines, Natural gas, CO_2	CO_2	Level	Level	Trend			
1A4b_i Stationary combustion, Residential wood combustion, CH_4	CH_4				Level	Level	
1A4b_i/1A4c_i Stationary Combustion, Residential and agricultural straw combustion, CH_4	CH_4				Level	Level	
1A1 Stationary Combustion, Solid fuels, N_2O	N_2O				Level		Trend
1A1 Stationary Combustion, Gaseous fuels, N_2O	N_2O				Level		
1A1 Stationary Combustion, Waste, N_2O	N_2O						Trend
1A1 Stationary Combustion, Biomass, N_2O	N_2O					Level	Trend
1A2 Stationary Combustion, Liquid fuels, N_2O	N_2O				Level	Level	Trend
1A2 Stationary Combustion, Gaseous fuels, N_2O	N_2O					Level	Trend
1A2 Stationary Combustion, Biomass, N_2O	N_2O					Level	Trend
1A4 Stationary Combustion, Liquid fuels, N_2O	N_2O				Level		Trend
1A4b_i Stationary Combustion, Residential wood combustion, N_2O	N_2O					Level	Trend

1.4 Key Categories for other pollutants

Key category analysis for non-GHGs is based on EEA (2023) Approach 1 for level and trend. The stationary combustion key categories are shown in Table 3-5. The complete results of the key category analysis are available in the Annual Danish informative inventory report (Nielsen et al., 2025b).

Table 3   Key categories for stationary combustion, NFR reporting for 2023.

NFR	NO_x	NMVOC	SO_2	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
1A1a Public electricity and heat production	L1, T1		L1, T1		L1	T1			L1
1A1b Petroleum refining			L1						
1A1c Manufacture of solid fuels and other energy industries	L1								
1A2e Food processing, beverages and tobacco			L1, T1						
1A2f Non-metallic minerals	L1		L1						
1A4b i Residential: Stationary	L1	L1, T1	L1, T1		L1, T1	L1, T1	L1, T1	L1	L1, T1
1A4c i Agriculture/Forestry					L1, T1	L1, T1	T1	L1, T1	

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

Table 4 Key categories for stationary combustion, NFR reporting for 2023.

NFR	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
1A1a Public electricity and heat production	T1	L1, T1	L1, T1	L1, T1	L1, T1	T1	T1	L1, T1	T1
1A1b Petroleum refining		L1			L1			L1	
1A2e Food processing, beverages and tobacco			L1	L1			L1, T1		
1A2f Non-metallic minerals			L1	L1					
1A2g viii Other manufacturing industries							T1		
1A4b i Residential		L1, T1	L1		L1				L1, T1

Table 5 Key categories for stationary combustion, NFR reporting for 2023.

NFR	PCDD/PCDF	benzo(a)-pyrene	benzo(b)-fluoran-thene	benzo(k)-fluoran-thene	Indeno (1,2,3-cd)-pyrene	Total PAH	HCB	PCBs
1A1a Public electricity and heat production	T1						L1, T1	L1, T1
1A4bi Residential: Stationary	L1, T1	L1, T1	L1, T1	L1, T1	L1, T1	L1, T1	L1	L1
1A4ci Agriculture/ Forestry/Fishing: Stationary		L1	L1	L1	L1	L1		

2 Fuel consumption data

In 2023, the total fuel consumption for stationary combustion plants was 323 PJ of which 142 PJ was fossil fuels and 182 PJ was biomass.

Fuel consumption distributed according to the stationary combustion subcategories is shown in Figure 1 and Figure 2. The fuel consumption in Public electricity and heat production adds up to 53 % of the fuel consumption in stationary combustion plants. Other source categories with high fuel consumption are Residential and Industry.

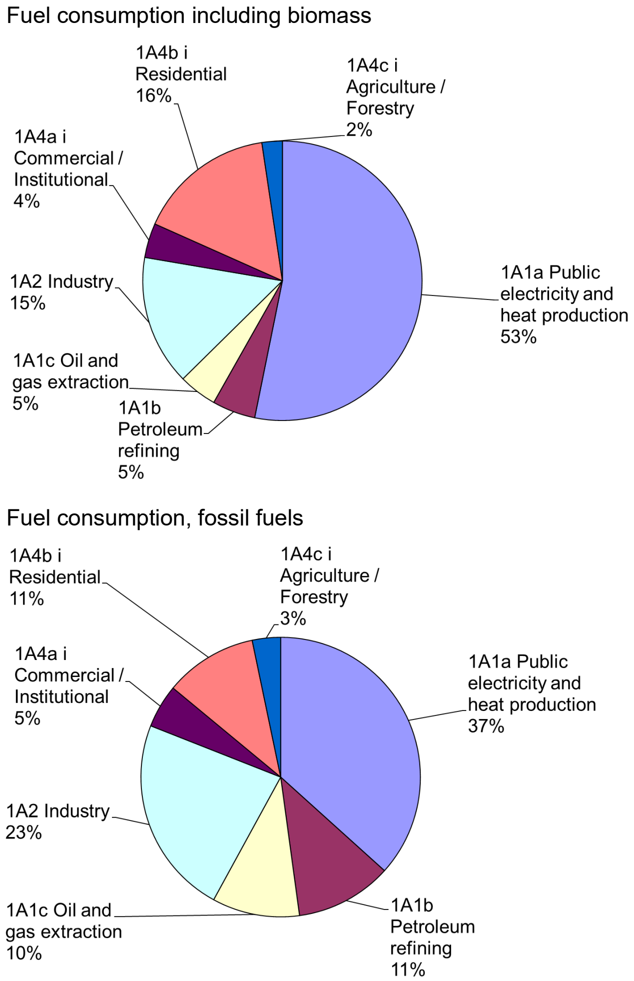


Figure 1 Fuel consumption of stationary combustion source categories, 2023. Based on DEA (2024a).

Natural gas, wood pellets, wood, coal, biomethane and waste are the most utilised fuels for stationary combustion plants. Natural gas and biomethane is used in all sectors (see Figure 2). Wood and wood pellets are mainly applied for public electricity and heat production and in residential plants. Coal and waste are mainly used in power plants.

Detailed fuel consumption rates are shown in Annex 2.

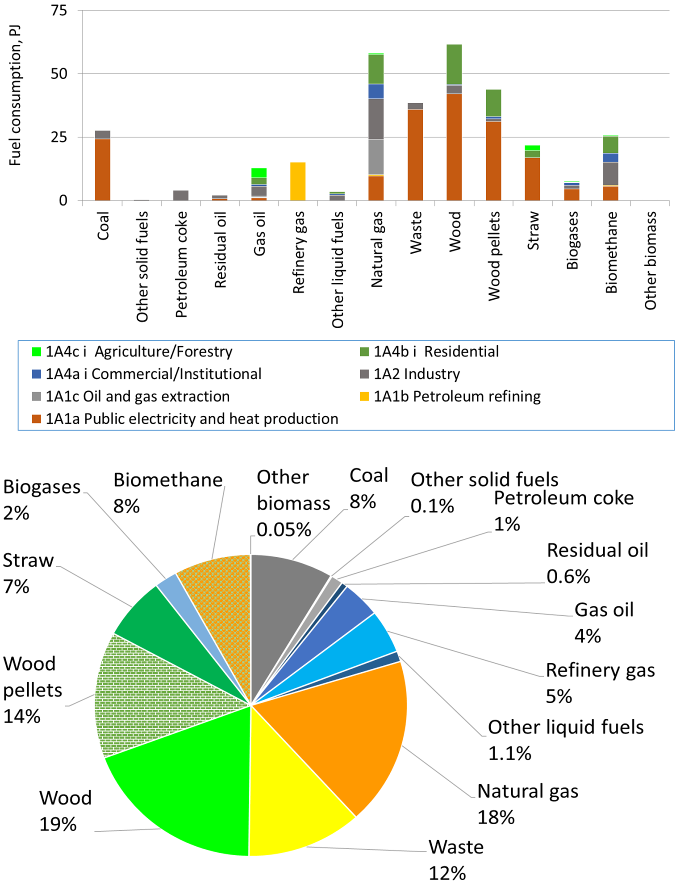
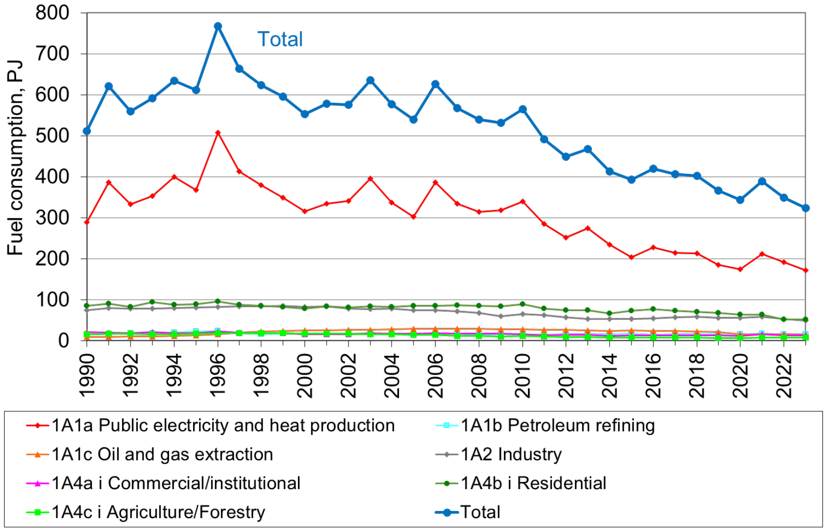


Figure 2 Fuel consumption of stationary combustion 2023, disaggregated to fuel type. Based on DEA (2024a).

Time series for fuel consumption for stationary combustion plants are presented in Figure 3. The fuel consumption for stationary combustion was 37 % lower in 2023 than in 1990, while the fossil fuel consumption was 70 % lower and the biomass fuel consumption 4.5 times the level in 1990.

The consumption of waste and biomass has increased since 1990 whereas the consumption of fossil fuels has decreased.



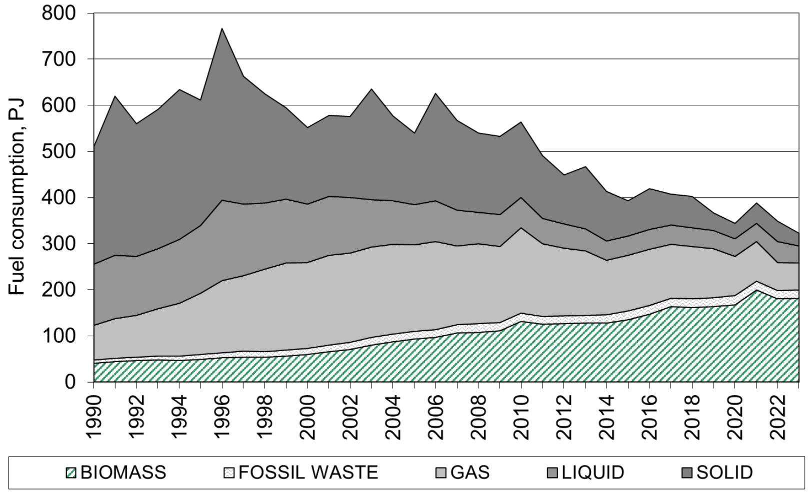


Figure 3 Fuel consumption time series, stationary combustion. Based on DEA (2024a).

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, 2003 and 2006 due to a large net electricity export. In 2023, the net electricity import was 11 PJ, whereas there was a 5 PJ net electricity import in 2022.

The Danish electricity production is highly dependent on the electricity trade with especially Germany, Sweden, and Norway.

To be able to follow the national energy consumption, 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 (2016e) and updated data (DEA, 2024d). The corrections are included here to explain the fluctuations in the time series for fuel rates and emissions.

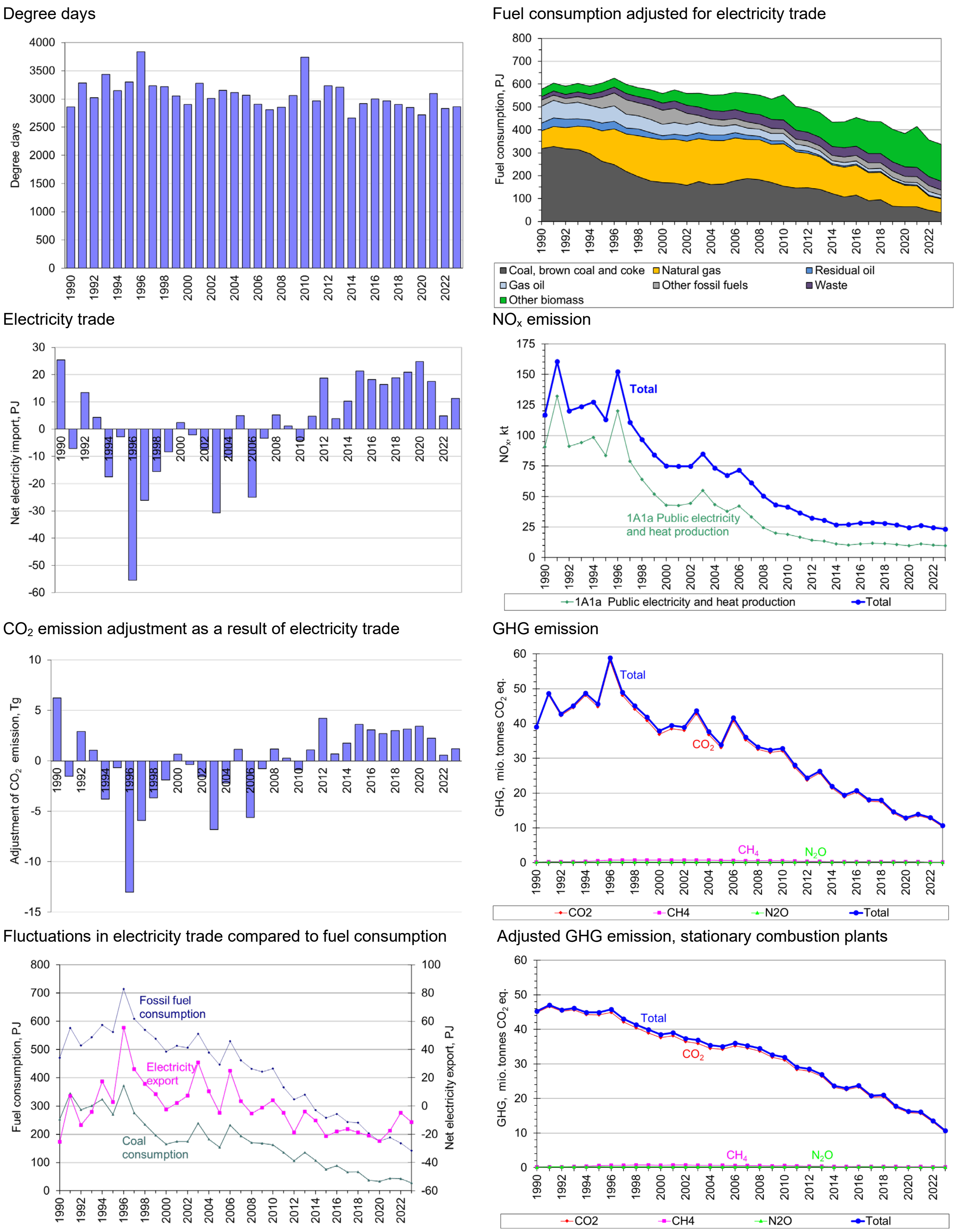


Figure 4 Comparison of time series fluctuations for net electricity import, fuel consumption, CO_2 emission, and NO_x emission. Based on DEA (2024a).

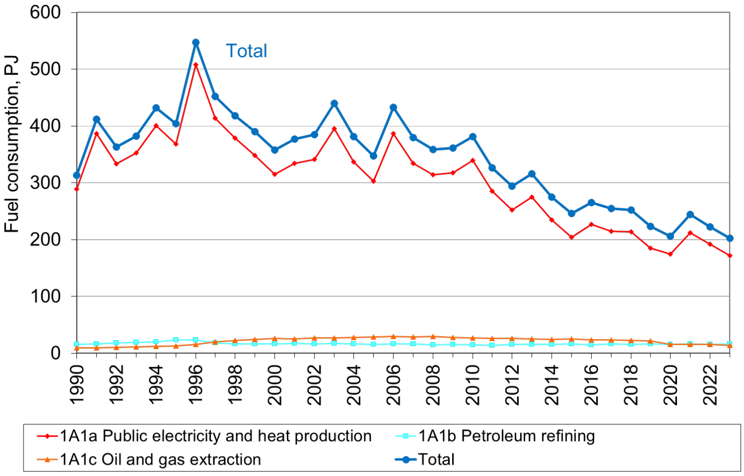
Fuel consumption time series for the subcategories to stationary combustion are shown in Figure 5, 6 and 7.

Fuel consumption for Energy industries fluctuates due to electricity trade as discussed above. The fuel consumption in 2023 was 35 % lower than in 1990 and the fossil fuel consumption was 72 % 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 2023 added up to 120 PJ, which is 7.4 times the level in 1990 but 2 % lower than in 2022.

The fuel consumption in Industry was 35 % lower in 2023 than in 1990 (Figure 6) and the fossil fuel consumption was 53 % lower. The fuel consumption in industrial plants decreased considerably after 2006 as a result of the financial crisis. The biomass fuel consumption in Industry in 2023 added up to 16 PJ, which is 2.7 times the consumption in 1990.

The fuel consumption in Other Sectors decreased 41 % since 1990 (Figure 7). The large decrease in fuel consumption from 2021 to 2022 is related to the high energy prices in the winter 2022/-23. The fossil fuel consumption in Other Sectors decreased 74 % since 1990 and was 10% lower than in 2022. The biomass fuel consumption in Other sectors in 2023 added up to 45 PJ, which is 2.4 times the consumption in 1990. The consumption of wood and wood pellets in residential plants in 2023 was 3.0 times the consumption in 1990.

Time series for subcategories are shown in Chapter 5.



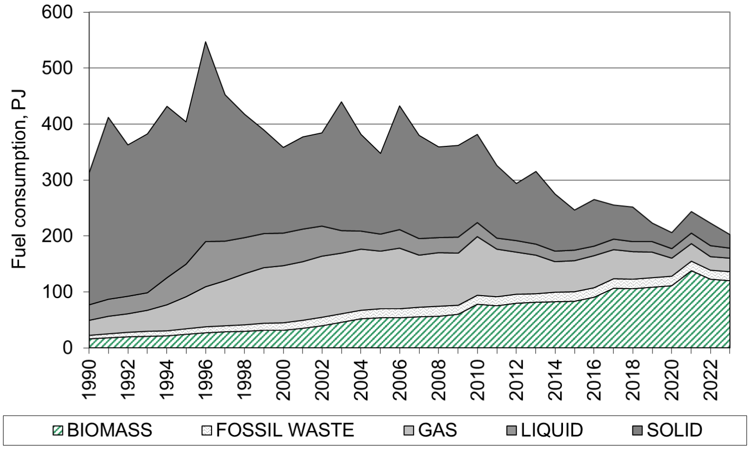


Figure 5 Fuel consumption time series for subcategories - 1A1 Energy Industries.

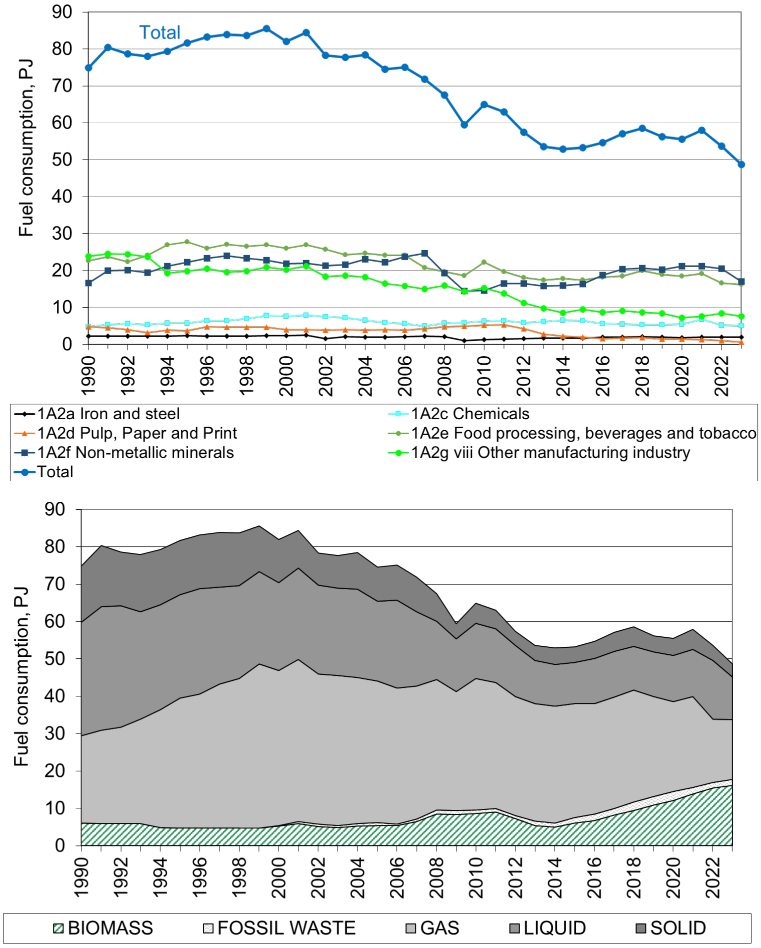


Figure 6 Fuel consumption time series for subcategories - 1A2 Industry.

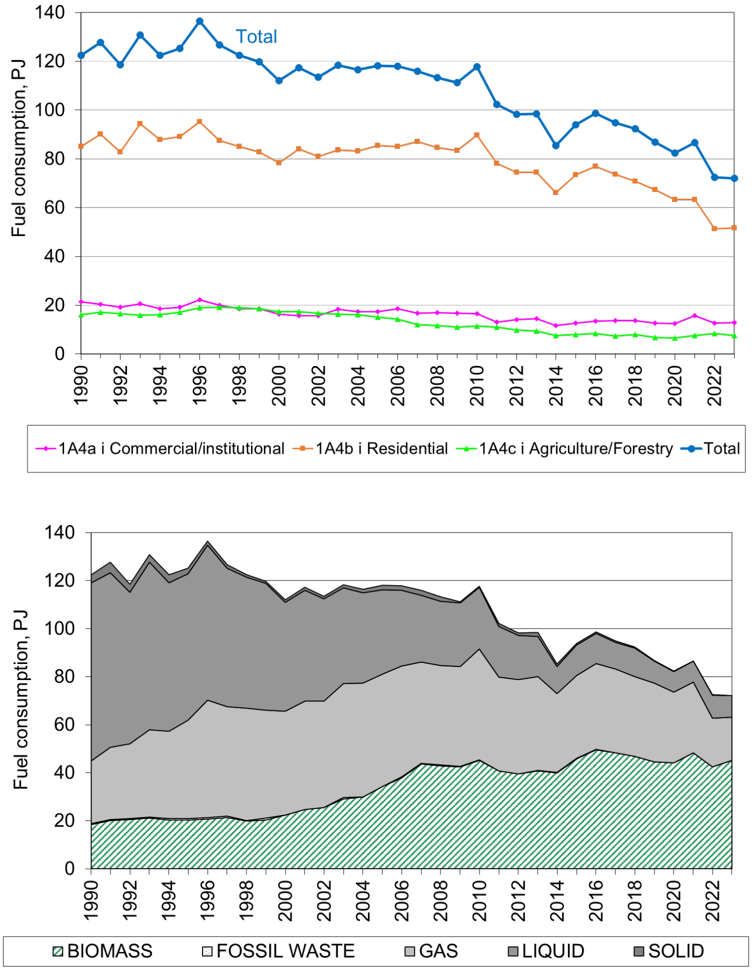


Figure 7 Fuel consumption time series for subcategories - 1A4 Other Sectors.

3 Emissions of greenhouse gases

3.1 Greenhouse gas emission

The greenhouse gas emissions from stationary combustion are listed in Table 6. The emission from stationary combustion accounted for 28.1 % of the national greenhouse gas emission (including LULUCF) in 2023.

The CO_2 emission from stationary combustion plants accounted for 42 % of the national CO_2 emission (including LULUCF) in 2023. The CH_4 emission accounted for 2.4 % of the national CH_4 emission and the N_2O emission accounted for 3.2 % of the national N_2O emission.

Table 6 Greenhouse gas emission, 2023 [1)].

	CO_2	CH_4	N_2O
	kt CO_2 equivalent		
1A1 Fuel combustion, Energy industries	6390	92	66
1A2 Fuel combustion, Manufacturing industries and construction[1)]	2302	15	31
1A4 Fuel combustion, Other sectors [1)]	1677	111	44
Emission from stationary combustion plants	10369	218	141
Emission share for stationary combustion (LULUCF included)	42%	2.4%	3.2%

[1)] Only stationary combustion sources of the category are included.

CO_2 is the most important greenhouse gas for stationary combustion accounting for 96.7 % of the greenhouse gas emission (CO_2 equivalents). CH_4 accounts for 2.0 % and N_2O for 1.3 % of the greenhouse gas emission (CO_2 equivalents) from stationary combustion (Figure 8).

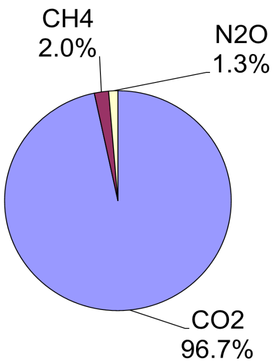


Figure 8 Greenhouse gas emission from stationary combustion (CO_2 equivalents), contribution from each pollutant, 2023.

Figure 9 shows the time series of greenhouse gas emissions (CO_2 equivalents) from stationary combustion. The development of the greenhouse gas emission follows the CO_2 emission development very closely. Both the CO_2 and the total greenhouse gas emission are lower in 2023 than in 1990, CO_2 is 73.2 % lower and greenhouse gas emissions are 72.5 % lower. However, fluctuations in the GHG emission level are large.

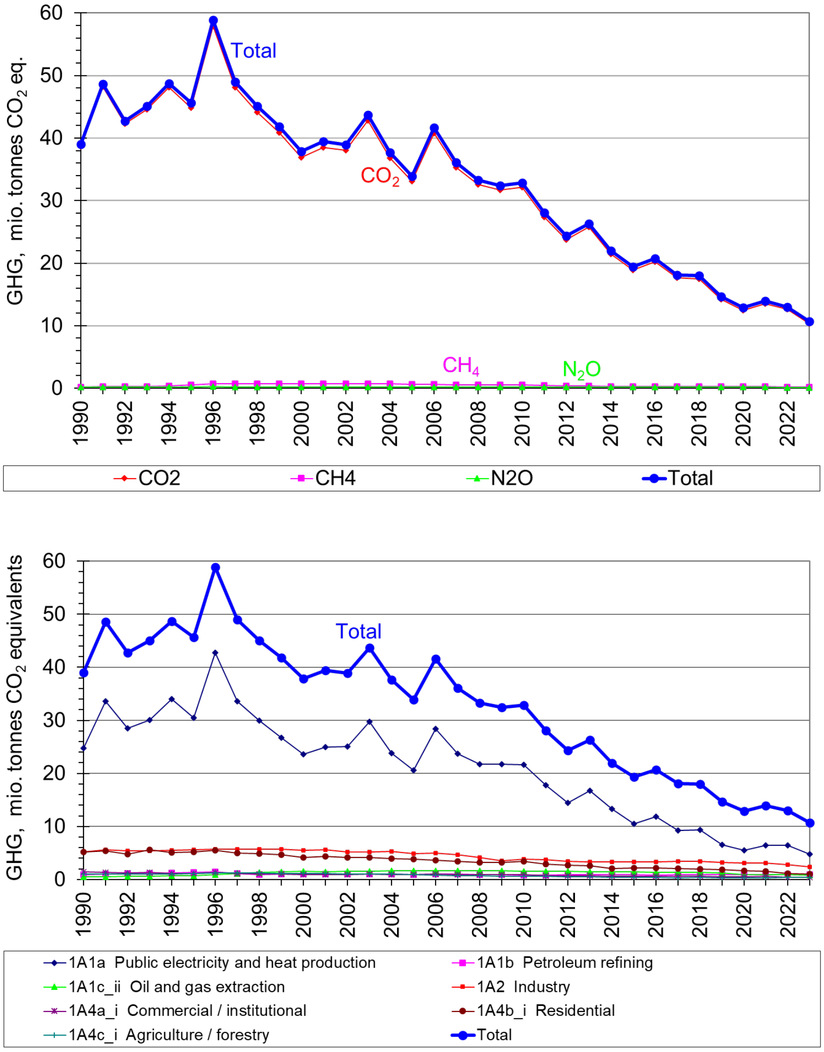


Figure 9 GHG emission time series for stationary combustion.

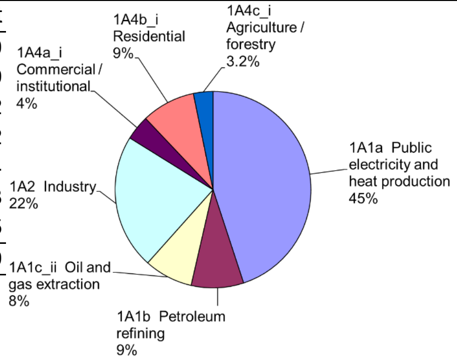
The fluctuations in the time series are largely a result of electricity import/export, but also of outdoor temperature variations from year to year. The fluctuations follow the fluctuations in fuel consumption discussed in Chapter 2. As mentioned in Chapter 2, the Danish Energy Agency estimates a correction 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 76.3 % since 1990, and the CO_2 emission by 76.9 %. These data are included here to explain the fluctuations in the emission time series.

3.2 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 42 % of the national CO_2 emission (LULUCF included). Table 7 lists the CO_2 emission inventory for stationary combustion plants for 2023. Public electricity and heat production accounts for 45 % of the CO_2 emission from stationary combustion. Industry[9] accounts for 22 % of the CO_2 emission. These source categories also account for a considerable share of fuel consumption.

Table 7 CO_2 emission from stationary combustion plants, 2023[1)].

	CO_2 kt
1A1a Public electricity and heat production	4660
1A1b Petroleum refining	899
1A1c Oil and gas extraction	832
1A2 Industry	2302
1A4a Commercial/Institutional	424
1A4b Residential	918
1A4c Agriculture/Forestry	335
Total	10369

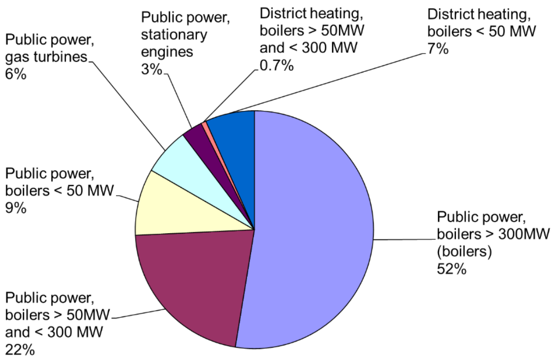


[1)] Only emissions from stationary combustion plants in the categories are included.

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 8. The largest subcategory is power plant boilers > 300MW.

Table 8 CO_2 emission from subcategories to 1A1a Public electricity and heat production.

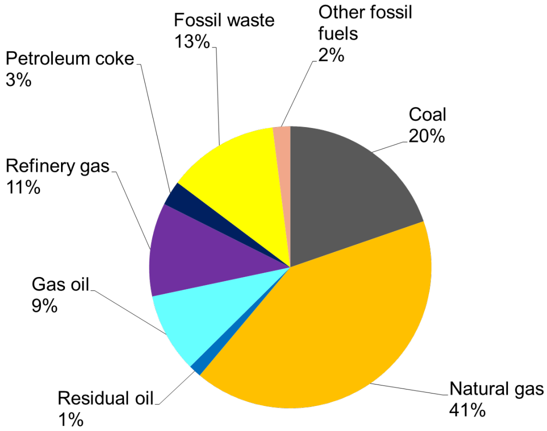
SNAP name	CO_2, kt
Public power	
Combustion plants ≥ 300MW (boilers)	2450
Combustion plants ≥ 50MW and < 300 MW (boilers)	1010
Combustion plants < 50 MW (boilers)	423
Gas turbines	298
Stationary engines	134
District heating plants	
Combustion plants ≥ 50MW and < 300 MW (boilers)	33
Combustion plants < 50 MW (boilers)	312



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 2023, the CO_2 emission from biomass combustion in stationary plants was 16 925 kt.

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.

[9] Includes only stationary combustion, whereas CO_2 from industrial processes e.g. calcination in cement production is included elsewhere.



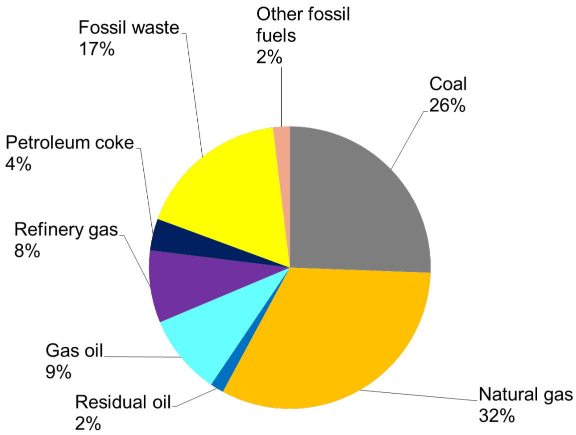


Figure 10 CO_2 emission, fuel origin.

The time series for CO_2 emission is provided in Figure 11. Despite a decrease in fuel consumption of 37 %[10] since 1990, the CO_2 emission from stationary combustion has decreased by 73 % due to 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.

[10] The consumption of fossil fuels has decreased 70 %.

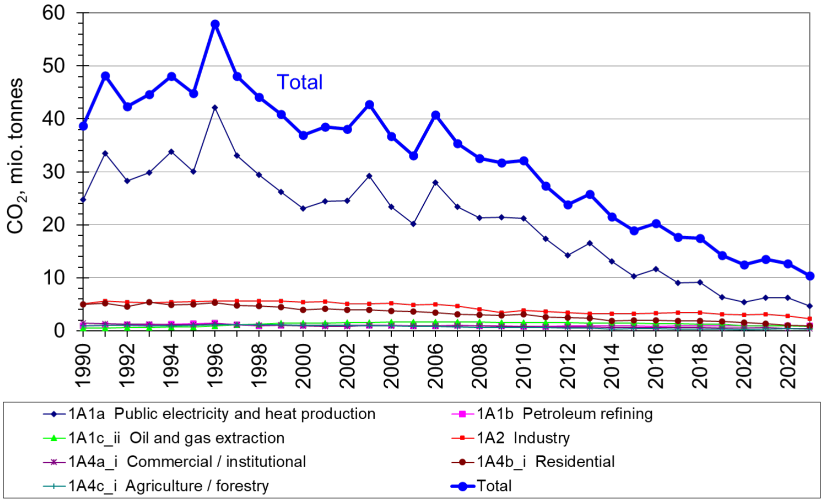


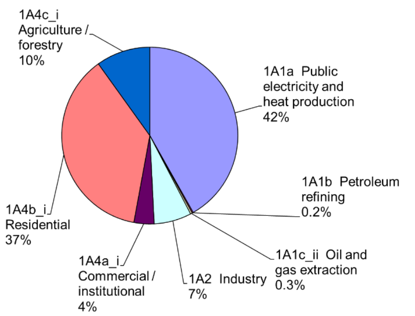
Figure 11 CO_2 emission time series for stationary combustion plants.

3.3 CH_4

The methane (CH_4) emission from stationary combustion plants accounts for 2.4 % of the national CH_4 emission. Table 9 lists the CH_4 emission inventory for stationary combustion plants in 2023. Public electricity and heat production accounts for 42 % of the CH_4 emission from stationary combustion. The emission from residential plants adds up to 37 % of the emission.

Table 9 CH_4 emission from stationary combustion plants, 2023[1)].

	CH_4, tonnes
1A1a Public electricity and heat production	3249
1A1b Petroleum refining	18
1A1c Oil and gas extraction	24
1A2 Industry	535
1A4a Commercial/Institutional	287
1A4b Residential	2888
1A4c Agriculture/Forestry	772
Total	7772



[1)] Only emission from stationary combustion plants in the source categories is 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 2023, these plants accounted for 45 % 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, biomethane or biogas. Residential wood combustion is also a large emission source accounting for 17 % of the emission in 2023. Other large emission sources are residential gas boilers and straw combustion in residential/agricultural boilers.

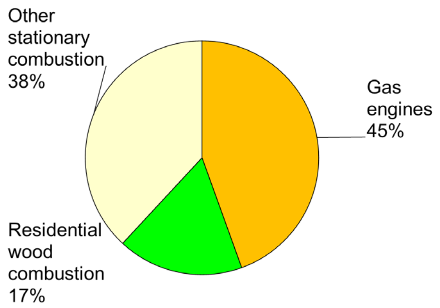


Figure 12 CH_4 emission share for gas engines and residential wood combustion, 2023.

Figure 13 shows the time series for CH_4 emission. The CH_4 emission from stationary combustion was 4 % higher in 2023 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 after 2004 is due to structural changes in the Danish electricity market, which resulted in fewer profitable operational hours each year for the gas engines.

The CH_4 emission from residential plants was 46 % lower in 2023 than in 1990. For residential plants, the main emission source is combustion of biomass. The consumption of wood in residential plants has increased, whereas the emission factor for residential wood combustion has decreased due to implementation of new improved stoves and boilers. Combustion of wood (including wood pellets) accounted for 47 % of the CH_4 emission from residential plants in 2023.

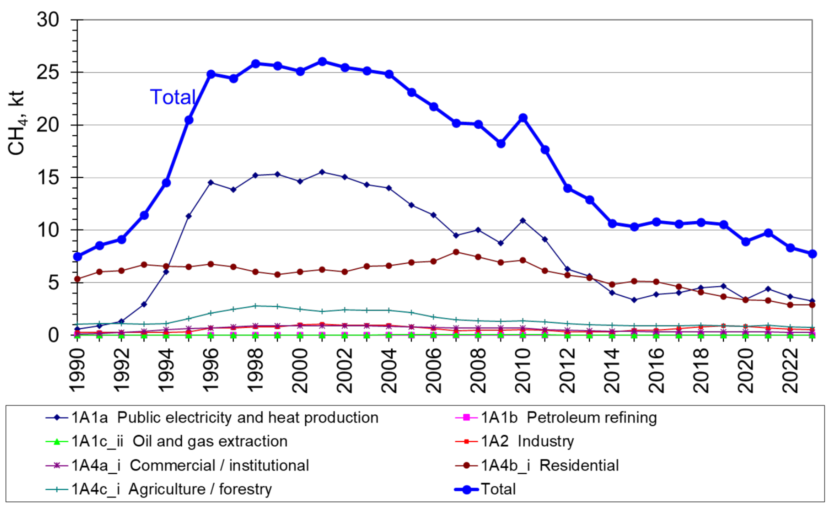


Figure 13 CH_4 emission time series for stationary combustion plants.

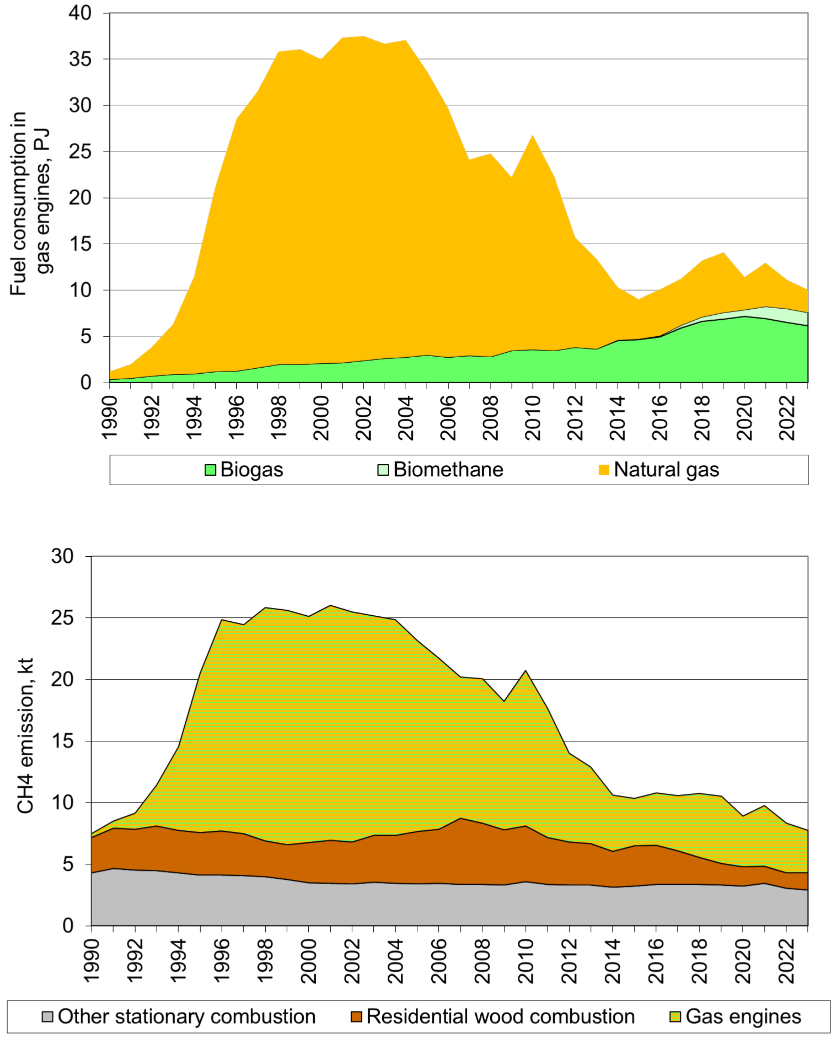


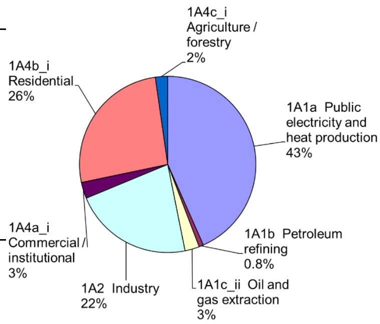
Figure 14 Time series for a) fuel consumption in gas engines and b) CH_4 emission from gas engines, residential wood combustion and other plants.

3.4 N_2O

The nitrous oxide (N_2O) emission from stationary combustion plants accounts for 3.2 % of the national N_2O emission. Table 10 lists the N_2O emission inventory for stationary combustion plants in the year 2023. Public electricity and heat production accounts for 43 % of the N_2O emission from stationary combustion.

Table 10 N_2O emission from stationary combustion plants, 2023[1)].

	N_2O, tonnes
1A1a Public electricity and heat production	230
1A1b Petroleum refining	4
1A1c Oil and gas extraction	14
1A2 Industry	116
1A4a Commercial/Institutional	16
1A4b Residential	138
1A4c Agriculture/Forestry	12
Total	531



1) Only emission from stationary combustion plants in the source categories is included.

Figure 15 shows the time series for N_2O emission. The N_2O emission from stationary combustion was 14 % lower in 2023 than in 1990, but again fluctuations in emission level due to electricity import/export are considerable. The large decrease between 2021 and 2022 is caused mainly by the lower consumption of wood pellets in residential plants and installation of a high temperature afterburner in an industrial plant.

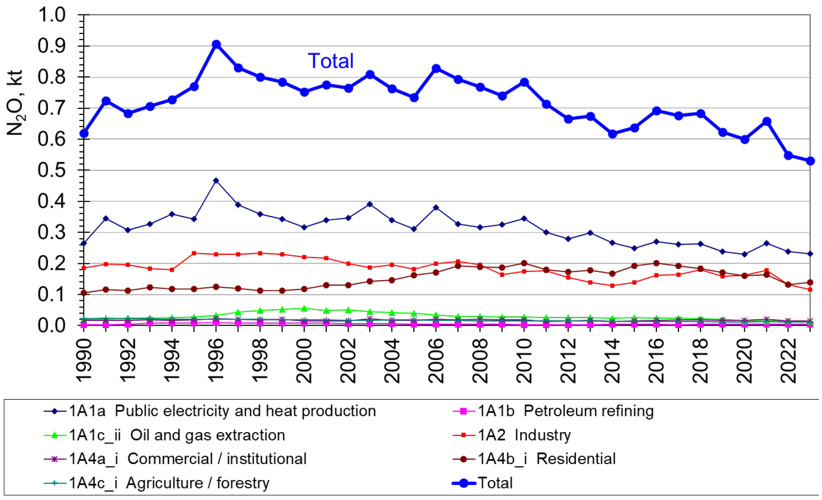


Figure 15 N_2O emission time series for stationary combustion plants.

4 Emissions of other pollutants

4.1 SO_2

Stationary combustion is the largest emission source for SO_2 accounting for 56 % of the national emission in 2023. Table 11 presents the SO_2 emission inventory for the stationary combustion subcategories.

The largest emission sources are Industry accounting for 24 % of the emission and Public electricity and heat production accounting for 46 % of the emission from stationary combustion.

The main emission sources for industrial plants are cement industry, food, beverages and tobacco industry (mainly from coal combustion), and other non-metallic minerals (mainly from mineral wool industry). Until year 2000, the SO_2 emission from the industrial category only accounted for a small part of the emission from stationary combustion, but due to reduced emissions from power plants, the share has now increased.

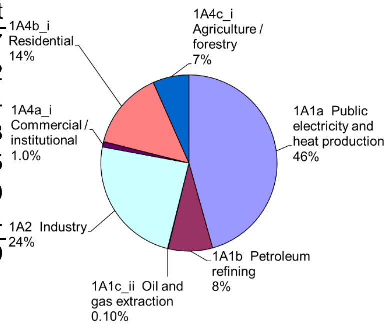
The main emission sources for Public electricity and heat production are large power plants, and combustion of straw and wood in district heating plants. Flue gas desulphurisation equipment is installed in large power plants. In the Danish inventory, the source category Public electricity and heat production 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 49 % and 24 % of the emission.

The time series for SO_2 emission from stationary combustion is shown in Figure 17. The SO_2 emission from stationary combustion plants has decreased by 97 % since 1990 and 99 % since 1980. 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. 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 2014.

Table 11 SO_2 emission from stationary combustion plants, 2023[1)].

		SO_2, t
1A1a	Public electricity and heat production	2087
1A1b	Petroleum refining	372
1A1c	Oil and gas extraction	4
1A2	Industry	1098
1A4a	Commercial/Institutional	45
1A4b	Residential	660
1A4c	Agriculture/Forestry	304
Total		4569



1) Only emission from stationary combustion plants in the source categories is included.

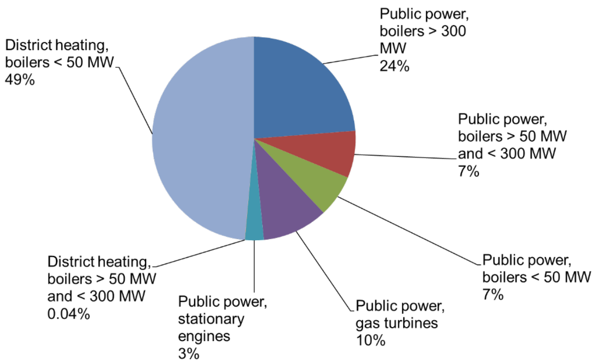


Figure 16 Disaggregated SO_2 emissions from 1A1a Public electricity and heat production.

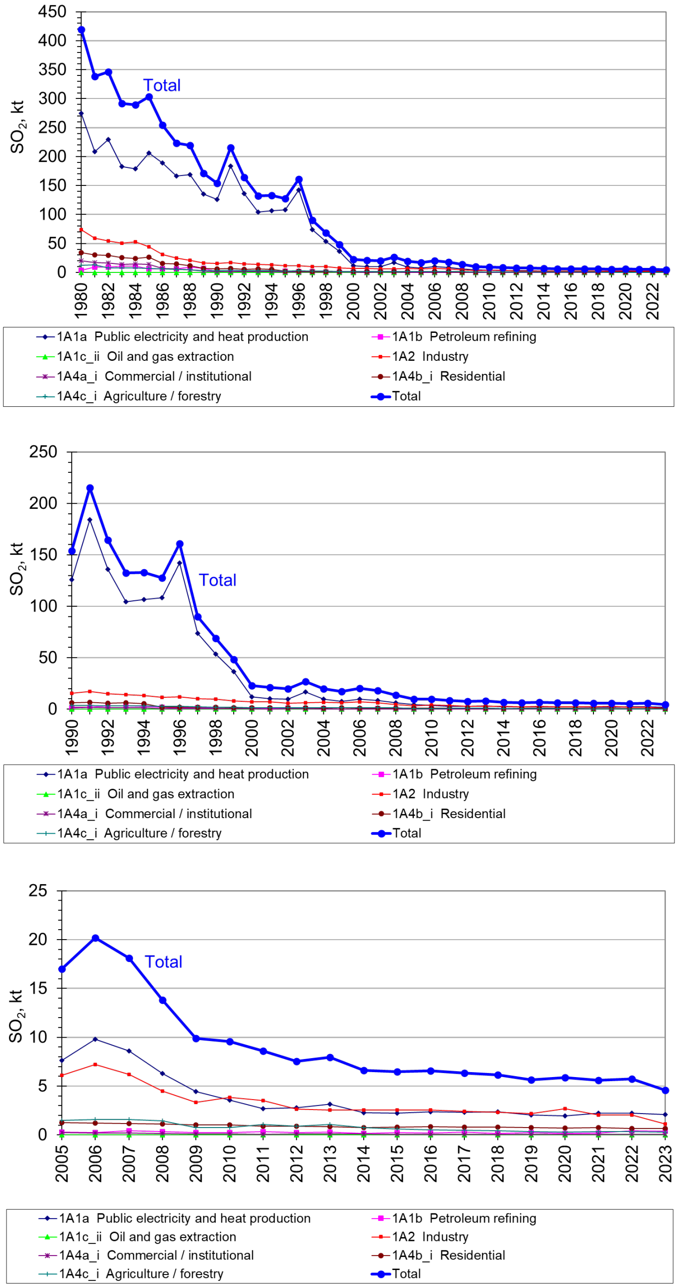


Figure 17 SO_2 emission time series for stationary combustion.

4.2 NO_x

Stationary combustion accounted for 29 % of the national NO_x emission in 2023. Table 12 shows the NO_x emission inventory for stationary combustion subcategories.

Public electricity and heat production is the largest emission source accounting for 42 % of the emission from stationary combustion plants. The emission from Public power boilers > 50 MW_{th} accounts for 39 % of the emission in this subcategory, and District heating < 50MW for 25 %.

Industrial combustion plants are also an important emission source accounting for 22 % of the emission. The main industrial emission source is cement production, which accounts for 46 % of the emission from industrial plants.

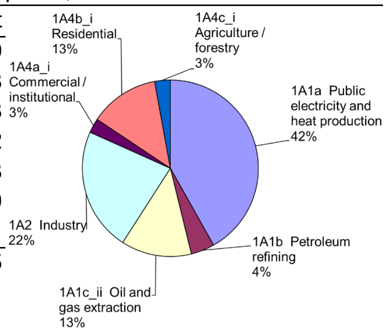
Residential plants account for 13 % of the NO_x emission. Oil and gas extraction, which is mainly offshore gas turbines accounts for 13 % of the NO_x emission.

Time series for NO_x emission from stationary combustion are shown in Figure 18. NO_x emission from stationary combustion plants has decreased by 80 % since 1990 and 84 % since 1985. 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 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 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 12 NO_x emission from stationary combustion plants, 2023[1].

		NO_x, t
1A1a	Public electricity and heat production	9749
1A1b	Petroleum refining	1008
1A1c	Oil and gas extraction	3018
1A2	Industry	5262
1A4a	Commercial/Institutional	618
1A4b	Residential	2980
1A4c	Agriculture/Forestry	671
Total		23305



[1] Only emission from stationary combustion plants in the source categories is included.

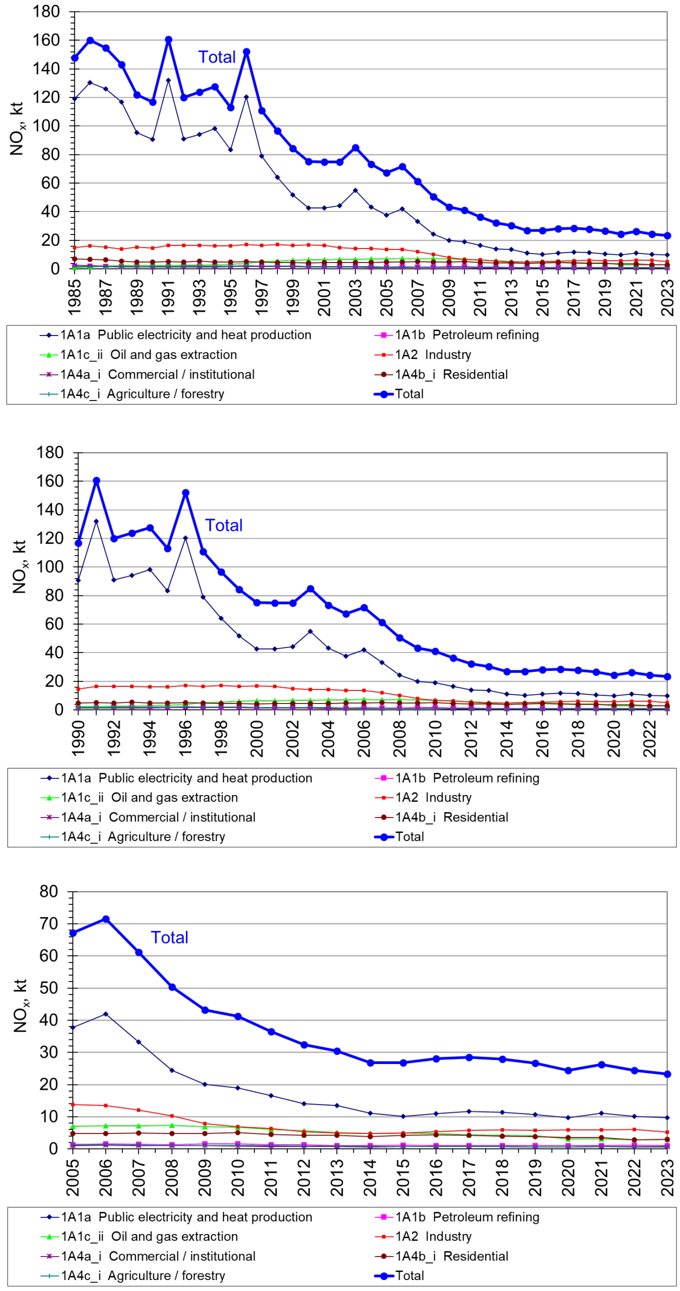


Figure 18 NO_x emission time series for stationary combustion.

4.3 NMVOC

Stationary combustion plants accounted for 10 % of the national NMVOC emission in 2023. Table 13 presents the NMVOC emission inventory for the stationary combustion subcategories.

Residential plants are the largest emission source accounting for 71 % 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 9 % 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 fuelled by natural gas, biomethane or biogas.

Agricultural plants accounted for 13 % of the emission in 2023. Combustion of straw was the main emission source in this category.

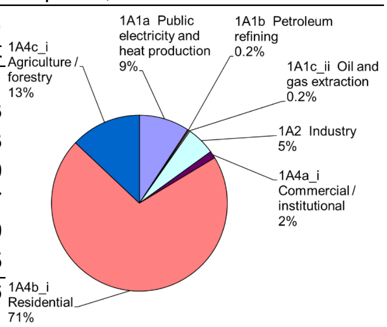
The time series for NMVOC emission from stationary combustion is shown in Figure 20. The emission has decreased by 44 % from 1990 and 50 % from 1985. The emission increased until 2007 and decreased after 2007. The increased emission is mainly a result of the increasing wood consumption in residential plants and of the increased use of lean-burn gas engines in CHP plants. The decrease after 2007 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 from residential plants has decreased 43 % since 1990. The NMVOC emission from residential wood combustion was 34 % lower in 2023 than in 1990. The consumption of wood in residential plants increased until 2007. However, 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 emission from straw combustion in farmhouse boilers has decreased over this period due to both a decreasing emission factor and decrease in straw consumption in this source category.

Table 13 NMVOC emissions from stationary combustion plants, 2023[1).]

	NMVOC, t
1A1a Public electricity and heat production	891
1A1b Petroleum refining	23
1A1c Oil and gas extraction	23
1A2 Industry	509
1A4a Commercial/Institutional	127
1A4b Residential	6789
1A4c Agriculture/Forestry	1245
Total	9606



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

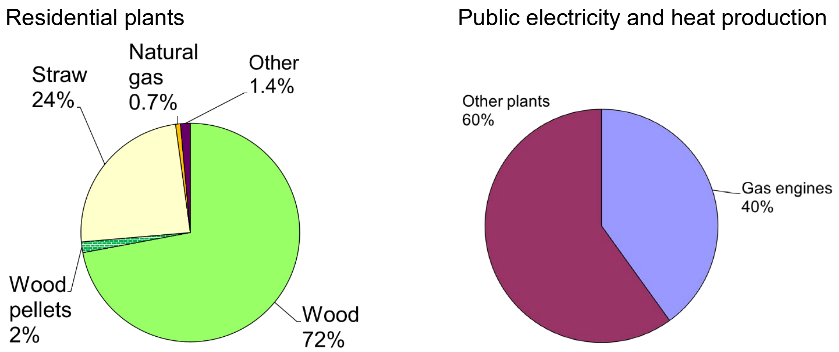


Figure 19 NMVOC emission from Residential plants and from Public electricity and heat production, 2023.

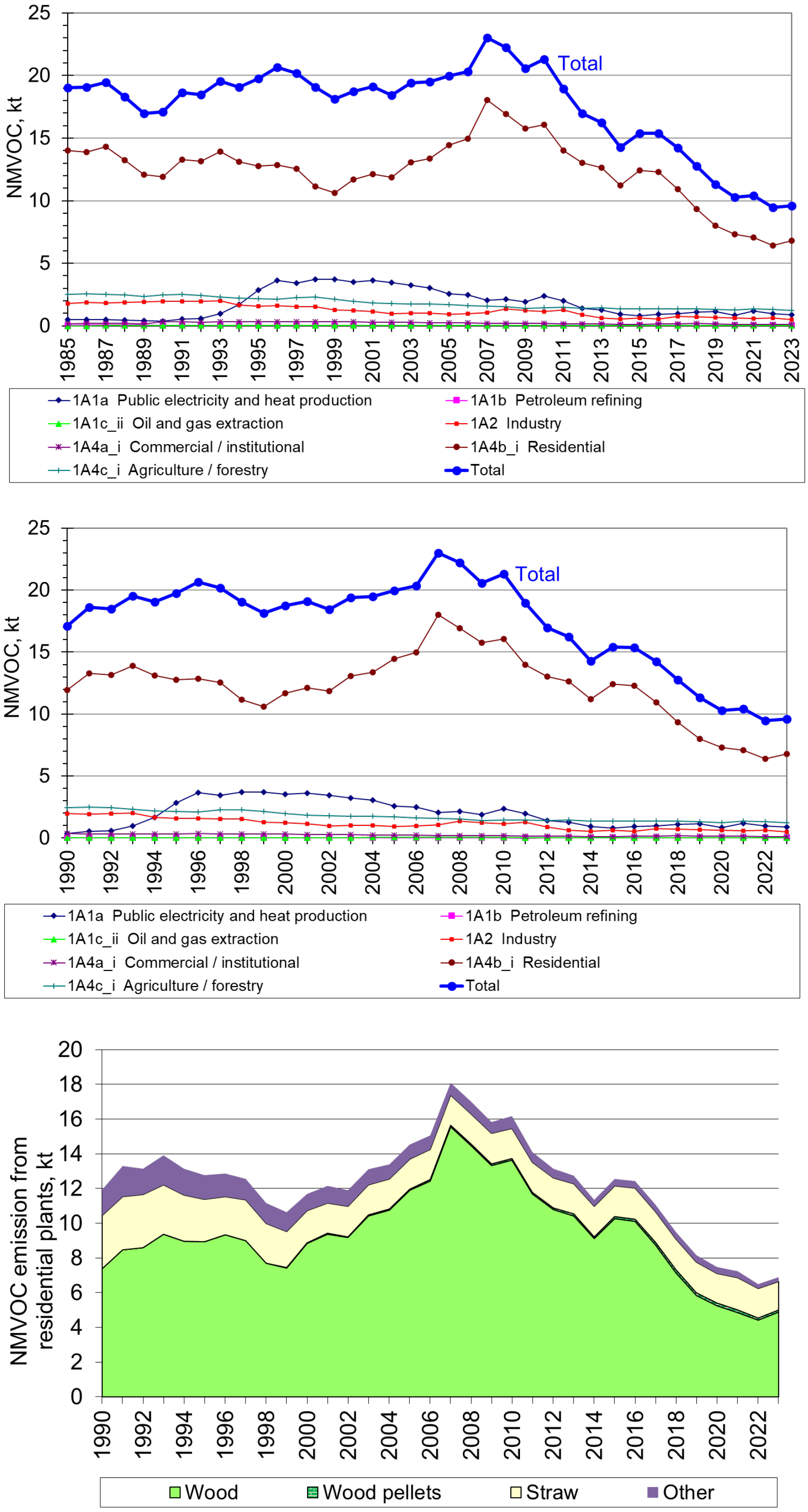


Figure 20 (a) NMVOC emission time series for stationary combustion and (b) Fuel specific emissions for residential plants.

4.4 CO

Stationary combustion accounts for 40 % of the national CO emission in 2023. Table 14 presents the CO emission inventory for stationary combustion subcategories.

Residential plants are the largest emission source, accounting for 66 % of the emission. Wood combustion accounted for 80 % of the emission from residential plants in 2023, see Figure 21. Combustion of straw and wood pellets are also a considerable emission sources, whereas the emission from other fuels used in residential plants is almost negligible.

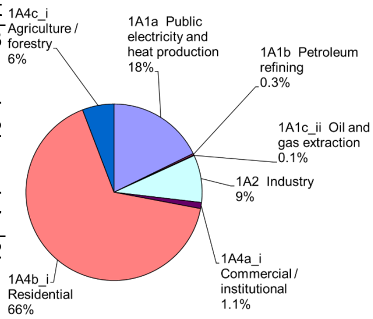
The time series for CO emission from stationary combustion is shown in Figure 22. The emission has decreased by 59 % from 1985 and 55 % from 1990. The time series for CO from stationary combustion plants follow the time series for CO emission from residential plants.

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 2007 was 3.1 times the 1990 level. In 2023, the consumption was 1.8 times the 1990 consumption level. The decreased CO-emission in 2007-2023 is mainly a result of implementation of improved residential wood combustion technologies and the fact that the rapid increase of wood consumption until 2007 have stopped.

For residential straw combustion, both consumption and the CO emission factor have decreased since 1990.

Table 14 CO emission from stationary combustion plants, 2023[1)].

	CO, t
1A1a Public electricity and heat production	12633
1A1b Petroleum refining	211
1A1c Oil and gas extraction	74
1A2 Industry	6172
1A4a Commercial/Institutional	791
1A4b Residential	47064
1A4c Agriculture/Forestry	4137
Total	71082



[1)] Only emission from stationary combustion plants in the source categories is included.

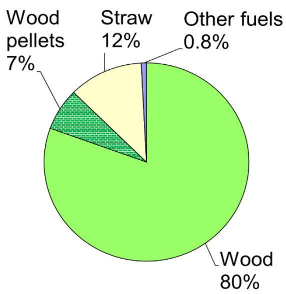


Figure 21 CO emission sources, Residential plants, 2023.

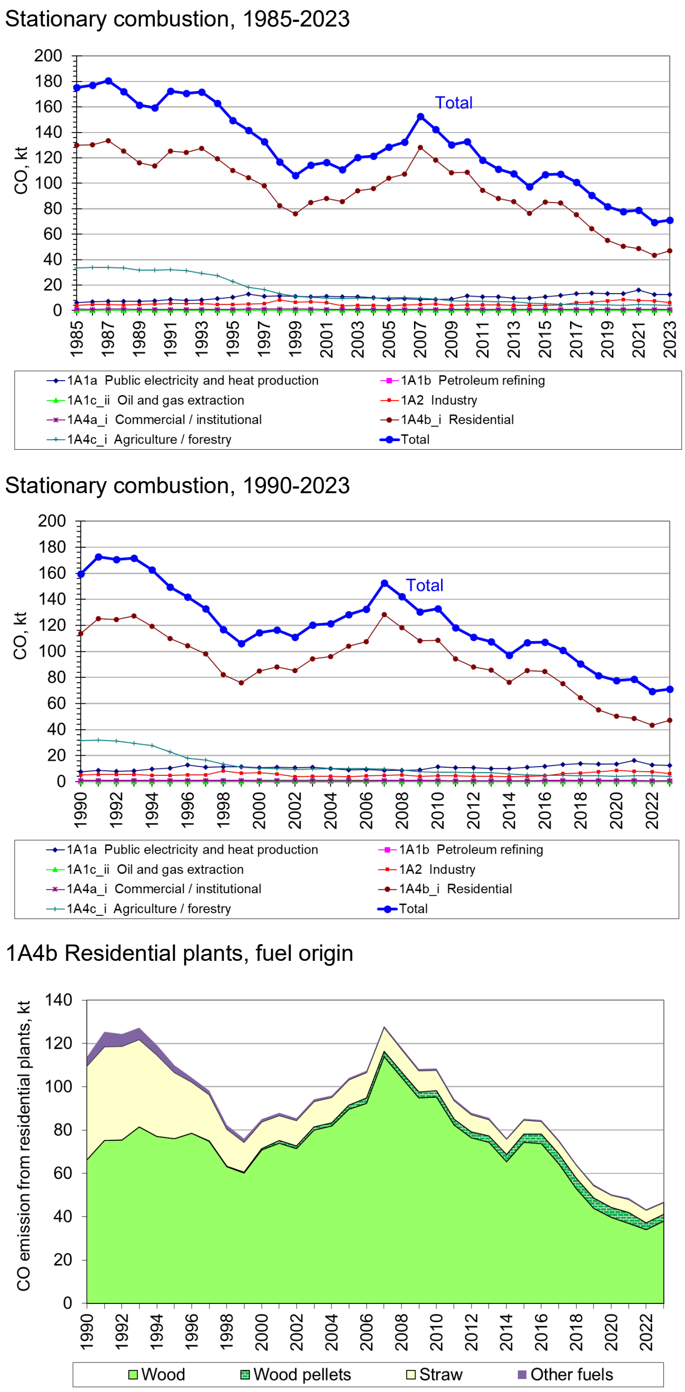


Figure 22 CO emission time series for stationary combustion.

4.5 NH_3

Stationary combustion plants accounted for 1.5 % of the national NH_3 emission in 2023.

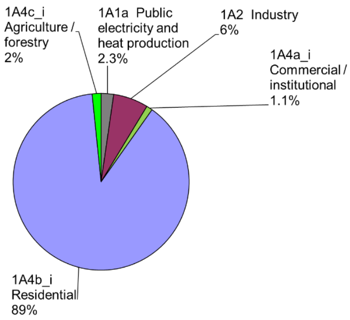
The NH_3 emission from non-residential plants is small and default emission factors are only available for biomass combustion in EEA Guidebook (EEA, 2023). However, based on national references, the NH_3 emission from waste incineration has been included in the Danish inventory.

Table 15 shows the NH_3 emission inventory for the stationary combustion subcategories. Residential plants account for 89 % of the emission. Wood combustion accounts for 82 % of the emission from residential plants, straw for 3 %, and wood pellets for 15 %.

The time series for NH_3 emission is presented in Figure 23. The NH_3 emission has increased 48 % from 1990. The time series reported 1985-1989 is not correct and will be improved in the 2026 reporting [11].

Table 15 NH_3 emission from stationary combustion plants, 2023[1)].

	NH_3, t
1A1a Public electricity and heat production	23
1A1b Petroleum refining	-
1A1c Oil and gas extraction	-
1A2 Industry	63
1A4a Commercial/Institutional	11
1A4b Residential	873
1A4c Agriculture/Forestry	16
Total	986



1) Only the emission from stationary combustion plants in the source categories is included.

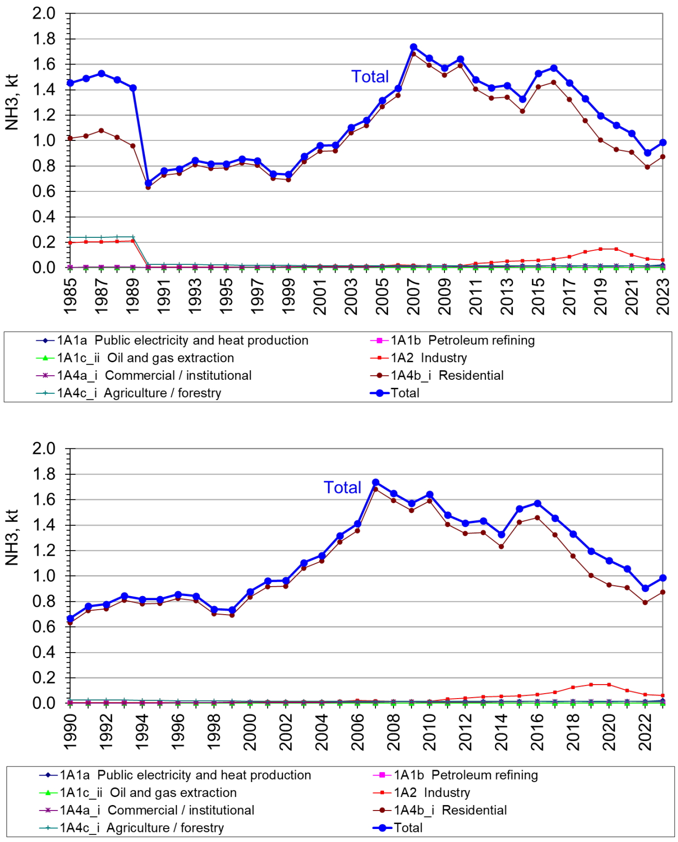


Figure 23 NH_3 emission time series, stationary combustion plants[11].

[11] The high emission illustrated in in the figure for 1985-1989 is caused by incorrect emission factors for straw applied in agricultural / residential plants and for wood applied in small non-residential plants. The emission factors will be corrected in the 2026 reporting.

4.6 Particulate matter (PM)

TSP from stationary combustion accounted for 9 % of the national emission in 2023. The emission shares for PM_{10} and $PM_{2.5}$ are 34 % and 63 %, respectively.

PM emission data include condensable particles if data references including condensable are available.

Table 16 and Figure 24 show the PM emission inventory for the stationary combustion subcategories. Residential plants is the largest emission source accounting for 80 % 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
- Residential plants combusting wood pellets
- Wood combusted in district heating plants

The PM emission from wood combusted in residential plants is the predominant source. Thus, 58 % of the $PM_{2.5}$ emission from stationary combustion is emitted from residential wood combustion. This corresponds to 35 % of the national emission.

Figure 25 shows the fuel consumption and the $PM_{2.5}$ emission of residential plants. Wood combustion accounts for 70 % of the $PM_{2.5}$ emission from residential plants, wood pellets for 9 % and straw for 21 %.

Emission inventories for PM are reported for the years 1990-2023. The time series for PM emission from stationary combustion is shown in Figure 26. The time series for PM emission from stationary combustion plants follows the time series for PM emission from residential plants. The emissions of TSP, PM_{10} and $PM_{2.5}$ was 38 %, 41 % and 40 %, respectively, lower in 2023 than in 1990.

The PM emissions increased until 2007 and decreased after 2007. 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 after 2007 and decreased emission factor for residential wood combustion has resulted in a decrease of PM emission from stationary combustion after 2007.

Table 16 PM emission from stationary combustion plants, 2023[1)].

		TSP, t	PM_{10}, t	$PM_{2.5}$, t
1A1a	Public electricity and heat production	553	404	326
1A1b	Petroleum refining	76	76	76
1A1c	Oil and gas extraction	4	3	3
1A2	Industry	185	136	96
1A4a	Commercial/Institutional	75	71	68
1A4b	Residential	6015	5770	5675
1A4c	Agriculture/Forestry	849	848	846
Total		7757	7307	7091

[1)] Only emission from stationary combustion plants in the source categories is included.

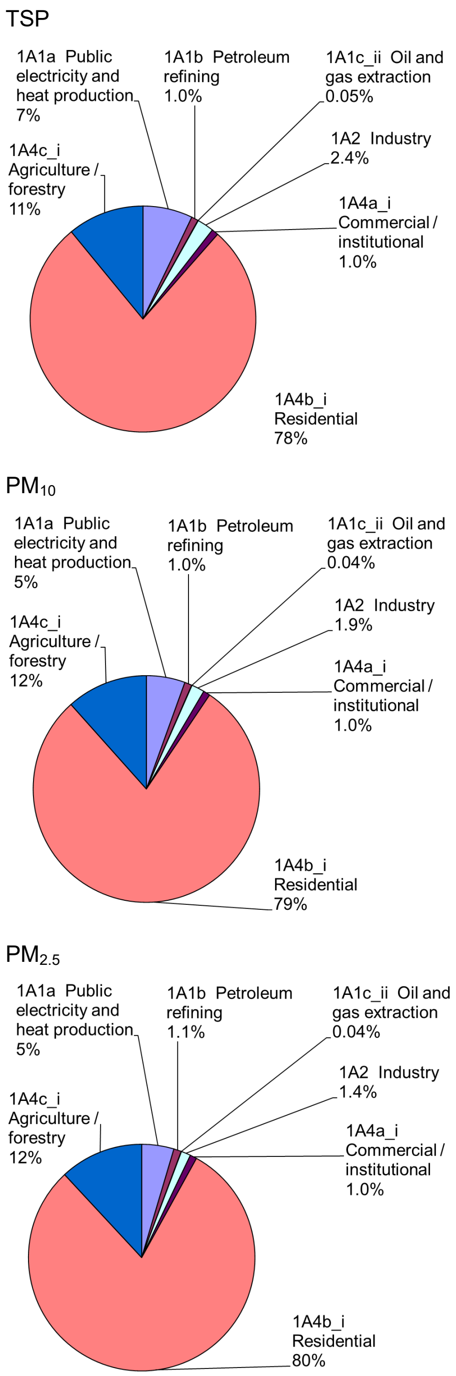


Figure 24 PM emission sources, stationary combustion plants, 2023.

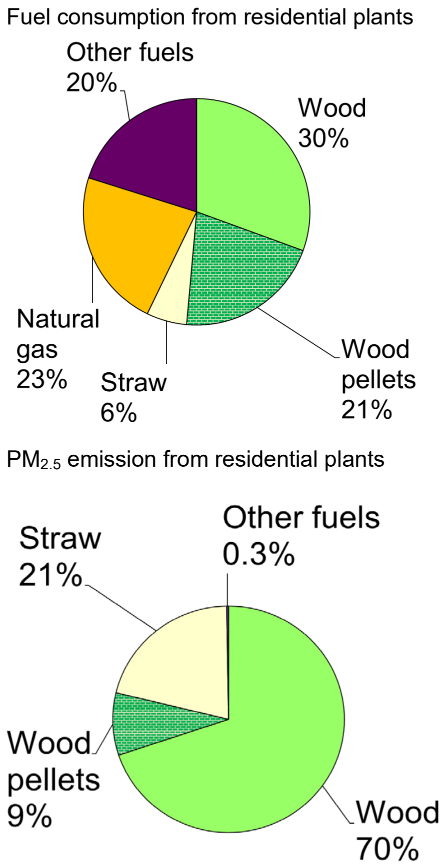


Figure 25 Fuel consumption and $PM_{2.5}$ emission from residential plants.

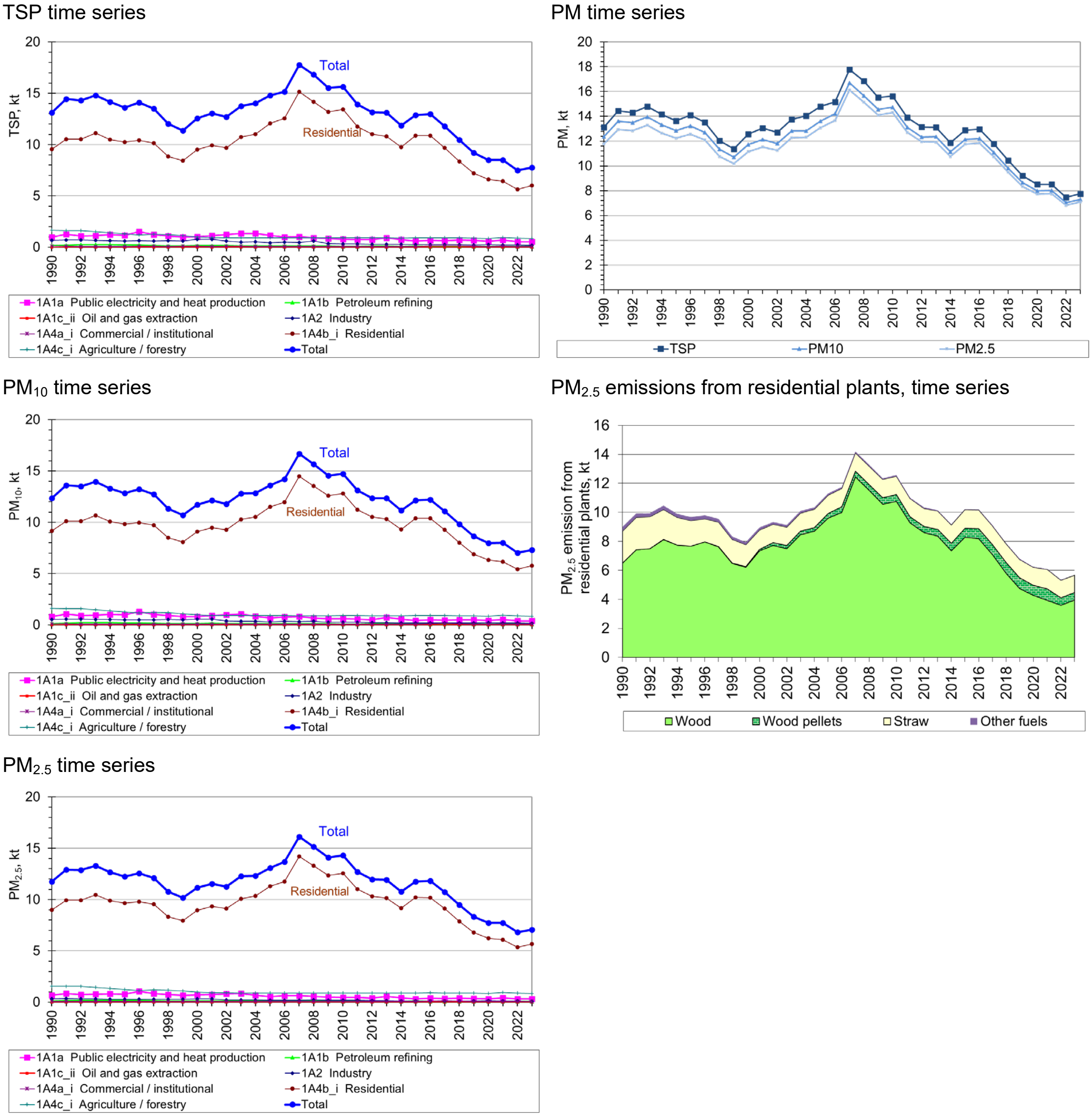


Figure 26 PM emission time series for stationary combustion.

4.7 Black carbon (BC)

Black carbon (BC) from stationary combustion accounted for 64 % of the national emission in 2023. Residential combustion is the main emission source accounting for 70 % of the emission from stationary combustion. Plants in Agriculture/forestry account for 24 % of the emission.

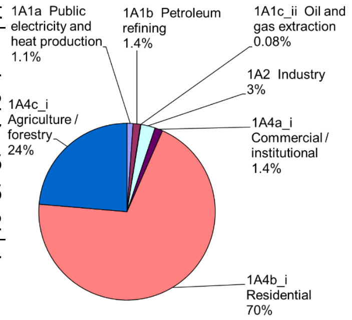
Combustion of straw, wood and wood pellets are the main emission sources for residential plants accounting for 47 %, 43 %, and 11 %, respectively.

Table 17 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 in 2023 was 27 % lower than in 1990.

Table 17 BC emission from stationary combustion plants, 2023[1)].

	BC, t
1A1a Public electricity and heat production	11
1A1b Petroleum refining	14
1A1c Oil and gas extraction	0.82
1A2 Industry	27
1A4a Commercial/Institutional	15
1A4b Residential	715
1A4c Agriculture/Forestry	242
Total	1024



[1)] Only emission from stationary combustion plants in the source categories is included.

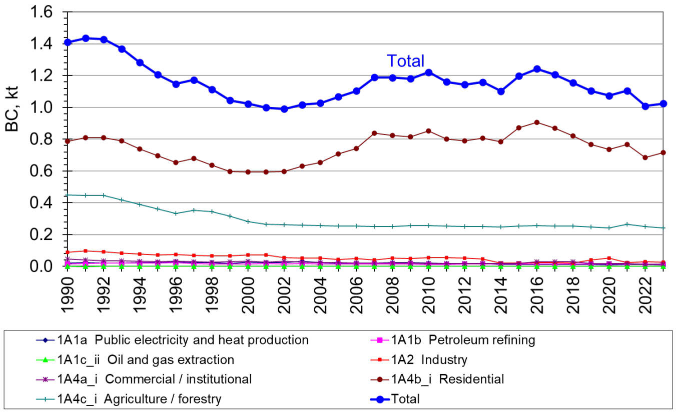


Figure 27 BC emission time series for stationary combustion.

4.8 Heavy metals

Stationary combustion plants are among the most important emission sources for heavy metals. The emission share for stationary combustion compared to national total is shown for each metal in Table 18.

Table 18 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 18 Heavy metal emission from stationary combustion plants, 2023[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	40	31	147	133	96	209	305	239	270
1A1b Petroleum refining	5	33	101	50	6	111	24	23	256
1A1c Oil and gas extraction	2	0	0	0	1	0	0	0	0
1A2 Industry	54	19	50	60	43	415	205	45	511
1A4a Commercial/Institutional	1	1	3	4	2	3	4	1	9
1A4b Residential	8	384	679	178	19	59	797	15	15110
1A4c Agriculture/Forestry	1	26	48	14	2	6	64	3	1034
Total	111	493	1029	438	170	802	1399	327	17190
Emission share from stationary combustion	54%	83%	44%	0.7%	80%	20%	11%	72%	30%

[1)] Only emission from stationary combustion plants in the source categories is included.

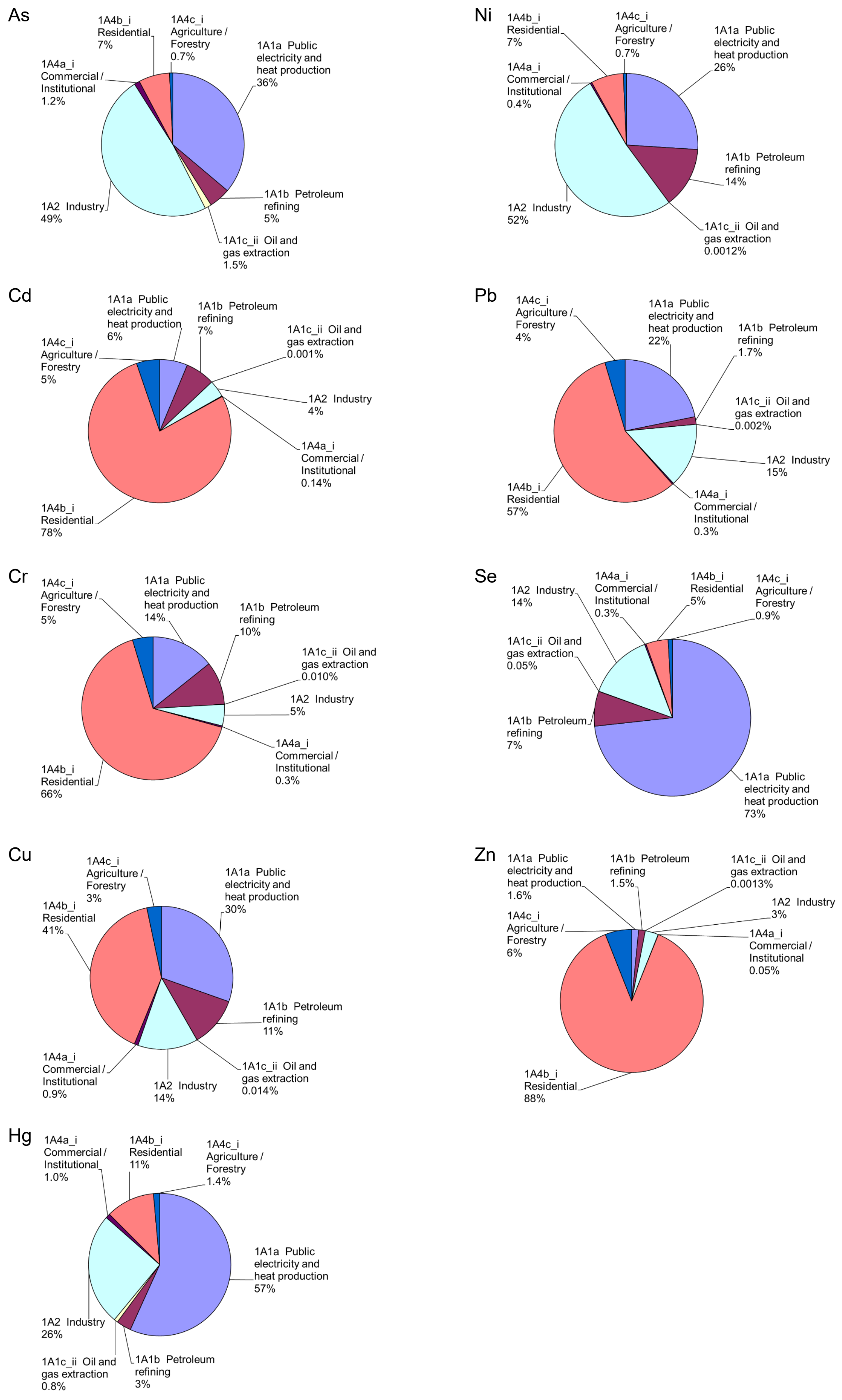


Figure 28 Heavy metal emission sources, stationary combustion plants, 2023.

The time series for heavy metal emissions are provided in Figure 29. Emissions of all heavy metals have decreased considerably (45 % - 94 %) since 1990, see Table 19. 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. The Zn and Cd emissions decrease only 45 % and 54 %, respectively. The smaller decrease compared to other HMs is due to a relatively high emission share from residential wood combustion even in 1990.

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 19 Decrease in heavy metal emission 1990-2023.

Pollutant	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
Decrease since 1990, %	90	54	82	88	94	94	91	92	45

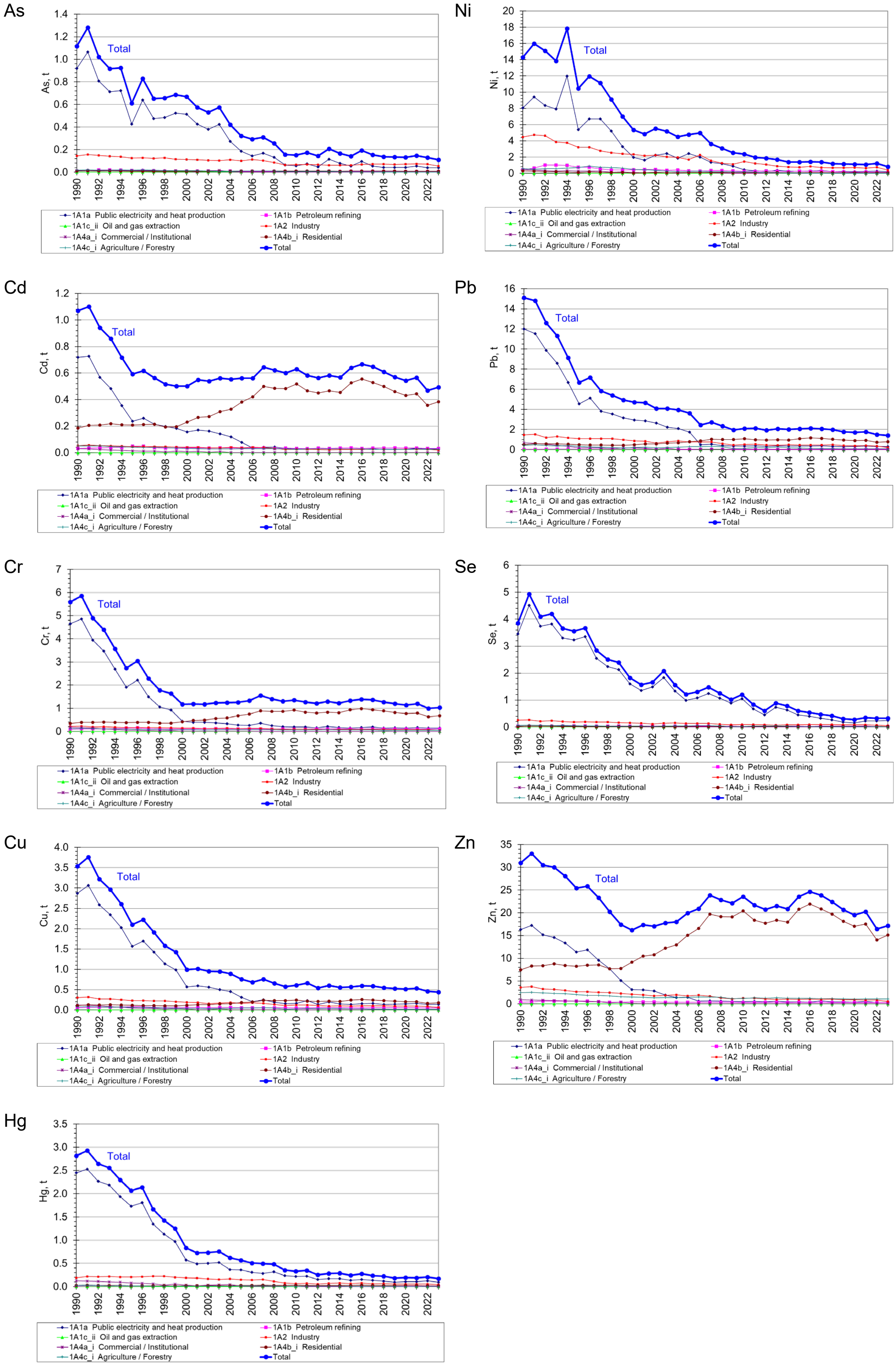


Figure 29 Heavy metal emission time series, stationary combustion plants.

4.9 Polycyclic aromatic hydrocarbons (PAH)

Stationary combustion plants accounted for more than 78 % of the PAH emission in 2023.

Table 20 and Figure 30 present the PAH emission inventories for the stationary combustion subcategories. Residential combustion is the largest emission source accounting for more than 80 % of the emission. Combustion of wood is the predominant source, accounting for more than 94 % of the PAH emission from residential plants, see Figure 31.

The time series for PAH emissions are presented in Figure 32. The time series for wood combustion in residential plants is also provided in Figure 32. The wood combustion in residential plants has increased whereas the emission factors have decreased due to installation of new residential wood combustion units. The consumption of wood applied in residential plants has decreased in 2016-2023.

Table 20 PAH emission from stationary combustion plants, 2023[1)].

	Benzo(a)-pyrene, kg	Benzo(b)-fluoranthene, kg	Benzo(k)-fluoranthene, kg	Indeno (1,2,3-c,d) pyrene, kg
1A1a Public electricity and heat production	12	46	30	8.7
1A1b Petroleum refining	0.02	0.08	0.02	0.03
1A1c Oil and gas extraction	0.07	0.24	0.07	0.13
1A2 Industry	0.9	9	10	4
1A4a Commercial/Institutional	63	83	28	45
1A4b Residential	1035	1035	584	574
1A4c Agriculture/Forestry	72	84	32	47
Total	1183	1258	684	679
Emission share from stationary combustion	88%	85%	81%	79%

1) Only emission from stationary combustion plants in the source categories is included.

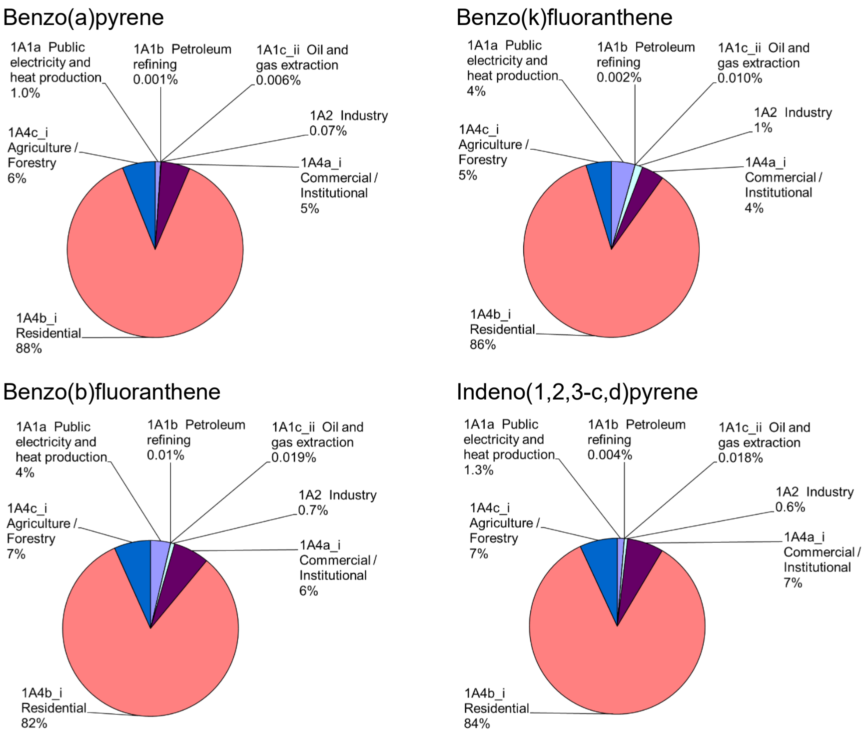


Figure 30 PAH emission sources, stationary combustion plants, 2023.

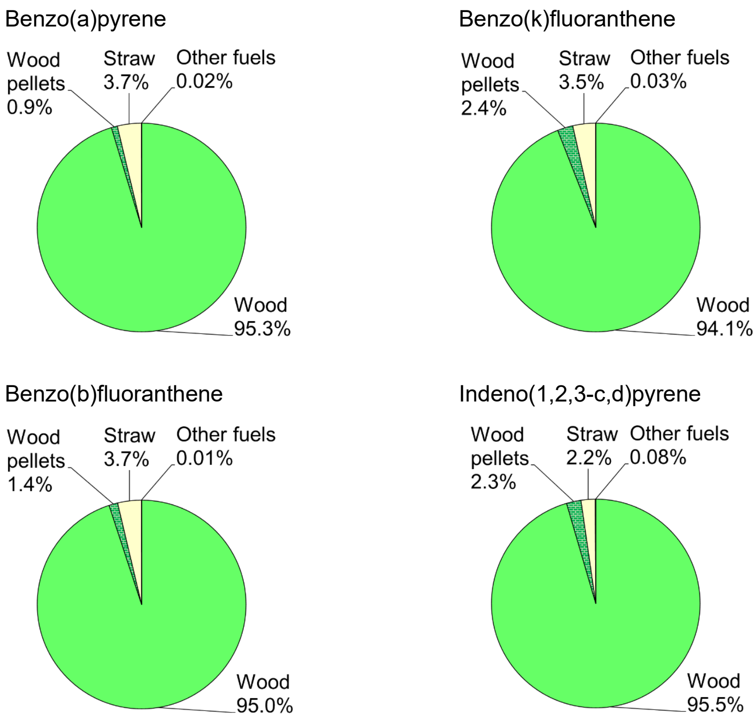


Figure 31 PAH emission from residential combustion plants (stationary), fuel origin.

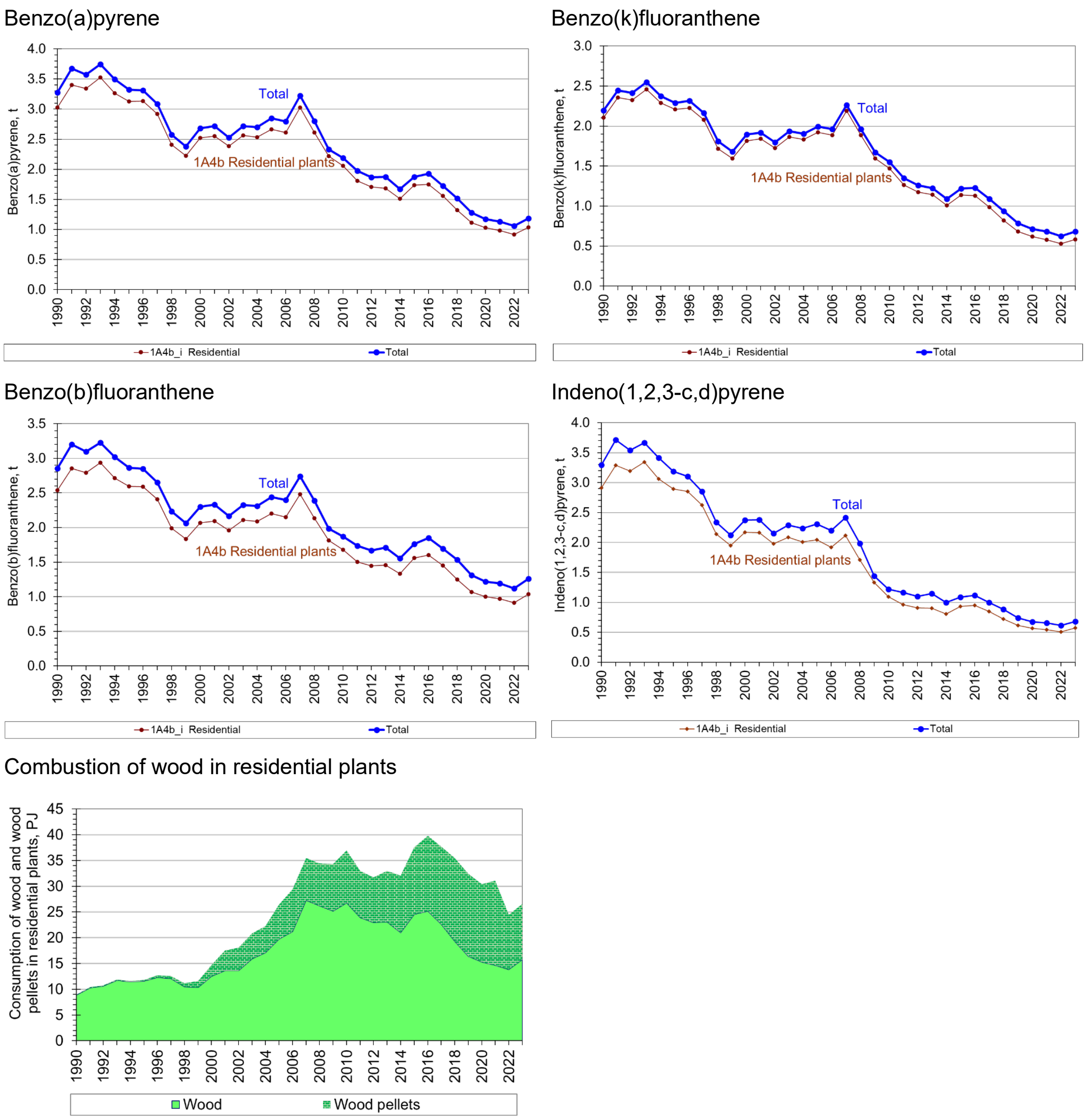


Figure 32 PAH emission time series, stationary combustion plants. Comparison with wood consumption in residential plants.

4.10 Polychlorinated dibenzodioxins and -furans (PCDD/F)

Stationary combustion plants accounted for 81 % of the national emission of polyclorinated dibenzodioxins and –furans (PCDD/F) in 2023.

Table 21 presents the PCDD/F emission inventories for the stationary combustion subcategories. In 2023, the emission from residential plants accounted for 85 % of the emission. Combustion of wood and wood pellets are the predominant sources accounting for 70 % and 21 % of the emission from residential plants (Figure 33).

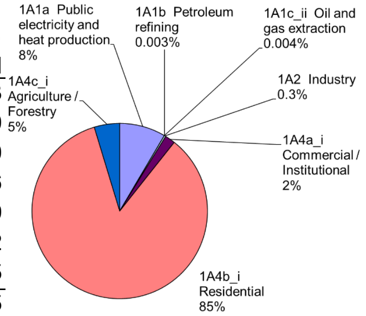
The time series for PCDD/F emission is presented in Figure 34. The PCDD/F emission has decreased 57 % since 1990 mainly due to installation of dioxin filters in waste incineration plants.

The emission from residential plants has increased due to increased wood consumption in this source category. However, both wood consumption and emission of PCDD/F have decreased since 2016 for residential plants.

The dioxin emission factors for residential wood combustion are dependent on the wood origin but independent of stove technology (Chapter 6.13). Thus, the dioxin emission from residential wood combustion has not decreased similar to e.g. the PM and PAH emissions due to implementation of new improved stoves and boilers.

Table 21 PCDD/F emission from stationary combustion plants, 2023[1).]

	PCDD/F, g I-teq
1A1a Public electricity and heat production	1.73
1A1b Petroleum refining	0.00
1A1c Oil and gas extraction	0.00
1A2 Industry	0.06
1A4a Commercial/Institutional	0.39
1A4b Residential	17.22
1A4c Agriculture/Forestry	0.95
Total	20.35



[1)] Only emission from stationary combustion plants in the source categories is included.

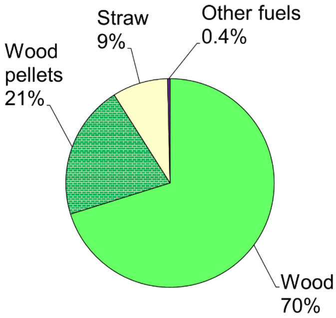
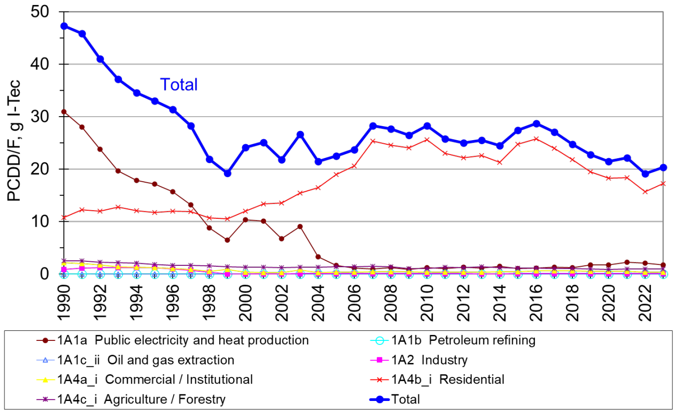
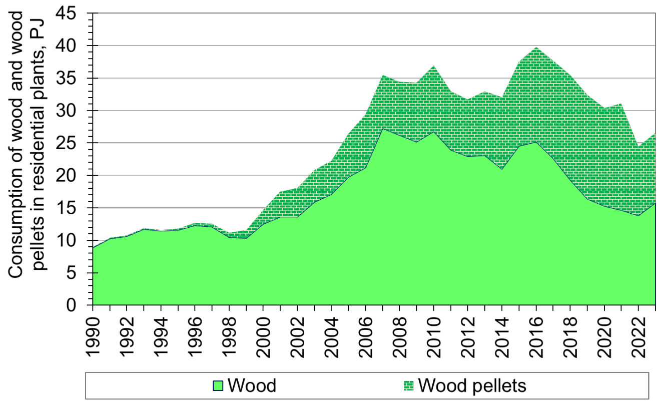


Figure 33 PCDD/F emission from residential plants, fuel origin.



Combustion of wood in residential plants



Time series for residential PCDD/F-emission

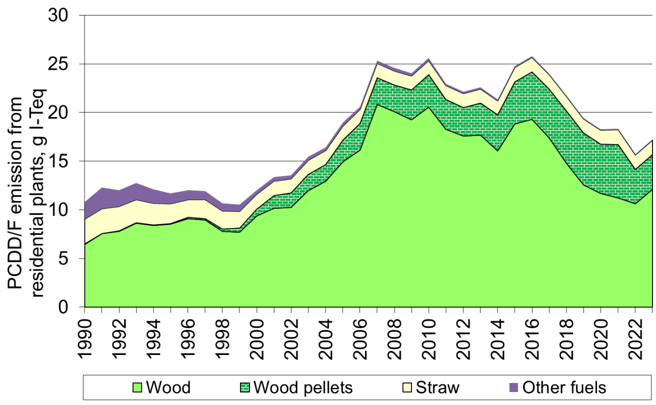


Figure 34 PCDD/F emission time series, stationary combustion plants.

4.11 Hexachlorobenzene (HCB)

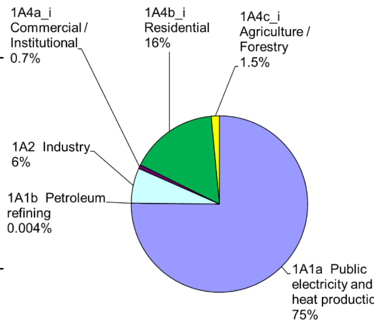
Stationary plants accounted for 44 % of the estimated national emission of hexachlorobenzene (HCB) in 2023.

Table 22 shows the HCB emission inventory for the stationary combustion subcategories. Public electricity and heat production account for 75 % of the emission. Residential plants account for 16 % of the emission.

The time series for HCB emission is presented in Figure 35. The HCB emission has decreased 84 % 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 22 HCB emission from stationary combustion plants, 2023[1)].

	HCB, kg
1A1a Public electricity and heat production	0.689
1A1b Petroleum refining	0.00004
1A1c Oil and gas extraction	0.0001
1A2 Industry	0.059
1A4a Commercial/Institutional	0.007
1A4b Residential	0.148
1A4c Agriculture/Forestry	0.014
Total	0.917



1) Only the emission from stationary combustion plants in the source categories is included.

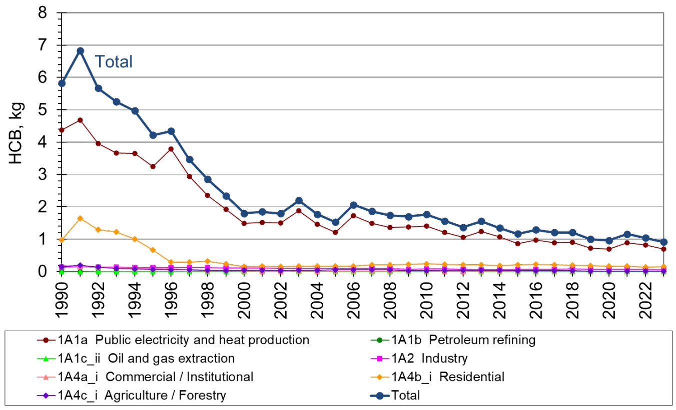


Figure 35 HCB emission time series, stationary combustion plants.

4.12 Polychlorinated biphenyls (PCB)

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% [12].

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

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

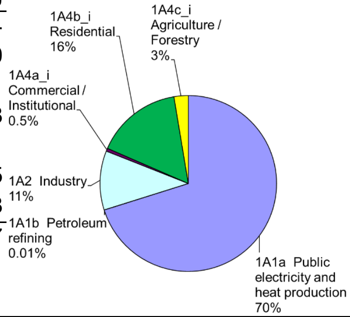
Stationary plants accounted for 77 % of the estimated national PCB emission in 2023.

Table 23 shows the dl-PCB emission inventory for the stationary combustion subcategories. Public electricity and heat production accounted for 70 % of the emission in 2023. Residential plants accounted for 16 % of the emission.

The time series for dl-PCB emission is presented in Figure 36. The dl-PCB emission has decreased 74 % 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 23 PCB emission from stationary combustion plants, 2023[1)].

	PCB, kg
1A1a Public electricity and heat production	0.224
1A1b Petroleum refining	0.00020
1A1c Oil and gas extraction	0.00001
1A2 Industry	0.038
1A4a Commercial/Institutional	0.001
1A4b Residential	0.045
1A4c Agriculture/Forestry	0.008
Total	0.317



[1)] Only the emission from stationary combustion plants in the source categories is included.

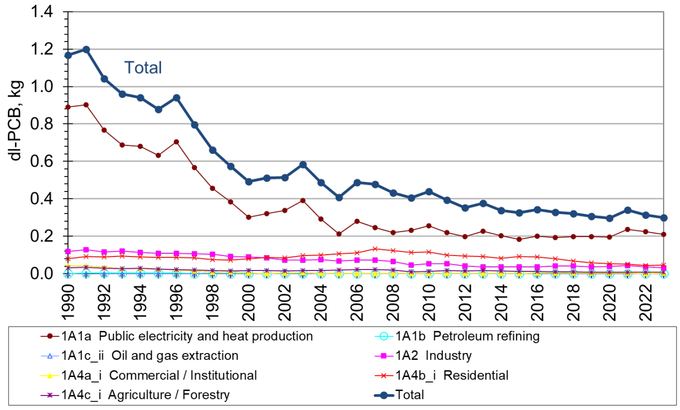


Figure 36 PCB emission time series, stationary combustion plants.

5 Trend for subsectors

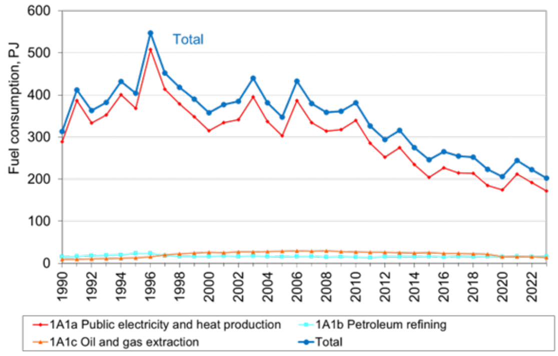
In addition to the data for stationary combustion, this chapter presents and discusses data for each of the subcategories in which stationary combustion is included. Time series are presented for fuel consumption and emissions.

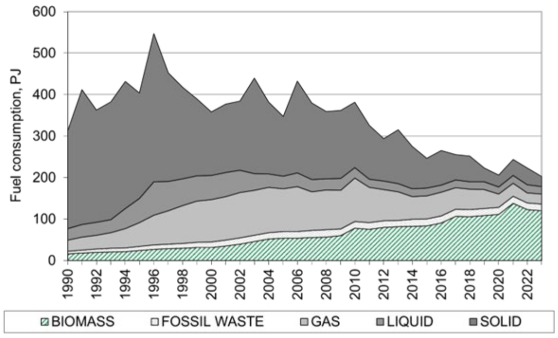
5.1 1A1 Energy industries

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

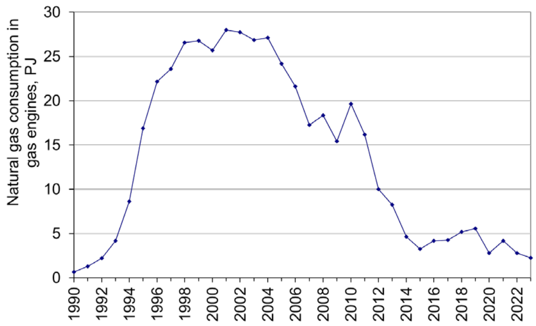
- 1A1a Public electricity and heat production
- 1A1b Petroleum refining
- 1A1c Oil and gas extraction

Figure 37-42 present time series for 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.

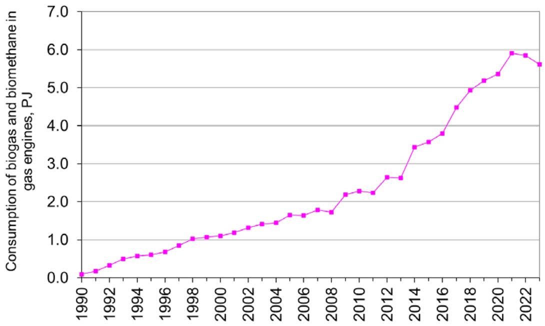




Natural gas fuelled engines



Biogas fuelled engines (biogas, bio gasification gas and biomethane)



Residual oil in petroleum refining

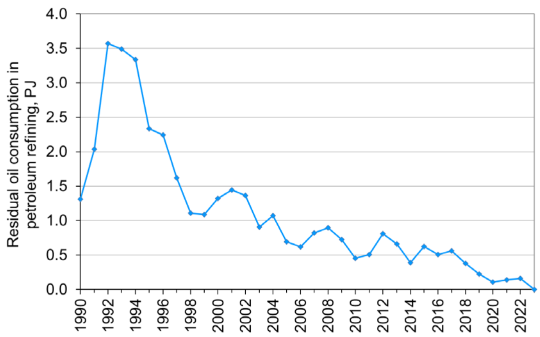


Figure 37 Time series for fuel consumption, 1A1 Energy industries.

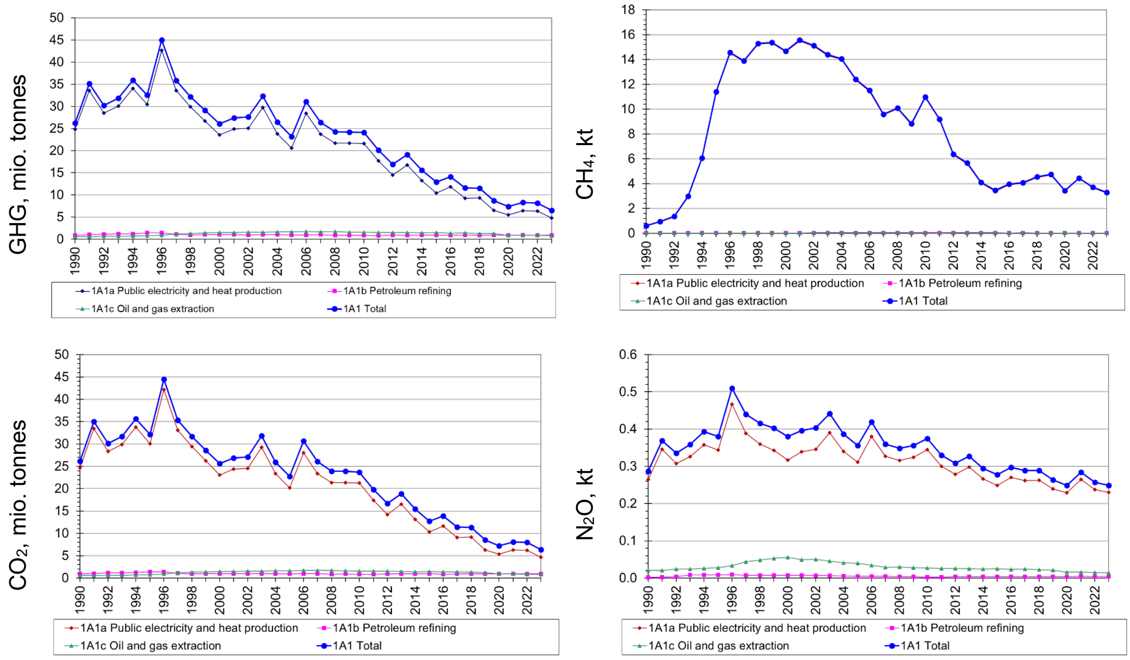


Figure 38 Time series for greenhouse gas emissions, 1A1 Energy industries.

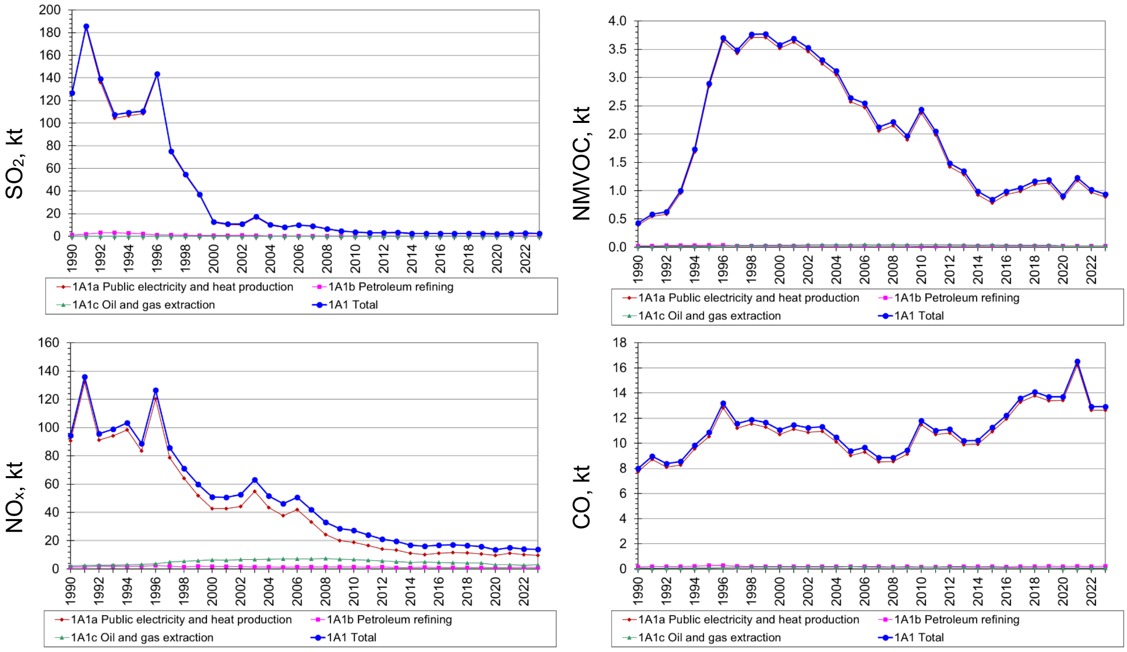


Figure 39 Time series for emission of SO_2, NO_x, NMVOCs and CO, 1A1 Energy industries.

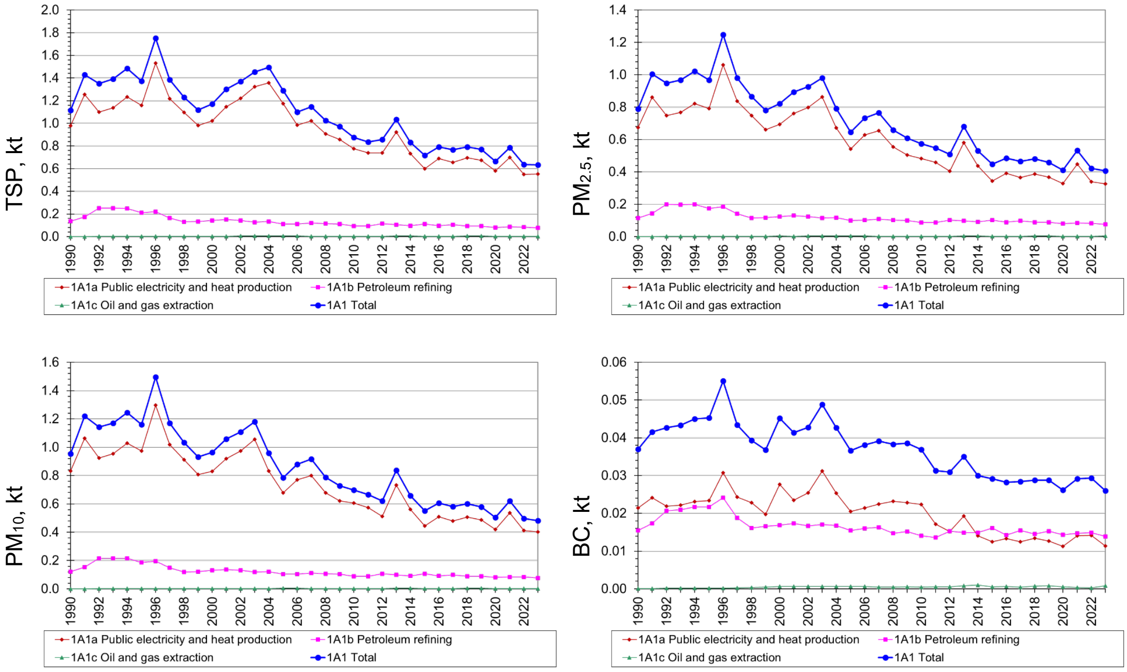


Figure 40   Time series for PM and BC emission, 1A1 Energy industries.

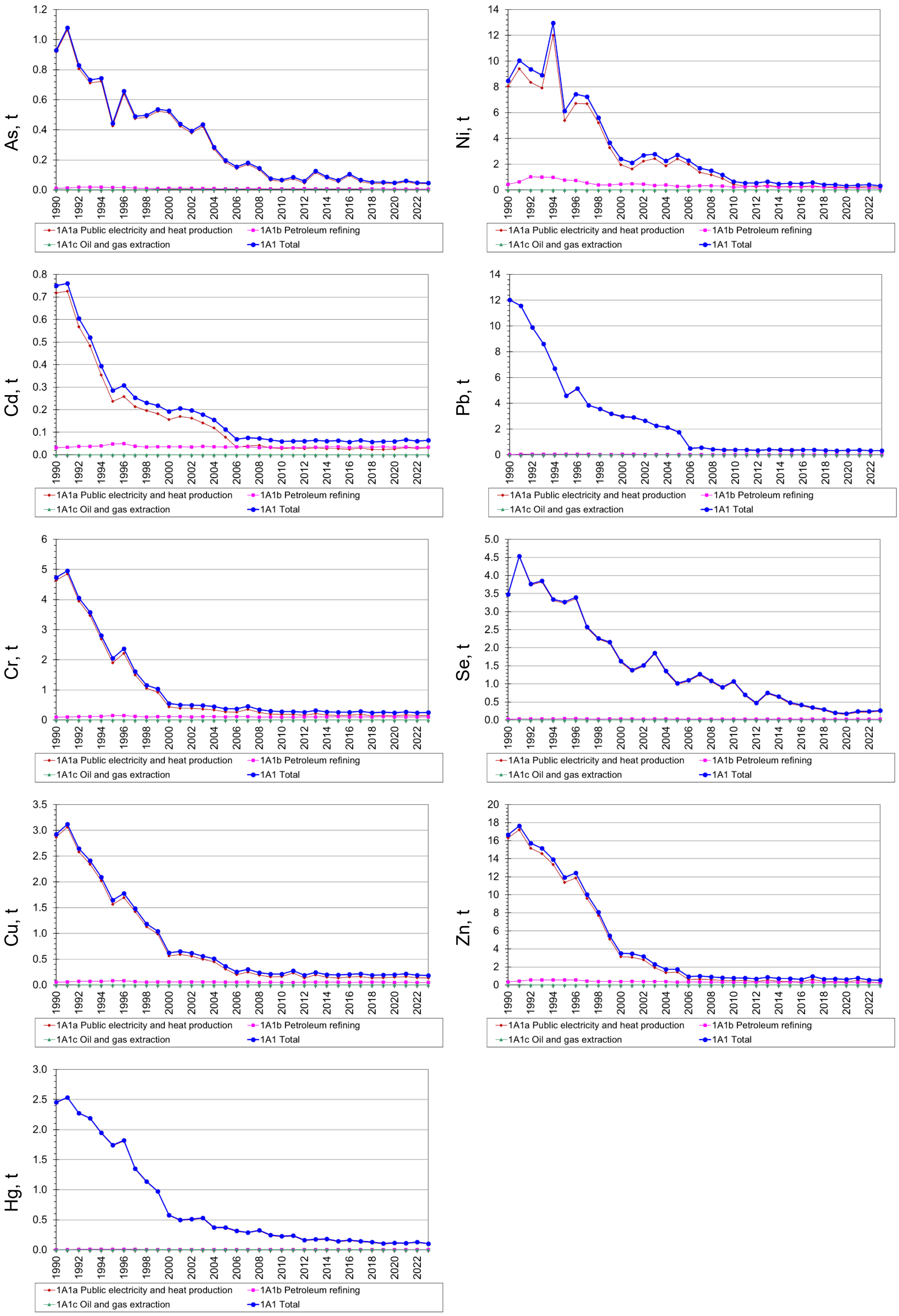


Figure 41 Time series for HM emissions, 1A1 Energy industries.

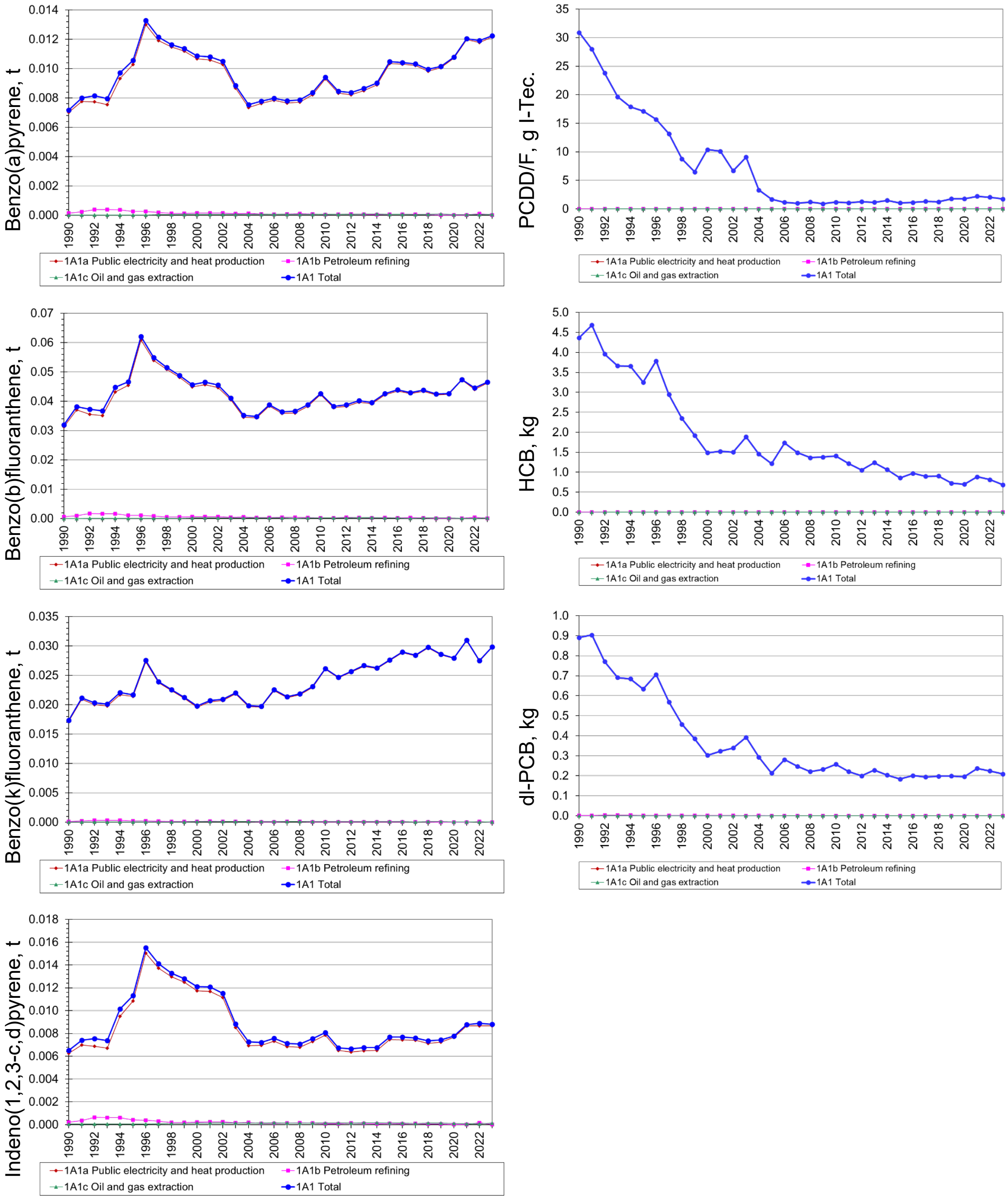


Figure 42 Time series for emission of PAH, PCDD/Fs, HCB, and dl-PCBs, 1A1 Energy industries.

5.1.1 1A1a Public 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 and Figure 44 show the time series for fuel consumption and emissions.

The fuel consumption in public electricity and heat production was 41 % lower in 2023 than in 1990. In addition to fuel type changes, the total fuel consumption is also influenced by the fact that the Danish wind and solar power production has increased.

The fuel consumption has decreased from 2022 to 2023 partly due to a higher electricity import in 2023. The electricity production based on wind turbines and solar power plants have increased whereas the production based on fuels have decreased (DEA, 2024e). The production of district heating has increased, but this increase is partly based on biomass and solar heating.

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 was the main fuel in the source category in the 1990s, but the consumption has been decreasing in later years. The coal consumption in 2023 was only 10 % of the 1990 consumption in this sector. The consumption of natural gas increased in 1990-2000 but has decreased since 2010. A considerable part of the natural gas was combusted in gas engines (Figure 37). The consumption of wood, wood pellets and waste has increased.

The CO_2 emission was 81 % lower in 2023 than in 1990. This decrease – in spite of only a 41 % decrease in fuel consumption - is a result of the change of fuel types used.

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 resulted in fewer profitable operational hours each year for the gas engines (Figure 37). The CH_4 emission in 2023 was 5.6 times the 1990 emission level.

The N_2O emission in 2023 was 13 % lower than the emission in 1990. The emission fluctuates similar to the fuel consumption.

The SO_2 emission has decreased 98 % from 1990 to 2023. This decrease is a result of both lower sulphur content in fuels and installation and improved performance of desulphurisation plants. The emission was 6 % lower in 2023 than in 2022.

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 4 % lower in 2023 than in 2022.

The emission of NMVOC in 2023 was 2.3 times the emission 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 after 2004 is results of the decreasing fuel consumption for natural gas engines (Figure 37). In addition, the NMVOC emission factor for engines decreased in 1995-2007 due to introduction of an emission limits for unburned hydrocarbon[13] (DEPA, 2005).

The CO emission in 2023 was 63 % higher than in 1990. The fluctuations follow the fluctuations of the fuel consumption. In addition, the emission from gas engines is considerable.

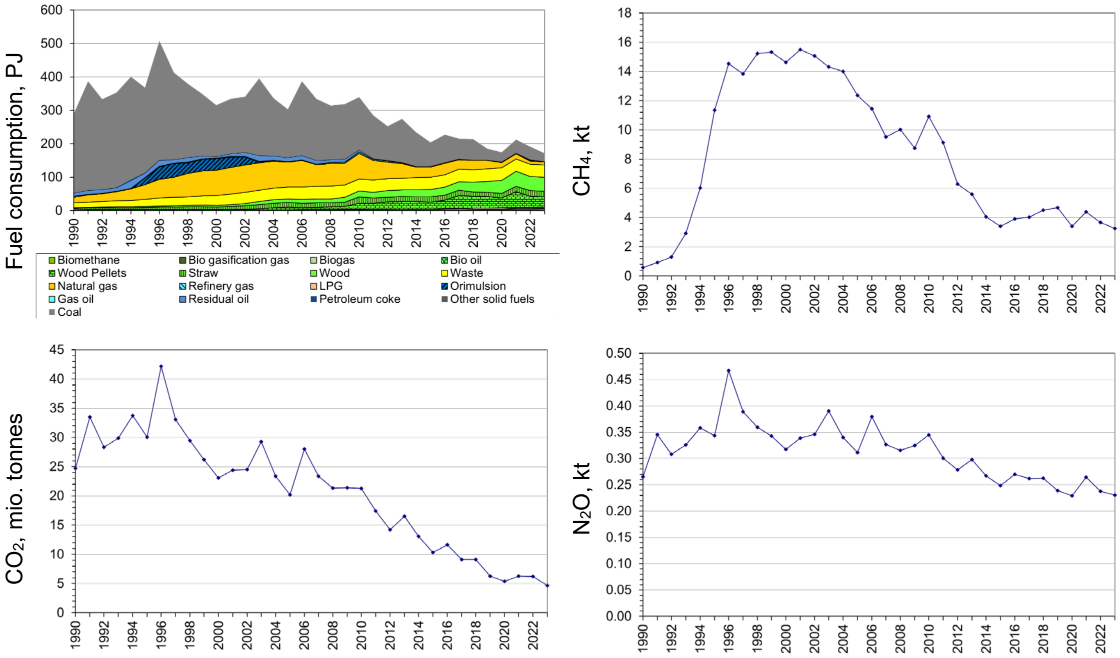


Figure 43 Time series for fuel consumption and GHG emissions from 1A1a Public electricity and heat production.

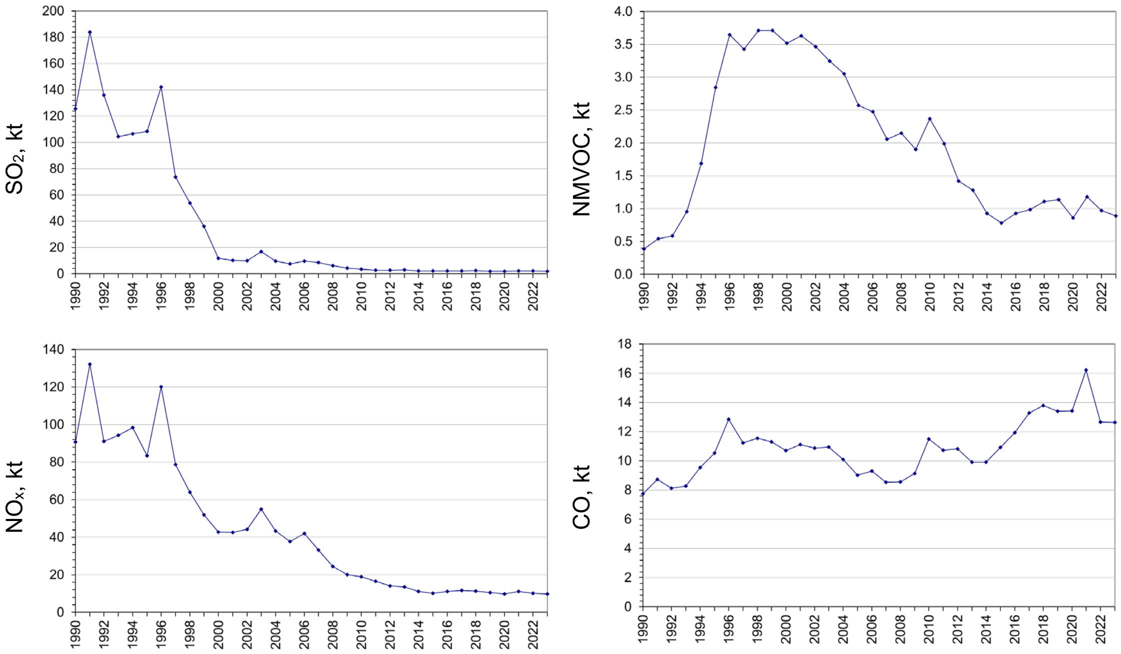


Figure 44 Time series for SO_2, NO_x, NMVOCs and CO from 1A1a Public electricity and heat production.

[13] Including methane.

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 two refineries operating in Denmark. Figure 45 and Figure 46 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 6 % since 1990. The CO_2 emission was 1 % lower in 2023 than in 1990.

The CH_4 emission has was the same in 2023 as in 1990. The reduction in CH_4 emission from 1995 to 1996 was caused by the closure of a refinery.

The N_2O emission was 99 % higher in 2023 than in 1990. The emission increased in 1993 as a result of the installation of a gas turbine in one of the refineries (DEA, 2024b).

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. This emission factor decreases in the years 2000-2007. This caused the decrease of the N_2O emission in 2000-2007.

The emission of SO_2 has shown a pronounced decrease (68 %) since 1990, mainly because decreased consumption of residual oil also shown in Figure 45. The increase in SO_2 emission in 1990-1992 also follows the residual oil consumption. The increase of the SO_2-emission from 2021 to 2022 relate to a shutdown and startup of one refinery. Data for SO_2 are plant specific since 2005.

The NO_x emission in 2023 was 27 % lower than in 1990. Since 2005, data for NO_x are plant specific data stated by the refineries.

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

A description of the Danish emission inventory for fugitive emissions from fuels is given in Plejdrup et al. (2021).

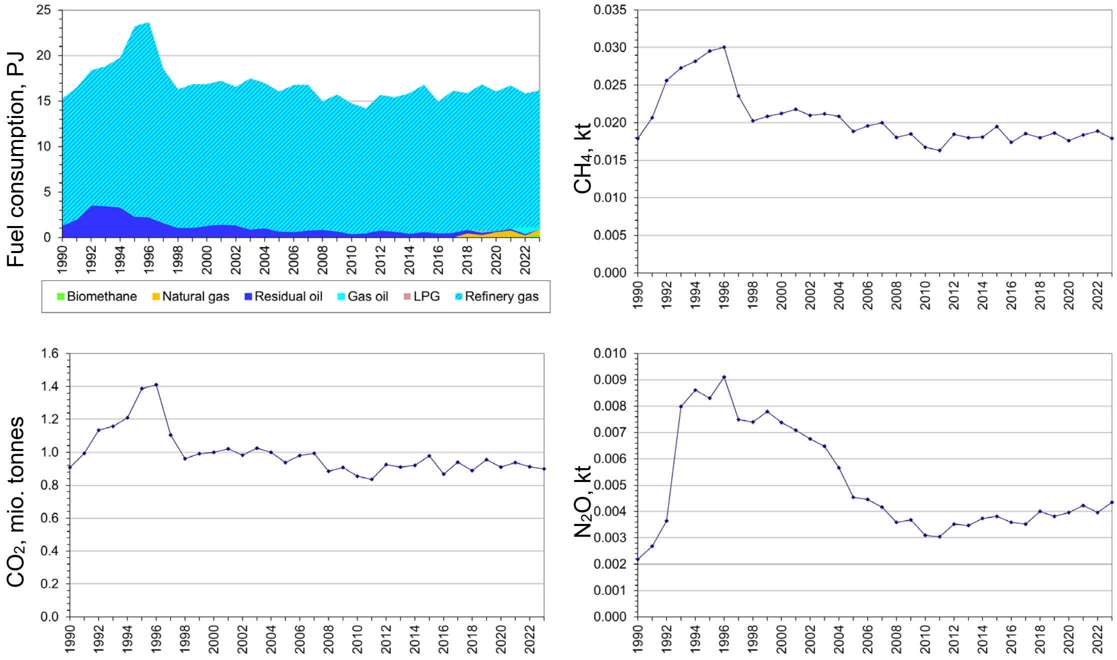


Figure 45   Time series for fuel consumption and GHG emissions from 1A1b Petroleum refining.

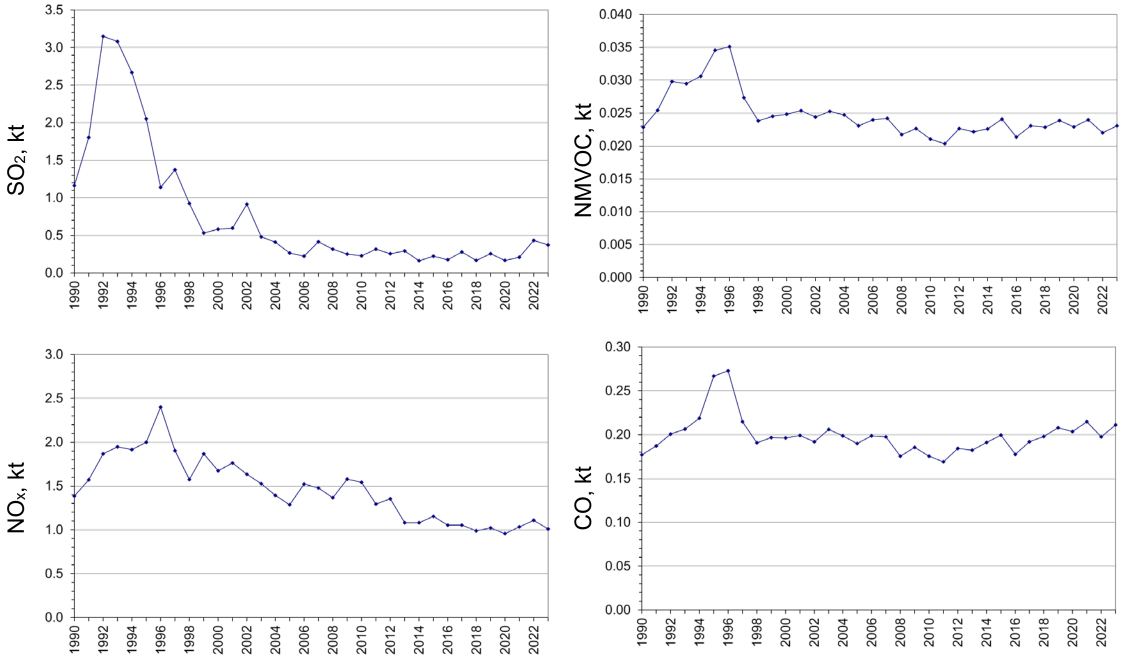


Figure 46   Time series for emission of SO_2, NO_x, NMVOCs and CO from 1A1b Petroleum refining.

5.1.3 1A1c Oil and gas extraction

The source category Oil and gas extraction comprises natural gas consumption in the offshore industry. Gas turbines are the main plant type. In addition, a small consumption of gas oil in offshore plants and the fuel consumption in the Danish gas treatment plant[14] is included in this subsector. Fugitive emissions from fuels are not included in the sector. Venting and flaring are included in the sector 1B2c Venting and Flaring.

Figure 47 and Figure 48 show the time series for fuel consumption and emissions.

The fuel consumption in 2023 was 56 % higher than in 1990. The fuel consumption has decreased since 2008. The large decrease between 2019 and 2020 is related to renovation of the largest gas field, Tyra.

The CO_2 emission follows the fuel consumption and the emission in 2023 was 57 % higher than in 1990.

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

The emissions of SO_2, NO_x, NMVOC and CO follow the fuel consumption. The decrease of CO emission in 2005–2007 is a result of a lower emission factor. This decrease of emission factor is valid for gas turbines in cogeneration 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.

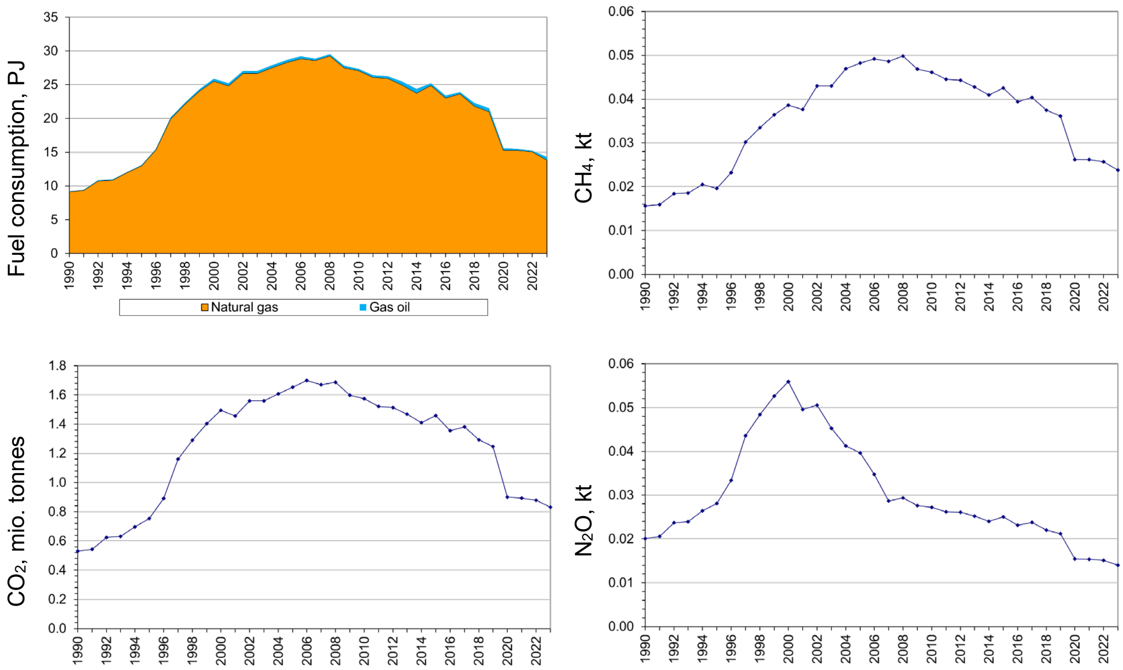


Figure 47 Time series for fuel consumption and GHG emissions from 1A1c Oil and gas extraction.

[14] Nybro.

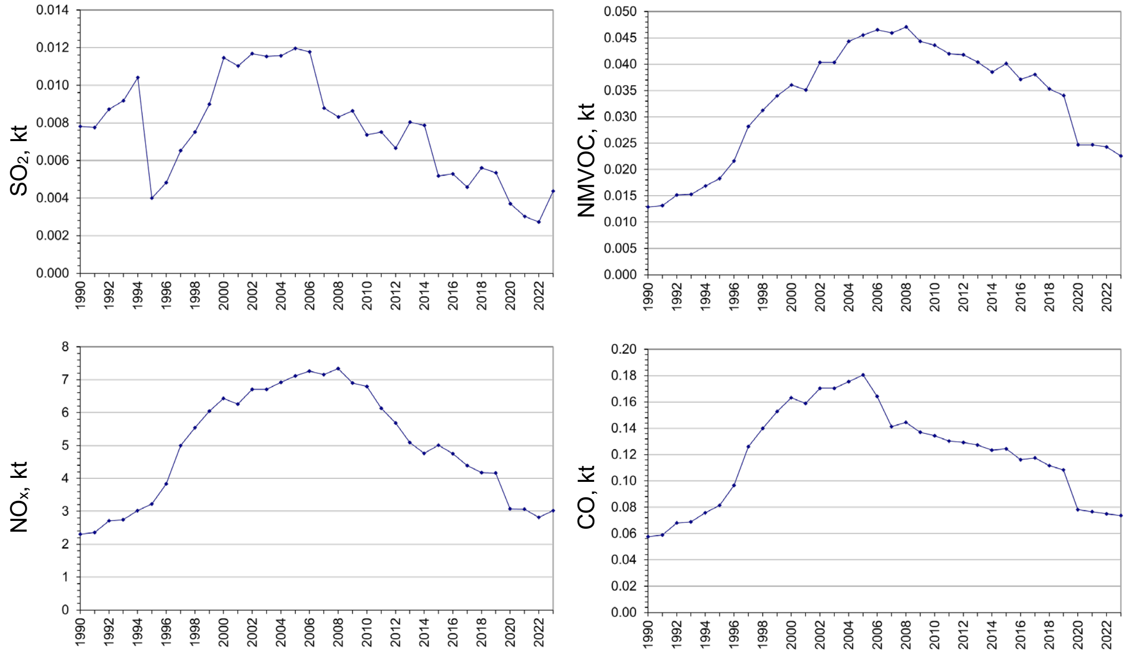


Figure 48 Time series for emission of SO_2, NO_x, NMVOCs and CO from 1A1c Oil and gas extraction.

5.2 1A2 Industry

Manufacturing industries and construction (Industry) consists of both stationary and mobile sources. In this chapter, only stationary sources are included. Emissions from industrial processes e.g. calcination are not included in the sector stationary combustion.

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 49-54 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 35 % lower in 2023 than in 1990. The consumption of fossil fuels was 53 % lower. The fuel consumption in industrial plants decreased considerably after 2006 as a result of the financial crisis. The biomass fuel consumption in Industry in 2023 added up to 16 PJ, which is 2.7 times the consumption in 1990. The consumption of coal and liquid fossil fuels have decreased since 1990.

The greenhouse gas emission and the CO_2 emission are both rather stable until 2006 following the small fluctuations in fuel consumption. The emissions decreased in 2006-2009. Due to change of applied fuels, the greenhouse gas and CO_2 emissions have decreased more than the fuel consumption since 1990; the GHG emission has decreased 55 % since 1990 and the CO_2 emission also decreased 55%.

The CH_4 emission has increased from 1994-2001, decreased from 2001–2007 and increased again from 2013-2019. In 2023, the emission was 95 % higher than the emission level in 1990. The CH_4 emission follows the consumption of natural gas and biogas in gas engines (Figure 49). 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 increased emission after 2013 is related to new biogas fuelled gas engines installed in dairies.

The N_2O emission has decreased 37 % since 1990. The emission from mineral wool production[15] is a large emission source, and the production of mineral wool production has increased in recent years. This causes the increase of the N_2O emission in 2014-2018. The large decrease in N_2O emission between 2021 and 2022 is caused by installation of a high temperature afterburner in a mineral wool production plant.

The increase of N_2O emission from 1994 to 1995 is related to combustion of coke oven coke in mineral wool production. Plant specific fuel consumption

[15] Included in sector 1A2f Non-metallic minerals.

data are only available from 1995 onwards for the mineral wool production plants.

The SO_2 emission has decreased 93 % since 1990. This is mainly a result of lower consumption of residual oil in the industrial sector (Figure 49). 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 64 % since 1990 due to the reduced emission from industrial boilers in general. Cement production is the main emission source accounting for 46 % of the emission from industrial combustion in 2023 and more than 28 % of the emission in 1990-2023.

The NO_x emission from cement production was reduced considerably in 2009-2013. The emission increased in 2013-2023. The NO_x emission from cement industry was 46 % of the total emission from manufacturing industries and construction in 2023. The NO_x emission from cement production was reduced 63 % since 1990. The reduced emission is a result of installation of SCR on all production units at the cement production plant in 2004-2007[16] and improved performance of the SCR units in recent years. A NO_x tax was introduced in 2010 (DMT, 2008). The increase in 2015-2023 is related to a reduction of the NO_x-tax from 2015 (DMT, 2015) and an increased production.

The NMVOC emission has decreased 74 % 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 49). The NMVOC emission factor for gas engines is much higher than for boilers regardless of the fuel.

The CO emission in 2023 was 19 % higher 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 of 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).

[16] To meet emission limit.

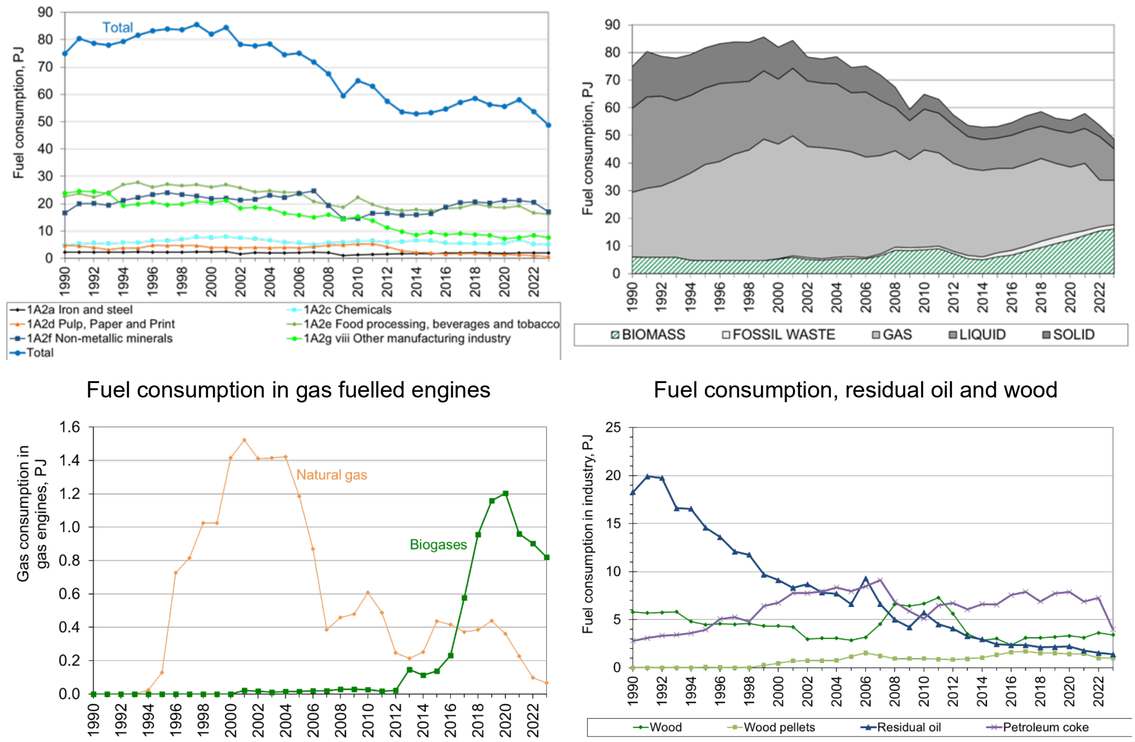


Figure 49 Time series for fuel consumption, 1A2 Industry.

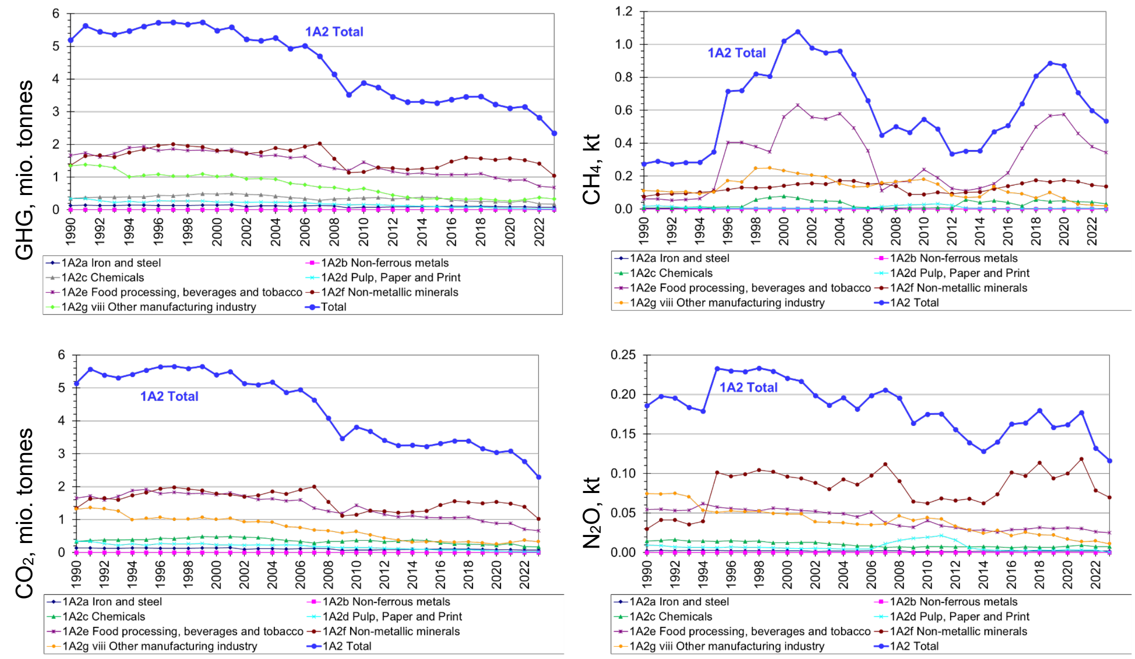


Figure 50 Time series for greenhouse gas emissions, 1A2 Industry.

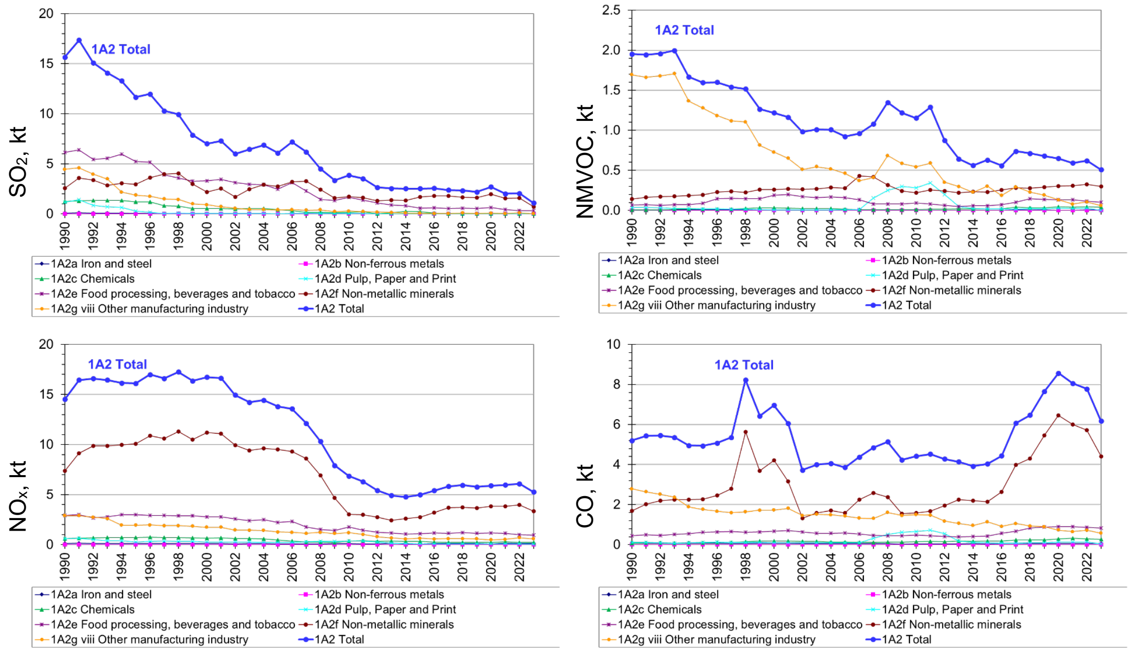


Figure 51 Time series for emission of SO_2, NO_x, NMVOC and CO, 1A2 Industry.

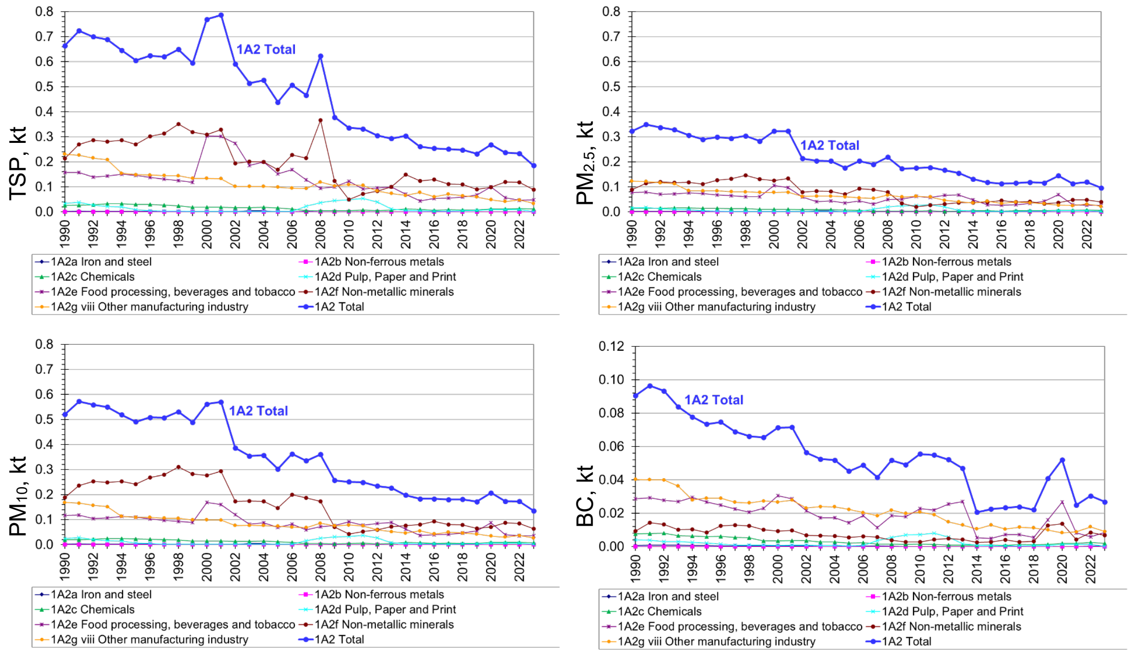


Figure 52 Time series for PM and BC emission, 1A2 Industry.

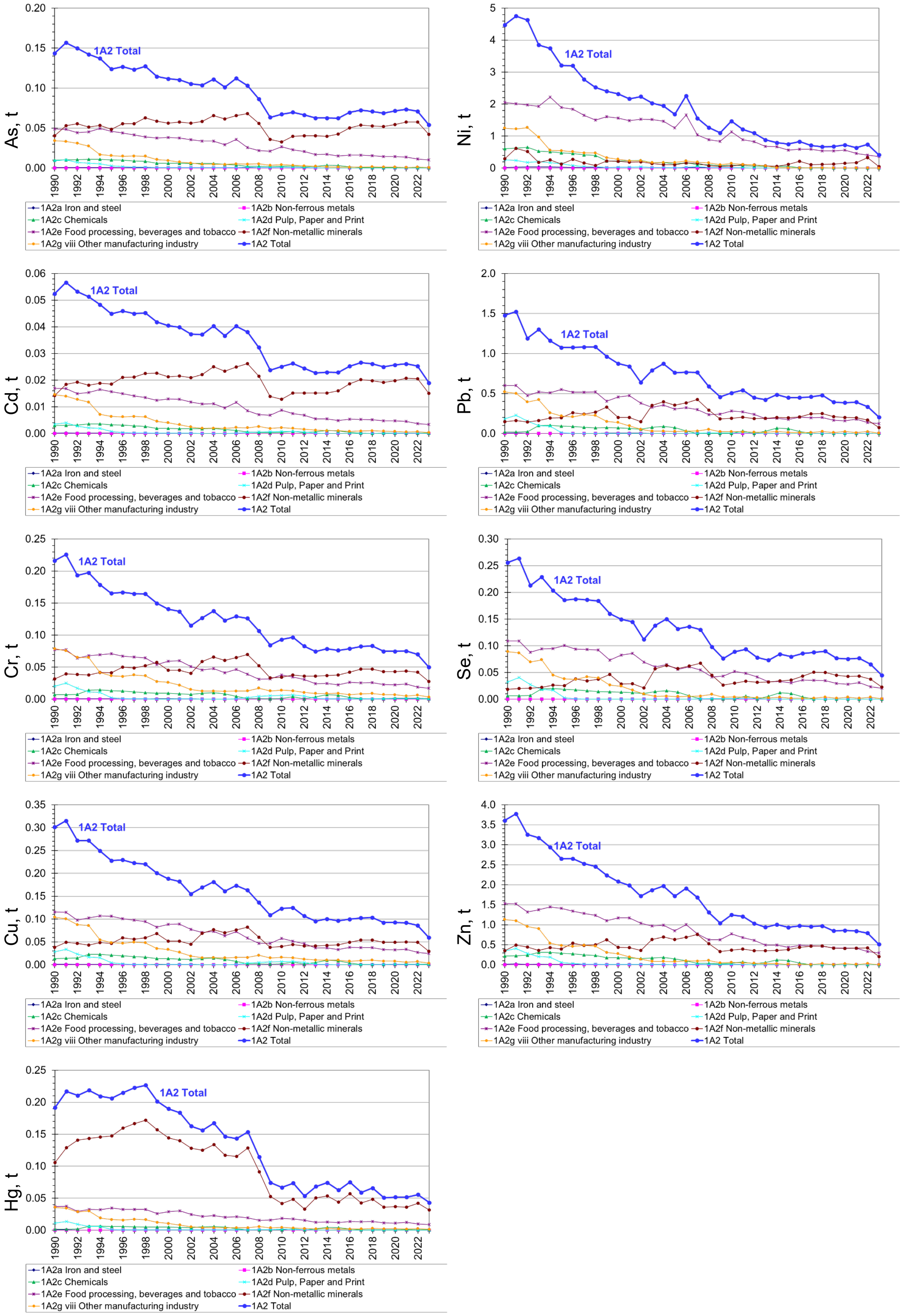


Figure 53 Time series for HM emissions, 1A2 Industry.

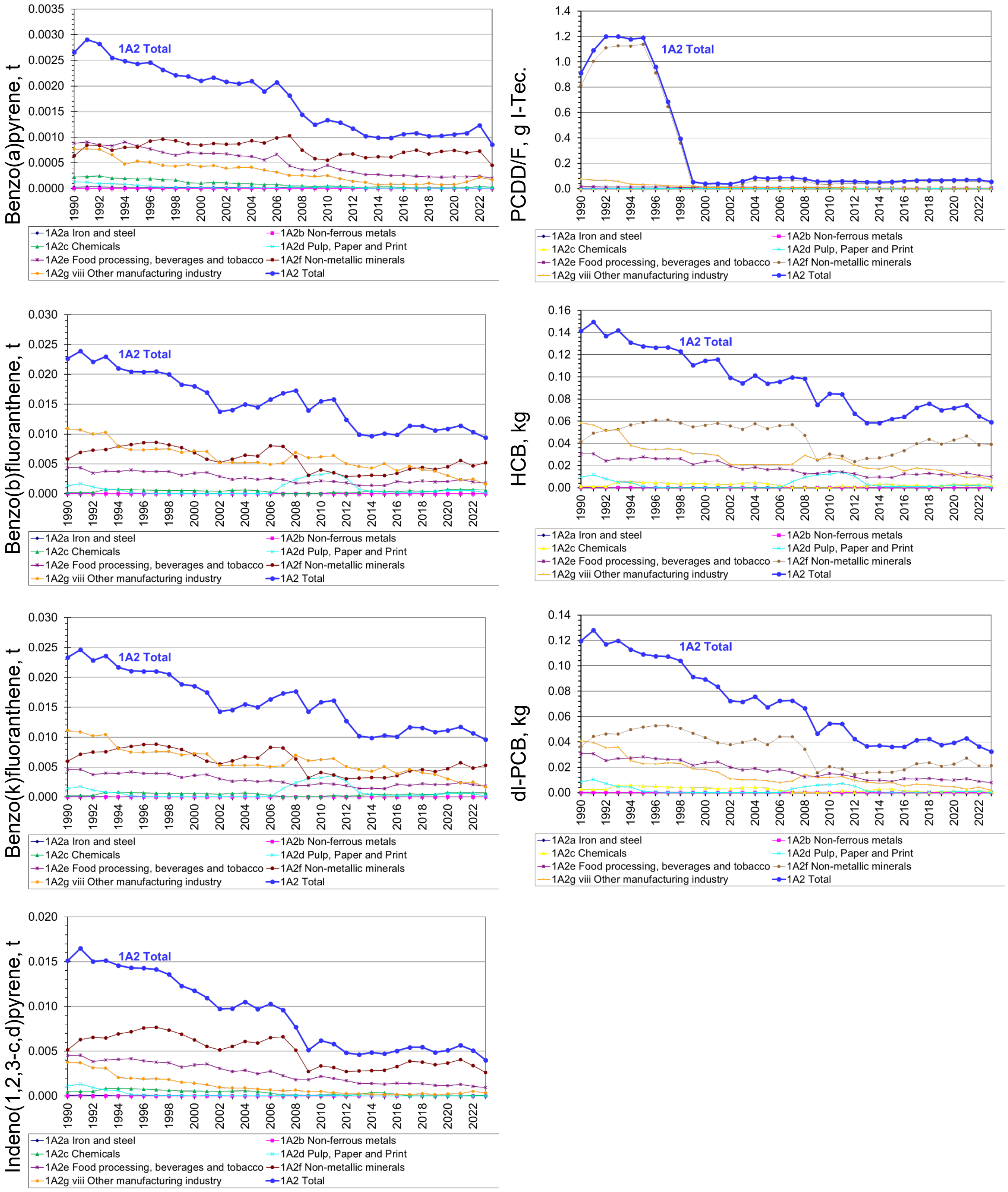


Figure 54 Time series for emission of PAHs, PCDD/Fs, HCB and dioxin-like PCBs, 1A2 Industry.

5.2.1 1A2a Iron and steel

Iron and steel is a very small emission source category. Figure 55 and Figure 56 show the time series for fuel consumption and emissions.

Natural gas is the main fuel in the subsector. In recent years, the consumption of biomethane is also considerable. An increasing part of the distributed gas is biomethane.

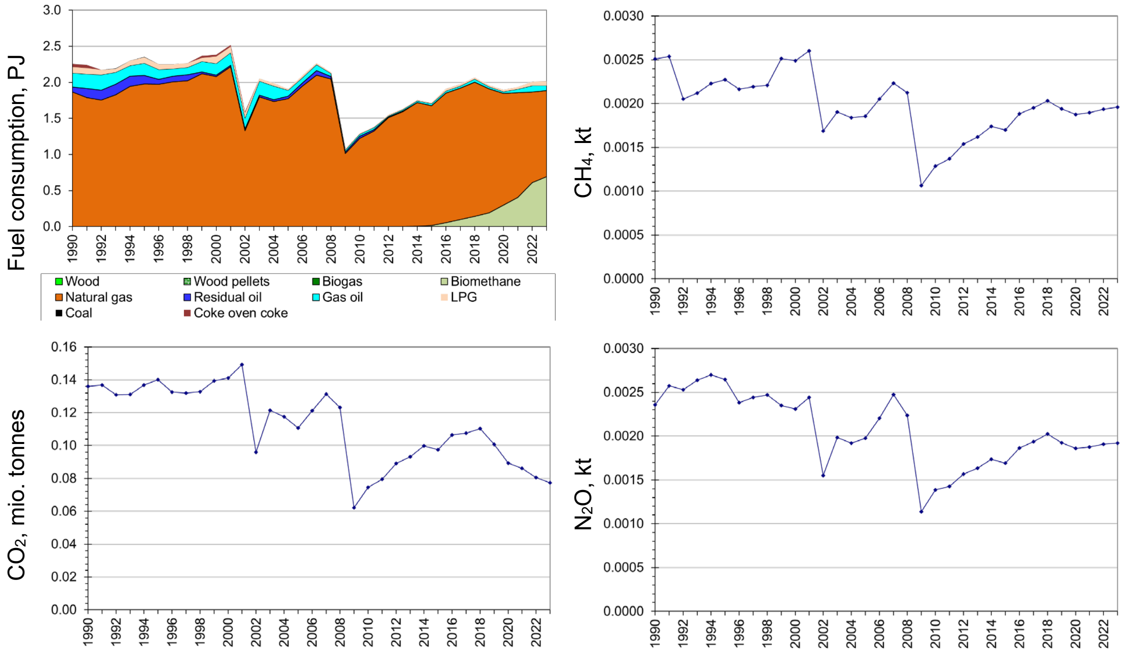


Figure 55 Time series for fuel consumption and GHG emissions from 1A2a Iron and steel.

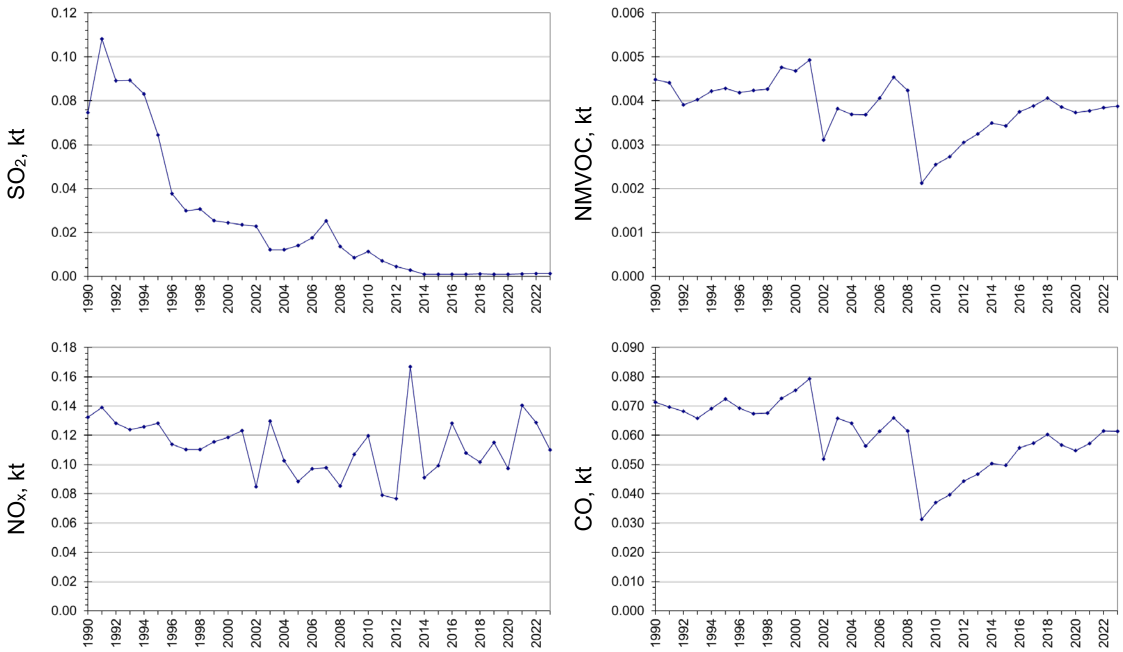


Figure 56 Time series for emission of SO_2, NO_x, NMVOCs and CO from 1A2a Iron and steel.

5.2.2 1A2b Non-ferrous metals

No fuel consumption is reported for non-ferrous metals in the Danish energy statistics.

5.2.3 1A2c Chemicals

Chemicals is a minor emission source category. Figure 57 and Figure 58 show the time series for fuel consumption and emissions.

The fuel consumption was 5 % higher in 2023 than in 1990. Natural gas and in recent years also biomethane are the main fuels in this subsector. The CO_2 emission was 48 % lower in 2023 than in 1990. The time series for CH_4 emission 1997-2006 is related to consumption of natural gas in gas engines. The higher and fluctuating CH_4 emission in 2012 to 2023 is related to a few biogas-fuelled engines in the industry. 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. The increased emission of NMVOCs and CO in 2016 onwards is related to the consumption of wood.

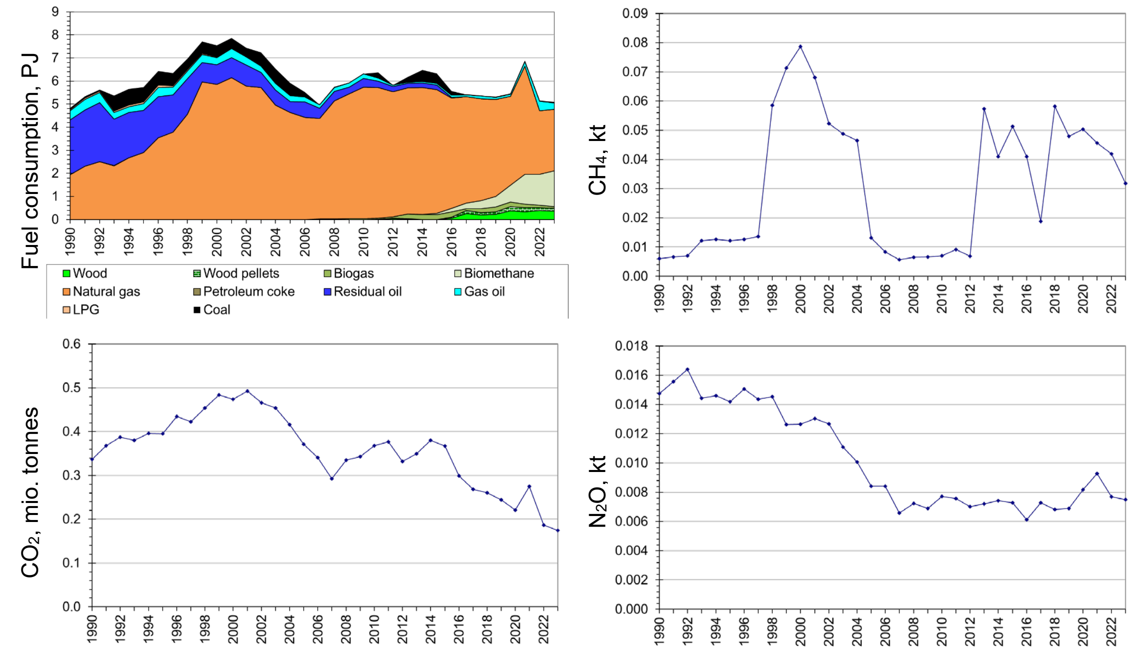


Figure 57 Time series for fuel consumption and GHG emissions from 1A2c Chemicals.

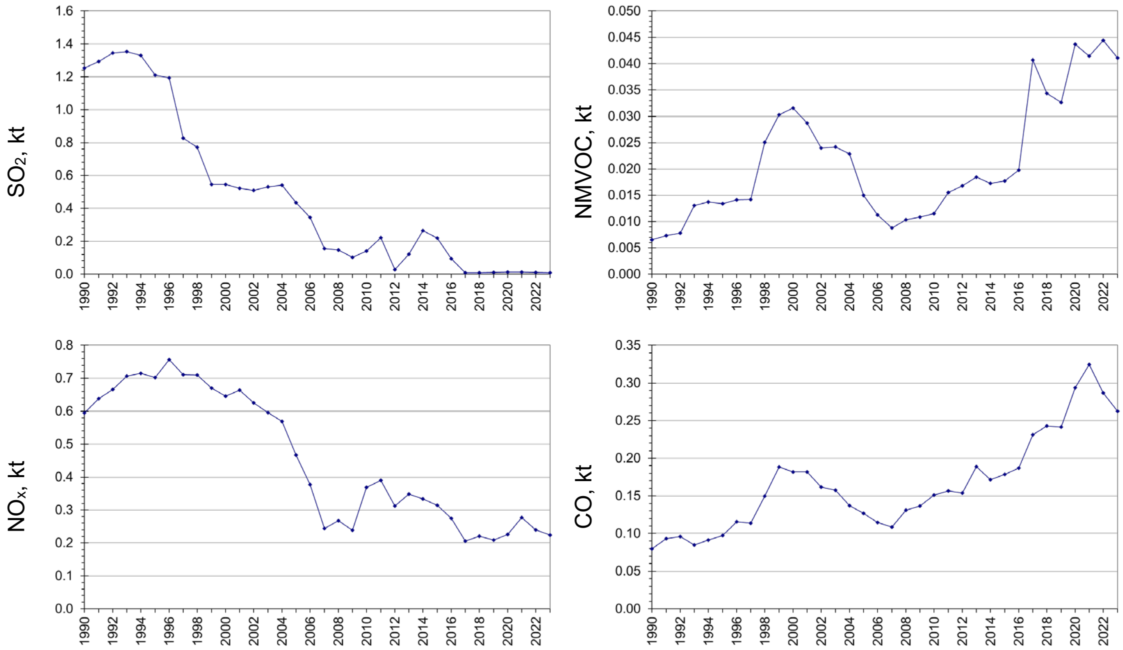


Figure 58 Time series for emission of SO_2, NO_x, NMVOCs and CO from 1A2c Chemicals.

5.2.4 1A2d Pulp, paper, and print

Pulp, paper and print is a minor emission source category. Figure 59 and Figure 60 show the time series for fuel consumption and emissions.

The fuel consumption has decreased 86 % from 1990. The time series are related to both closure of plants and new combustion units in exiting plants. In addition, the liberalisation of the electricity market caused less operational hours of a natural gas fuelled gas turbine. Natural gas, and in 2007-2013 and 2020-2022 also wood, are the main fuels in the subsector.

The increased consumption of wood in 2007-2013 is 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 2007-2013 has resulted in a considerable increase and decrease in NMVOC and CO emission in 2007-2013.

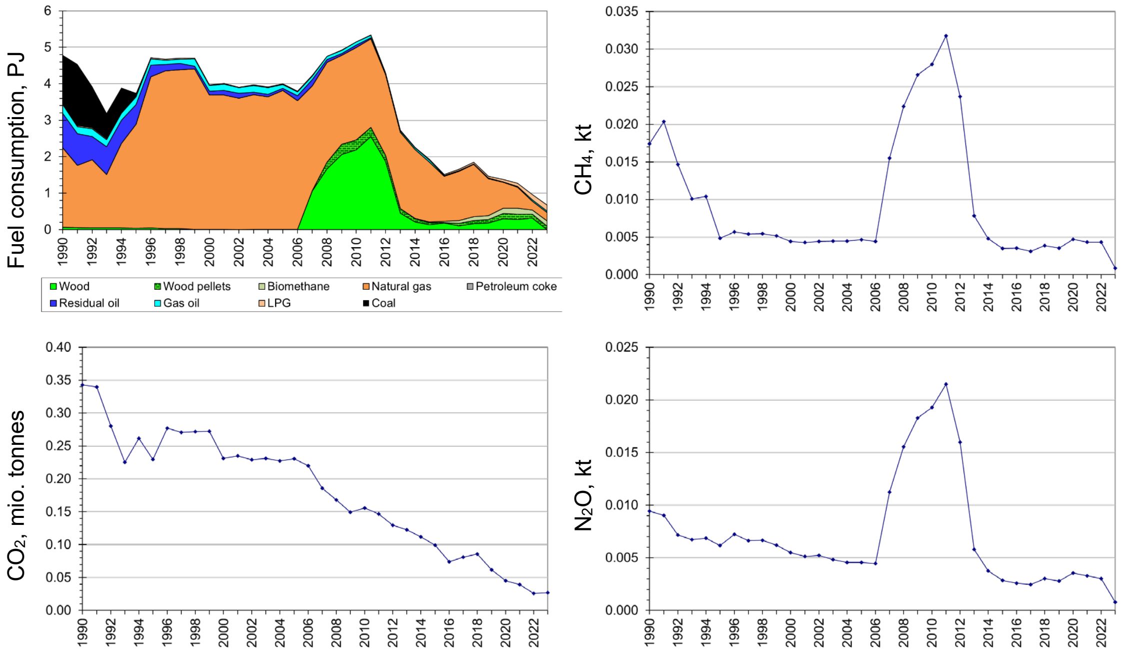


Figure 59 Time series for fuel consumption and GHG emissions from 1A2d Pulp, paper, and print.

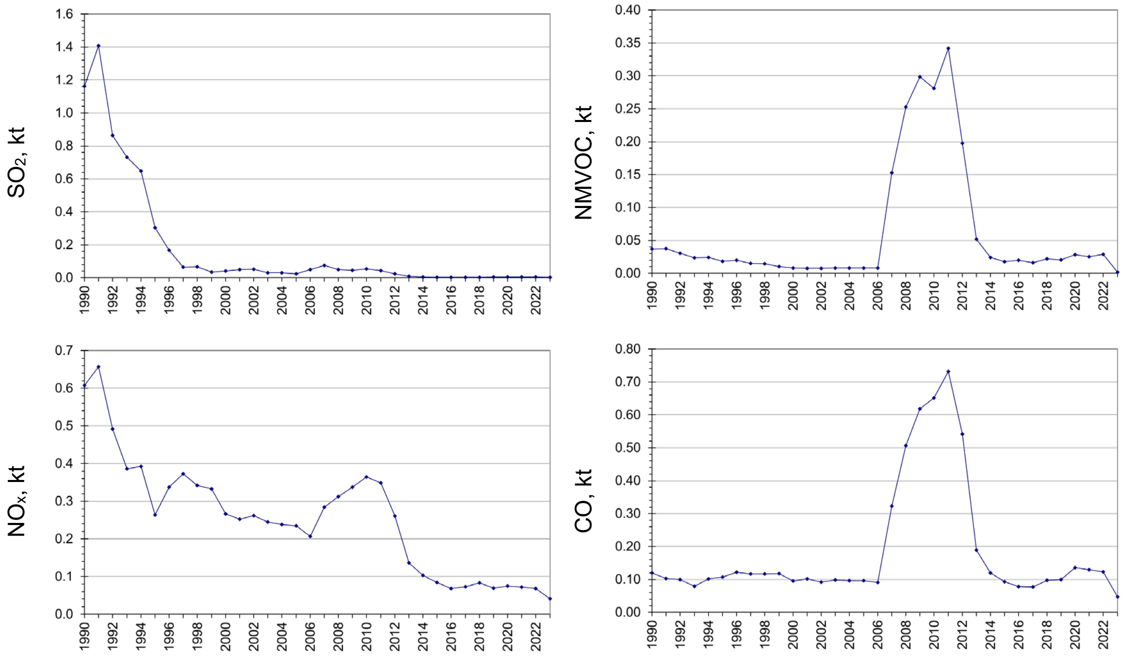


Figure 60 Time series for emission of SO_2, NO_x, NMVOCs and CO from 1A2d Pulp, paper, and print.

5.2.5 1A2e Food processing, beverages, and tobacco

Food processing, beverages and tobacco is a considerable industrial subsector. Figure 61 and Figure 62 show the time series for fuel consumption and emissions.

The fuel consumption decreased 28 % since 1990. Natural gas, biomethane, residual oil and coal are the main fuels in the subsector. The consumption of coal and residual oil has decreased.

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

The decreased consumption of residual oil and coal is reflected in the SO_2 emission time series. The time series for NMVOC and CO are influenced by the time series for consumption of natural gas and biogases in gas engines, see also Figure 49.

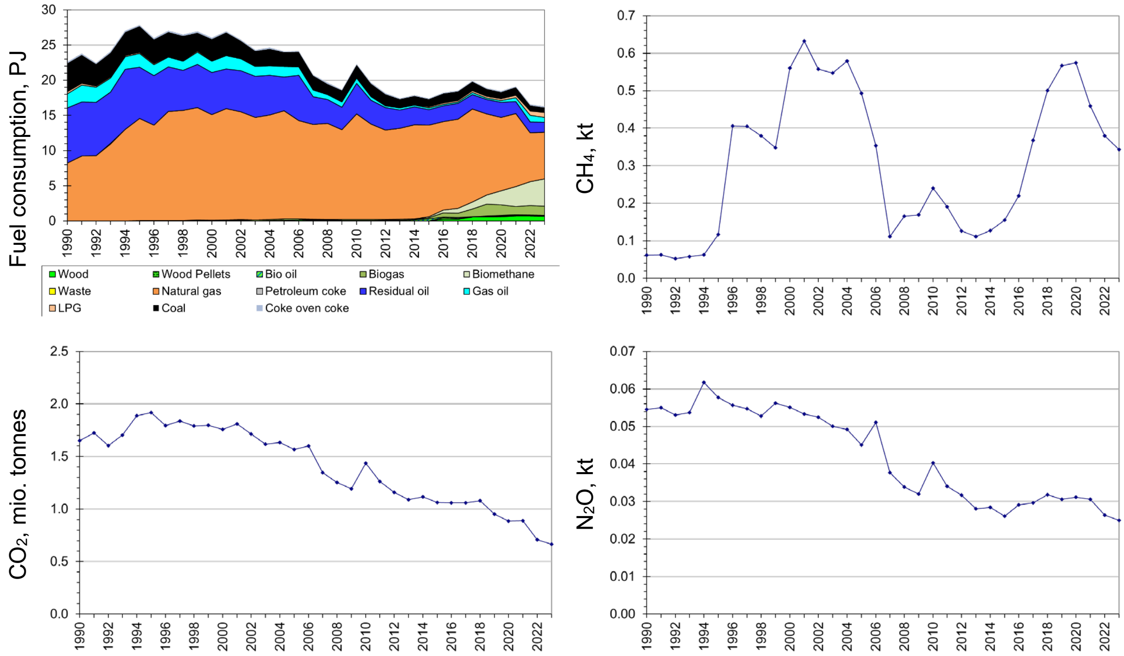


Figure 61 Time series for fuel consumption and GHG emissions from 1A2e Food processing, beverages and tobacco.

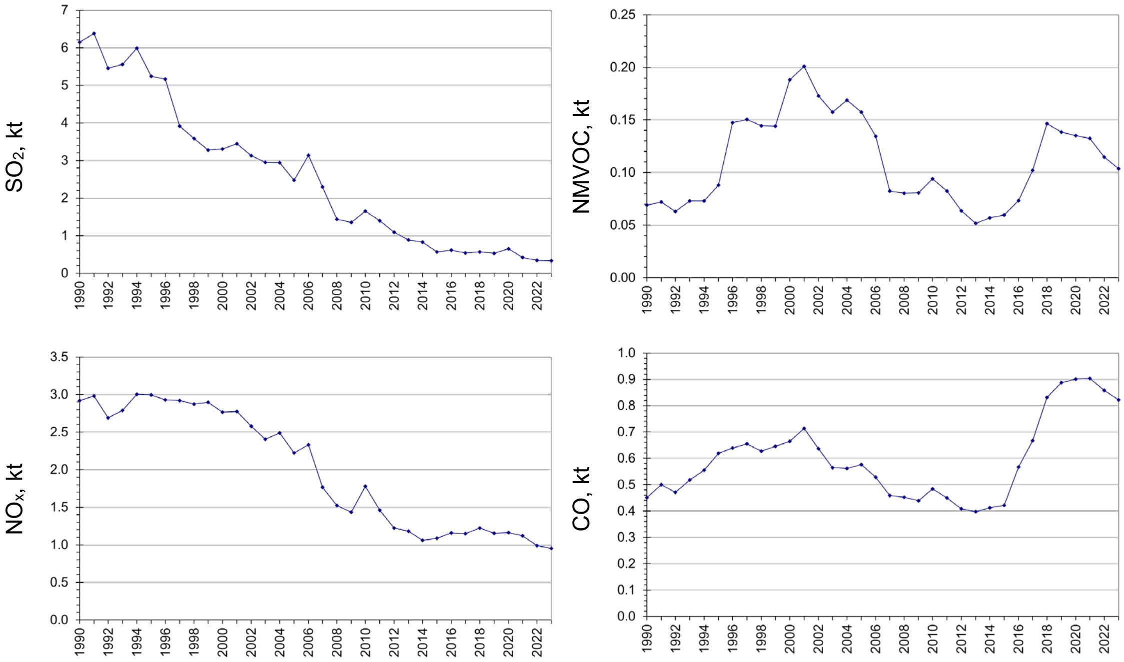


Figure 62 Time series for emission of SO_2, NO_x, NMVOCs and CO from 1A2e Food processing, beverages and tobacco.

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. Production of mineral wool and glass is also included in the subsector. Figure 63 and Figure 64 shows the time series for fuel consumption and emissions.

The fuel consumption in 2023 was 3 % higher than in 1990. Due to the global recession, cement production decreased in 2008 and 2009 but then increased again. This is reflected in the time series for fuel consumption. Petroleum coke, natural gas, biomethane, waste and coal are the main fuels in the subsector in recent years. The consumption of coal has decreased.

Combustion of coke oven coke in mineral wool 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.

Emissions from industrial processes e.g. calcination are not included in the sector stationary combustion. Thus, the CO_2 time series for cement production shown in Figure 63 is only for combustion of fossil fuels in the cement industry. The calcination in cement industry is included in the emission inventory sector 2A Industrial processes and product use, Mineral industry.

The emission of SO_2 was 72 % lower in 2023 than in 1990.

The emission of NO_x was 54 % lower in 2023 than in 1990. The reduced NO_x emission is a result of installation of SCR on all production units at the cement production plant in 2004-2007[17] and improved performance of the SCR units in the following years. A NO_x tax was introduced in 2010 (DMT, 2008). The increased emission after 2015 is related to a reduction of the NO_x-tax (DMT, 2015) and an increased production rate.

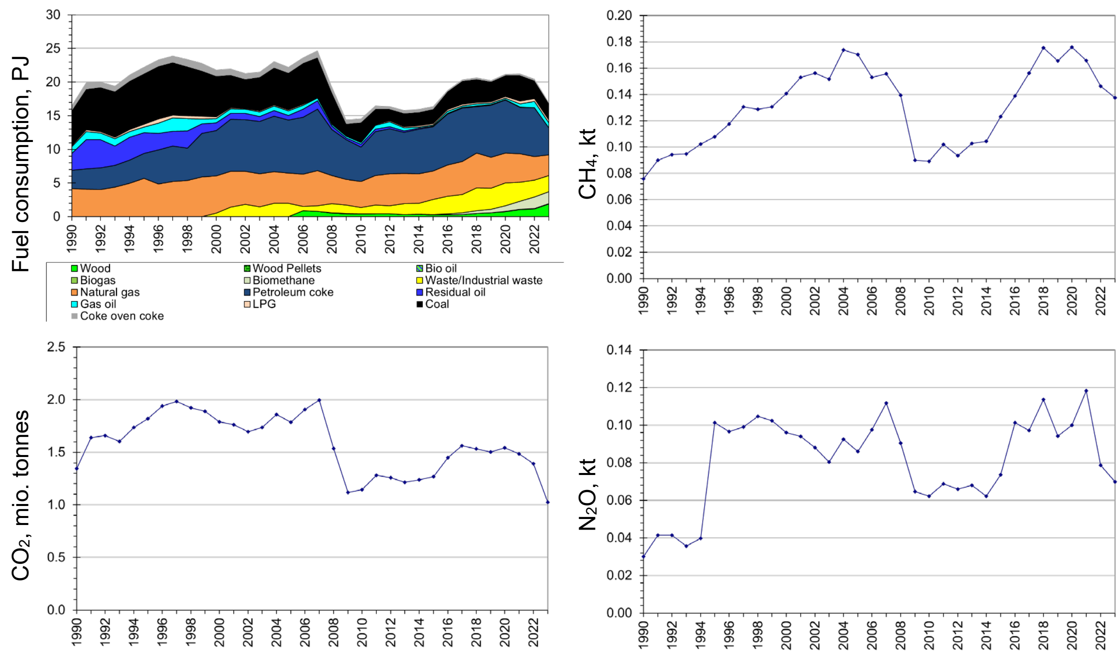


Figure 63 Time series for fuel consumption and GHG emissions from 1A2f Non-metallic minerals.

[17] To meet emission limit.

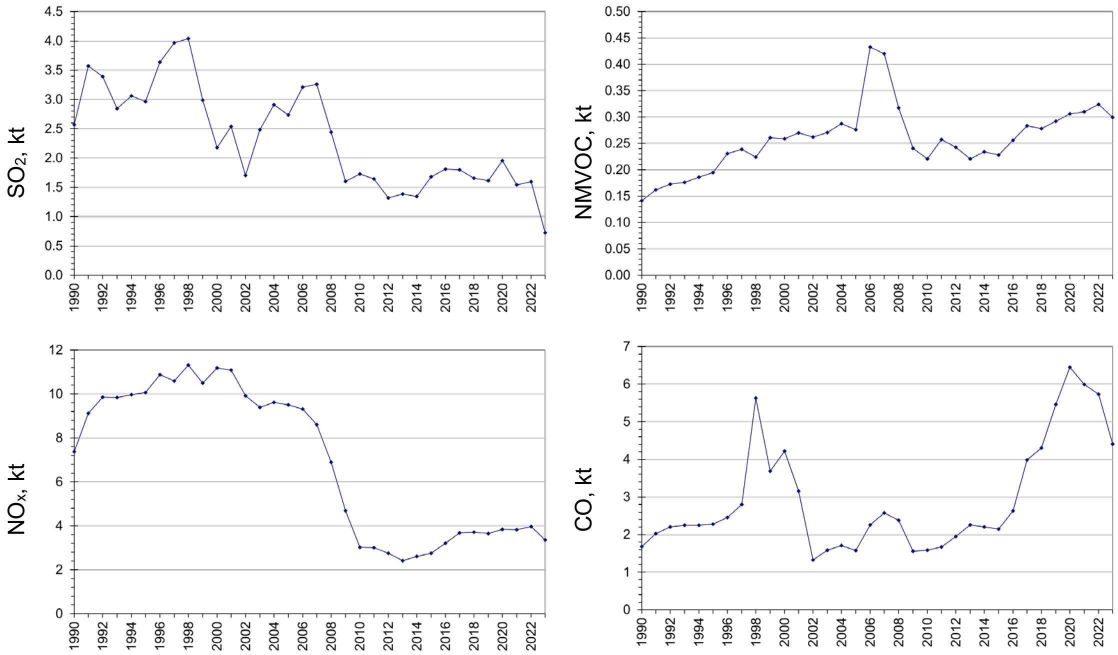


Figure 64 Time series for emission of SO_2, NO_x, NMVOCs and CO from 1A2f Non-metallic minerals.

5.2.7 1A2g Other manufacturing industry

Other manufacturing industry is a considerable industrial subsector including Process furnaces without contact, Textile and leather industry, Transport Equipment, Machinery, Wood and wood products, Construction and Non-specified industry. Figure 65 and Figure 66 show the time series for fuel consumption and emissions.

The fuel consumption decreased 68 % since 1990. Natural gas, biomethane, wood and gas oil were the main fuels in the subsector in 2023. The consumption of coal and oil has decreased since 1990.

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

The SO_2 emission decreased 99 % since 1990 as a result of both lower fuel consumption and a change of fuels towards fuels with lower sulphur content.

The NO_x emission decreased 80 % since 1990.

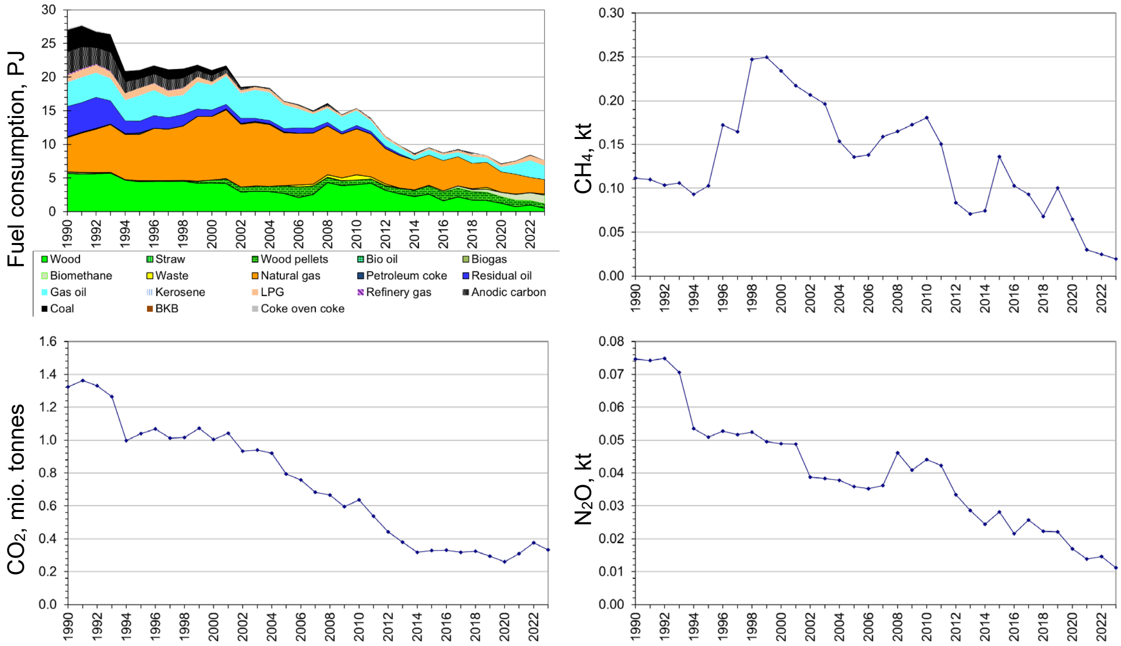


Figure 65 Time series for fuel consumption and GHG emissions from 1A2g Industry - other.

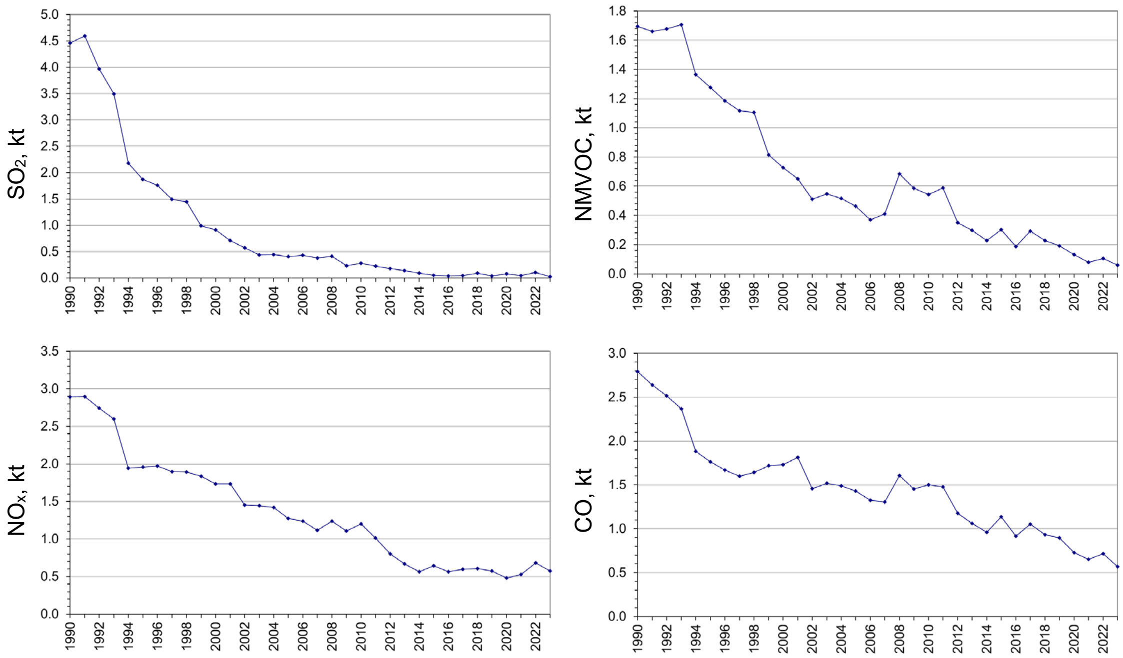


Figure 66   Time series for emission of SO_2, NO_x, NMVOCs and CO from 1A2g Other manufacturing industry.

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 67-72 present time series for this emission source category. Residential plants are the dominant subcategory accounting for the largest part of all emissions. Time series for GHGs, SO_2, NO_x, NMVOCs and CO are discussed below for each subcategory.

The PM emissions increased until 2007 and decreased after 2007. 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 (see Chapter 6.13). The stabilisation of wood consumption in residential plants in 2007-2023 has resulted in a decrease of PM emission from stationary combustion after 2007. The PM emission data for residential wood combustion include condensable particles.

The emission of BC was 24 % lower in 2023 than in 1990. The largest emission sources for BC is combustion of wood and straw in residential plants and in agricultural/forestry plants. The consumption of wood in residential plants has increased since 1990, but the emission factor has decreased due to implementation of new improved stoves and boilers, see Chapter 6.13.

The emission of some HMs has increased since 1990, whereas the emission of other HMs has decreased. The decreased emissions are related to lower consumption of solid and liquid fossil fuels and waste. The emissions of Zn and Cd have increased due to a considerable emission from residential wood combustion even in 1990. The emission factors for HMs from residential wood combustion are not considered dependent of combustion technology (Chapter 6.13), and thus the increasing consumption of wood until 2007 is reflected in the HM emissions.

Residential wood combustion is the predominant emission source for PAH emissions. The emission factors applied for residential wood combustion are technology dependent (Chapter 6.13) and thus the PAH emissions decrease in spite of the increasing consumption of wood.

The emission of PCDD/F has increased 20 % since 1990. The main emission sources are residential combustion of wood, wood pellets, and straw. The dioxin emission factors for residential wood combustion are dependent on the wood origin but independent of stove technology (Chapter 6.13). Thus, the dioxin emission from residential wood combustion has not decreased similar to e.g. the PM and PAH emissions due to replacements of old stoves and boilers.

The emission of dl-PCBs has decreased 64 % since 1990.

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.

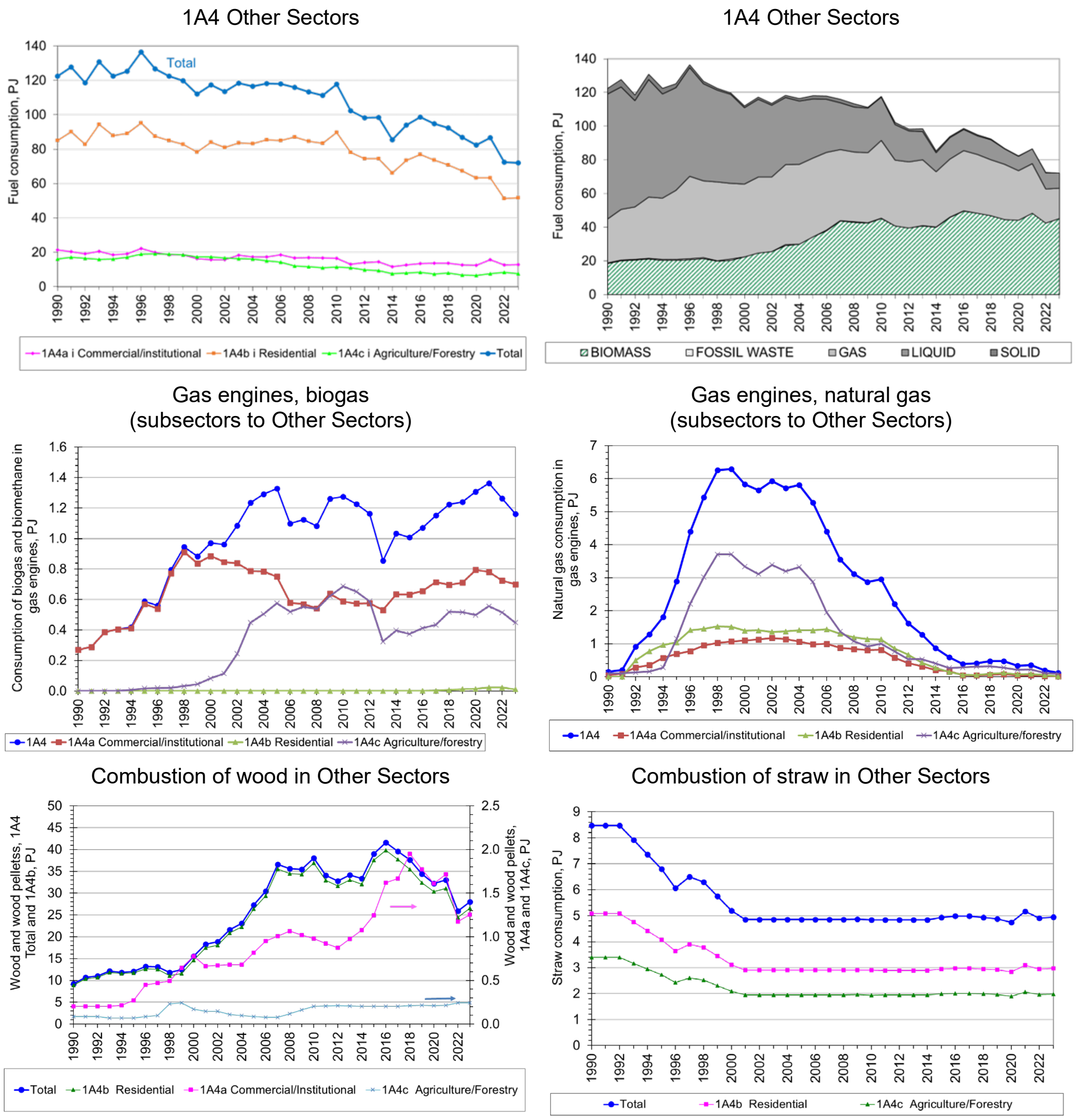


Figure 67 Time series for fuel consumption, 1A4 Other sectors.

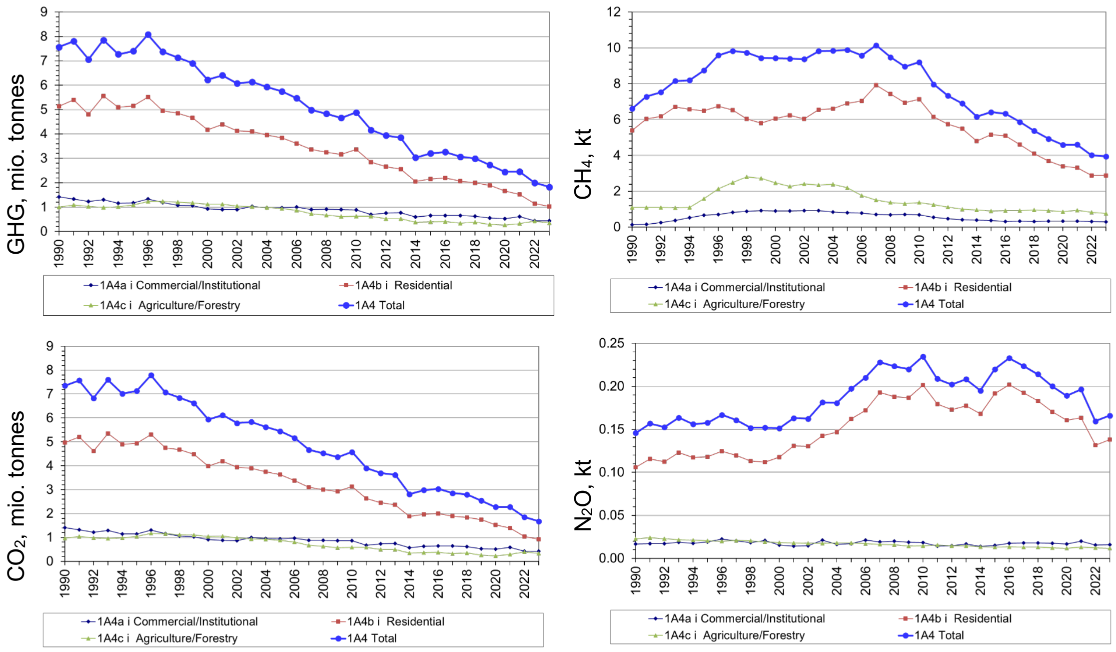


Figure 68 Time series for greenhouse gas emission, 1A4 Other sectors.

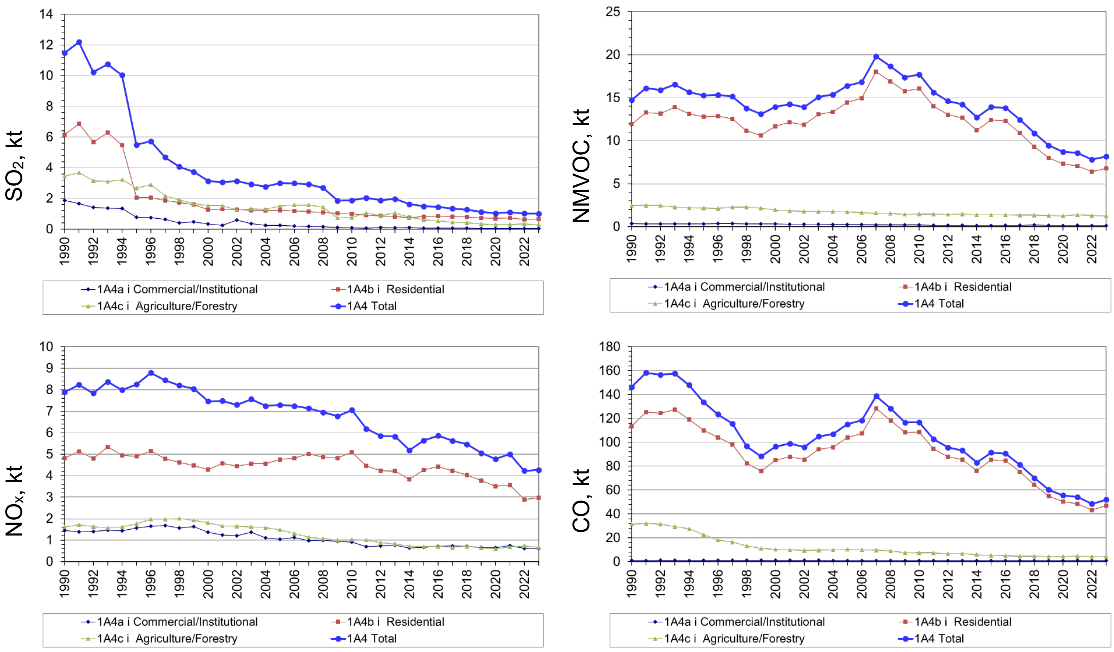


Figure 69 Time series for emission of SO_2, NO_x, NMVOCs and CO emission, 1A4 Other sectors.

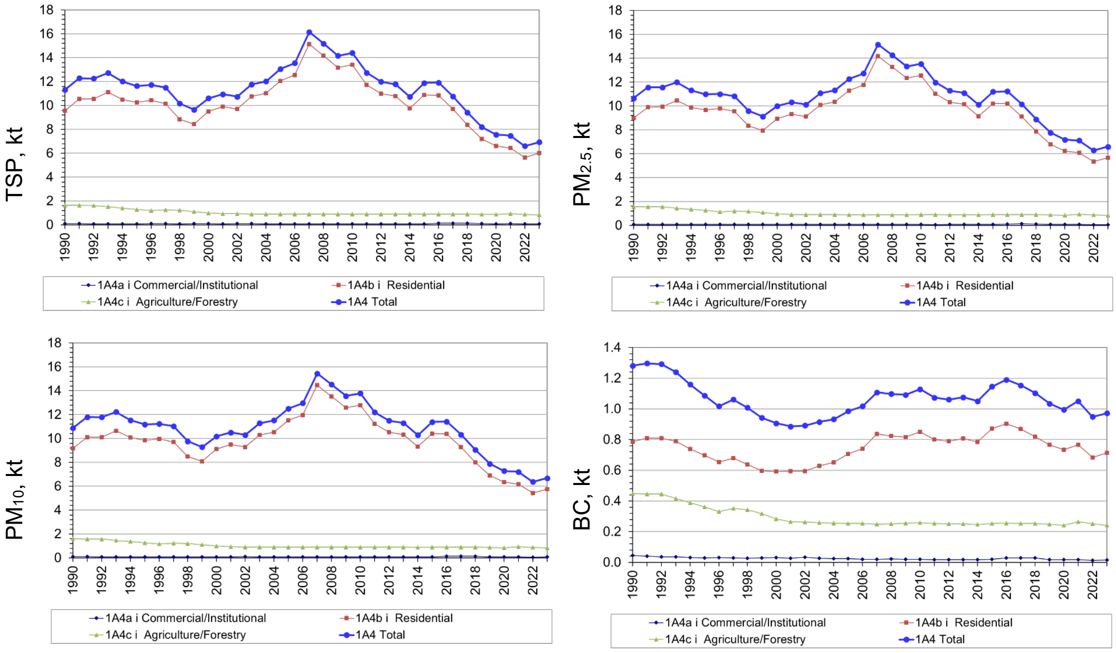


Figure 70 Time series for PM and BC emission, 1A4 Other sectors.

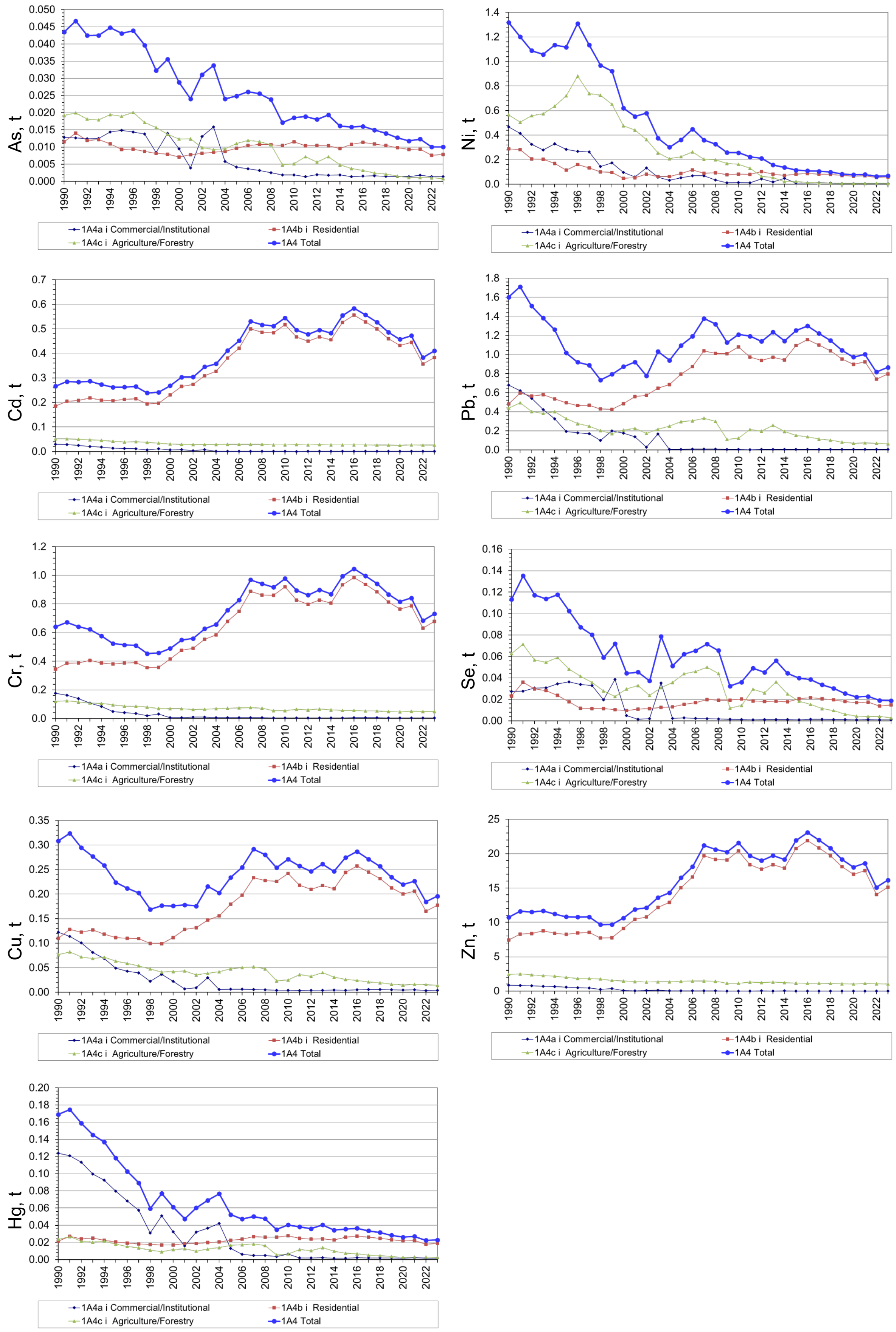


Figure 71 Time series for HM emissions, 1A4 Other sectors.

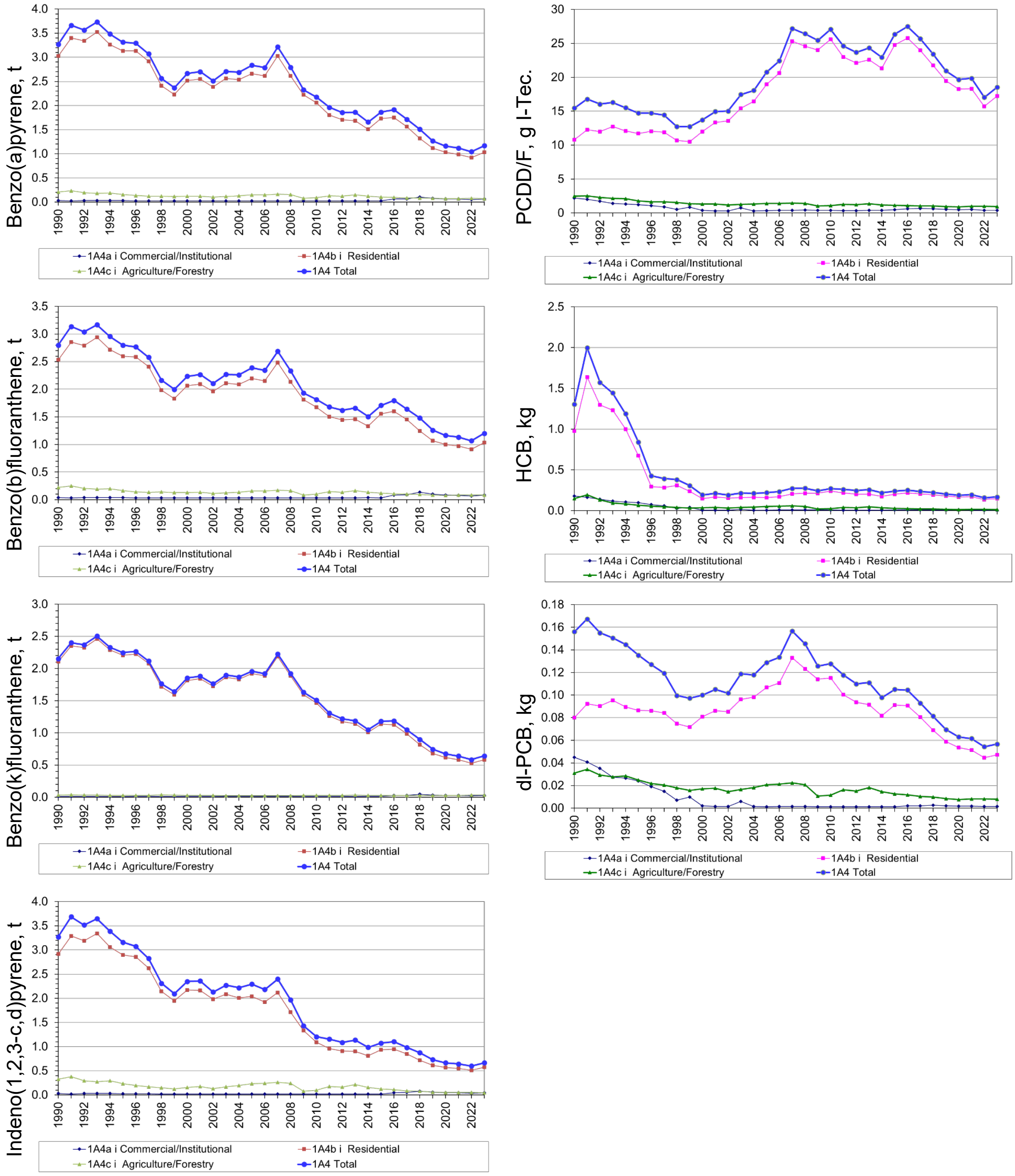


Figure 72 Time series for emission of PAHs, PCDD/F, HCB and dioxin-like PCBs, 1A4 Other sectors.

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 73 and Figure 74 show 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 40 % since 1990 and the fuels applied have changed. In later years, the main fuel is natural gas and biomethane. The consumption of gas oil has decreased since 1990.

The decrease in fuel consumption between 2021 and 2022 is related to high energy prices for natural gas and wood pellets in 2022. In addition, a limitation to the allowed temperatures in public office buildings and schools in the winter 2022-2023 caused a decrease of fuel consumption in this sector.

The CO_2 emission has decreased 70 % since 1990. Both the decrease of fuel consumption and the change of fuels contribute to the decreased CO_2 emission.

The CH_4 emission in 2023 was 2.2 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 67.

The N_2O emission in 2023 was 6 % 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 98 % 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 58 % lower in 2023 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 2023 was 64 % lower than the 1990 emission level. The combustion of wood has increased but the emission factor has decreased. The increase and decrease of natural gas consumption in gas engines (Figure 67) is also reflected in the time series for NMVOC emission.

The CO emission has decreased 24 % since 1990. This is a result of the change of fuels used in the sector. The emission from wood has increased whereas the emission from gas oil has decreased.

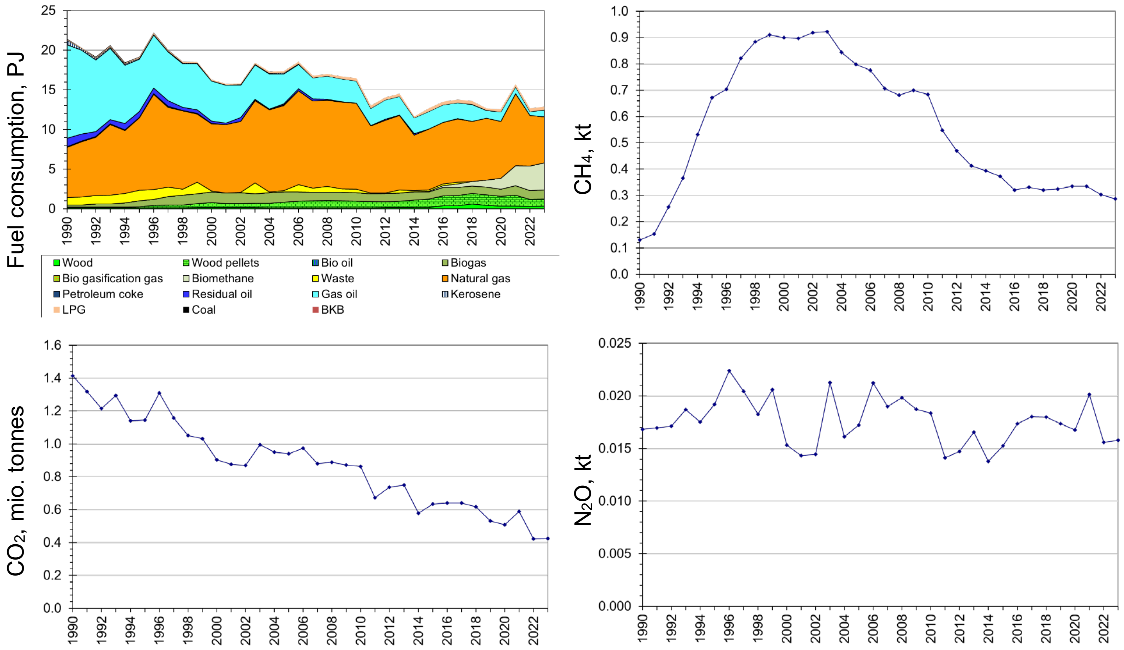


Figure 73 Time series for fuel consumption and GHG emissions from 1A4a Commercial /institutional.

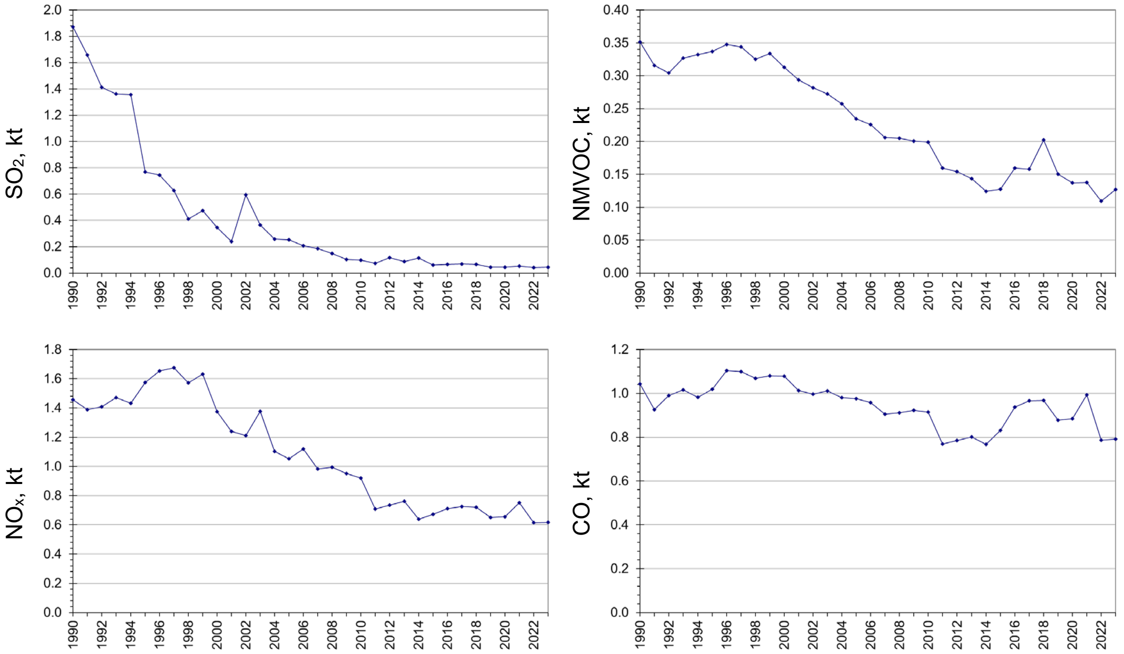


Figure 74 Time series for emission of SO_2, NO_x, NMVOCs and CO from 1A4a Commercial /institutional.

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 75 to Figure 79 show the time series for fuel consumption and emissions. Time series for emissions of PM, PAHs, PCDD/F, HCB, and dl-PCBs are also shown for this subsector because residential plants is a large emission source for these pollutants. The time series for residential combustion of wood and wood pellets is also shown in the figures.

For residential plants, the total fuel consumption was 39 % lower in 2023 than in 1990. Both energy savings, increased use of district heating, and installation of electrical heat pumps added to the lower fuel consumption in 2023.

The consumption of gas oil has decreased since 1990 whereas the consumption of wood, wood pellets and biomethane has increased considerably.

The large decrease (19 %) from 2021 to 2022 was caused by high fuel prices in the winter 2022/2023, especially for natural gas/biomethane and wood pellets.

Residential wood combustion is a large emission source for several pollutants. Replacement of older stoves and boilers with new improved stoves and boilers has been implemented in the emission inventory for residential wood combustion, see also Chapter 6.13.

The CO_2 emission has decreased by 82 % since 1990. This decrease is a result of:

- Improved isolation that has caused lower energy consumption for heating in spite of an increased area.
- A higher share of the residential heating is based on district heating and electrical heat pumps. Thus, the emissions are included in sector 1A1a.
- The considerable change in fuels used from gas oil to log wood, wood pellets, biomethane and natural gas.

The CH_4 emission from residential plants was 46 % lower in 2023 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. Replacement of older stoves and boilers with new improved stoves and boilers cause a lower CH_4 emission factor for residential wood combustion, see also Chapter 6.13.

The change of fuel from gas oil to wood has resulted in a 31 % increase of N_2O emission since 1990 due to a higher emission factor for wood than for gas oil.

The large decrease (89 %) 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 (less than 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. Finally, coal consumption in residential plants in the early 1990s was a considerable emission source for SO_2 emission until 1996.

The NO_x emission has decreased by 38 % since 1990. As mentioned above the fuel consumption has decreased 39 %. 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[18]. However, the NO_x emission factor for natural gas has decreased.

The emission of NMVOC has decreased 43 % since 1990. The consumption of wood has increased but the emission factor has decreased since 1990. The emission factors for wood and straw are higher than for liquid or gaseous fuels.

The CO emission has decreased 59 % 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 whereas the consumption of wood pellets has increased since 1990.

The NH_3 emission increased from 1990-2007 and decreased after 2007. The emission from residential wood combustion is the predominant source all years. The emission factor for older stoves/boilers is higher than for the modern stoves/boilers. The decreased consumption of wood and the decreasing implied emission factor for residential wood combustion (due to replacement of older units) both cause a decreasing NH_3 emission after 2007.

Time series for emissions of PM, BC, HMs, PAHs, PCDD/F, PCB, HCB are shown in Figure 77-79.

[18] The NO_x emission factor for residential wood is technology dependent. The emission factor for new stoves is higher than for old stoves, see Chapter 6.13.

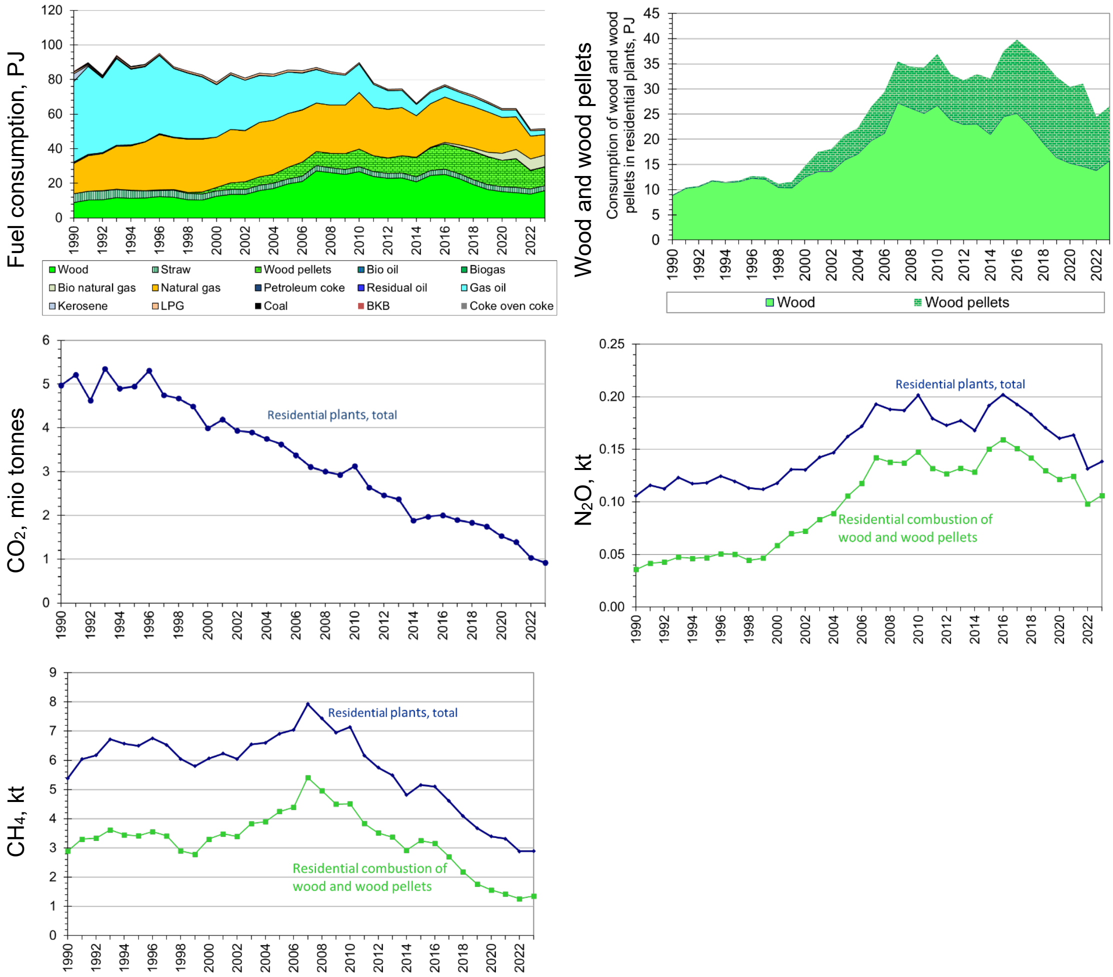


Figure 75 Time series for fuel consumption and GHG emissions from 1A4b Residential plants.

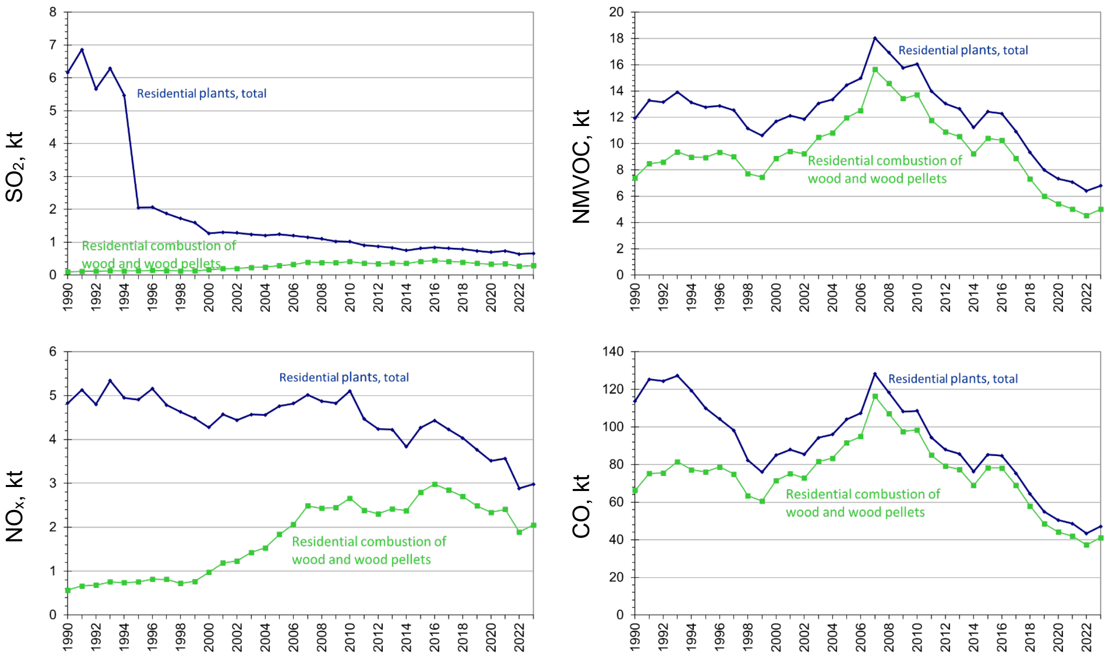


Figure 76 Time series for emission of SO_2, NO_x, NMVOCs and CO from 1A4b Residential plants.

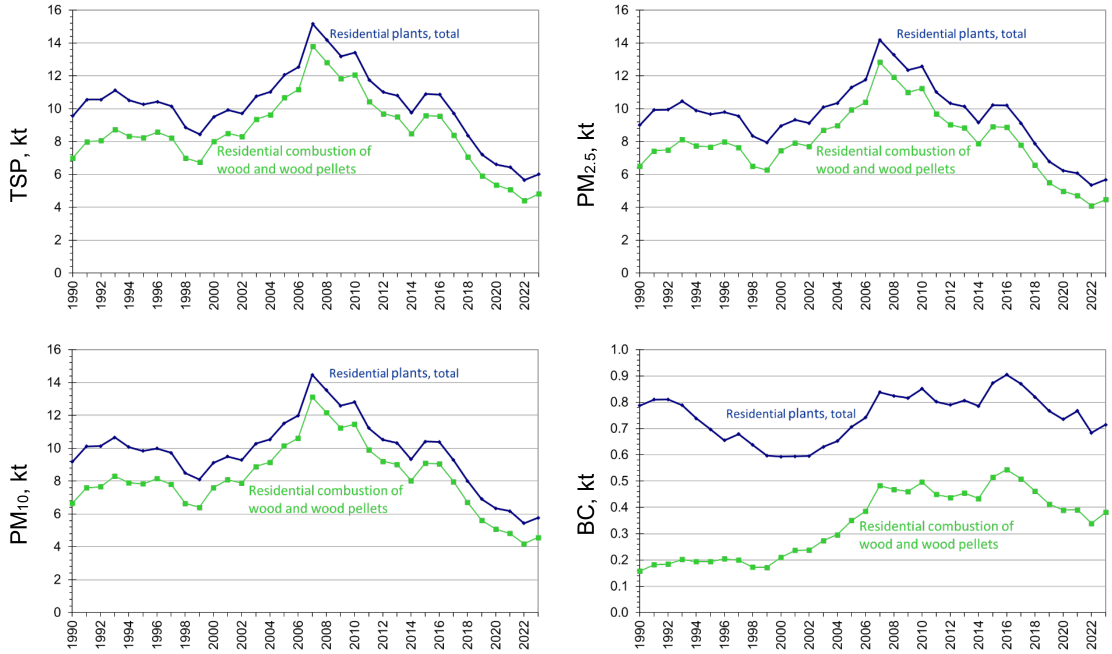


Figure 77 Time series for PM emissions from Residential plants.

Figure 78 Time series for PAH emissions from Residential plants.

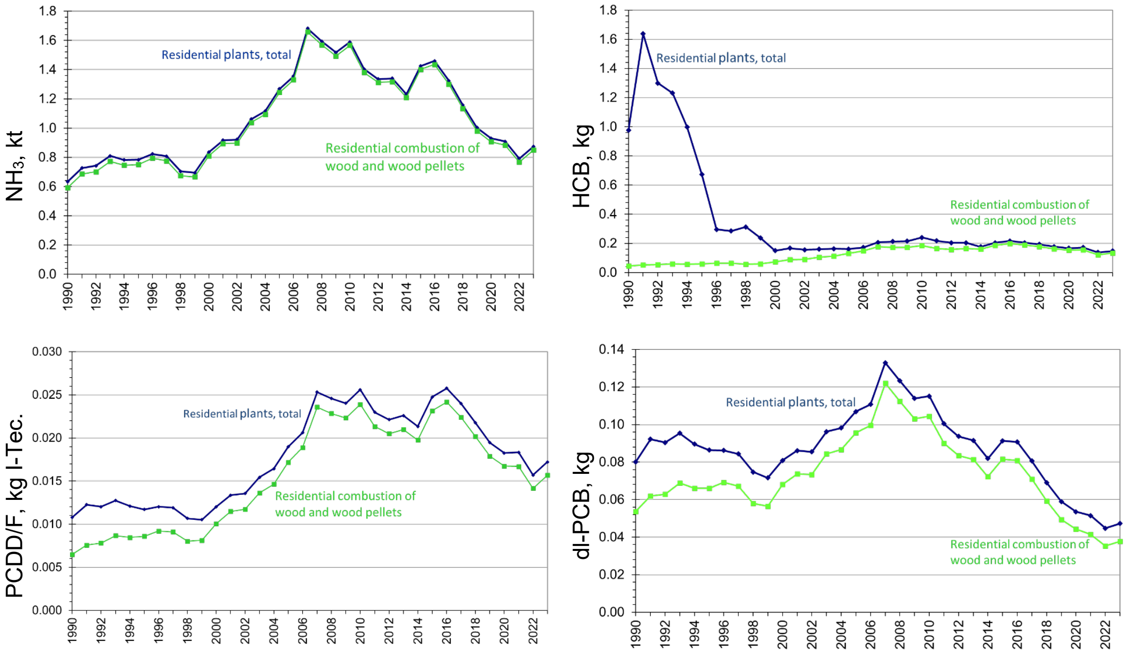


Figure 79 Time series for emissions of NH_3, PCDD/F, HCB, and dl-PCBs from Residential plants.

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 80 and Figure 81 show the time series for fuel consumption and emissions.

For plants in Agriculture/forestry, the fuel consumption has decreased 53 % since 1990.

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 67). 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 2023 was 65 % 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 2023 was 29 % lower than in 1990. The emission follows the time series for natural gas combusted in gas engines (Figure 67). 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 48 % 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 91 % lower in 2023 than in 1990.

The emission of NO_x was 58 % lower in 2023 than in 1990.

The emission of NMVOC has decreased 49 % since 1990.

The CO emission has decreased 87 % 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.

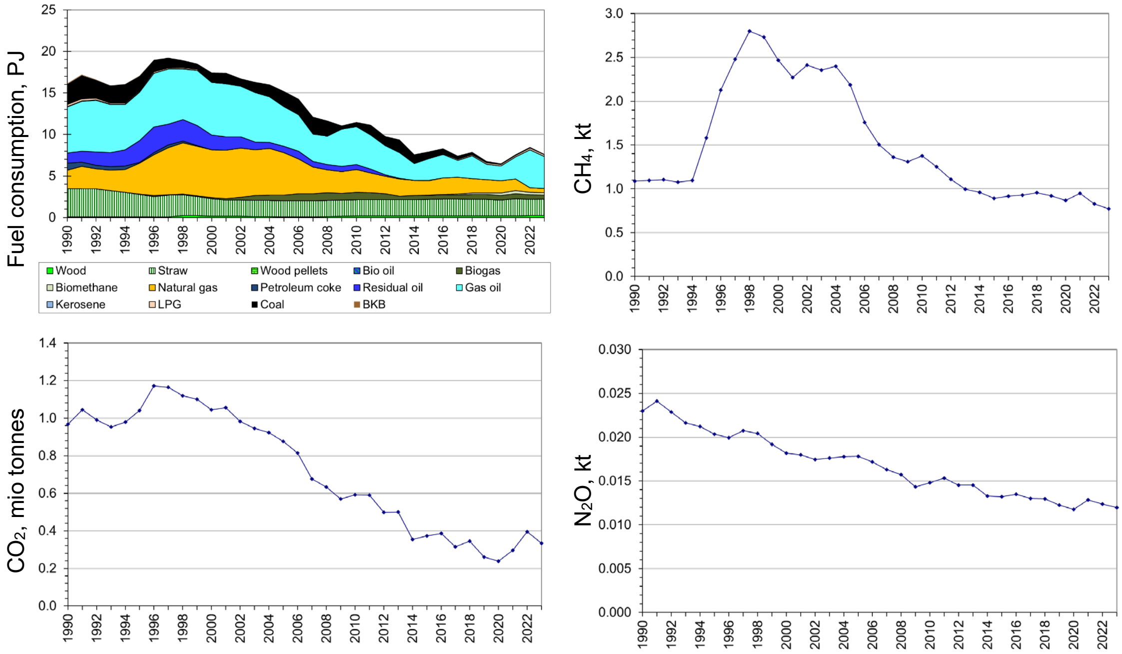


Figure 80 Time series for fuel consumption and GHG emissions from 1A4c Agriculture/forestry.

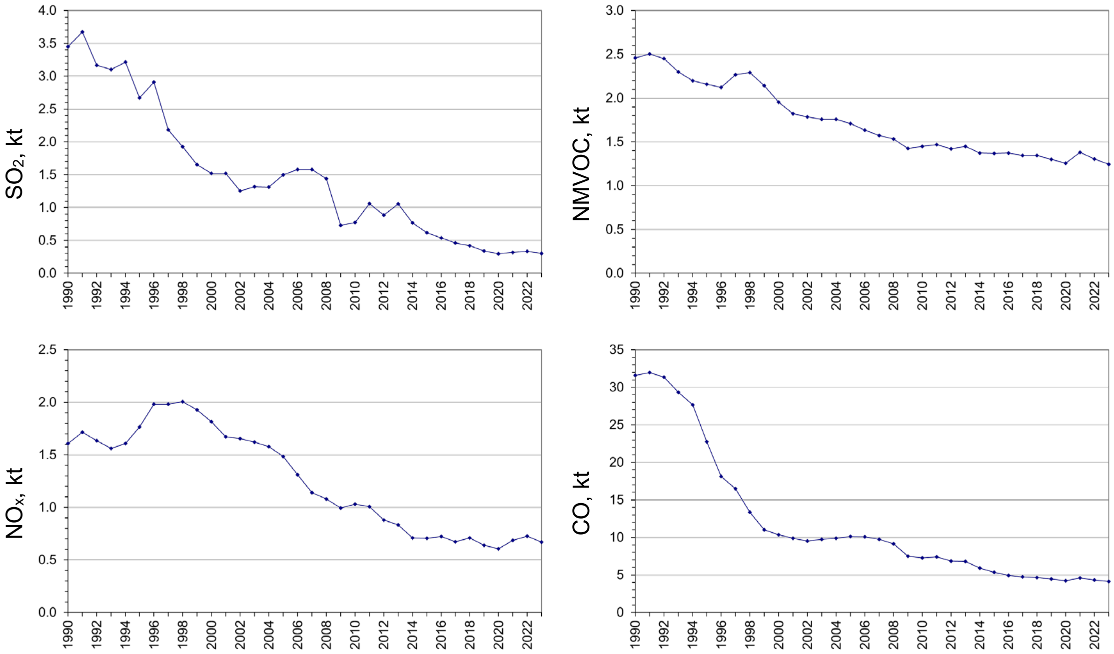


Figure 81 Time series for emission of SO_2, NO_x, NMVOC and CO from 1A4c Agriculture/forestry.

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 EMEP/EEA Guidebook (EEA, 2023). 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 CRT 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.

A large part of the emissions is based on higher tier methods using either technology-specific, country-specific, or plant-specific emission factors. For large point sources, the emissions of SO_2, NO_x, PM and heavy metals are generally plant specific and hence tier 3. The sources of emission factors are described in Chapter 7.

Recalculations and improvements are shown in Chapter 13.

6.1 Tiers for the GHG emission inventory

The type of GHG emission factor and the applied tier level for each emission source are shown in Table 24 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 24 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)[19].

This year, two source categories based only on tier 1 approach have been identified as key sources, i.e. CO_2 from kerosene combustion and N_2O from residential wood combustion. The total emission from these emission sources adds up to 29 kt CO_2 equivalent or 0.08 % of the national total in 2023. In 1990, the emission from the three emission sources adds up to 377 kt or 0.5 % of national total.

The 1990 CO_2 emission from kerosene was also identified as a key category in earlier emission reporting, and thus implementation of a tier 2 methodology has been considered. The consumption of kerosene in stationary combustion plants was high in 1990 compared to the years before and after. The high consumption is related to the time series in the Danish energy statistics for kerosene consumption in Single family houses. In 1990, this consumption was 6 times the consumption in 1989 and 9 times the consumption in 1991. The Danish Energy Agency has explained that they have not been able to confirm that the 1990-data are incorrect, and thus data will not be revised (Zarnaghi, 2021).

N_2O emission from residential wood combustion is a key source, and if possible, a tier 2 emission factor will be implemented in future inventories. At present, a national referenced emission factor for N_2O is not available for residential wood combustion.

Five key category emission sources (N_2O from 1A1 biomass, N_2O from 1A2 liquid fuels, N_2O from 1A2 biomass, N_2O from 1A4 liquid fuels and CH_4 from residential/agricultural plants) are partly based on a tier 1 approach. However, a large part of the emission from these source categories are based on higher tiers.

[19] Key category according to the KCA approach 1 or approach 2 for Denmark (excluding Greenland and Faroe Islands), including LULUCF, level 1990/ level 2023/ trend.

Table 24 Methodology and type of emission factor, 2023.

		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 [3)]	CS	Yes
1A Stationary combustion, BKB	CO_2	Tier 1	D	No
1A Stationary combustion, Coke oven coke	CO_2	Tier 1/Tier 3	D/PS	No
1A Stationary combustion, Fossil waste, ETS data	CO_2	Tier 3	PS/CS	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 2/Tier 3 [6)]	CS / PS	Yes
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/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	CS	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/Tier 2	D/CS	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/Tier 3	D/PS	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	Yes
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)	No
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 2023 or trend 1990-2023.
3. Only 2.9 % of the total coal consumption is included in the non-ETS category in 2023.
4. 50 % of the total residual oil consumption is included in the non-ETS category in 2023
5. Tier 3 for less than 2 % of the gas oil consumption in 2023.
6. Tier 3 for less than 1 % of the LPG consumption in 2023.

Table 25 Emission data for key sources for which the estimated emissions are based on the tier 1 approach.

Source category	CO_2 emission 1990, kt CO_2 equivalent	CO_2 emission 2023, kt CO_2 equivalent	Key source (KCA approach)
1A Kerosene, CO_2	368	1	Level 1990 (KCA 1), Trend (KCA 1)
1A4b_i Residential wood combustion, N_2O	9	28	Level 2023 (KCA 2), Trend (KCA 2)
Key sources for which the estimated emissions are based on the tier 1 approach, total	377	29	

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 2023, 71 stationary combustion plants are specified as large point sources. Plant specific emission data[20] are available from 63 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; DEPA, 2015a, DEPA, 2020b).
- 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 2023 inventory was 167 PJ. This corresponds to 52 % of the overall fuel consumption for stationary combustion.

A list of the large point sources for 2023 is provided in Annex 5. The number of large point sources registered in the databases increased from 1990 to 2023. 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

[20] For CO_2 or other pollutants.

the general Danish emission factors. Which emission data are plant-specific is shown in Annex 6.

The plant-specific emission data from the EU ETS data represent 59 % of the total fossil CO_2 emission from stationary combustion. CO_2 emission factors are plant specific for the major power plants, refineries, offshore gas turbines, large municipal waste incineration plants 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 below.

Emission measurement data for CH_4 and N_2O are applied for estimating emission factors but in general not implemented as plant specific data. However, plant specific emission factors for N_2O have been estimated for two plants.

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

If plant-specific emission factors are not available, emission factors for area sources are used.

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 Chapter 7.

6.4 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. 7.9 PJ in 2023. The use of fuels for non-energy purposes is included in the inventory in sector 2D Non-energy products from fuels and solvent use.

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 10.

6.5 Activity rates, fuel consumption

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 cf. Annex 3. The net calorific values 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 4.

The fuel consumption of the CRT 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, 2024c). The fuel consumption data flow is shown in Figure 82.

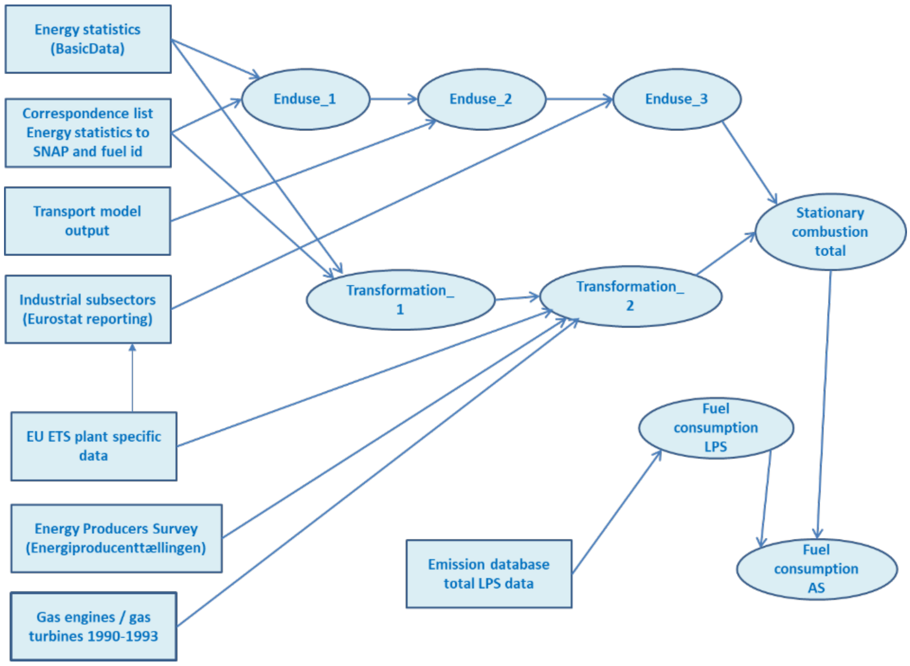


Figure 82 Fuel consumption data flow.

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 100-628 TJ in 1992-2018[21]) 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, 2024b). 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 database (DEA, 2024b) 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.

[21] No border trade of petroleum coke in 2019-2023.

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

Fuel consumption data are presented in Chapter 2.

6.6 Fuel consumption for 1A1c Oil and gas extraction

The fuel consumption data for natural gas applied in 1A1c Oil and gas extraction reported in the EU ETS are not in agreement with the energy statistics for 1990-2020. This is because data in the energy statistics was earlier based on the default net calorific value (NCV) for natural gas applied in Denmark, whereas the EU ETS data were based on fuel analysis of the natural gas applied offshore at each individual platform. For 2021 onwards, the fuel consumption in the energy statistics is in agreement with the EU ETS data. The fuel consumption data applied in the emission inventory for natural gas refer to the EU ETS data.

The gas oil consumption offshore included in EU ETS data have been implemented in the emission inventory. In the energy statistics this consumption is included in domestic sea transport (DEA, 2021).

6.7 Refinery gas consumption for 1A1b Petroleum refining

The EU ETS data for refinery gas consumption reported by the two Danish refineries are not always in agreement with the energy statistics due to the use of default values for net calorific value (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.

6.8 Biomethane

Biomethane is biogas upgraded for distribution in the natural gas grid. Biomethane has been included as a separate fuel in the energy statistics and in the emission inventory. In this report the fuel is referred to as biomethane, but others might refer to this fuel as bio natural gas or upgraded biogas.

Gas distributed in the Danish gas distribution system consists of (fossil) natural gas and biomethane. In the emission inventory (CRT), the biomethane part of the energy content has been assumed equal for all appliances in Denmark, except for offshore consumption.[22] This assumption is in agreement with the Danish energy statistics (DEA, 2024a) and with the IPCC Guidelines (2006). According to IPCC Guidelines (2006) the GHG emission inventories should be based on physical data, and thus the trading of certificates is not included in the inventories. In 2023, 36.7 % of the energy content in distributed gas was biomethane (DEA, 2024a).

In the EU ETS data system, trading of biomethane Guarantees of origin (GoOs)[23] has been included in the fuel consumption data from the reporting for year 2021. This agrees with the EU Guidance document for biomass issues

[22] The consumption offshore is 100 % fossil natural gas.
[23] The biogas provider must obtain certificates to prove that the gas fulfils sustainability and greenhouse gas saving criteria.

in the EU ETS (EU, 2022), see *Chapter 5.3 Biogas in natural gas grids* that specifies the system requirements for the purchase of biomethane certificates. In the EU ETS data set for Denmark, all distributed gas is considered (fossil) natural gas if no biomethane certificates have been purchased. The differences regarding biomethane cause some differences when comparing CO_2 emission data in CRT and the sum of EU ETS emission data.

In the emission inventory, plant specific fuel consumption data for (fossil) natural gas and biomethane from EU ETS are implemented in the emission inventory by adding natural gas and biomethane and afterwards dividing into the two fuels according to the national split for pipeline gas.

The gas consumption offshore and in the Danish gas treatment plant have been assumed to be 100 % fossil natural gas. This is also in accordance with the Danish energy statistics.

6.9 Biogas and biomethane distributed in the town gas grid

The energy statistics includes a consumption of biogas and biomethane for town gas production. In 2023, 129 TJ biogas and 170 TJ biomethane was distributed in the town gas grid.

In the energy statistics, biogas and biomethane distributed in the town gas grid is included in the fuel category town gas. In the emission inventory, biogas and biomethane distributed in the town gas grid have been included in the fuel categories biogas and biomethane.

6.10 Town gas

Town gas (the fossil part) has been included in the fuel category natural gas. The consumption of town gas in Denmark is very low, e.g. 0.5 PJ in 2023. 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[24]. The use of coal for town gas production ceased in the early 1980s.

An indicative composition of town gas in 2015 according to the largest supplier of town gas in Denmark is shown in Table 26 (KE, 2015).

Table 26 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 net calorific value of the town gas 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

[24] Biomethane and biogas is part of the input fuels for town gas production, but in the emission inventory these fuels are treated as part of the fuel categories biomethane and biogas, see above.

natural gas in 2015 (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.

In earlier years, the composition of town gas was somewhat different. Table 27 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 27 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 net 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 sectoral 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.

Biogas and biomethane are applied for production of town gas, but in the emission inventory these fuels are included in the fuel categories biogas and biomethane, see Biogas and biomethane distributed in the town gas grid on page 112.

6.11 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 83. In 2021, 2 % of the incinerated waste was hazardous waste.

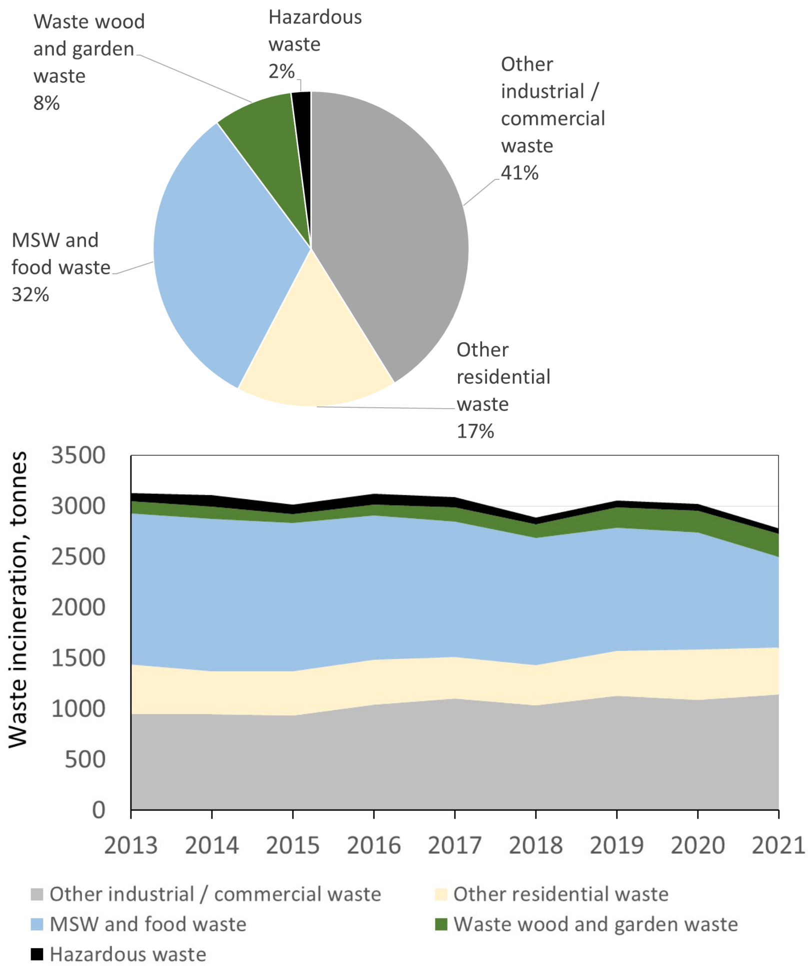


Figure 83 Waste fractions (weight) for incinerated waste in 2021 and the corresponding time series 2013-2021 (DEPA, 2023a).

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.

6.12 Biogas

Biogas includes landfill gas, sludge gas and manure/organic waste gas[25]. In 2023, 82 % of the produced biogas was upgraded to biomethane. An increasing part of the biogas is upgraded to biomethane.

Biogas upgraded for distribution in the natural gas grid reported as biomethane and is not included in the fuel category "biogas" in the rest of this report. This is also the case for bio gasification gas.

[25] Based on manure with addition of other organic waste.

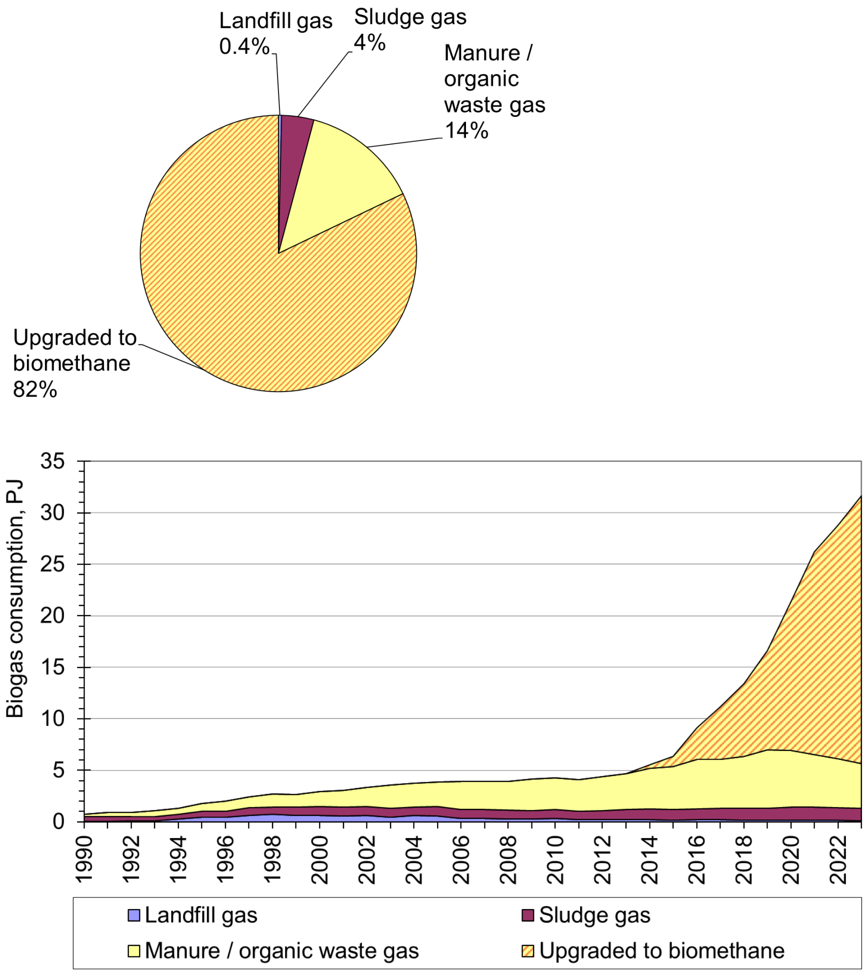


Figure 84 Biogas types (including biomethane) 2023 and the corresponding time series 1990-2023 (DEA, 2024e; DEA 2024a).

6.13 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. The model for residential wood combustion emissions was revised in 2020 and reported in Nielsen et al. (2021b).

6.13.1 Residential wood combustion, fuel consumption

The total wood consumption is provided in the official energy statistics published by the DEA. However, for the purposes of calculating emissions from residential wood combustion, it is necessary to break down the wood consumption to different technologies, as different technologies have widely different emission factors.

In the Danish emission inventory, there is a differentiation between different types of stoves and boiler. In addition, there is a technology category for open fireplaces and similar and one for masonry stoves and similar. Wood pellets considered a separate fuel. The categories used in the inventory are provided in Table 28 below.

Table 28 Overview of residential wood burning technologies.

Technology
Stoves (-1989)
Stoves (1990-2007)
Stoves (2008-2014)
Stoves (2015-2016)
Stoves (2017-)
Eco labelled stoves / new advanced stoves (-2014)
Eco labelled stoves / new advanced stoves (2015-2016)
Eco labelled stoves / new advanced stoves (2017-)
Open fireplaces and similar
Masonry heat accumulating stoves and similar
Boilers with accumulation tank (-1979)
Boilers without accumulation tank (-1979)
Boilers with accumulation tank (1980-)
Boilers without accumulation tank (1980-)
Pellet boilers / pellet stoves

The total number of wood-burning appliances has been estimated based on data from the Danish Chimneysweepers Association (SFL) supplemented with data from the Danish Building and Dwelling Register and data for replacement of older units. For further information, please see Nielsen et al. (2021b). The estimated wood consumption rates for each category are shown in Table 29 and Figure 85 below.

The time series for wood consumption in the 15 different technologies are illustrated in Figure 85. The consumption in new/ecolabelled stoves has increased. Details about disaggregation of the wood consumption between technologies are given in Nielsen et al. (2021b).

Table 29 Time series for fuel consumption in residential wood combustion, TJ.

Technology	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
Stoves (-1989)	5059	5505	4684	4829	4390	2069	430	299	193	137
Stoves (1990-2007)	189	1456	3004	6476	8545	7389	3971	3639	3277	3536
Stoves (2008-2014)	0	0	0	0	172	350	218	208	197	224
Stoves (2015-2016)	0	0	0	0	0	48	60	57	54	62
Stoves (2017-)	0	0	0	0	0	0	120	143	162	216
Eco labelled stoves / new advanced stoves (-2014)	0	0	0	1079	4003	5400	3347	3194	3004	3398
Eco labelled stoves / new advanced stoves (2015-2016)	0	0	0	0	0	432	538	515	487	555
Eco labelled stoves / new advanced stoves (2017-)	0	0	0	0	0	0	1076	1288	1461	1943
Open fireplaces and similar	215	276	289	439	581	533	331	317	300	342
Masonry heat accumulating stoves and similar	51	65	69	104	138	126	79	75	71	81
Boilers with accumulation tank (-1979)	1108	1064	745	566	1	0	0	0	0	0
Boilers without accumulation tank (-1979)	1108	1064	745	566	1	0	0	0	0	0
Boilers with accumulation tank (1980-)	681	1355	1965	3866	6307	6195	3905	3738	3535	4029
Boilers without accumulation tank (1980-)	426	773	1012	1786	2661	2029	1211	1159	1096	1250
Pellet boilers / pellet stoves	117	201	2112	6690	10105	12999	15101	16460	10652	10759

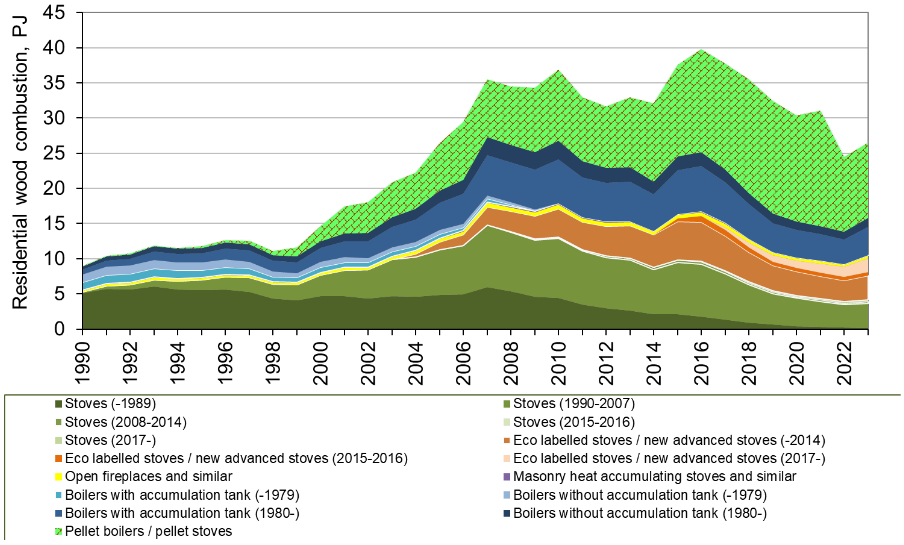


Figure 85 Technology specific wood consumption rates in residential plants.

6.13.2 Residential wood combustion, technology specific EFs

For the pollutants CH_4, NO_x, NMVOC, CO, NH_3, TSP, PM_{10}, $PM_{2.5}$, BC, PCDD/F, PCB and PAH emission factors have been based on fuel consumption data and technology specific emission factors for 15 different technologies. Technology specific emission factors and implied emission factors for 2023 are shown in Table 30.

References for the technology specific emission factors are shown in Table 31 and time series for implied emission factors (IEFs) are shown in Table 32.

Emission measurements performed in Denmark applying dilution tunnel have been prioritised. Thus, condensable particles are included in the emission factors.

The emission factors for dioxin are dependent on the applied wood but independent of stove technology. Four different emission factors are applied for: stoves, open fireplaces, boilers, and pellet stoves/boilers.

The BC emission is often stated as a percentage of the $PM_{2.5}$ emission even though the BC fraction varies considerably and no direct correlation exists. This is also stated by Andersen & Hvidbjerg (2017) and in Kindbom et al. (2017) (boilers, chapter 3.6). The emission factor for BC from ecolabelled stoves is not lower than for old stoves.

For pollutants not included in Table 30, technology specific emission factors and time series have not been estimated, and the emission factors are included in Chapter 7.

Table 30 Technology specific emission factors for residential wood combustion and IEF for log wood/wood chips, 2023.

Technology	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	PCDD/F, ng/GJ	dl-PCBs, ng/GJ	Benzo (a) pyrene, mg/GJ	Benzo (b) fluoran-thene, mg/GJ	Benzo (k) fluoran-thene, mg/GJ	Indeno (1.2.3-c,d) pyrene, mg/GJ	CH_4 g/GJ
Stoves (-1989)	50	1200	8000	70	1000	950	930	17	1048	7049	116	55	119	62	430
Stoves (1990-2007)	50	600	4000	70	500	475	465	17	1048	7049	48	59	50	27	215
Stoves (2008-2014)	80	350	1900	37	389	370	362	31	1048	931	43	65	19	31	125
Stoves (2015-2016)	80	350	1900	37	317	301	295	31	1048	931	43	65	19	31	125
Stoves (2017-)	80	350	1900	37	253	240	235	31	1048	931	43	65	19	31	125
Eco labelled stoves / new advanced stoves (-2014)	75	175	1900	37	253	240	235	31	1048	466	43	65	19	31	2
Eco labelled stoves / new advanced stoves (2015-2016)	75	175	1900	37	190	181	177	31	1048	466	43	65	19	31	2
Eco labelled stoves / new advanced stoves (2017-)	75	175	1900	37	127	121	118	31	1048	466	43	65	19	31	2
Open fireplaces and similar	50	600	4000	74	882	838	820	34	55	60	35	25	29	21	430
Masonry heat accumulating stoves and similar	50	600	2402	70	63	60	59	18	282	7049	17	8	10	25	215
Boilers with accumulation tank (-1979)	80	350	9001	74	588	559	547	24	282	7049	991	926	632	1092	211
Boilers without accumulation tank (-1979)	80	350	10890	74	736	699	684	24	282	7049	991	926	632	1092	256
Boilers with accumulation tank (1980-)	95	175	1613	37	64	61	60	6	282	466	90	60	40	40	50
Boilers without accumulation tank (1980-)	95	350	1952	37	335	318	312	6	282	931	120	80	50	60	50
IEF residential log wood/wood chips, 2023	**75.4**	**310**	**2403**	**45.7**	**270**	**257**	**251**	**19.4**	**766**	**2075**	**62.6**	**62.3**	**34.8**	**34.7**	**83.8**
Pellet boilers / pellet stoves	**80**	**10**	**300**	**12**	**51**	**48**	**47**	**7**	**333**	**466**	**0.9**	**1.3**	**1.3**	**1.2**	**3**

Technology specific references and assumptions

The technology specific emission factor for each pollutant and technology are shown in Table 31. The reference and assumptions for each of the emission factor are also included in the table.

Table 31 Emission factors for residential wood combustion.

	Pollutant	Emission factor	Unit	Reference
Stoves (-1989)	NO_x	50	g/GJ	Pettersson et al. (2011). Also applied in EEA (2023), Small combustion, Table 3-40, Tier 2, Conventional stoves.
Stoves (1990-2007)	NO_x	50	g/GJ	Pettersson et al. (2011). Also applied in EEA (2023), Small combustion, Table 3-40, Tier 2, Conventional stoves.
Stoves (2008-2014)	NO_x	80	g/GJ	Pettersson et al. (2011). Also applied in EEA (2023), Small combustion, Table 3-41, Tier 2, High-efficiency stoves.
Stoves (2015-2016)	NO_x	80	g/GJ	Same as Stoves (2008-2014)
Stoves (2017-)	NO_x	80	g/GJ	Same as Stoves (2008-2014)
Eco labelled stoves / new advanced stoves (-2014)	NO_x	75	g/GJ	Andersen & Hvidbjerg (2017)
Eco labelled stoves / new advanced stoves (2015-2016)	NO_x	75	g/GJ	Andersen & Hvidbjerg (2017)
Eco labelled stoves / new advanced stoves (2017-)	NO_x	75	g/GJ	Andersen & Hvidbjerg (2017)
Open fireplaces and similar	NO_x	50	g/GJ	Pettersson et al. (2011). Also applied in EEA (2023), Small Combustion, Tier 2, Open fireplaces, Table 3-39.
Masonry heat accumulating stoves and similar	NO_x	50	g/GJ	Pettersson et al. (2011). Also applied in EEA (2023), Small combustion, Tier 2, Table 3-40, conventional stoves.
Boilers with accumulation tank (-1979)	NO_x	80	g/GJ	Pettersson et al. (2011). Also applied in EEA (2023), Small combustion, Tier 2, Table 3-43, conventional boilers.
Boilers without accumulation tank (-1979)	NO_x	80	g/GJ	Pettersson et al. (2011). Also applied in EEA (2023), Small combustion, Tier 2, Table 3-43, conventional boilers.
Boilers with accumulation tank (1980-)	NO_x	95	g/GJ	Pettersson et al. (2011). Also applied in EEA (2023), Small combustion, Tier 2, Table 3-42, advanced / ecolabelled stoves and boilers.
Boilers without accumulation tank (1980-)	NO_x	95	g/GJ	Pettersson et al. (2011). Also applied in EEA (2023), Small combustion, Tier 2, Table 3-42, advanced / ecolabelled stoves and boilers.
Pellet boilers / pellet stoves	NO_x	80	g/GJ	Pettersson et al. (2011). Also applied in EEA (2023), Small combustion, Tier 2, Table 3-44, pellet stoves and boilers.
Stoves (-1989)	NMVOC	1200	g/GJ	Assumed two times Stoves (1990-2007). Pettersson et al. (2011). Also applied in EEA (2023), Small combustion, table 3-40, Tier 2, Conventional stoves; 600 g/GJ (20 g/GJ - 3000 g/GJ).
Stoves (1990-2007)	NMVOC	600	g/GJ	Pettersson et al. (2011). Also applied in EEA (2023), Small combustion, Table 3-40, Tier 2, Conventional stoves.

	Pollutant	Emission factor	Unit	Reference
Stoves (2008-2014)	NMVOC	350	g/GJ	Johansson et al. (2004). Also applied in EEA (2023), Small combustion, Table 3-41, High-efficiency stoves.
Stoves (2015-2016)	NMVOC	350	g/GJ	Same as Stove (2008-2014).
Stoves (2017-)	NMVOC	350	g/GJ	Same as Stove (2008-2014).
Eco labelled stoves / new advanced stoves (-2014)	NMVOC	175	g/GJ	Assumed ½ Stoves (2008-2014). The EEA (2023) 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 stoves / new advanced stoves (2015-2016)	NMVOC	175	g/GJ	Same as ecolabelled stoves (-2014).
Eco labelled stoves / new advanced stoves (2017-)	NMVOC	175	g/GJ	Same as ecolabelled stoves (-2014).
Open fireplaces and similar	NMVOC	600	g/GJ	Pettersson et al. (2011) and McDonald et al. (2000). Also applied in EEA (2023), Small combustion, Open fireplaces, Table 3-39.
Masonry heat accumulating stoves and similar	NMVOC	600	g/GJ	Pettersson et al. (2011). Also applied in EEA (2023), Small combustion, Table 3-40, conventional stoves.
Boilers with accumulation tank (-1979)	NMVOC	350	g/GJ	Johansson et al. (2004). Also applied in EEA (2023), Small combustion, Table 3-43, Conventional boilers.
Boilers without accumulation tank (-1979)	NMVOC	350	g/GJ	Johansson et al. (2004). Also applied in EEA (2023), Small combustion, Table 3-43, Conventional boilers.
Boilers with accumulation tank (1980-)	NMVOC	175	g/GJ	Assumed equal to ecolabelled stoves (-2014).
Boilers without accumulation tank (1980-)	NMVOC	350	g/GJ	Assumed 2 times the emission from boilers with accumulation tank (1980-).
Pellet boilers / pellet stoves	NMVOC	10	g/GJ	Johansson et al. (2004) and Boman et al. (2011). Also applied in EEA (2023), Small combustion, Table 3-44, Pellet stoves and boilers.
Stoves (-1989)	CH_4	430	g/GJ	Methane emissions from residential biomass combustion, Paulrud et al. (2005) (SMED report, Sweden).
Stoves (1990-2007)	CH_4	215	g/GJ	Assumed ½ the emission factor for stoves (-1989).
Stoves (2008-2014)	CH_4	125	g/GJ	Estimated based on the emission factor for stoves (1990-2007) and the emission factors for NMVOC.
Stoves (2015-2016)	CH_4	125	g/GJ	Same as stoves (2008-2014).
Stoves (2017-)	CH_4	125	g/GJ	Same as stoves (2008-2014).
Eco labelled stoves / new advanced stoves (-2014)	CH_4	2	g/GJ	Low emissions from wood burning in an ecolabelled residential boiler. Olsson & Kjällstrand (2005).
Eco labelled stoves / new advanced stoves (2015-2016)	CH_4	2	g/GJ	Same as advanced / ecolabelled stoves.
Eco labelled stoves / new advanced stoves (2017-)	CH_4	2	g/GJ	Same as advanced / ecolabelled stoves.
Open fireplaces and similar	CH_4	430	g/GJ	Assumed equal to stoves (-1989).
Masonry heat accumulating stoves and similar	CH_4	215	g/GJ	Assumed equal to stoves (-1989).
Boilers with accumulation tank (-1979)	CH_4	211	g/GJ	Methane emissions from residential biomass combustion, Paulrud et al. (2005) (SMED report, Sweden).

	Pollutant	Emission factor	Unit	Reference
Boilers without accumulation tank (-1979)	CH_4	256	g/GJ	Methane emissions from residential biomass combustion, Paulrud et al. (2005) (SMED report, Sweden).
Boilers with accumulation tank (1980-)	CH_4	50	g/GJ	Emission characteristics of modern and old-type residential boilers fired with wood logs and wood pellets. Johansson et al. (2004).
Boilers without accumulation tank (1980-)	CH_4	50	g/GJ	Emission characteristics of modern and old-type residential boilers fired with wood logs and wood pellets. Johansson et al. (2004).
Pellet boilers / pellet stoves	CH_4	3	g/GJ	Methane emissions from residential biomass combustion, Paulrud et al. (2005) (SMED report, Sweden).
Stoves (-1989)	CO	8000	g/GJ	Assumed two times Stoves (1990-2007). This emission factor refers to Pettersson et al. (2011) and Goncalves et al. (2012). Also applied in EEA (2023), Small combustion, Table 3-40, Tier 2, Conventional stoves; 4000 g/GJ (1000 g/GJ - 10000 g/GJ).
Stoves (1990-2007)	CO	4000	g/GJ	Pettersson et al. (2011) and Goncalves et al. (2012). Also applied in EEA (2023), Small combustion, Table 3-40, Tier 2, conventional stoves.
Stoves (2008-2014)	CO	1900	g/GJ	Andersen & Hvidbjerg (2017) and Kindbom et al. (2017).
Stoves (2015-2016)	CO	1900	g/GJ	Andersen & Hvidbjerg (2017) and Kindbom et al. (2017).
Stoves (2017-)	CO	1900	g/GJ	Andersen & Hvidbjerg (2017) and Kindbom et al. (2017).
Eco labelled stoves / new advanced stoves (-2014)	CO	1900	g/GJ	Andersen & Hvidbjerg (2017) and Kindbom et al. (2017).
Eco labelled stoves / new advanced stoves (2015-2016)	CO	1900	g/GJ	Andersen & Hvidbjerg (2017) and Kindbom et al. (2017).
Eco labelled stoves / new advanced stoves (2017-)	CO	1900	g/GJ	Andersen & Hvidbjerg (2017) and Kindbom et al. (2017).
Open fireplaces and similar	CO	4000	g/GJ	Goncalves et al. (2012). Also applied in EEA (2023), Small Combustion, Table 3-39 Open fireplaces.
Masonry heat accumulating stoves and similar	CO	2402	g/GJ	Kindbom et al. (2017).
Boilers with accumulation tank (-1979)	CO	9001	g/GJ	Winther (2008).
Boilers without accumulation tank (-1979)	CO	10890	g/GJ	Winther (2008).
Boilers with accumulation tank (1980-)	CO	1613	g/GJ	Winther (2008).
Boilers without accumulation tank (1980-)	CO	1952	g/GJ	Winther (2008).
Pellet boilers / pellet stoves	CO	300	g/GJ	Schmidl et al. (2011) and Johansson et al. (2004). Also applied in EEA (2023), Small Combustion, Table 3-44 Pellet stoves and boilers.
Stoves (-1989)	NH_3	70	g/GJ	Roe et al. (2004).
Stoves (1990-2007)	NH_3	70	g/GJ	Roe et al. (2004).
Stoves (2008-2014)	NH_3	37	g/GJ	Roe et al. (2004).
Stoves (2015-2016)	NH_3	37	g/GJ	Roe et al. (2004).
Stoves (2017-)	NH_3	37	g/GJ	Roe et al. (2004).
Eco labelled stoves / new advanced stoves (-2014)	NH_3	37	g/GJ	Roe et al. (2004).

	Pollutant	Emission factor	Unit	Reference
Eco labelled stoves / new advanced stoves (2015-2016)	NH_3	37	g/GJ	Roe et al. (2004).
Eco labelled stoves / new advanced stoves (2017-)	NH_3	37	g/GJ	Roe et al. (2004).
Open fireplaces and similar	NH_3	74	g/GJ	Roe et al. (2004).
Masonry heat accumulating stoves and similar	NH_3	70	g/GJ	Roe et al. (2004).
Boilers with accumulation tank (-1979)	NH_3	74	g/GJ	Roe et al. (2004).
Boilers without accumulation tank (-1979)	NH_3	74	g/GJ	Roe et al. (2004).
Boilers with accumulation tank (1980-)	NH_3	37	g/GJ	Roe et al. (2004).
Boilers without accumulation tank (1980-)	NH_3	37	g/GJ	Roe et al. (2004).
Pellet boilers / pellet stoves	NH_3	12	g/GJ	Roe et al. (2004).
Stoves (-1989)	TSP	1000	g/GJ	Glasius et al. (2005).
Stoves (1990-2007)	TSP	500	g/GJ	Glasius et al. (2005), Glasius et al. (2007), Kindbom et al. (2017) and Schleicher (2018).
Stoves (2008-2014)	TSP	389	g/GJ	Kindbom et al. (2017).
Stoves (2015-2016)	TSP	317	g/GJ	MST (2015). Limit value 5 g/kg.
Stoves (2017-)	TSP	253	g/GJ	MST (2015). Limit value 4 g/kg.
Eco labelled stoves / new advanced stoves (-2014)	TSP	253	g/GJ	Nordic Ecolabelling limit 2012 update for hand fed stove for temporary firing or inset stove (4 g/kg).
Eco labelled stoves / new advanced stoves (2015-2016)	TSP	190	g/GJ	Nordic Ecolabelling limit update for hand fed stove for temporary firing or inset stove (3 g/kg).
Eco labelled stoves / new advanced stoves (2017-)	TSP	127	g/GJ	Nordic Ecolabelling limit update.
Open fireplaces and similar	TSP	882	g/GJ	Alves et al. (2011).
Masonry heat accumulating stoves and similar	TSP	63	g/GJ	Tissari et al. (2009).
Boilers with accumulation tank (-1979)	TSP	588	g/GJ	Winther (2008).
Boilers without accumulation tank (-1979)	TSP	736	g/GJ	Winther (2008).
Boilers with accumulation tank (1980-)	TSP	64	g/GJ	Winther (2008).
Boilers without accumulation tank (1980-)	TSP	335	g/GJ	Winther (2008).
Pellet boilers / pellet stoves	TSP	51	g/GJ	Kindbom et al. (2017).
Stoves (-1989)	PM_{10}	950	g/GJ	95% of TSP. Boman et al. (2011), Pettersson et al. (2011) and the TNO CEPMEIP.
Stoves (1990-2007)	PM_{10}	475	g/GJ	95% of TSP. Boman et al. (2011), Pettersson et al. (2011) and the TNO CEPMEIP.
Stoves (2008-2014)	PM_{10}	370	g/GJ	95% of TSP. Boman et al. (2011), Pettersson et al. (2011) and the TNO CEPMEIP.
Stoves (2015-2016)	PM_{10}	301	g/GJ	95% of TSP. Boman et al. (2011), Pettersson et al. (2011) and the TNO CEPMEIP.
Stoves (2017-)	PM_{10}	240	g/GJ	95% of TSP. Boman et al. (2011), Pettersson et al. (2011) and the TNO CEPMEIP.
Eco labelled stoves / new advanced stoves (-2014)	PM_{10}	240	g/GJ	95% of TSP. Boman et al. (2011), Pettersson et al. (2011) and the TNO CEPMEIP.

	Pollutant	Emission factor	Unit	Reference
Eco labelled stoves / new advanced stoves (2015-2016)	PM_{10}	181	g/GJ	95% of TSP. Boman et al. (2011), Pettersson et al. (2011) and the TNO CEPMEIP.
Eco labelled stoves / new advanced stoves (2017-)	PM_{10}	121	g/GJ	95% of TSP. Boman et al. (2011), Pettersson et al. (2011) and the TNO CEPMEIP.
Open fireplaces and similar	PM_{10}	838	g/GJ	95% of TSP. Boman et al. (2011), Pettersson et al. (2011) and the TNO CEPMEIP.
Masonry heat accumulating stoves and similar	PM_{10}	60	g/GJ	95% of TSP. Boman et al. (2011), Pettersson et al. (2011) and the TNO CEPMEIP.
Boilers with accumulation tank (-1979)	PM_{10}	559	g/GJ	95% of TSP. Boman et al. (2011), Pettersson et al. (2011) and the TNO CEPMEIP.
Boilers without accumulation tank (-1979)	PM_{10}	699	g/GJ	95% of TSP. Boman et al. (2011), Pettersson et al. (2011) and the TNO CEPMEIP.
Boilers with accumulation tank (1980-)	PM_{10}	61	g/GJ	95% of TSP. Boman et al. (2011), Pettersson et al. (2011) and the TNO CEPMEIP.
Boilers without accumulation tank (1980-)	PM_{10}	318	g/GJ	95% of TSP. Boman et al. (2011), Pettersson et al. (2011) and the TNO CEPMEIP
Pellet boilers / pellet stoves	PM_{10}	48	g/GJ	95% of TSP. Boman et al. (2011), Pettersson et al. (2011) and the TNO CEPMEIP.
Stoves (-1989)	$PM_{2.5}$	930	g/GJ	93% of TSP. Boman et al. (2011), Pettersson et al. (2011) and the TNO CEPMEIP.
Stoves (1990-2007)	$PM_{2.5}$	465	g/GJ	93% of TSP. Boman et al. (2011), Pettersson et al. (2011) and the TNO CEPMEIP.
Stoves (2008-2014)	$PM_{2.5}$	362	g/GJ	93% of TSP. Boman et al. (2011), Pettersson et al. (2011) and the TNO CEPMEIP.
Stoves (2015-2016)	$PM_{2.5}$	295	g/GJ	93% of TSP. Boman et al. (2011), Pettersson et al. (2011) and the TNO CEPMEIP.
Stoves (2017-)	$PM_{2.5}$	235	g/GJ	93% of TSP. Boman et al. (2011), Pettersson et al. (2011) and the TNO CEPMEIP.
Eco labelled stoves / new advanced stoves (-2014)	$PM_{2.5}$	235	g/GJ	93% of TSP. Boman et al. (2011), Pettersson et al. (2011) and the TNO CEPMEIP.
Eco labelled stoves / new advanced stoves (2015-2016)	$PM_{2.5}$	177	g/GJ	93% of TSP. Boman et al. (2011), Pettersson et al. (2011) and the TNO CEPMEIP.
Eco labelled stoves / new advanced stoves (2017-)	$PM_{2.5}$	118	g/GJ	93% of TSP. Boman et al. (2011), Pettersson et al. (2011) and the TNO CEPMEIP.
Open fireplaces and similar	$PM_{2.5}$	820	g/GJ	93% of TSP. Boman et al. (2011), Pettersson et al. (2011) and the TNO CEPMEIP.
Masonry heat accumulating stoves and similar	$PM_{2.5}$	59	g/GJ	93% of TSP. Boman et al. (2011), Pettersson et al. (2011) and the TNO CEPMEIP.
Boilers with accumulation tank (-1979)	$PM_{2.5}$	547	g/GJ	93% of TSP. Boman et al. (2011), Pettersson et al. (2011) and the TNO CEPMEIP.

	Pollutant	Emission factor	Unit	Reference
Boilers without accumulation tank (-1979)	$PM_{2.5}$	684	g/GJ	93% of TSP. Boman et al. (2011), Pettersson et al. (2011) and the TNO CEPMEIP.
Boilers with accumulation tank (1980-)	$PM_{2.5}$	60	g/GJ	93% of TSP. Boman et al. (2011), Pettersson et al. (2011) and the TNO CEPMEIP.
Boilers without accumulation tank (1980-)	$PM_{2.5}$	312	g/GJ	93% of TSP. Boman et al. (2011), Pettersson et al. (2011) and the TNO CEPMEIP.
Pellet boilers / pellet stoves	$PM_{2.5}$	47	g/GJ	93% of TSP. Boman et al. (2011), Pettersson et al. (2011) and the TNO CEPMEIP.
Stoves (-1989)	PCDD/F	1048	ng/GJ	Schleicher (2018), Glasius et al. (2005), Glasius et al. (2007) and Andersen & Hvidbjerg (2017).
Stoves (1990-2007)	PCDD/F	1048	ng/GJ	Schleicher (2018), Glasius et al. (2005), Glasius et al. (2007) and Andersen & Hvidbjerg (2017).
Stoves (2008-2014)	PCDD/F	1048	ng/GJ	Schleicher (2018), Glasius et al. (2005), Glasius et al. (2007) and Andersen & Hvidbjerg (2017).
Stoves (2015-2016)	PCDD/F	1048	ng/GJ	Schleicher (2018), Glasius et al. (2005), Glasius et al. (2007) and Andersen & Hvidbjerg (2017).
Stoves (2017-)	PCDD/F	1048	ng/GJ	Schleicher (2018), Glasius et al. (2005), Glasius et al. (2007) and Andersen & Hvidbjerg (2017).
Eco labelled stoves / new advanced stoves (-2014)	PCDD/F	1048	ng/GJ	Schleicher (2018), Glasius et al. (2005), Glasius et al. (2007) and Andersen & Hvidbjerg (2017).
Eco labelled stoves / new advanced stoves (2015-2016)	PCDD/F	1048	ng/GJ	Schleicher (2018), Glasius et al. (2005), Glasius et al. (2007) and Andersen & Hvidbjerg (2017).
Eco labelled stoves / new advanced stoves (2017-)	PCDD/F	1048	ng/GJ	Schleicher (2018), Glasius et al. (2005), Glasius et al. (2007) and Andersen & Hvidbjerg (2017).
Open fireplaces and similar	PCDD/F	55	ng/GJ	Gullet et al. (2005).
Masonry heat accumulating stoves and similar	PCDD/F	282	ng/GJ	Assumed equal to boilers.
Boilers with accumulation tank (-1979)	PCDD/F	282	ng/GJ	Glasius et al. (2005), Glasius et al. (2007), Hübner et al. (2005) and Hedman et al. (2006).
Boilers without accumulation tank (-1979)	PCDD/F	282	ng/GJ	Glasius et al. (2005), Glasius et al. (2007), Hübner et al. (2005) and Hedman et al. (2006).
Boilers with accumulation tank (1980-)	PCDD/F	282	ng/GJ	Glasius et al. (2005), Glasius et al. (2007), Hübner et al. (2005) and Hedman et al. (2006).
Boilers without accumulation tank (1980-)	PCDD/F	282	ng/GJ	Glasius et al. (2005), Glasius et al. (2007), Hübner et al. (2005) and Hedman et al. (2006).
Pellet boilers / pellet stoves	PCDD/F	333	ng/GJ	Hedman et al. (2006).
Stoves (-1989)	Benzo(a)	116	µg/GJ	Glasius et al. (2005).
Stoves (1990-2007)	Benzo(a)	48	µg/GJ	Glasius et al. (2005) except for Benzo(b)fluoranthene that refers to Schleicher (2018).
Stoves (2008-2014)	Benzo(a)	43	µg/GJ	Schleicher (2018).
Stoves (2015-2016)	Benzo(a)	43	µg/GJ	Schleicher (2018).

	Pollutant	Emission factor	Unit	Reference
Stoves (2017-)	Benzo(a)	43	µg/GJ	Schleicher (2018).
Eco labelled stoves / new advanced stoves (-2014)	Benzo(a)	43	µg/GJ	Schleicher (2018).
Eco labelled stoves / new advanced stoves (2015-2016)	Benzo(a)	43	µg/GJ	Schleicher (2018).
Eco labelled stoves / new advanced stoves (2017-)	Benzo(a)	43	µg/GJ	Schleicher (2018).
Open fireplaces and similar	Benzo(a)	35	µg/GJ	Gullet et al. (2003).
Masonry heat accumulating stoves and similar	Benzo(a)	17	µg/GJ	Tissari et al. (2007).
Boilers with accumulation tank (-1979)	Benzo(a)	991	µg/GJ	Winther (2008).
Boilers without accumulation tank (-1979)	Benzo(a)	991	µg/GJ	Winther (2008).
Boilers with accumulation tank (1980-)	Benzo(a)	90	µg/GJ	Johansson et al. (2006).
Boilers without accumulation tank (1980-)	Benzo(a)	120	µg/GJ	Johansson et al. (2006).
Pellet boilers / pellet stoves	Benzo(a)	0.9	µg/GJ	Orasche et al. (2012), distribution between Benzo(b)fluoranthene and Benzo(k)fluoranthene according to Lamberg et al. (2011).
Stoves (-1989)	Benzo(b)	55	µg/GJ	Glasius et al. (2005).
Stoves (1990-2007)	Benzo(b)	59	µg/GJ	Glasius et al. (2005) except for Benzo(b)fluoranthene that refers to Schleicher (2018).
Stoves (2008-2014)	Benzo(b)	65	µg/GJ	Schleicher (2018).
Stoves (2015-2016)	Benzo(b)	65	µg/GJ	Schleicher (2018).
Stoves (2017-)	Benzo(b)	65	µg/GJ	Schleicher (2018).
Eco labelled stoves / new advanced stoves (-2014)	Benzo(b)	65	µg/GJ	Schleicher (2018).
Eco labelled stoves / new advanced stoves (2015-2016)	Benzo(b)	65	µg/GJ	Schleicher (2018).
Eco labelled stoves / new advanced stoves (2017-)	Benzo(b)	65	µg/GJ	Schleicher (2018).
Open fireplaces and similar	Benzo(b)	25	µg/GJ	Gullet et al. (2003).
Masonry heat accumulating stoves and similar	Benzo(b)	7.6	µg/GJ	Tissari et al. (2007).
Boilers with accumulation tank (-1979)	Benzo(b)	926	µg/GJ	Winther (2008).
Boilers without accumulation tank (-1979)	Benzo(b)	926	µg/GJ	Winther (2008).
Boilers with accumulation tank (1980-)	Benzo(b)	60	µg/GJ	Johansson et al. (2006).
Boilers without accumulation tank (1980-)	Benzo(b)	80	µg/GJ	Johansson et al. (2006).
Pellet boilers / pellet stoves	Benzo(b)	1.3	µg/GJ	Orasche et al. (2012), distribution between Benzo(b)fluoranthene and Benzo(k)fluoranthene according to Lamberg et al. (2011).
Stoves (-1989)	Benzo(k)	119	µg/GJ	Glasius et al. (2005).
Stoves (1990-2007)	Benzo(k)	50	µg/GJ	Glasius et al. (2005) except for Benzo(b)fluoranthene that refers to Schleicher (2018).
Stoves (2008-2014)	Benzo(k)	19	µg/GJ	Schleicher (2018).
Stoves (2015-2016)	Benzo(k)	19	µg/GJ	Schleicher (2018).
Stoves (2017-)	Benzo(k)	19	µg/GJ	Schleicher (2018).
Eco labelled stoves / new advanced stoves (-2014)	Benzo(k)	19	µg/GJ	Schleicher (2018).
Eco labelled stoves / new advanced stoves (2015-2016)	Benzo(k)	19	µg/GJ	Schleicher (2018).
Eco labelled stoves / new advanced stoves (2017-)	Benzo(k)	19	µg/GJ	Schleicher (2018).

	Pollutant	Emission factor	Unit	Reference
Open fireplaces and similar	Benzo(k)	29	µg/GJ	Gullet et al. (2003).
Masonry heat accumulating stoves and similar	Benzo(k)	9.5	µg/GJ	Tissari et al. (2007).
Boilers with accumulation tank (-1979)	Benzo(k)	632	µg/GJ	Winther (2008).
Boilers without accumulation tank (-1979)	Benzo(k)	632	µg/GJ	Winther (2008).
Boilers with accumulation tank (1980-)	Benzo(k)	40	µg/GJ	Johansson et al. (2006).
Boilers without accumulation tank (1980-)	Benzo(k)	50	µg/GJ	Johansson et al. (2006).
Pellet boilers / pellet stoves	Benzo(k)	1.3	µg/GJ	Orasche et al. (2012), distribution between Benzo(b)fluoranthene and Benzo(k)fluoranthene according to Lamberg et al. (2011).
Stoves (-1989)	Indeno	62	µg/GJ	Glasius et al. (2005).
Stoves (1990-2007)	Indeno	27	µg/GJ	Glasius et al. (2005) except for Benzo(b)fluoranthene that refers to Schleicher (2018).
Stoves (2008-2014)	Indeno	31	µg/GJ	Schleicher (2018).
Stoves (2015-2016)	Indeno	31	µg/GJ	Schleicher (2018).
Stoves (2017-)	Indeno	31	µg/GJ	Schleicher (2018).
Eco labelled stoves / new advanced stoves (-2014)	Indeno	31	µg/GJ	Schleicher (2018).
Eco labelled stoves / new advanced stoves (2015-2016)	Indeno	31	µg/GJ	Schleicher (2018).
Eco labelled stoves / new advanced stoves (2017-)	Indeno	31	µg/GJ	Schleicher (2018).
Open fireplaces and similar	Indeno	21	µg/GJ	Gullet et al. (2003).
Masonry heat accumulating stoves and similar	Indeno	25	µg/GJ	Tissari et al. (2007).
Boilers with accumulation tank (-1979)	Indeno	1092	µg/GJ	Winther (2008).
Boilers without accumulation tank (-1979)	Indeno	1092	µg/GJ	Winther (2008).
Boilers with accumulation tank (1980-)	Indeno	40	µg/GJ	Johansson et al. (2006).
Boilers without accumulation tank (1980-)	Indeno	60	µg/GJ	Johansson et al. (2006)
Pellet boilers / pellet stoves	Indeno	1.2	µg/GJ	Orasche et al. (2012), distribution between Benzo(b)fluoranthene and Benzo(k)fluoranthene according to Lamberg et al. (2011).
Stoves (-1989)	dl-PCB	7049	ng/GJ	Hedman (2006), old boiler. Recalculation from TEQ to sum of dioxin-like PCB *133 (Thistlethwaite, 2001).
Stoves (1990-2007)	dl-PCB	7049	ng/GJ	Hedman (2006), old boiler. Recalculation from TEQ to sum of dioxin-like PCB *133 (Thistlethwaite, 2001).
Stoves (2008-2014)	dl-PCB	931	ng/GJ	Hedman (2006), modern boiler. Recalculation from TEQ to sum of dioxin-like PCB *133 (Thistlethwaite, 2001).
Stoves (2015-2016)	dl-PCB	931	ng/GJ	Same as stoves (2008-2014).
Stoves (2017-)	dl-PCB	931	ng/GJ	Same as stoves (2008-2014).
Eco labelled stoves / new advanced stoves (-2014)	dl-PCB	466	ng/GJ	Hedman (2006), assumed ½ stoves (2017-).
Eco labelled stoves / new advanced stoves (2015-2016)	dl-PCB	466	ng/GJ	Same as Eco labelled stoves / new advanced stoves (-2014).
Eco labelled stoves / new advanced stoves (2017-)	dl-PCB	466	ng/GJ	Same as Eco labelled stoves / new advanced stoves (-2014).
Open fireplaces and similar	dl-PCB	60	ng/GJ	Hedman et al. (2006), Open fireplaces.

	Pollutant	Emission factor	Unit	Reference
Masonry heat accumulating stoves and similar	dl-PCB	7049	ng/GJ	Hedman (2006), old boiler. Recalculation from TEQ to sum of dioxin-like PCB *133 (Thistlethwaite, 2001).
Boilers with accumulation tank (-1979)	dl-PCB	7049	ng/GJ	Hedman (2006), old boiler. Recalculation from TEQ to sum of dioxin-like PCB *133 (Thistlethwaite, 2001).
Boilers without accumulation tank (-1979)	dl-PCB	7049	ng/GJ	Hedman (2006), old boiler. Recalculation from TEQ to sum of dioxin-like PCB *133 (Thistlethwaite, 2001).
Boilers with accumulation tank (1980-)	dl-PCB	466	ng/GJ	Assumed equal to Eco labelled stoves / new advanced stoves (-2014).
Boilers without accumulation tank (1980-)	dl-PCB	931	ng/GJ	Hedman (2006), modern boiler. Recalculation from TEQ to sum of dioxin-like PCB *133 (Thistlethwaite, 2001).
Pellet boilers / pellet stoves	dl-PCB	466	ng/GJ	Hedman (2006), assumed ½ modern boiler.
Stoves (-1989)	BC	17	g/GJ	Schleicher (2018).
Stoves (1990-2007)	BC	17	g/GJ	Schleicher (2018).
Stoves (2008-2014)	BC	31	g/GJ	Andersen & Hvidbjerg (2017).
Stoves (2015-2016)	BC	31	g/GJ	Andersen & Hvidbjerg (2017).
Stoves (2017-)	BC	31	g/GJ	Andersen & Hvidbjerg (2017).
Eco labelled stoves / new advanced stoves (-2014)	BC	31	g/GJ	Andersen & Hvidbjerg (2017).
Eco labelled stoves / new advanced stoves (2015-2016)	BC	31	g/GJ	Andersen & Hvidbjerg (2017).
Eco labelled stoves / new advanced stoves (2017-)		31	g/GJ	Andersen & Hvidbjerg (2017).
Open fireplaces and similar	BC	34	g/GJ	Alves et al. (2011).
Masonry heat accumulating stoves and similar		18	g/GJ	Tissari et al. (2007).
Boilers with accumulation tank (-1979)	BC	24	g/GJ	Kindbom et al. (2017).
Boilers without accumulation tank (-1979)	BC	24	g/GJ	Kindbom et al. (2017).
Boilers with accumulation tank (1980-)	BC	6	g/GJ	Kindbom et al. (2017).
Boilers without accumulation tank (1980-)	BC	6	g/GJ	Kindbom et al. (2017).
Pellet boilers / pellet stoves	BC	7	g/GJ	Kindbom et al. (2017).

Implied emission factors for residential wood, time series

The time series for the residential wood combustion emission factors (not including wood pellets) have been estimated based on the time series for wood consumption in each technology. The time series are shown in Table 32.

For some pollutants the emission factor is not lower for new ecolabelled stoves than for old stoves. Thus, the implied emission factor is higher in 2023 than in 1990 for NO_x, BC and PCDD/F.

Table 32 Implied emission factor time series for residential wood combustion (not including wood pellets).

Year	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	PCDD/F, ng/GJ	dl-PCB, ng/GJ	Benzo(a)-pyrene, mg/GJ	Benzo(b)-fluoran-thene, mg/GJ	Benzo(k)-fluoran-thene, mg/GJ	Indeno (1,2,3-c,d)-pyrene, mg/GJ	CH_4, g/GJ
1990	63.2	836	7488	67.0	792	752	737	17.8	731	6076	330	274	234	316	327
1991	63.3	823	7302	66.5	776	737	722	17.6	733	6000	316	263	225	302	321
1992	63.4	810	7118	66.1	760	722	707	17.3	734	5924	303	251	215	287	314
1993	63.6	798	6934	65.6	744	707	692	17.1	735	5849	290	240	206	272	308
1994	63.7	785	6753	65.2	728	692	677	16.9	736	5774	276	228	197	258	302
1995	63.8	773	6574	64.8	712	677	663	16.7	738	5701	263	217	188	243	296
1996	63.9	761	6397	64.3	697	662	648	16.5	739	5629	250	206	179	229	289
1997	64.0	748	6208	63.9	680	646	633	16.2	741	5560	237	195	170	214	283
1998	64.1	734	6022	63.5	664	631	617	16.0	743	5492	224	183	161	200	276
1999	64.2	721	5838	63.1	647	615	602	15.8	746	5425	211	172	152	185	270
2000	64.3	708	5656	62.7	631	600	587	15.6	747	5359	198	161	143	171	263
2001	64.4	691	5448	62.3	611	581	569	15.4	749	5293	184	151	134	157	256
2002	64.5	673	5240	61.9	592	562	550	15.2	751	5226	171	140	124	143	248
2003	64.5	656	5037	61.6	572	544	533	15.0	753	5162	159	130	115	129	240
2004	65.3	629	4785	60.3	548	520	509	15.2	755	4921	146	119	106	116	227
2005	66.0	603	4544	59.1	524	498	487	15.4	758	4687	133	109	96	102	215
2006	66.5	587	4359	58.1	507	482	472	15.5	761	4509	121	99	87	89	206
2007	67.0	570	4176	57.2	491	466	456	15.6	764	4333	109	89	79	77	197
2008	67.6	553	3988	56.1	473	450	440	15.7	766	4142	98	79	71	64	188
2009	68.3	530	3771	55.0	452	430	421	15.8	766	3930	86	70	62	52	178
2010	69.0	508	3555	53.9	431	410	401	15.9	766	3718	75.0	60.6	53.5	39.6	167
2011	69.5	489	3443	53.3	417	396	388	16.1	766	3588	73.6	60.7	51.6	39.0	160
2012	70.0	471	3335	52.6	403	383	375	16.4	766	3459	72.3	60.8	49.8	38.4	152
2013	70.5	453	3228	52.0	390	370	363	16.7	766	3330	71.0	60.9	48.1	37.8	145
2014	71.0	435	3125	51.3	377	358	351	17.0	766	3200	69.7	61.1	46.4	37.3	138
2015	71.5	418	3025	50.7	363	345	338	17.2	766	3071	68.6	61.2	44.8	36.8	131
2016	72.0	401	2929	50.0	349	332	325	17.5	766	2941	67.4	61.3	43.2	36.4	124
2017	72.5	386	2838	49.4	336	319	313	17.8	766	2814	66.5	61.4	41.7	36.0	117
2018	73.0	371	2752	48.7	324	307	301	18.1	766	2686	65.6	61.6	40.3	35.7	111
2019	73.5	357	2672	48.1	312	296	290	18.3	766	2560	64.8	61.8	39.1	35.4	105
2020	74.0	344	2596	47.5	300	285	279	18.6	766	2435	64.2	61.9	37.9	35.2	99
2021	74.4	332	2526	46.9	289	275	269	18.9	766	2312	63.5	62.1	36.7	35.0	94
2022	74.9	320	2461	46.2	279	265	260	19.1	766	2192	63.0	62.2	35.7	34.8	88.5
2023	75.4	310	2403	45.7	270	257	251	19.4	766	2075	62.6	62.3	34.8	34.7	83.8

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 the IPCC Guidelines (2006). The emission factors for other pollutants are either nationally referenced or based on the EMEP/EEA Guidebook (EEA, 2023)[26].

An overview of the type of CO_2 emission factor is shown in Table 41. A complete list of emission factors including time series and references is provided in Chapter 7.2 – 7.16 and Annex 4.

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. For these plants the reporting to the EU Emission Trading Scheme (EU ETS) are based on plant specific fuel analysis. In addition, emission factors for offshore gas turbines and refinery gas are based on EU ETS data. These emission factors are based on average values of plant specific data based on fuel analysis. The EU ETS data have been applied for the years 2006 - 2023. For 2021-2023, the EU ETS data set include data for CO_2 emission from biomass.

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, 2018), 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 are all based on fuel quality measurements[27], not default values from the Danish UNFCCC reporting. All fuel analyses are performed according to ISO 17025.

7.1.1 EU ETS data presentation

The EU ETS data include plant specific emission factors for the fossil fuels coal, residual oil, gas oil, natural gas, refinery gas, petroleum coke, coke oven coke and fossil waste. The EU ETS data accounted for 59 % of the fossil CO_2 emission from stationary combustion in 2023.

[26] And former editions of the EEA Guidebook.

[27] Applying specific methods defined in the EU decision.

EU ETS data for coal

EU ETS data for 2023 were available from 11 coal fired plant (or units). The plant specific information accounts for 97 % of the Danish coal consumption and 25 % of the total fossil CO_2 emission from stationary combustion plants.

Data from 10 of the 11 plants (/units) have been applied for estimating an average CO_2 emission factor for coal[28]. The average CO_2 emission factor for coal for these 10 units was 95.11 kg per GJ (Table 33). Time series are shown in Table 34. The plants all apply bituminous coal.

Table 33 EU ETS data for 10 coal fired plants/units, 2023.

	Average	Min	Max
Heating value, GJ per tonne	23.5	17.07	27.35
CO_2 implied emission factor, kg per GJ[1)]	95.11	91.83	97.25
Oxidation factor	0.995	0.992	1.000

1) Including oxidation factor.

Table 34 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
2016	94.95
2017	94.37
2018	94.04
2019	94.13
2020	94.20
2021	93.94
2022	94.51
2023	95.11

1) Including oxidation factor.

EU ETS data for residual oil

EU ETS data for 2023 based on higher tier methodologies were available from 5 plants (or units) combusting residual oil. The EU ETS data accounts for 50 % of the residual oil consumption in stationary combustion.

Data from 4 of the 5 plants have been applied for estimating an average CO_2 emission factor for residual oil[29]. Aggregated data and time series are shown in Table 35 and Table 36.

28 Fuel consumption of the 10 plants/units adds up to more than 99.9% of the fuel consumption of the 11 plants. One plant is not considered representative for the coal consumption in Denmark.

29 Fuel consumption of the 4 plants adds up to 45% of the fuel consumption of the 5 plants. The excluded plant is not considered representative for the residual oil consumption in Denmark.

Table 35 EU ETS data for 4 plants combusting residual oil, 2023.

	Average	Min	Max
Heating value, GJ per tonne	40.47	40.4	41.0
CO_2 implied emission factor, kg per GJ	78.95	77.70	79.41
Oxidation factor	1.000	1.000	1.000

Table 36 CO_2 implied emission factor time series for residual oil applied in power plant units. Implied emission factors 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
2015	79.17
2016	79.29
2017	79.19
2018	79.42
2019	79.32
2020	79.03
2021	79.15
2022	78.94
2023	78.95

[1)] Including oxidation factor.

EU ETS data for gas oil

EU ETS data for 2023 based on higher tier methodologies were included from only two plants combusting gas oil. Average values for CO_2 emission factors based on plant specific fuel analysis in the EU ETS data are shown in Table 37 for 2006-2018. The 2019-2023 average values are not included, because measurement-based emission factors were only available from one or two plants for each year.

Table 37 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	74.2
2015	73.8
2016	74.4
2017	74.7
2018	74.2
2019	-
2020	-
2021	-
2022	-
2023	-

[1)] Including oxidation factor. The 2019-2023 value are not shown because data were only available from one or two plants each year.

EU ETS data for waste

EU ETS data for 2023 based on higher tier methodologies were included from 19 waste incineration plants[30] (or units). The EU ETS data for waste incineration are based on emission measurements. The EU ETS data for 2021-2023 included CO_2-emission data for the biomass part of the waste. The average emission factor values are shown below.

The average emission factor 2023 for fossil CO_2 emission is based on 18 units[31]. The average fossil waste emission factor is 48.1 kg fossil CO_2 per kg total waste. The interval is 33.9 kg per GJ to 63.8 kg per GJ. The time series for the fossil CO_2-emission factor is shown in Table 39.

Table 38 EU ETS data for waste incineration 2023, 18 units with data for fossil CO_2.

	Average	Min	Max
Heating value, GJ per tonne	10.54	9.84	12.83
Fossil CO_2 implied emission factor, kg fossil CO_2 per GJ total waste	48.1	33.9	63.8
Oxidation factor	1.000	1.000	1.000

Table 39 Fossil CO_2 implied emission factor time series for waste incineration.

Year	CO_2 implied emission factor, kg per GJ
2013	43.0
2014	40.8
2015	43.3
2016	43.0
2017	41.4
2018	43.5
2019	42.5
2020	42.6
2021	41.2
2022	45.2
2023	48.1

The estimated average fossil CO_2 emission factor have been considerably higher in 2022-2023. The calorific value (NCV) is not a mandatory part of the EU ETS reporting from the waste incineration plants. For reporting purposes, the Danish Energy Statistics adds NCV to data set "Artikel-21" that includes all EU ETS data for a year. The NCV values added to "Artikel-21" refer to the Energy Producers Survey. However, the NCV reported by the plants to the Energy Producers Survey is often the default value, and thus the increased CO_2 emission factor might reflect inaccurate NCV values rather than an increase of the fossil CO_2 emission factor for waste. The Danish Energy Agency recently finished collection of plant specific NCV values for 2021, 2022 and 2023. An updated time series (2017-2024) of the default CO_2 emission factor for waste will be implemented in the next emission inventory (reported in 2026). Since the plant specific CO_2 emission data from EU ETS is implemented in the emission inventory, the possible inaccuracy of the fossil CO_2 from waste only relate to the 29 % of the waste for which the inventory is based on the default emission factor (42.5 kg fossil CO_2 per kg total waste). The fossil CO_2 emission factor will be revised in the next emission inventory.

[30] Co-incineration plants in the EU ETS Directive (Guidance on Interpretation of Annex I of the EU ETS Directive).
[31] The waste applied in one unit is not considered representative.

The average emission factor for biogenic CO_2 emission is based on 15 units[32]. The average emission factors for fossil CO_2, biogenic CO_2 and total CO_2 are shown in Table 40. The average fossil CO_2 emission factor is 48.7 kg per GJ, the average biogenic CO_2 emission factor is 49.2 kg per GJ, and the total CO_2 emission factor is 98.0 kg per GJ. The CO_2 emission factor for biomass waste is based on the EU ETS data for 2021, see also Chapter 7.2.15.

Table 40 EU ETS data for waste incineration 2023, 15 units with data for fossil and biogenic CO_2.

	Average	Min	Max
Heating value, GJ per tonne	10.54	9.84	12.83
Oxidation factor	1.000	1.000	1.000
Fossil CO_2 implied emission factor, kg fossil CO_2 per GJ total waste	48.74	33.9	63.8
Biogenic CO_2 implied emission factor, kg biogenic CO_2 per GJ total waste	49.21	29.57	65.28
Total CO_2 implied emission factor, kg CO_2 per GJ waste	97.95	73.85	125.13

The EU ETS data includes a fuel category for mixed fossil and biomass. This fuel category is included in the fuel categories waste or industrial waste in the emission inventory. Data are not presented here, because the data are confidential.

The EU ETS data accounts for 77 % of the energy content of incinerated waste (including industrial waste).

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

The implemented EU ETS data set also includes CO_2 emission factors for industrial waste, petroleum coke and coke oven coke. The industrial plants with additional EU ETS data include cement industry, sugar production, glass 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 7.2.13.

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 41 % of the fossil CO_2 emission in 2023.

The CO_2 emission factors applied for 2023 are presented in Table 41. Time series have been estimated for:

- Coal
- Residual oil
- Refinery gas
- Natural gas applied in offshore gas turbines
- Natural gas, other

[32] A few units did not include data for biogenic CO_2.

- Waste, fossil part
- Wood

For all other fuels, the same emission factor has been applied for 1990-2023.

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 combusted in Denmark. The correspondence list between the DCE fuel categories and the IPCC fuel categories is also provided in Table 41.

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 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 CRT, the fuel consumption and emissions from the fossil content of the waste is reported in the fuel category Other fossil fuels whereas the biomass part is reported in fuel category Biomass.

Table 41 CO_2 emission factors, 2023.

Fuel	Emission factor, kg per GJ		Reference type	IPCC fuel category
	Biomass	Fossil fuel		
Coal	-	95.11 1)	Country specific	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)	-	94.51	Country specific	Solid
Petroleum coke	-	93 3)	Country-specific	Liquid
Residual oil	-	78.95 1)	Country-specific	Liquid
Gas oil	-	74.1 1)	Country-specific	Liquid
Kerosene	-	71.9	IPCC (2006)	Liquid
Orimulsion	-	80 2)	Country-specific	Liquid
LPG	-	64.8	Country-specific	Liquid
Refinery gas	-	56.280	Country-specific	Liquid
Natural gas, offshore gas turbines	-	57.522	Country-specific	Gas
Natural gas, other 7)	-	57.14	Country-specific	Gas
Waste	59.2 3)4)	+ 42.5 1)3)4)	Country-specific	Biomass and Other fuels
Industrial waste	59.2 3)4)	+ 42.5 1)3)4)	Country-specific	Biomass and Other fuels
Straw	100	-	Country-specific	Biomass
Wood (national average 2023 for firewood, wood chips and wood waste)	103.254	-	Country-specific	Biomass
Wood pellets	97.4	-	Country-specific	Biomass
Bio oil	70.8	-	IPCC (2006)	Biomass
Biogas	81.9	-	Country-specific	Biomass
Biomass gasification gas	142.9 5)	-	Country-specific	Biomass
Biomethane 7)	54.9	-	Country-specific	Biomass

1) Plant specific data from EU ETS incorporated for individual plants.
2) Not applied in 2023. 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 (42.5+59.2) 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 CRT. The corresponding fossil CO_2 emission factor for Other fuels is 94.4 kg CO_2 per GJ fossil waste and 107.6 kg biomass CO_2 per GJ biomass waste.
5) Includes a high content of CO_2 in the gas.
6) Anodic carbon. Not applied in Denmark in 2014-2023.
7) Gas distributed in the gas grid consist of a mixture of two fuels: Biomethane and (fossil) natural gas. The two fuels are treated as separate fuels in the emission inventories, see also Chapter 6.8.

7.2.1 Coal

As mentioned above, EU ETS data have been utilised for the years 2006 - 2023 in the emission inventory. The emission factor for coal 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 2023, the implied emission factor for CO_2 (including oxidation factor) was 95.11 kg per GJ. The implied emission factor values were between 91.83 and 97.25 kg per GJ.

The emission factors for coal in the years 2006-2023 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 (94 kg/GJ) refers to the average IEF for 2006-2010.

In 2023, the CO_2 emission from coal consumption was based on the emission factor (95.11 kg per GJ) for 2.9 % of the coal consumption. The remaining 97.1 % was covered by EU ETS data.

Time series for the CO_2 emission factor are shown in Table 42.

Table 42 CO_2 emission factor time series for coal.

Year	CO_2 emission factor kg per GJ
1990-2005	94.0
2006	94.4
2007	94.3
2008	94.0
2009	93.6
2010	93.6
2011	93.73
2012	94.25
2013	93.95
2014	94.17
2015	94.46
2016	94.95
2017	94.37
2018	94.04
2019	94.13
2020	94.20
2021	93.94
2022	94.51
2023	95.11

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 1990-2023.

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 1990-2023.

7.2.4 Other solid fossil fuels (Anodic carbon)

Anodic carbon was not applied in 2023. Anodic carbon has been applied in Denmark in 2009-2013 in two mineral wool production units. The emission factor 118 kg per 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 CO_2 emission data from EU ETS have been applied for each plant. The default emission factor (94.51 for 2023) has been assumed equal to the emission factor for coal.

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 2006-2023.

7.2.7 Residual oil

The emission factor for residual oil is based on EU ETS data.

EU ETS data have been utilised for the 2006 - 2023 emission inventories. In 2023, the implied emission factor (including oxidation factor) for the plants combusting residual oil was 78.95 kg per GJ. The implied emission factor values were between 77.7 and 79.4 kg per GJ.

The emission factors for residual oil in the years 2006-2023 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 refers to the average IEF for 2006-2010.

In 2023, the CO_2-emission estimate was based on the emission factor for 50 % of the residual oil consumption, whereas plant specific EU ETS data were available for 50 % of the residual oil consumption.

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

Table 43 CO_2 emission factor time series for residual oil.

Year	CO_2 emission factor kg per GJ
1990-2005	78.7
2006	78.6
2007	78.5
2008	78.5
2009	78.9
2010	79.2
2011	79.25
2012	79.21
2013	79.28
2014	79.49
2015	79.17
2016	79.29
2017	79.19
2018	79.42
2019	79.32
2020	79.03
2021	79.15
2022	78.94
2023	78.95

7.2.8 Gas oil

The emission factor for gas oil, 74.1 kg per GJ, is based on EU ETS data for the years 2008-2016. The emission factor is consistent with the IPCC default emission factor for gas oil (74.1 kg per GJ). The same emission factor has been applied for 1990-2023.

Plant specific EU ETS data have been utilised for a few plants each year in the 2006 - 2023 emission inventories. In 2023, EU ETS data were only available from two plants representing less than 2 % of the consumption of gas oil.

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 1990-2023.

7.2.10 Orimulsion

The emission factor for orimulsion, 80 kg per GJ, refers to the Danish Energy Agency (DEA, 2024a). 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

Emission factor 2019 onwards

According to Danish legislation, the butane content of LPG is below 7.5 % and the content of higher hydrocarbons (C5+) below 0.2 % (Danish Safety Technology Authority, 2018; Danish Safety Authority, 2012). Thus, since 2012 the minimum content of propane is 92.3 %.

According to Drivkraft Danmark, the LPG delivered to Denmark has a propane content of minimum 93 % in recent years (Rosvall, 2021). Bio LPG sold in Denmark is based on certificates from other countries (Rosvall, 2021) and thus all LPG applied in Denmark is considered fossil.

The CO_2 emission factor 64.8 kg/GJ (based on Rosvall, 2021) is applied for 2019 onwards. This emission factor is based on the gas composition from Drivkraft Danmark, 93 % propane and 7 % butane (Rosvall, 2021). The 93 % propane on which the estimate is based is a minimum, but the emission factor for 100 % propane is 64.6 kg/GJ and thus the emission factor is in the interval 64.6-64.8 kg/GJ.

Different mixtures of propane and butane have been considered and the estimated CO_2 emission factors and calorific values for each of them are shown in Table 44. For all the considered compositions, the CO_2 emission factors are higher than the emission factor from IPCC Guidelines (2006). The emission factor in IPCC Guidelines (2006), 63.1 kg/GJ, is lower than the emission factors for both propane and butane (see Table 44 and Juhrich, 2016). The butane content has been considered 1/3 i-Butane and 2/3 n-Butane referring to Kjellander (2021).

In Germany, Sweden, Norway and the Netherlands the applied emission factor for 2019 were 66.33 kg/GJ (NIR Germany, 2021)[33], 65.1 kg/GJ (NIR Sweden, 2021), 65.08 kg/GJ (NIR Norway, 2021), and 66.7 kg/GJ (NIR Netherlands, 2021), respectively.

Time series

In 1990-2005, mixed gases with higher butane content were also sold in Denmark (Rosvall, 2021; Kjellander, 2021; Tønder, 2021). The applied mixed gases were primarily applied for vehicles (Kjellander, 2021; Tønder, 2021) and the mixture proportions were 30%/70% in the summer and 50%/50% in the winter (Rosvall, 2021). The use of mixed gases is included in the fuel category LPG in the energy statistics. However, the use of mixed gases was low. The average LPG composition including mixed gases have been estimated to be 90 % propane and 10 % butane in 1990 (Rosvell, 2021; Kjellander, 2021). In 2005-2017, the minimum propane content was 95 % (Tønder, 2021).

The estimated CO_2 emission factors for different butane shares of LPG is shown in Table 44. The emission factors for both the 1990 and the 2019 composition is 64.8 kg/GJ. The CO_2 emission factor for 2005-2017 is 64.7 kg/GJ. Due to the marginal difference and the uncertainty, DCE has decided to use the CO_2 emission factor 64.8 kg/GJ for all years.

Table 44 Estimated NCV and CO_2 emission factors for different LPG compositions.

	Propane	Butane[34]	NCV, MJ/kg	CO_2 emission factor, kg/GJ
LPG according to legislation for LPG gas quality[35] (Danish Safety Technology Authority, 2018)	92.5 %	<7.5 %	46.3	64.8
LPG according to Drivkraft Danmark (Rosvall, 2021)	93 %	7 %	46.3	64.8
LPG according to specification 2005-2017 (Tønder, 2021)	95 %	5 %	46.3	64.7
LPG applied in 1990, (Rosvall, 2021; Kjellander, 2021)	90 %	10 %	46.2	64.8
100 % propane	100 %	0%	46.3	64.6
100 % butane (1/3 i-Butane)	0 %	100 %	45.7	66.3
100 % i-Butane	0 %	100 %	45.6	66.5
100 % n-Butane	0 %	100 %	45.7	66.2

[33] 64.0-66.6 kg/GJ (Juhrich, 2016).
[34] Assumed 2/3 n-Butane and 1/3 i-butane (Kjellander, 2021).
[35] <0.2 % higher hydrocarbons (C5+) have not been taken into account.

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 for 2006-2009 (57.6 kg per GJ) have been applied for the years 1990-2005. This emission factor is consistent with the emission factor of 57.6 kg per GJ stated in the IPCC Guidelines (IPCC, 2006). The time series is shown in Table 45.

Table 45 CO_2 emission factors for refinery gas, time series.

Year	CO_2 emission factor, kg per GJ
1990-2005	57.6
2006	57.812
2007	57.848
2008	57.948
2009	56.817
2010	57.134
2011	57.861
2012	58.108
2013	58.274
2014	57.620
2015	57.508
2016	57.335
2017	57.109
2018	56.144
2019	56.452
2020	56.813
2021	56.486
2022	56.554
2023	56.280

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 2006-2023. Based on data for each oilfield, implied emission factors have been estimated for 2006-2023. 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 factors for offshore gas turbines, time series.

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
2016	57.704
2017	57.628
2018	57.639
2019	57.588
2020	57.456
2021	57.356
2022	57.443
2023	57.522

7.2.14 Natural gas, other source categories

The fuel category Natural gas refers to fossil natural gas. In recent years, biomethane[36] has also been distributed in the gas grid in Denmark. Natural gas (fossil) and biomethane is considered two separate fuels in the emission inventory.

The emission factor for natural gas is estimated by the Danish gas transmission company, Energinet[37]. The calculation is based on gas analysis carried out daily by Energinet at Egtved. At the end of 2022, the Baltic Pipe was in full operation. The Baltic Pipe connects the Norwegian gas fields with the gas grid in Denmark, and Poland. Figure 86 shows the Danish gas transmission grid.

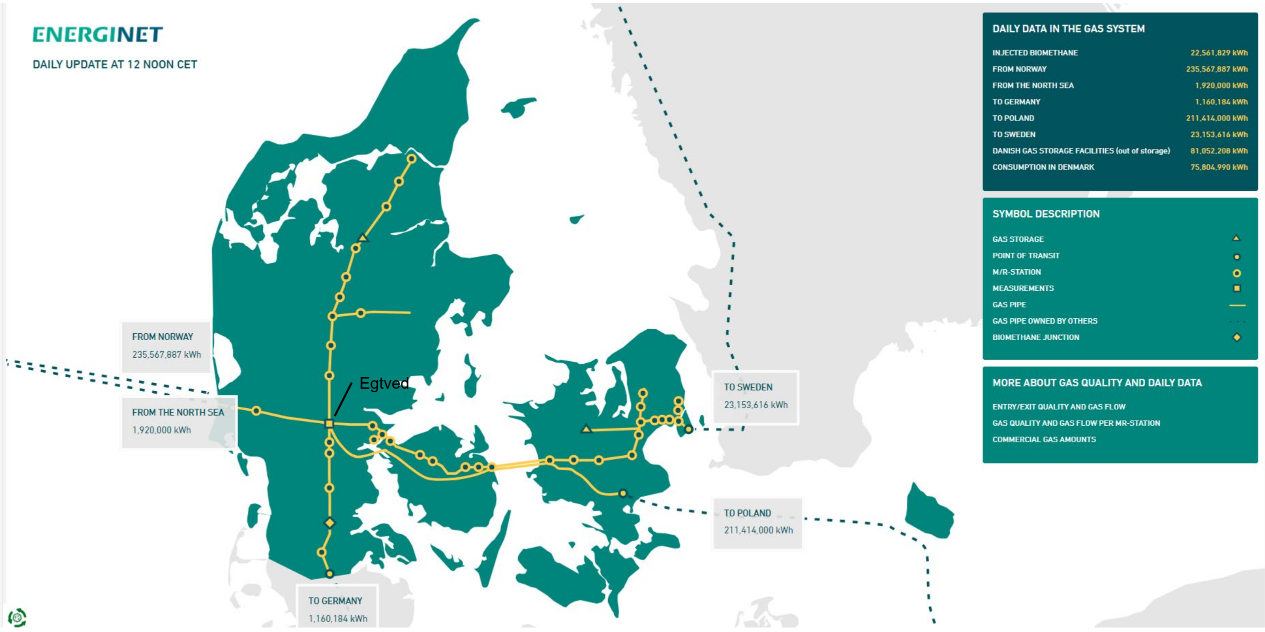


Figure 86 The Danish gas transmission grid (a random date). Energinet.dk (2024).

The offshore gas platform Tyra in the North Sea has for decades been the major gas supplier for Denmark. The platform was shut down for redevelopment from September 2019 to winter 2023/2024 (Energinet, 2023). Thus in 2023, the import of natural gas was high, and the production low compared to the years before 2019. This caused a change in gas quality and CO_2 emission factor in 2020 - 2023. In 2023, the total Danish natural gas production was 49 PJ, the import was 310 PJ, and the export 303 PJ.

Before 2010, only natural gas from the Danish gas fields was utilised in Denmark. Energinet 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 German border differed less than 0.3 % for 2011 (Bruun, 2012b).

Energinet and the Danish Gas Technology Centre have calculated emission factors for 2000-2023. The emission factor applied for 1990-1999 refers to Fenhann & Kilde (1994). This emission factor was confirmed by the two major

[36] Upgraded biogas.
[37] Former Gastra and before that part of DONG. Historical data refer to these companies.

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
2016	57.01
2017	57.00
2018	56.89
2019	56.54
2020	55.52[1)]
2021	55.47[1)]
2022	56.38[1) 2)]
2023	57.14[1) 2)]

[1)] The low CO_2 emission factor in 2020 -2022 is caused by shut down of the offshore gas platform Tyra in the North Sea. The platform was shut down for redevelopment from September 2019 to the winter 2023/2024 (Energinet, 2023). The gas quality of import gas differs from the gas quality from Tyra.

[2)] The Baltic Pipe (gas from Europipe II) was in operation from 2022.

7.2.15 Waste – fossil CO_2 and biomass CO_2

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 biomass part of the waste, which is reported as a memo item.

EU ETS data included only data for fossil CO_2 for the years 2013-2020. For 2021-2023, EU ETS data included data for both fossil CO_2 and biomass CO_2.

Fossil waste CO_2

The fossil CO_2 emission factor 42.5 kg fossil CO_2 per GJ total waste is based on EU ETS data for 2013-2016. The annual average emission factors for the plants that applied plant specific data are shown in Table 48 below. The emission factor applied for 2013-2023 is the average value for 2013-2016, 42.5 kg fossil CO_2 per GJ total waste. The emission factor for the fossil fraction corresponds to 94.44 kg fossil CO_2 per GJ fossil waste.

The increasing waste separation and recycling might influence the composition of incinerated waste. However, until 2021, the annual average values of EU ETS emission data have not indicated a need for revision of the emission factor. The average emission factors for 2022 - 2023 are however higher than for previous years, and a revision of the default emission factor will be implemented next year.

As mentioned, plant specific EU ETS data for fossil CO_2 emission have been reported by CHP plants incinerating waste for 2013-2023. In the emission inventory for 2023, plant specific emission factors have been implemented for 19 plants or units using municipal waste. In 2023, the average fossil CO_2 emission factor for 18 plants (one plant not included, se also EU ETS data presentation above) was 48.1 kg fossil CO_2 per GJ total waste. The emission factors vary between plants from 33.9 kg per GJ to 63.8 kg per GJ.

The CO_2 emission data included from EU ETS are based on flue gas emission measurements. The content of biogenic and fossil carbon is based on measurements. Two different methods are applied: a radiocarbon dating (14C analysis) of CO_2 sampled from the flue gas, and an approved mass and energy balance calculation.

The EU ETS data accounts for 77 % of the energy content of incinerated waste (including industrial waste).

The emission factor for 1990-2010 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 of the fossil emission factors for waste was estimated to be 37 kg per GJ waste and the interval for the five plants was 25 – 51 kg per GJ. The five plants represented 44 % of the incinerated waste in 2010. The emission factor 37 kg per GJ waste corresponds to 82.22 kg per GJ fossil waste.

The time series for the fossil CO_2 emission factor is shown in Table 49.

Table 48 Average fossil CO_2 emission factors based on EU ETS data for waste.

Year	Fossil CO_2 emission factor, kg fossil CO_2 per GJ waste (total)
2013	43.0
2014	40.8
2015	43.3
2016	43.0
2017	41.4
2018	43.5
2019	42.5
2020	42.6
2021	41.2
2022	45.2
2023	48.1
Average 2013-2016	42.5

Table 49 Time series for the fossil CO_2 emission factor for waste.

Year	CO_2 emission factor, kg per GJ
1990-2010	37.0
2011	37.5
2012	40.0
2013-2023	42.5

Data from the waste statistics have been analysed with the purpose to improve the time series for 1990-2012 of the fossil waste emission factor. However, the data analysis has shown that it is difficult to relate the available waste fraction data and the measured fossil CO_2 emission. Thus, currently it is not possible to estimate an improved time series for the emission factor for the years 1990-2012.

Biomass waste CO_2

The CO_2 emission factor for the biomass part of waste is based on plant specific emission data reported to the EU ETS for 2021. The estimated emission factor is 59.2 kg biogenic CO_2 per GJ total waste. Assumed that 55 % of the energy content of waste is biogenic, this corresponds to 107.6 kg biogenic CO_2 per GJ biogenic waste.

The emission factor is based on 15 data sets including both total CO_2 emission and fossil CO_2 emission. The plants represent 86 % of the municipal waste consumption in EU ETS (industrial waste excluded) for 2021 or 62 % of the total waste consumption (including industrial waste) in Denmark in 2021.

For the years before 2021, the total CO_2 emission and the biomass CO_2 emission was not reported in the EU ETS data. The CO_2 emission factor for the biomass part of waste applied for 1990-2020 has been assumed equal to the CO_2 emission factor for 2021.

For 2022 and 2023, the average biogenic CO_2 emission factors for waste was 53.2 kg/GJ and 49.2 kg/GJ. These implied emission factors are considerably lower than for 2021, and as for the fossil CO_2 emission factor, a revision of the CO_2 emission factor for biomass waste will be implemented next year.

7.2.16 Industrial waste – fossil CO_2 and biomass CO_2

The fuel category industrial waste is only applied for one plant: the cement production plant Aalborg Portland. The waste applied in this plant differ considerably from waste applied in waste incineration plants.

Plant specific data are considered confidential, and thus the *default* CO_2 emission factors for both Other fuels (fossil) (42.5 kg fossil CO_2 per GJ total waste) and biomass (59.2 kg biogenic CO_2 per GJ total waste) are equal to the CO_2 emission factors for waste. However, only the plant specific emission factors are actually applied.

Plant specific data for fossil CO_2 emission are available from EU ETS since 2006, and thus the emission inventories are based on these data.

The CO_2 emission data for the biomass part of waste is based on plant specific emission data reported to the EU ETS for 2022-2023. Data are confidential, but plant specific data have been implemented in the emission inventory.

The waste applied by Aalborg Portland includes several industrial waste products but no municipal waste. The fossil content of each of the applied waste fuels is defined in the EU ETS data.

7.2.17 Wood

The fuel category wood includes three fuel categories from the Danish energy statistics:

- Firewood
- Wood chips
- Wood waste

Wood pellets is included as a separate fuel in the emission inventory and thus not included in the fuel category Wood.

The carbon content of dry wood is considered the same for all three wood types, but the water content and thus the NCV is different for the three wood types.

NCV

The net calorific value (NCV) of firewood applied in the Danish energy statistics is 10.40 GJ/m^3 for hardwood[38] and 7.60 GJ/m^3 for conifer[38]. These values are based on 15 % water content and refers to a note from the Danish Energy Agency that was updated by EA Energy Analysis in 2018 (EA & DEA, 2018b). The NCVs are 18.7 GJ/ton dry matter for hardwood and 19.4 GJ/ton dry matter for conifer (EA & DEA, 2018b). The estimated NCVs in GJ/ton with a water content of 15 % are:

Deciduous:	18.7 GJ/ton • 0.85 – 2.45 GJ/ton • 0.15 = 15.5 GJ/ton
Conifers:	19.4 GJ/ton • 0.85 – 2.45 GJ/ton • 0.15 = 16.1 GJ/ton

The net calorific value (NCV) of wood chips is based on plant specific data from EU ETS available for a larger number of plants. The plant specific NCVs reported to EU ETS for 2014-2021 have been collected. The average NCV for plants with plant specific data is 10.42 GJ/ton for 2014-2021. The plants with plant specific NCVs represent 44 – 59 % of the annual total wood chip consumption in Denmark. The NCV for dry wood 19 GJ/ton and the NCV for wet wood 10.42 GJ/ton corresponds to a water content of 40 %. The Danish energy statistics applies the same NCV for 2022 onwards (DEA, 2023).

19.0 GJ/ton • 0.60 – 2.45 GJ/ton • 0.40 = 10.4 GJ/ton

The net calorific value (NCV) of wood waste applied in the Danish energy statistics is 14.7 GJ/ton. This value is based on 20 % water content and refers to a note from the Danish Energy Agency that was updated by EA Energy Analysis in 2018 (EA & DEA, 2018d).

According to EA & DEA (2018d), the dry matter calorific value is 19.0 GJ/ton and with a 20 % water content the NCV 14.7 GJ/ton is estimated.

19.0 GJ/ton • 0.80 – 2.45 GJ/ton • 0.20 = 14.7 GJ/ton

A large part of the consumption of wood waste is included in EU ETS, but in general for waste wood the default NCV has been applied rather than plant specific data.

CO_2 emission factor

The carbon content of wood is available from several studies, see Table 50. The carbon content 50 %-weight (dry matter) is applied for all three wood types. The NCV (dry) 19.0 GJ/ton is applied for all three wood types (EA & DEA, 2018b; EA & DEA, 2018c; EA & DEA, 2018d).

[38] m^3 of solid wood volume.

Table 50 Carbon content in wood.

Reference	Wood type	Carbon content, %-w dry basis
Bech & Dahlin (1989)	Wood	(37.5 wet) 50.0
Frey (2019)	Wood	50
Bäfver et al. (2011)	Wood logs	50.6
Gustavsson et al. (2004)	Wood logs	50.6
Johansson et al. (2004)	Wood logs	50.6
Lamlom & Savidge (2003)	Hardwood (22 types)	46.27-49.97
Lamlom & Savidge (2003)	Softwood (19 types)	47.21-55.2
Schmidl et al. (2011)	Beech logs	50
Schmidl et al. (2011)	Briquettes	51
Schmidl et al. (2011)	Oak logs	48
Schmidl et al. (2011)	Spruce logs	51
Schmidl et al. (2011)	Wood chips	47

The estimated CO_2 emission factors for wood are:

Firewood: (1000• 0.50•(1-0.15)•44/12)/(19*(1-0.15)-2.45•0.15) = 98.7 kg/GJ

Wood chips: (1000•0.50•(1-0.40)•44/12)/(19*(1-0.40)-2.45•0.40) = 105.6 kg/GJ

Wood waste: (1000• 0.50•(1-0.20)•44/12)/(19*(1-0.20)-2.45•0.20) = 99.7 kg/GJ

The revised emission factors are all below the IPCC (2006) default emission factor for wood, 112 kg/GJ.

In the emission inventories firewood, wood chips and wood waste are added and thus an implied emission factor for CO_2 based on the Danish energy statistics is applied. The implied emission factor is estimated each year. The same emission factor is applied for all subsectors.

The time series for the CO_2 emission factor is shown in Table 51.

Table 51 Time series for the implied emission factor for CO_2 from wood.

Year	Implied emission factor for CO_2 from wood
1990	99.785
1991	99.661
1992	99.718
1993	99.691
1994	99.802
1995	99.819
1996	99.897
1997	99.894
1998	100.081
1999	100.057
2000	99.948
2001	100.009
2002	100.161
2003	100.583
2004	100.615
2005	100.448
2006	100.490
2007	100.293
2008	100.658
2009	100.955
2010	101.041
2011	101.299
2012	101.512
2013	101.275
2014	101.481
2015	101.277
2016	101.537
2017	102.088
2018	102.492
2019	102.793
2020	103.115
2021	103.380
2022	103.331
2023	103.254

7.2.18 Wood pellets

The net calorific value (NCV) of wood pellets applied in the Danish energy statistics is 17.5 GJ/ton. This value refers to a note from the Danish Energy Agency that was updated by EA Energy Analysis in 2018 (EA & DEA, 2018e). According to EA & DEA (2018e), the dry matter calorific value is 17.5 GJ/ton based on numerous laboratory analyses. The water content of wood pellets is 7 % and thus the estimated NCV is:

$$19 \text{ GJ/ton} \cdot 0.07 - 2.45 \text{ GJ/ton} \cdot 0.07 = 17.5 \text{ GJ/ton}$$

Based on 50 %-weight (dry) C, the estimated CO_2 emission factor for wood pellets is:

$$\text{Wood pellets } (1000 \cdot 0.50 \cdot (1 - 0.07) \cdot 44/12)/(19 \cdot (1 - 0.07) - 2.45 \cdot 0.07) = 97.4 \text{ kg/GJ}$$

The CO_2-emission factor 97.4 kg/GJ is applied for all years.

7.2.19 Straw

The net calorific value (NCV) of straw applied in the Danish energy statistics is 14.5 GJ/ton. This value refers to a note from the Danish Energy Agency that was updated by EA Energy Analysis in 2018 (EA & DEA, 2018a).

According to EA & DEA (2018), the dry matter calorific value is 17.5 GJ/ton based on numerous laboratory analyses. The water content of straw is 15 % and thus the estimated NCV is:

$$17.5 \text{ GJ/ton} \cdot 0.85 - 2.45 \text{ GJ/ton} \cdot 0.15 = 14.5 \text{ GJ/ton}$$

The water content and NCV of straw was confirmed by Kristensen (2022a).

The carbon content of straw is available from several studies, see Table 52. The table also includes data for NCV and water content. Some original data are based on dry straw (d) and some on dry ash free straw (daf).

The emission factor is based on the average value from Videncenter (1995). This reference includes data from Denmark, and the CO_2 emission factor levels agree with other references considered. The estimated emission factor is 100 kg/GJ. This emission factor is applied for all years.

Table 52 Data for NCV and carbon content for straw.

Reference	Comments	Water content (weight %)	NCV (GJ/ton) dry basis[4]	NCV (GJ/ton) at 15 % water	Carbon content (weight %, dry basis)	Carbon content (weight %, 15 % water)	CO_2 emission factor, kg/GJ
Bech & Dahlin (1989)		10	-	(14.5)[1]	(43 wet) 47.8	40.6	103
Videncenter (1993)	Yellow straw	15		14.4	-		-
Videncenter (1993)	Grey straw	15		15.0	-		-
Videncenter (1995)	Barley 1	-	(18.65 daf) 18.0	14.9	48.13	40.9	101
Videncenter (1995)	Barley 2	-	(18.55 daf) 17.8	14.8	47.44	40.3	100
Videncenter (1995)	Wheat	-	(18.71 daf) 17.8	14.8	47.38	40.3	100
Videncenter (1995)	Rye	-	(18.80 daf) 18.2	15.1	47.38	40.3	98
Videncenter (1995)	Rapeseed	-	(18.63 daf) 17.7	14.7	47.95	40.8	102
Frey et al. (2017)	Yellow straw	10-20[2]	(18.2 daf) 17.5	14.4	(42 wet)[2] 49.4	42[2]	107[2]
Frey et al. (2017)	Grey straw	10-20[2]	(18.7 daf) 18.1	15	(43 wet)[2] 50.6	43[2]	105[2]
Jensen et al. (2017)	Yellow straw	8.8	17.20	14.3	-	-	-
Jensen et al. (2017)	Grey straw	9.4	16.98	14.1	-	-	-
Jensen et al. (2017)	Grey straw	9.2	17.40	14.4	-	-	-
Bakker et al. (2013)	Wheat straw	10.4	(18.181 daf) 16.9	14.0	(49 daf) 45.5	38.7	101
Zeng et al. (2017)	Test fuel A1, wheat straw 2	10.9	16.9	(14.0)	45.3	38.5	101
Zeng et al. (2017)	Test fuel A2, wheat straw 2	9.4	16.5	(13.7)	44.9	38.2	102
Zeng et al. (2017)	Reference fuel A, wheat straw	11.6	16.7	(13.8)	45.8	38.9	103
Skøtt (2011)	Yellow straw	10-20		(14.4[3])	42		-
Skøtt (2011)	Grey straw	10-20		(15.0[3])	43		-

1) Assumed equal to the value applied in the energy statistics.
2) Assumed 15 % water.
3) The water content corresponding to this NCV is unknown.
4) daf: Dry ash-free, d: dry.

7.2.20 Bio-oil

The emission factor, 70.8 kg per GJ refers to the IPCC (2006). The consumption of bio-oil in stationary combustion plants is below 2 PJ all years.

7.2.21 Biogas

In Denmark, three different types of biogases are applied: Manure/organic waste-based biogas, landfill-based biogas, and wastewater treatment biogas (sludge gas). Manure / organic waste-based biogas represented 92 % of the biogas production in 2023. Most of the biogas based on manure / organic waste is however upgraded to biomethane, that is included as a separate fuel in the emission inventories. The CO_2 emission factor for biomethane differs from the emission factor for biogas.

The fuel category *Biogas* includes the not-upgraded biogas from manure (79 % in 2020), landfill gas (2 % in 2020) and sludge gas (19 % in 2020). Seven fuel analysis were measured by Kristensen (2003). The fuel analyses, that include manure gas, sludge gas and landfill gas, are shown in Table 53. The average CO_2 emission factor for five of the fuel analysis have been estimated to 81.9 kg/GJ. Two analyses were not included in the average: #24 is an outlier, and #5 does not sum up to 100 %. The emission factor 81.9 kg/GJ is close to the factor for manure gas.

The emission factor 81.9 kg/GJ is applied for all biogas types and all years in the emission inventory.

Table 53 Biogas analysis from Kristensen (2003). The CO_2 emission factors have been added by DCE.

Biogas type	CH_4 mol %	CO_2 mol %	N_2 mol %	O_2 mol %	NCV $MJ/m^3{}_n$	CO_2 emission factor kg/GJ
Manure gas #4	61.00	33.76	4.48	0.76	21.92	84.9
Manure gas #5 [2)]	63.06	29.03	6.39	1.17	22.73	79.5
Manure gas #18	69.10	30.00	0.81	0.18	24.82	78.4
Sludge gas #21	64.91	34.10	0.64	0.35	23.33[1)]	83.3
Sludge gas #25	67.88	31.30	0.56	0.26	24.39	79.8
Landfill gas #22	62.61	32.29	5.10	0.00	22.5	82.9
Landfill gas #24	47.63	32.63	19.14	0.6	17.11	92.1

[1)] A typing error in the report has been corrected.
[2)] The sum is not 100 % for this biogas.

7.2.22 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 142.9 kg/GJ have been estimated by Danish Gas Technology Centre (Kristensen, 2010) based on the gas composition measured on the plant with the highest consumption. The emission factor includes the CO_2 content of the gasification gas.

The consumption of biomass gasification gas is below 2 PJ for all years.

7.2.23 Biomethane

Biogas upgraded for distribution in the natural gas grid is referred to as biomethane in this report. Other references might refer to this fuel as bio natural gas or upgraded biogas. Biomethane has been applied in Denmark since 2014.

A typical biomethane composition have been stated by Energinet (Energinet, 2022). The gas composition is 99.15 mole-% CH_4, 0.37 mole-% N_2, 0.12 mole-% O_2 and 0.36 mole-% CO_2 (Energinet, 2022). This corresponds to the CO_2 emission factor 54.9 kg/GJ. This emission factor is applied all years.

7.3 CH_4 emission factors

The CH_4 emission factors applied for 2023 are presented in Table 54. In general, the same emission factors have been applied for 1990-2023. However, time series have been estimated for both natural gas fuelled engines and biogas fuelled engines, residential wood combustion, combustion of straw in residential and agricultural plants, natural gas fuelled gas turbines[39] 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 accounted for 45 % of the CH_4 emission from stationary combustion plants in 2023. The relatively high emission factor for gas engines is well documented and further discussed below.

[39] A minor emission source.

Table 54 CH_4 emission factors, 2023.

Fuel group	Fuel	CRT source category	CRT 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)]
	BKB	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	0105	0.9	IPCC (2006), Tier 3, Table 2-6, Utility, gas oil, boilers.
		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).

Fuel group	Fuel	CRT source category	CRT source category	SNAP	Emission factor, g per GJ	Reference
		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.
				020204	24	Nielsen et al. (2010a)
		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	03	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	37.5	Schweitzer, 2020.
				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.

Fuel group	Fuel	CRT source category	CRT source category	SNAP	Emission factor, g per GJ	Reference
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	83.8	DCE estimate based on technology distribution, Nielsen et al. (2021b). 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).
				0102	30	IPCC (2006), Tier 1, Table 2-2, Energy industries, other primary solid biomass.
		1A4b i	Residential	0202	276	DCE estimate based on DEPA (2022) and IPCC (2006). A time series has been estimated.
		1A4c i	Agriculture/ Forestry	020300	276	DCE estimate based on DEPA (2022) and IPCC (2006). A time series has been estimated.
				020302	30	IPCC (2006), Tier 1, Table 2-2, Energy industries, other primary solid biomass (large agricultural plants considered equal to this plant category).
	Wood pellets	1A1a	Public electricity and heat production	0101	3.1	Nielsen et al. (2010a).
				0102	3	Paulrud et al. (2005).
		1A2 a-g	Industry	03	3	Paulrud et al. (2005).
		1A4a	Commercial/ Institutional	0201	3	Paulrud et al. (2005).
		1A4b i	Residential	0202	3	Paulrud et al. (2005).
		1A4c i	Agriculture/ Forestry	0203	3	Paulrud et al. (2005).
	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	369	Kristensen (2023)
				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	369	Kristensen (2023)
		1A4a	Commercial/ Institutional	0201	5	IPCC (2006), Tier 1, Table 2-4, Commercial, other biogas.
				020105	369	Kristensen (2023).
		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	369	Kristensen (2023).
	Bio gasification 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).

Fuel group	Fuel	CRT source category	CRT source category	SNAP	Emission factor, g per GJ	Reference
	Biomethane	1A1a	Public electricity and heat production	0101 0102	1	Assumed equal to natural gas.
				Tur-bines	1.7	Assumed equal to natural gas.
				Engines	481	Assumed equal to natural gas.
		1A1b	Petroleum refining	0103	1	Assumed equal to natural gas.
		1A2 a-g	Industry	03	1	Assumed equal to natural gas.
				Tur-bines	1.7	Assumed equal to natural gas.
				Engines	481	Assumed equal to natural gas.
		1A4a	Commercial/ Institu-tional	0201	1	Assumed equal to natural gas.
				Engines	481	Assumed equal to natural gas.
		1A4b	Residential	0202	37.5	Assumed equal to natural gas.
				Engines	481	Assumed equal to natural gas.
		1A4c	Agriculture/ Forestry	0203	1	Assumed equal to natural gas.
				Engines	481	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 (Nielsen et al., 2021b) and technology specific emission factors that refer to Paulrud et al. (2005), Johansson et al. (2004) and Olsson & Kjällstrand (2005). The emission factor is within the IPCC (2006) interval for residential wood combustion (100-900 g per 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, 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)[40]. 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 factors for different gas engine types were determined.

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

Natural gas, gas engines

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.

[40] The emission factor for CH_4 from biogas fuelled engines has been revised for the years 2015 onwards, se 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 took place after 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 are 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 55 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
2007-2023	481

Gas engines, biogas, 1990-2014

The emission factor for biogas engines was estimated to 434 g per GJ in 2006. 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 for 1990-2014. 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 56.

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 56 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 - 2014	434

The emission factor for later years refers to a recent study, see Chapter 7.3.2.

Gas turbines, natural gas

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 has been estimated.

CHP, wood

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

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

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 has 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 Biogas fuelled gas engines

The CH_4 emission factor for biogas-fuelled gas engines has been revised this year. The revised emission factor for 2019 onwards is based on a report from the Danish Gas Technology Centre (Kristensen, 2023). A time series has been estimated based on the assumption that the decrease took place in 2014-2019. The reference for 1990 – 2014 is discussed above.

Table 57 CH_4 emission factor time series for biogas-fuelled engines, all years.

Year	CH_4 emission factor, g/GJ
1990	239
1991	251
1992	264
1993	276
1994	289
1995	301
1996	305
1997	310
1998	314
1999	318
2000	323
2001	342
2002	360
2003	379
2004	397
2005	416
2006-2014	434
2015	421
2016	408
2017	395
2018	382
2019 onwards	369

7.3.3 Residential boilers, natural gas and biomethane

The CH_4 emission factor for residential boilers is based on Schweitzer (2020). The emission factor is 37.5 g/GJ. The reference includes emissions during start and stop of gas boilers.

7.3.4 Residential wood combustion

The emission factor for residential wood combustion (not including wood pellets) is based on technology specific data. The emission factor time series is shown in Table 58 below. Technology specific emission factors and references are shown in Chapter 6.13.2.

Table 58 CH_4 emission factor time series for residential wood combustion[1]).

Year	Emission factor, g per GJ
1990	327
1991	321
1992	314
1993	308
1994	302
1995	296
1996	289
1997	283
1998	276
1999	270
2000	263
2001	256
2002	248
2003	240
2004	227
2005	215
2006	206
2007	197
2008	188
2009	178
2010	167
2011	160
2012	152
2013	145
2014	138
2015	131
2016	124
2017	117
2018	111
2019	105
2020	99
2021	94
2022	88.5
2023	83.8

1) Wood pellets not included.

7.3.5 Wood pellets

The emission factor for wood pellets refers to Paulrud et al. (2005). For further details, see Nielsen et al. (2021b).

7.3.6 Straw, residential, and agricultural plants

The emission factor for straw combusted in residential or agricultural plants takes into account the legislation for new boilers < 1MW combusting solid fuels (DEPA, 2022). It has been assumed that 4 % of the straw was combusted in new boilers in 2022. The fuel rate has been assumed to increase 4 %-point each year after 2022.

The emission factor for old boilers, 300 g/GJ, refer to the IPCC Guidelines (IPCC, 2006). The emission factor for new boilers, 4 g/GJ, refer to the Danish legislation for new plants. It has been assumed that half the new plants are automatically fuelled (DCE assumption). It has been assumed that 1/3 of the OGC is CH_4 (also a DCE assumption).

The emission factor time series is shown in Table 59 below.

Table 59 CH_4 emission factor time series for straw combustion in residential and agricultural plants.

Year	CH_4 emission factor, g/GJ
1990-2021	300
2022	288
2023	276

7.3.7 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 2023 emission inventory are listed in Table 60. 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 1990-2023.

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 Ørsted).

Plant specific emission factors have been included for two industrial plants.

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 onshore 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 60 N_2O emission factors 2023.

Fuel group	Fuel	CRT source category	CRT 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].
	BKB	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.
			Industry – mineral wool	030701	46	Emission factor based on plant specific data for the mineral wool industry, 2023
		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.
				031600	1.5	-
		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 010105	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).

Fuel group	Fuel	CRT source category	CRT source category	SNAP	Emission factor, g per GJ	Reference
				0102	0.4	IPCC (2006), Tier 3, Table 2-6, Utility, gas oil boilers.
		1A1b	Petroleum refining	010306	0.6	IPCC (2006), Tier 1, Table 2-2, Energy industries, gas oil.
		1A1c	Oil and gas extraction	010500	0.4	IPCC (2006), Tier 3, Table 2-6, Utility, gas oil boilers.
		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. (2010a)
			Industry – mineral wool	030701	46	Emission factor based on plant specific data for the mineral wool industry, 2023.
		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, Residen-tial, gas oil.
				Engines	2.1	Nielsen et al. (2010a)
		1A4c	Agriculture/ Forestry	0203	0.4	IPCC (2006), Tier 3, Table 2-10, Commercial, gas oil boilers[1)].
				Engines	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.
			Industry – mineral wool	030701	46	Emission factor based on plant specific data for the mineral wool industry, 2023.
		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. (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.
		1A1b	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).

Fuel group	Fuel	CRT source category	CRT source category	SNAP	Emission factor, g per GJ	Reference
		1A2 a-g	Industry	03	1	IPCC (2006), Tier 3, Table 2-7, Industry, natural gas boilers.
				Gas tur-bines	1	Nielsen et al. (2010a).
				Engines	0.58	Nielsen et al. (2010a).
			Industry – mineral wool	030701	46	Emission factor based on plant specific data for the mineral wool industry, 2023.
		1A4a	Commercial/ Institutional	020100 020103	1	IPCC (2006), Tier 3, Table 2-10, Commercial, natural gas boilers.
				Engines	0.58	Nielsen et al. (2010a).
		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.
	Industrial 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	7	IPCC (2006), Table 2-7 Industrial source emission factors, wood / wood waste boilers.
		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 biomass.
		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.
	Wood pellets	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	Agriculture/ Forestry	0203	4	IPCC (2006), Tier 1, Table 2-4, Commercial, wood.

Fuel group	Fuel	CRT source category	CRT source category	SNAP	Emission factor, g per GJ	Reference
	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	0.4	Assumed equal to gas oil.
		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 gasification gas	1A1a	Public electricity and heat production	010101	0.1	Assumed equal to biogas.
				010105	2.7	Nielsen et al. (2010a).
		1A4a	Commercial/ Institutional	020105	2.7	Nielsen et al. (2010a).
	Biomethane	1A1a	Public electricity and heat production	0101 or 0102	1	Assumed equal to natural gas.
				Engines	0.58	Assumed equal to natural gas.
		1A1b	Petroleum refining	0103	1	Assumed equal to natural gas.
		1A2 a-g	Industry	03	1	Assumed equal to natural gas.
				Engines	0.58	Assumed equal to natural gas.
		1A2 f	Industry – mineral wool	030701	46	Emission factor based on plant specific data for the mineral wool industry, 2023.
		1A4a	Commercial/ Institutional	0201	1	Assumed equal to natural gas.
				Engines	0.58	Assumed equal to natural gas.
		1A4b	Residential	0202	1	Assumed equal to natural gas.
				Engines	0.58	Assumed equal to natural gas.
		1A4c	Agriculture/ Forestry	0203	1	Assumed equal to natural gas.
				Engines	0.58	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 61. Further details are included in Nielsen et al. (2018).

Time series are shown in Annex 4. Time series have been estimated for:

- Combustion of coal in power plants
- Combustion of coal in other plants (including district heating and industrial plants)
- Combustion of coal in food industry
- Combustion of coal, petroleum coke and industrial waste in cement industry.
- Combustion of BKB in residential and industrial plants
- Combustion of coke oven coke in power plants
- Combustion of coke oven coke in residential and industrial plants
- 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 61 SO_2 emission factors and references, 2023.

Fuel type	Fuel	NFR	NFR_name	SNAP	SO_2 emission factor, g/GJ	Reference
Solid	Anodic carbon [1)]	1A2g	Industry - other	032002	855	DCE estimate based on plant specific data.
	Coal	1A1a	Public electricity and heat production	0101	12	DCE estimate based on emission data reported by plant owners and fuel consumption data from EU ETS (2024).
				0102	557	DCE estimate based on country specific coal data from Dong Energy (Jensen, 2017) and coal import data from DEA (2024c).
		1A2a-g	Industry	03 except 0309, 0316, and 030701	557	DCE estimate based on country specific coal data from Dong Energy (Jensen, 2017) and coal import data from DEA (2024c).
		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 030701	557	DCE estimate based on country specific coal data from Dong Energy (Jensen, 2017) and coal import data from DEA (2024c).
		1A4b i	Residential	020200	557	DCE estimate based on country specific coal data from Dong Energy (Jensen, 2017) and coal import data from DEA (2024c).
		1A4c i	Agriculture/ Forestry	0203	557	DCE estimate based on country specific coal data from Dong Energy (Jensen, 2017) and coal import data from DEA (2024c).
	Fly ash fossil	1A1a	Public electricity and heat production	010101	12	Assumed equal to coal.
	BKB	1A4b	Residential	0202	557	Assumed equal to coal. DCE assumption.
	Coke oven coke	1A2a-g	Industry	03	557	Assumed equal to coal. DCE assumption.
		1A2e	Industry, food, beverages and tobacco	0309	231	DCE estimate based on plant specific data for 2010.
		1A2g	Mineral wool production	Mineral wool 030701	557	Assumed equal to coal. DCE assumption.
		1A4b	Residential	0202	557	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	Public 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	339	DCE estimate based on plant specific data for year 2019.
		1A2a-g	Industry	03	344	DCE estimate based on EOF (2017) and DEA (2016a).
		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	5.7	DCE estimate based on DEA (2022e).
		1A1b	Petroleum refining	010306	5.7	DCE estimate based on DEA (2022e).
		1A1c	Oil and gas extraction	0105	5.7	DCE estimate based on DEA (2022e).

Fuel type	Fuel	NFR	NFR_name	SNAP	SO_2 emission factor, g/GJ	Reference
		1A2a-g	Industry	03	5.7	DCE estimate based on DEA (2022e).
		1A4a	Commercial/ Institutional	0201	5.7	DCE estimate based on DEA (2022e).
		1A4b i	Residential	0202	5.7	DCE estimate based on DEA (2022e).
		1A4c	Agriculture/Forestry	0203	5.7	DCE estimate based on DEA (2022e).
	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 (2017) and Energinet (2013).
				010105, engines	0.5	Kristensen (2003).
		1A1b	Petroleum refining	0103	0.43	DCE estimate based on data from Energinet (2017) and Energinet (2013).
		1A1c	Oil and gas extraction	0105	0.43	DCE estimate based on data from Energinet (2017) and Energinet (2013).
		1A2a-g	Industry	03 except engines	0.43	DCE estimate based on data from Energinet (2017) and Energinet (2013).
				Engines	0.5	Kristensen (2003).
		1A4a	Commercial/ Institutional	0201 except engines	0.43	DCE estimate based on data from Energinet (2017) and Energinet (2013).
				Engines	0.5	Kristensen (2003).
		1A4b i	Residential	0202 except engines	0.43	DCE estimate based on data from Energinet (2017) and Energinet (2013).
				Engines	0.5	Kristensen (2003).
		1A4c i	Agriculture/ Forestry	0203 except engines	0.43	DCE estimate based on data from Energinet (2017) and Energinet (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).
	Industrial waste	1A2f	Industry – non-metallic minerals	031600	67	DCE estimate based on plant specific data for 2011-2015.

Fuel type	Fuel	NFR	NFR_name	SNAP	SO_2 emission factor, g/GJ	Reference
Bio-mass	Wood	1A1a	Public electricity and heat production	0101	1.9	Nielsen et al. (2010a).
				0102	11	EEA (2023), Energy Industries Table 3.15 Wood.
		1A2a-g	Industry	03	11	EEA (2023), Manufacturing industries and construction (combustion, Table 3-5 Biomass.
		1A4a	Commercial/ Institutional	0201	11	EEA (2023), Small combustion Table 3-10 and Table 3-45 to 3-48 wood.
		1A4b i	Residential	0202	11	EEA (2023), Small combustion Table 3-6 Residential, solid biomass and Table 3-39 to 3-44 Residential, wood.
		1A4c i	Agriculture/ Forestry	0203	11	EEA (2023), Small combustion Table 3-10 and Table 3-45 to 3-48 wood.
	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).
	Wood pellets	1A1a	Public electricity and heat production	0101	1.9	Nielsen et al. (2010a).
		1A2a-g	Industry	03	11	EEA (2023), Manufacturing industries and construction (combustion, Table 3-5 Biomass.
		1A4a	Commercial/ Institutional	0201	11	EEA (2023), Small combustion Table 3-10 and Table 3-45 to 3-48 wood.
		1A4b i	Residential	0202	11	EEA (2023), Small combustion Table 3-6 Residential, solid biomass and Table 3-39 to 3-44 Residential, wood.
		1A4c i	Agriculture/ Forestry	0203	11	EEA (2023), Small combustion Table 3-10 and Table 3-45 to 3-48 wood.
	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 en-gines	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).

Fuel type	Fuel	NFR	NFR_name	SNAP	SO_2 emission factor, g/GJ	Reference
		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 gasification gas	1A1a	Public electricity and heat production	010105	7	Kristensen (2017a) and Kristensen (2017b).
	Biomethane	1A1a	Public electricity and heat production	0101	0.43	Assumed equal to natural gas.
				010105	0.5	Assumed equal to natural gas.
		1A2a-g	Industry	03, except en-gines	0.43	Assumed equal to natural gas.
				03, Engines	0.5	Assumed equal to natural gas.
		1A4a	Commercial/ Institutional	0201, except engines	0.43	Assumed equal to natural gas.
				0201, engines	0.5	Assumed equal to natural gas.
		1A4b	Residential	0202, except engines	0.43	Assumed equal to natural gas.
				0202, engines	0.5	Assumed equal to natural gas.
		1A4c	Agriculture/ Forestry	0203, except engines	0.43	Assumed equal to natural gas.
				0203, engines	0.5	Assumed equal to natural gas.

1) The fuel is not applied in 2023.

7.6 NO_x emission factors

The NO_x emission factors for 2023 and references are shown in Table 62. Further details are included in Nielsen et al. (2018).

Time series are included in Annex 4. Time series have been 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 in industrial and residential plants
- Combustion of coke oven coke in industrial and residential plants
- Combustion of fossil fly ash
- Combustion of petroleum coke in public electricity and heat production
- Combustion of petroleum coke in industrial plants
- Combustion of residual oil in power plants
- Combustion of residual oil in industrial plants
- Combustion of gas oil in power plants
- Combustion of gas oil in offshore gas turbines
- 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 gas engines
- Combustion of natural gas in district heating plants, large industrial boilers, large boilers in commercial/institutional plants and large boilers in agriculture/forestry
- Combustion of natural gas in offshore gas turbines
- Combustion of natural gas in residential boilers
- Combustion of natural gas in non-metallic minerals (bricks and tiles)
- Waste incineration in CHP plants
- Combustion of wood in power plants
- Combustion of wood in residential plants
- Combustion of bio-oil in power plants
- Combustion of biogas in gas engines
- Combustion of biogas in power plants
- Combustion of biogas in large boilers
- Combustion of biogas in residential boilers
- Combustion of biomethane in power plants
- Combustion of biomethane in district heating plants and large boilers
- Combustion of biomethane in residential boilers

Table 62 NO_x emission factors and references, 2023.

Fuel type	Fuel	NFR	NFR_name	SNAP	NO_x emission factor, g/GJ	Reference
Solid	Anodic carbon[1)]	1A2g	Industry - other	032000	183	Assumed equal to coal. DCE assumption.
	Coal	1A1a	Public electricity and heat production	0101	16.9	DCE estimate based on plant specific emission data and EU ETS (2024).
				0102	95	DEPA (2001a).
		1A2a-g	Industry	03 except cement production	183	DCE estimate based on plant specific data for four plants in 2015.
		1A2f	Industry, cement production	0316	233	DCE estimate based on plant specific data for 2023.
		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	16.9	Assumed equal to the emission factor for coal.
	BKB	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	129	Assumed equal to residual oil. DCE assumption.
			Industry, non-metallic minerals, cement	0316	233	DCE estimate based on plant specific data for 2023.
		1A4a	Commercial/ Institutional	0201	51	EEA (2023). Tier 1, Small combustion, Table 3-5, liquid fuels applied in residential plants.
		1A4b	Residential	0202	51	EEA (2023). Tier 1, Small combustion, Table 3-5 liquid fuels applied in residential plants.
		1A4c	Agriculture/ Forestry	0203	51	EEA (2023). Tier 1, Small combustion, Table 3-5 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 (2009); Energinet (2010); Energinet (2011): EU ETS (2009-2011).
				0102	142	DEPA (2001a).
		1A1b	Petroleum refining	010306	142	EEA (2023), Energy Industries, Table 4-4 Tier 2 emission factors for source category 1.A.1.b, process furnaces using residual oil.
		1A2a-g	Industry	03	129	DCE estimate based on plant specific data for 2015.
		1A2f	Industry, non-metallic minerals, cement	0316	233	DCE estimate based on plant specific data for 2023.
		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.
				010104	230	DCE estimate based on plant specific data year 2015.
				010105	942	Nielsen et al. (2010a).
				0102	130	DEPA (2016b), DEPA (2012b), DEPA (2003b) and DEPA (1990).

Fuel type	Fuel	NFR	NFR_name	SNAP	NO_x emission factor, g/GJ	Reference
		1A1b	Petroleum refining	010306	65	EEA (2023), Energy Industries, Table 4-7 Tier 2 emission factors for source category 1.A.1.b, process furnaces, using gas oil.
		1A1c	Oil and gas extraction	010500	215	Assumed equal to natural gas combustion applied in offshore gas turbines. DCE assumption.
		1A2a-g	Industry	03 except engines and turbines	130	DEPA (2016b), DEPA (2012b), DEPA (2003b) and DEPA (1990).
				Turbines	230	DCE estimate based on plant specific data year 2015.
				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	51	EEA (2023). Small Combustion Table 3-5. The emission factor is for liquid fuels combusted in residential plants.
		1A4a	Commercial/ Institutional	0201	51	EEA (2023). Small Combustion Table 3-5. The emission factor is for liquid fuels combusted in residential plants.
		1A4b i	Residential	0202	51	EEA (2023). Small Combustion Table 3-5. The emission factor is for liquid fuels combusted in residential plants.
		1A4c i	Agriculture/ Forestry	0203	51	EEA (2023). Small Combustion Table 3-5. The emission factor is for liquid fuels combusted in residential plants.
	LPG	1A1a	Public electricity and heat production	All	96	IPCC (1996).
		1A2a-g	Industry	03	96	IPCC (1996).
		1A4a	Commercial/ Institutional	0201	71	IPCC (1996).
		1A4b i	Residential	0202	47	IPCC (1996)
		1A4c i	Agriculture/ Forestry	0203	71	IPCC (1996)
	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	28	DEPA (2012b); DEPA (2015b); DEPA (2016b).
				010103	30.32	Schweitzer & Kristensen (2015).
				010104	48	Nielsen et al. (2010a).
				010105	135	Nielsen et al. (2010a).
				0102	30.32	Schweitzer & Kristensen (2015).
		1A1b	Petroleum refining	0103	30.32	Schweitzer & Kristensen (2015).
		1A1c	Oil and gas extraction	010504	186	Estimate based on plant specific data. Nielsen & Bay (2024).
		1A2a-g	Industry	03	30.32	Schweitzer & Kristensen (2015).
				Engines	135	Nielsen et al. (2010a).
				Turbines	48	Nielsen et al. (2010a).

Fuel type	Fuel	NFR	NFR_name	SNAP	NO_x emission factor, g/GJ	Reference
		1A2f		030700 030703	87	DCE estimate based on plant specific data for 11 clay production plants, EU ETS (2011-2012); DEPA (2012b).
				030701 030702	30.32	Schweitzer & Kristensen (2015).
		1A4a	Commercial/ Institutional	0201	30.32	Schweitzer & Kristensen (2015).
				Engines	135	Nielsen et al. (2010a).
		1A4b i	Residential	0202	15.7	Schweitzer & Kristensen (2014).
				Engines	135	Nielsen et al. (2010a).
		1A4c i	Agriculture/ Forestry	0203	30.32	Schweitzer & Kristensen (2015).
				Engines	135	Nielsen et al. (2010a).
Waste	Waste	1A1a	Public electricity and heat production	0101	83	DCE estimate based on plant specific data for year 2023.
				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, cement	031600	233	DCE estimate based on plant specific data for 2023.
Biomass	Wood	1A1a	Public electricity and heat production	010101 010102	33	Average emission factor for four power plants, 2018.
				010103 010104	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	75.4	Nielsen et al. (2021b). The methodology for estimating this emission factor is also included in Chapter 6.13.
		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).
	Wood pellets	1A1a	Public electricity and heat production	010101 010102	33	Average emission factor for four power plants, 2018.
				010103 010104	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	80	Nielsen et al. (2021b).
		1A4c i	Agriculture/ Forestry	0203	90	Serup et al. (1999).
	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.

Fuel type	Fuel	NFR	NFR_name	SNAP	NO_x emission factor, g/GJ	Reference
	Biogas	1A1a	Public electricity and heat production	0101, not engines	28	Assumed equal to large natural gas fuelled boilers.
				Engines	202	Nielsen et al. (2010a).
				0102	28	DEPA (2001a).
		1A2a-g	Industry	03, not engines	28	Assumed equal to large natural gas fuelled boilers.
				03, engines	202	Nielsen et al. (2010a).
				030902	30.32	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	15.7	Assumed equal to natural gas.
		1A4c i	Agriculture/ Forestry	0203, not engines	28	DEPA (2001a).
				020304	202	Nielsen et al. (2010a).
	Bio gasification gas	1A1a	Public electricity and heat production	010105	173	Nielsen et al. (2010a).
	Biomethane	1A1a	Public electricity and heat production	010101 010102	28	Assumed equal to natural gas. DCE assumption.
				010103	30.32	Assumed equal to natural gas. DCE assumption.
				0102	30.32	Assumed equal to natural gas. DCE assumption.
		1A2a-g	Industry	03, except engines and turbines	30.32	Assumed equal to natural gas. DCE assumption.
				03, gas turbines	48	Assumed equal to natural gas. DCE assumption.
				03, engines	135	Assumed equal to natural gas. DCE assumption.
		1A2f		030700 030703	87	Assumed equal to natural gas. DCE assumption.
				030701 030702	30.32	Assumed equal to natural gas. DCE assumption.
		1A4a	Commercial/ Institutional	0201	30.32	Assumed equal to natural gas. DCE assumption.
				0201, engines	135	Assumed equal to natural gas. DCE assumption.
		1A4b	Residential	0202	15.7	Assumed equal to natural gas. DCE assumption.
				0202, engines	135	Assumed equal to natural gas. DCE assumption.
		1A4c	Agriculture/ Forestry	0203	30.32	Assumed equal to natural gas. DCE assumption.
				0203, engines	135	Assumed equal to natural gas. DCE assumption.

1) The fuel is not applied in 2023.

7.7 NMVOC emission factors

The NMVOC emission factors for 2023 and references are shown in Table 63.

The emission factors for NMVOC refer to:

- An emission measurement program for decentralised CHP plants (Nielsen et al., 2010a).
- The EEA Guidebook (EEA, 2023) and former editions.
- Aggregated emission factor based on the technology distribution for residential wood combustion (Nielsen et al., 2021b).
- 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).

The time series are included in Annex 4. 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, CHP, and district heating.
- Industrial waste incineration.
- 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.
- Straw applied in residential or agricultural plants.

The emission factor for combustion of straw in residential and agricultural plants is based on emission factor for boilers installed before and after 2022 and a 4 % linear annual replacement of old boilers. The emission factors for NMVOC are 600 g/GJ for old boilers and 9 g/GJ for new boilers. The emission factor for old boilers refers to EEA (2023)[41]. The emission factor for new boilers refers to Danish legislation (DEPA, 2022), assuming 50 % automatic boilers and 50 % manual fed boilers.

[41] EEA (2023), Tier 1, Small Combustion Table 3-6.

Table 63 NMVOC emission factors and references, 2023.

Fuel type	Fuel	NFR	NFR_name	SNAP	NMVOC, g/GJ	Reference
Solid	Anodic carbon [2)]	1A2g	Industry - other	0320	10	Assumed equal to coal. DCE assumption.
	Coal	1A1a	Public electricity and heat production	0101 0102	1.0	EEA (2023), Tier 1, Energy Industries Table 3-2, public electricity and heat production, hard coal.
		1A2a-g	Industry	03	10	EEA (2023), Tier 1, Industry Table 3-2, Manufacturing industries, solid fuels. Assumed lower interval.
		1A4c i	Agriculture/ Forestry	0203	88.8	EEA (2023), 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.
	BKB	1A4b i	Residential	0202	484	EEA (2023), Tier 1, Small combustion Table 3-3.
	Coke oven coke	1A2a-g	Industry	03	10	EEA (2023), Tier 1, Industry Table 3-2, assumed lower interval.
		1A4b	Residential	0202	484	EEA (2023), Tier 1, Small combustion Table 3-3, hard coal, and brown coal, residential.
Liquid	Petroleum coke	1A2a-g	Industry	03	25	EEA (2023) Tier 1, Industry Table 3-4, liquid fuels, residential.
		1A4a	Commercial/ Institutional	0201	20	EEA (2023), Tier 1, Small combustion Table 3-9.
		1A4b	Residential	0202	20	EEA (2023), Tier 1 for 1A4a/1A4c have been applied (DCE assumption). Small combustion, liquid fuels, Table 3-9.
		1A4c	Agriculture/ Forestry	0203	20	EEA (2023), Tier 1 for 1A4a/c, 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 (2023), Tier 1, Energy Industries Table 3-6.
				010105	2.3	EEA (2023), Tier 1, Energy Industries Table 3-6.
				010203	2.3	EEA (2023), Tier 1, Energy Industries Table 3-6.
		1A1b	Petroleum refining	010306	2.3	EEA (2023), assumed equal to public electricity and heat production.
		1A2a-g	Industry	03 except engines	0.8	Nielsen et al. (2010a).
				Engines	25	EEA (2023), Tier 1, Industry Table 3-4.
		1A4a	Commercial/ Institutional	0201	20	EEA (2023), Tier 1, Small combustion Table 3-9.
		1A4b	Residential	0202	20	EEA (2023), Tier 1, Small combustion Table 3-9, assumed equal to 1A4a/1A4c.
		1A4c i	Agriculture/ Forestry	0203	20	EEA (2023), Small combustion Tier 1, Table 3-9.
	Gas oil	1A1a	Public electricity and heat production	010101 010102 010103	0.8	EEA (2023), Tier 1, Energy Industries Table 3-7.

Fuel type	Fuel	NFR	NFR_name	SNAP	NMVOC, g/GJ	Reference
				010104	0.19	EEA (2023), Tier 2, Energy Industries Table 3-20.
				010105	37.1	EEA (2023), Tier 2, Energy Industries Table 3-21.
				0102	0.8	EEA (2023), Tier 1, Energy Industries Table 3-7.
		1A1b	Petroleum refining	010306	0.8	EEA (2023), Tier 1, Energy Industries Table 3-7.
		1A1c	Oil and gas extraction	010500	0.8	EEA (2023), Tier 1, Energy Industries Table 3-7.
		1A2a-g	Industry	03 boilers	0.8	EEA (2023), Tier 1, Energy Industries Table 3-7.
				Gas turbines	0.19	EEA (2023), Tier 2, Energy Industries Table 3-20.
				Engines	37.1	EEA (2023), Tier 2, Energy Industries Table 3-21.
		1A4a	Commercial/ Institutional	0201 except engines	20	EEA (2023), Tier 1, Small Combustion Table 3-9.
				Engines	37.1	EEA (2023), Tier 2, Energy Industries Table 3-21.
		1A4b i	Residential	0202	20	EEA (2023), Tier 1, Small Combustion Table 3-9.
				Engines	37.1	EEA (2023), Tier 2, Energy Industries Table 3-21.
		1A4c	Agriculture/Forestry	0203	20	EEA (2023), Tier 1, Small Combustion Table 3-9.
	Kerosene	1A2a-g	Industry	03	0.8	EEA (2023), Tier 1, Energy Industries Table 3-7.
		1A4a	Commercial/ Institutional	0201	20	EEA (2023), Tier 1, Small Combustion Table 3-9.
		1A4b i	Residential	0202	20	EEA (2023), Tier 1, Small Combustion Table 3-9.
		1A4c i	Agriculture/ Forestry	0203	20	EEA (2023), Tier 1, Small Combustion Table 3-9.
	LPG	1A1a	Public electricity and heat production	0101 0102	0.8	EEA (2023), Tier 1, Energy Industries Table 3-7.
		1A2a-g	Iron and steel	03	0.8	EEA (2023), Tier 1, Energy Industries Table 3-7.
		1A4a	Commercial/ Institutional	0201	20	EEA (2023), Tier 1, Small Combustion Table 3-9.
		1A4b i	Residential	0202	20	EEA (2023), Tier 1, Small Combustion Table 3-9.
		1A4c i	Agriculture/ Forestry	0203	20	EEA (2023), 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).

Fuel type	Fuel	NFR	NFR_name	SNAP	NMVOC, g/GJ	Reference
		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).
				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.
	Industrial 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 (2023), Tier 1, Energy Industries Table 3-8.
		1A2a-g	Industry	03	84	Estimate based on country specific data, see (1).
		1A4a	Commercial/ Institutional	0201	175	Estimate based on country specific data, see (1).
		1A4b i	Residential	0202	310	Nielsen et al. (2021b) The methodology for estimating this emission factor is also included in Chapter 6.13.
		1A4c i	Agriculture/ Forestry	0203	175	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 (2023), Tier 1, Energy Industries Table 3-8.
		1A4b i	Residential	0202	553	Time series based on DEPA (2022) and EEA (2023), Tier 1, Small Combustion Table 3-6.
		1A4c i	Agriculture/ Forestry	0203	553	Time series based on DEPA (2022) and EEA (2023), Tier 1, Small Combustion Table 3-6.
				020302	12	EEA (2023), Tier 2, Small Combustion Table 3-45.
	Wood pellets	1A1a	Public electricity and heat production	0101	5.1	Nielsen et al. (2010a).
				0102	7.3	EEA (2023), Tier 1, Energy Industries Table 3-8.
		1A2a-g	Industry	03	10	Nielsen et al. (2021b).
		1A4a	Commercial/ Institutional	0201	10	Nielsen et al. (2021b).
		1A4b i	Residential	0202	10	Nielsen et al. (2021b).
		1A4c i	Agriculture/ Forestry	0203	10	Nielsen et al. (2021b).
	Bio oil	1A1a	Public electricity and heat production	010102	0.8	EEA (2023), Tier 1, Energy Industries Table 3-7 (gas oil).
				010105	37	EEA (2023), Tier 2, Energy Industries Table 3-21 (gas oil, large stationary CI reciprocating engines).

Fuel type	Fuel	NFR	NFR_name	SNAP	NMVOC, g/GJ	Reference
				0102	0.8	EEA (2023), Tier 1, Energy Industries Table 3-7 (gas oil).
		1A2a-g	Industry	03, not engines	0.8	EEA (2023), Tier 1, Energy Industries Table 3-7 (gas oil).
				010105	37	EEA (2021), Tier 2, Energy Industries Table 3-21 (gas oil, large stationary CI reciprocating engines).
		1A4b i	Residential	0202	20	EEA (2023), 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).
				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 gasification gas	1A1a	Public electricity and heat production	010105	2	Nielsen et al. (2010a).
				0101 except engines	2	Assumed equal to natural gas. DCE assumption.
	Biomethane	1A1a	Public electricity and heat production	0101 except engines	2	Assumed equal to natural gas. DCE assumption.
				0101, gas turbines	1.6	Assumed equal to natural gas. DCE assumption.
				0101, engines	92	Assumed equal to natural gas. DCE assumption.
				0102	2	Assumed equal to natural gas. DCE assumption.
		1A1b	Petroleum refining	0103	2	Assumed equal to natural gas. DCE assumption.
		1A2a-g	Industry	03	2	Assumed equal to natural gas. DCE assumption.
				03, gas turbines	1.6	Assumed equal to natural gas. DCE assumption.
				03, gas engines	92	Assumed equal to natural gas. DCE assumption.
		1A4a	Commercial/ Institutional	0201	2	Assumed equal to natural gas. DCE assumption.
				0201, engines	92	Assumed equal to natural gas. DCE assumption.
		1A4b	Residential	0202	4	Assumed equal to natural gas. DCE assumption.
				0202, engines	92	Assumed equal to natural gas. DCE assumption.
		1A4c	Agriculture/ Forestry	0203	2	Assumed equal to natural gas. DCE assumption.
				0203, engines	92	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: industrial plants with production of electricity or district heating: 12 g/GJ (EEA, 2023) and other plants 350 g/GJ (EEA, 2023) in 1990-1995 and 175 g/GJ (EEA, 2023) since 2002 (DCE assumption). The aggregated emission factors for 2023 are 84 g/GJ for industrial plants and 175 g/GJ for commercial/institutional/agricultural plants. A time series has been applied in the inventory.

[2)] The fuel is not applied in 2023.

7.8 CO emission factors

The CO emission factors 2023 and references are shown in Table 64.

The emission factors for CO refer to:

- The EEA Guidebook (EEA, 2023)[42].
- An emission measurement program for decentralised CHP plants (Nielsen et al., 2010a).
- Danish legislation (DEPA, 2001a).
- Nielsen et al. (2021b). Aggregated emission factor based on the technology distribution for residential wood combustion and technology specific emission factors. See Chapter 6.13.
- 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).

The time series are included in Annex 4. Time series have been 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.
- Biogas fuelled engines.
- Wood pellet combustion in district heating plants.
- Wood pellet combustion in industrial plants.
- Wood pellet combustion in commercial/institutional plants.

The emission factor for combustion of straw in residential and agricultural plants is based on emission factor for boilers installed before and after 2022 and a 4 % linear annual replacement of old boilers. The emission factors for CO are 2000 g/GJ for old boilers and 312 g/GJ for new boilers. The emission factor for old boilers refers to EEA (2023), Jensen & Nielsen (1990), Bjerrum (2002) and Kristensen & Kristensen (2004). The emission factor for new boilers refers to Danish legislation (DEPA, 2022), assuming 50 % automatic boilers and 50 % manual fed boilers.

[42] And EEA (2007) for one emission factor.

Table 64 CO emission factors and references 2023.

Fuel type	Fuel	NFR	NFR_name	SNAP	CO emission factor, g/GJ	Reference
Solid	Anodic carbon [1)]	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.
		1A4b i	Residential	0202	4787	EEA (2023), Tier 2, Small Combustion Table 3-15, residential boilers, solid fuels.
		1A4c i	Agriculture/ Forestry	0203	931	EEA (2023), Tier 1, Small Combustion Table 3-7, 1A4a/c hard coal and brown coal.
	Fly ash fossil	1A1a	Public electricity and heat production	0101	10	Assumed equal to coal. DCE assumption.
	BKB	1A4b i	Residential	0202	4787	EEA (2023), Tier 2, Small Combustion Table 3-15, residential boilers, solid fuels.
	Coke oven coke	1A2a-g	Industry	03	10	Assumed the same emission factor as for coal. DCE assumption.
		1A4b	Residential	0202	4787	EEA (2023), Tier 2, Small Combustion Table 3-15, residential boilers, solid fuels.
Liquid	Petroleum coke	1A1a	Public electricity and heat production	0101	66	EEA (2023), Tier 1, Manufacturing industries and construction Table 3-4 for liquid fuels.
		1A2a-g	Industry	03	66	EEA (2023), Tier 1, Manufacturing industries and construction Table 3-4 for liquid fuels.
		1A4a	Commercial/Institutional	0201	93	EEA (2023), Tier 1, Small Combustion Table 3-9.
		1A4b	Residential	0202	93	EEA (2023), Tier 1, Small Combustion Table 3-9 (as-sumed equal to the emission factor for 1A4a/1A4c).
		1A4c	Agriculture/ Forestry	0203	93	EEA (2023), Tier 1, Small Combustion Table 3.9.
	Residual oil	1A1a	Electricity and heat production	010101 010104 010105	15	Sander (2002).
				010102 010103	2.8	Nielsen et al. (2010a).
				0102	15.1	EEA (2023), Tier 1, Energy Industries Table 3-6.
		1A1b	Petroleum refining	010306	6	EEA (2019), Tier 2, Energy Industries Table 4-4. No emission factor available in EEA (2023).
		1A2a-g	Industry	03 except engines	2.8	Nielsen et al. (2010a).
				Engines	130	EEA (2023). Tier 2 emission factor for gas oil fuelled engines in Energy Industries, Table 3-21. Refers to Nielsen et al. (2010a).
		1A4a	Commercial/Institutional	0201	40	EEA (2023). Tier 2, Small Combustion Table 3-25.
		1A4b	Residential	0202	57	EEA (2023), Tier 1, Small Combustion Table 3-5.
		1A4c i	Agriculture/ Forestry	0203	40	EEA (2023). Tier 2, Small Combustion Table 3-25.

Fuel type	Fuel	NFR	NFR_name	SNAP	CO emission factor, g/GJ	Reference
	Gas oil	1A1a	Public electricity and heat production	0101 except engines	15	Sander (2002).
				Engines	130	Nielsen et al. (2010a).
				0102	16.2	EEA (2023), Tier 1, Energy Industries Table 3-7, gas oil.
		1A1b	Petroleum refining	010306	16.2	EEA (2023), Tier 1, Energy Industries Table 4-7, gas oil.
		1A1c	Oil and gas extraction	0105	15	Sander (2002).
		1A2a-g	Industry	03 except gas turbines and engines	66	EEA (2023), Tier 1, Manufacturing industries and construction Table 3-4 for liquid fuels.
				Gas turbines	15	Sander (2002).
				Engines	130	Nielsen et al. (2010a).
		1A4a	Commercial/ Institutional	0201 except engines	40	EEA (2023). Tier 2, Small Combustion Table 3-24.
				Engines	130	Nielsen et al. (2010a).
		1A4b i	Residential	0202 except engines	3.7	EEA (2023). Tier 2, Small Combustion Table 3-18. Gas oil applied in small residential boilers.
				Engines	130	Nielsen et al. (2010a).
		1A4c	Agriculture/Forestry	0203	40	EEA (2023). Tier 2, Small Combustion Table 3-24.
	Kerosene	1A2a-g	Industry	03	66	EEA (2023), Tier 1, Manufacturing industries and construction Table 3-4 for liquid fuels.
		1A4a	Commercial/ Institutional	0201	40	EEA (2023). Tier 2, Small Combustion Table 3-24.
		1A4b i	Residential	0202	3.7	EEA (2023). Tier 2, Small Combustion Table 3-18. Gas oil applied in small residential boilers.
		1A4c i	Agriculture/ Forestry	0203	40	EEA (2023). Tier 2, Small Combustion Table 3-24.
	LPG	1A1a	Public electricity and heat production	0101 and 0102	16.2	EEA (2023), Tier 1, Energy Industries Table 3-7.
		1A2a-g	Industry	03	66	EEA (2023), Tier 1, Manufacturing industries and construction Table 3.4 for liquid fuels.
		1A4a	Commercial/ Institutional	0201	40	EEA (2023). Tier 2, Small Combustion Table 3-24.
		1A4b i	Residential	0202	3.7	EEA (2023). Tier 2, Small Combustion Table 3-18. Gas oil applied in small residential boilers.
		1A4c i	Agriculture/ Forestry	0203	40	EEA (2023). Tier 2, Small Combustion Table 3-24.
	Refinery gas	1A1b	Petroleum refining	0103	12.1	EEA (2019). Tier 1, Energy Industries Table 4.2 for refinery gas applied in petroleum refining. The emission factor is not included in EEA (2023).
Gas	Natural gas	1A1a	Public electricity and heat production	010101 and 010102	15	Sander (2002).
				010103	28	DEPA (2001a).
				010104	4.8	Nielsen et al. (2010a).
				010105	58	Nielsen et al. (2010a).
				0102	28	DEPA (2001a).
		1A1b	Petroleum refining	0103	28	Assumed equal to district heating plants.
		1A1c	Oil and gas extraction	0105	4.8	Nielsen et al. (2010a).

Fuel type	Fuel	NFR	NFR_name	SNAP	CO emission factor, g/GJ	Reference
		1A2a-g	Industry	03 except gas turbines and engines	28	DEPA (2001a).
				Gas turbines	4.8	Nielsen et al. (2010a).
				Engines	58	Nielsen et al. (2010a).
		1A4a	Commercial/ Institutional	0201 except engines	28	DEPA (2001a).
				Engines	58	Nielsen et al. (2010a).
		1A4b i	Residential	0202 except engines	20	Gruijthuijsen & Jensen (2000).
				Engines	58	Nielsen et al. (2010a).
		1A4c i	Agriculture/ Forestry	0203 except engines	28	DEPA (2001a).
				Engines	58	Nielsen et al. (2010a).
Waste	Waste	1A1a	Public electricity and heat production	0101	3.9	Nielsen et al. (2010a).
				0102	10	DCE calculation based on annual environmental reports for Danish plants year 2000.
		1A2a-g	Industry	03	10	DCE calculation based on annual environmental reports for Danish plants year 2000.
		1A4a	Commercial/ Institutional	0201	10	DCE calculation based on annual environmental reports for Danish plants year 2000.
	Industrial waste	1A2f	Industry	0316	10	Assumed equal to waste, district heating plants. DCE assumption.
Biomass	Wood	1A1a	Public electricity and heat production	0101	90	Nielsen et al. (2010a).
				010203	240	DEPA (2001a).
		1A2a-g	Industry	03	240	DEPA (2001a).
		1A4a	Commercial/ Institutional	020100	240	DEPA (2001a).
		1A4b i	Residential	0202	2403	Nielsen et al. (2021b). The methodology for estimating this emission factor is also included in Chapter 6.13.
		1A4c i	Agriculture/ Forestry	020300	240	DEPA (2001a).
	Straw	1A1a	Public electricity and heat production	0101	67	Nielsen et al. (2010a).
				0102	325	DEPA (2001a); Nikolaisen et al (1998).
		1A4b i	Residential	0202	1865	DEPA (2022); EEA (2007); Jensen & Nielsen (1990) and Bjerrum (2002), Kristensen & Kristensen (2004). Time series.
		1A4c i	Agriculture/ Forestry	0203	1865	DEPA (2022); EEA (2007); Jensen & Nielsen (1990) and Bjerrum (2002), Kristensen & Kristensen (2004). Time series.
				020302	325	DEPA (2001a); Nikolaisen et al (1998).
	Wood pellets	1A1a	Public electricity and heat production	0101	90	Nielsen et al. (2010a).
				010203	240	DEPA (2001a).
		1A2a-g	Industry	03	240	DEPA (2001a).
		1A4a	Commercial/ Institutional	020100	240	DEPA (2001a).

Fuel type	Fuel	NFR	NFR_name	SNAP	CO emission factor, g/GJ	Reference
		1A4b i	Residential	0202	300	Nielsen et al. (2021b).
		1A4c i	Agriculture/ Forestry	020300	240	DEPA (2001a).
	Bio oil	1A1a	Public electricity and heat production	0101	15	Assumed same emission factor as for gas oil. DCE assumption.
				0102	16.2	Assumed same emission factor as for gas oil. DCE assumption.
		1A2a-g	Industry	03	66	Assumed same emission factor as for gas oil. DCE assumption.
		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	DEPA (2001a).
				Engines	310	Nielsen et al. (2010a).
				0102	36	DEPA (2001a).
		1A2a-g	Industry	03 except engines	36	DEPA (2001a).
				Engines	310	Nielsen et al. (2010a).
		1A4a	Commercial/ Institutional	0201 except engines	36	DEPA (2001a).
				Engines	310	Nielsen et al. (2010a).
		1A4b	Residential	0202	20	Assumed equal to natural gas. DCE assumption.
		1A4c i	Agriculture/ Forestry	0203 except engines	36	DEPA (2001a).
				Engines	310	Nielsen et al. (2010a).
	Bio gasification gas	1A1a	Public electricity and heat production	010105	586	Nielsen et al. (2010a).
				010101	36	DEPA (2001a).
	Biomethane	1A1a	Public electricity and heat production	010101, 010102	15	Assumed equal to natural gas. DCE assumption.
				010103	28	Assumed equal to natural gas. DCE assumption.
				0101, gas turbines	4.8	Assumed equal to natural gas. DCE assumption.
				0101, engines	58	Assumed equal to natural gas. DCE assumption.
				0102	28	Assumed equal to natural gas. DCE assumption.
		1A1b	Petroleum refining	0103	28	Assumed equal to natural gas. DCE assumption.
		1A2a-g	Industry	03	28	Assumed equal to natural gas. DCE assumption.
				03, gas turbines	4.8	Assumed equal to natural gas. DCE assumption.
				03, engines	58	Assumed equal to natural gas. DCE assumption.
		1A4a	Commercial/ Institutional	0201	28	Assumed equal to natural gas. DCE assumption.
				0201, engines	58	Assumed equal to natural gas. DCE assumption.
		1A4b i	Residential	0202	20	Assumed equal to natural gas. DCE assumption.
				0202, engines	58	Assumed equal to natural gas. DCE assumption.
		1A4c i	Agriculture/ Forestry	0203	28	Assumed equal to natural gas. DCE assumption.
				0203, engines	58	Assumed equal to natural gas. DCE assumption.

[1)] The fuel has not been applied in 2023.

7.9 NH_3 emission factors

NH_3 emissions have been estimated for:

- Combustion of wood and wood pellets in residential plants.
- Combustion of wood and wood pellets 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 and heat production.
- Residential combustion of coal.
- Residential combustion of BKB.
- Residential combustion of coke oven coke.

The NH_3 emission factors 2023 and references are shown in Table 65.

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 Nielsen et al. (2021b). All other emission factors refer to the EEA (2023). An emission factor is also available for biogas in the EEA Guidelines (EEA, 2023), and this will be added in the next emission inventory.

Time series have been estimated for residential wood combustion, see Chapter 6.13 and Annex 4.

Table 65 NH_3 emission factors and references, 2023.

Fuel	NFR (SNAP)	Emission factor, g/GJ	Reference
Coal	1A4b	0.3	EEA (2023), Tier 1, Small combustion Table 3-3.
BKB	1A4b	0.3	EEA (2023), Tier 1, Small combustion Table 3-3.
Coke oven coke	1A4b	0.3	EEA (2023), Tier 1, Small combustion Table 3-3.
Wood	1A4b	45.66	Nielsen et al. (2021b). The methodology for estimating this emission factor is included in Chapter 6.13.
Wood	1A4a, 1A4c, 1A2	1	EEA (2023), Tier 1, Small Combustion Table 3-10.
Wood pellets	1A4b, 1A4a, 1A4c, 1A2	12	Nielsen et al. (2021b).
Waste	1A1a	0.29	Nielsen et al. (2010a).
Straw	1A4b, 1A4c	8	EEA (2023), Tier 1, Small Combustion Table 3-6.
Straw	1A4a, 1A2	1	EEA (2023), Tier 1, Small Combustion Table 3-10.

7.10 Particulate matter (PM) emission factors

The PM emission factors and references are shown in Table 66. 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).
  - DEPA (1995), The Danish Environmental Protection Agency, Bekendtgørelse 518 (legislation from Danish Environmental Protection Agency).
  - DEPA (2022), The Danish Environmental Protection Agency, Bekendtgørelse 199, 2022.
- Calculations based on plant-specific emission data from a considerable number of waste incineration plants.
- Calculations based on plant-specific emission data from 7 power plants combusting wood and/or wood pellets.
- Nielsen et al. (2021b). See also Chapter 6.13.
- 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, combustion of wood and wood pellets in power plants, combustion of straw in residential / agricultural plants, waste incineration in CHP plants, and waste incineration in other plants. All other emission factors have been considered constant in 1990-2023. The time series are included in Annex 4.

Further details for residential wood combustion are included in Chapter 6.13.

The emission factor for combustion of straw in residential and agricultural plants is based on emission factor for boilers installed before and after 2022 and a 4 % linear annual replacement of old boilers. The emission factors for TSP are 433 g/GJ for old boilers and 26 g/GJ for new boilers. The emission factor for old boilers refers to Kristensen, (2017c). The emission factor for new boilers refers to Danish legislation (DEPA, 2022), assuming 50 % automatic boilers and 50 % manual fed boilers.

Table 66 PM emission factors and references, 2023.

Fuel type	Fuel-id	Fuel	NFR	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 [1)]	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	BKB	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	1A2 a-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	NFR	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 has been estimated by DCE based on plant specific data from MSW incineration plants, district heating, 2008	3.2	2.1	The emission factors 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 has been estimated by DCE based on plant specific data from MSW incineration plants, district heating, 2008	3.2	2.1	The emission factors 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 has been estimated by DCE based on plant specific data from MSW incineration plants, district heating, 2008	3.2	2.1	The emission factors have been estimated by DCE based on plant specific data from MSW incineration plants, district heating, 2008

Fuel type	Fuel-id	Fuel	NFR	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 has been estimated by DCE based on plant specific data from MSW incineration plants, district heating, 2008	3.2	2.1	The emission factors have been estimated by DCE based on plant specific data from MSW incineration plants, district heating, 2008
Biomass	111A	Wood	1A1a	0101	1.3	DCE estimate based on data from 7 plants, 2020	1.3	1.3	Assumed equal to TSP due to flue gas cleaning in power plants.
				0102	19	DEPA (2001a)	13	10	DEPA (2001a), TNO (2001)
			1A2 a-g	03	19	DEPA (2001a)	13	10	DEPA (2001a), TNO (2001)
			1A4a i	0201	143	DEPA (2001a)	143	135	TNO (2001)
			1A4b i	0202	270.2	Nielsen et al. (2021b). See also Chapter 6.13.	256.7	251.4	Nielsen et al. (2021b). See also Chapter 6.13.
			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	400	Kristensen (2017c) and DEPA (2022). Time series.	400	400	Zefeng (2011)
			1A4c I	0203	400	Kristensen (2017c) and DEPA (2022). Time series.	400	400	Zefeng (2011)
				020302	21	DEPA (2001a)	15	12	TNO (2001)
	122A	Wood pellets	1A1a	0101	1.3	DCE estimate based on data from 7 plants, 2020	1.3	1.3	Assumed equal to TSP due to flue gas cleaning in power plants.
				0102	19	DEPA (2001a)	13	10	DEPA (2001a), TNO (2001)
			1A2 a-g	03	19	DEPA (2001a)	13	10	DEPA (2001a), TNO (2001)
			1A4a i	0201	51	Nielsen et al. (2021b). See also Chapter 6.13.	48	47	Nielsen et al. (2021b). See also Chapter 6.13.
			1A4b i	0202	51	Nielsen et al. (2021b). See also Chapter 6.13.	48	47	Nielsen et al. (2021b). See also Chapter 6.13.
			1A4c i	0203	51	Nielsen et al. (2021b). See also Chapter 6.13.	48	47	Nielsen et al. (2021b). See also Chapter 6.13.
	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)

Fuel type	Fuel-id	Fuel	NFR	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
	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)
			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 gasification 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	Biomethane	1A1a	0101	0.1	Assumed equal to natural gas	0.1	0.1	Assumed equal to natural gas
				Gas turbines	0.1	Assumed equal to natural gas	0.061	0.051	Assumed equal to natural gas
				Engines	0.76	Assumed equal to natural gas	0.189	0.161	Assumed equal to natural gas
				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
				Gas turbines	0.1	Assumed equal to natural gas	0.061	0.051	Assumed equal to natural gas
				Engines	0.76	Assumed equal to natural gas	0.189	0.161	Assumed equal to natural gas
			1A4a	0201	0.1	Assumed equal to natural gas	0.1	0.1	Assumed equal to natural gas
				Engines	0.76	Assumed equal to natural gas	0.189	0.161	Assumed equal to natural gas
			1A4b	0202	0.1	Assumed equal to natural gas	0.1	0.1	Assumed equal to natural gas
				Engines	0.76	Assumed equal to natural gas	0.189	0.161	Assumed equal to natural gas
			1A4c	0203	0.1	Assumed equal to natural gas	0.1	0.1	Assumed equal to natural gas
				Engines	0.76	Assumed equal to natural gas	0.189	0.161	Assumed equal to natural gas

[1)] The fuel has not been applied in 2023.

7.11 Black carbon (BC) emission factors

The BC share of $PM_{2.5}$ and the BC emission factors are shown in Table 67. Table 67 also includes references for the BC share. The BC share depend on fuel and sector.

Emission factor shares for BC all refer to EEA (2023). All emission factors are shown as percentage of $PM_{2.5}$ and in g per GJ.

The time series are included in Annex 4. Time series have been estimated for residential wood combustion, combustion of straw in residential / agricultural plants, and for waste incineration. The BC share of $PM_{2.5}$ is considered constant for each fuel/technology.

Table 67 BC emission factors and BC share of $PM_{2.5}$, 2023.

Fuel	Fuel	NFR	SNAP	BC share of $PM_{2.5}$	BC emission factor, g/GJ	Reference for BC share
101A	Anodic carbon	1A2	03	2.2%	0.154	EEA (2023), Energy Industries, Table 3-2.
102A	Coal	1A1a	0101	2.2%	0.0462	EEA (2023), Energy Industries, Table 3-2.
102A	Coal	1A1a	0102	2.2%	0.11	EEA (2023), Energy Industries, Table 3-2.
102A	Coal	1A2	03	6.4%	0.448	EEA (2023), Manufacturing Industries, Table 3-2.
102A	Coal	1A4a	0201	6.4%	0.448	EEA (2023), Small Combustion, Table 3-7.
102A	Coal	1A4b	0202	6.4%	0.448	EEA (2023), Small Combustion, Table 3-3.
102A	Coal	1A4c	0203	6.4%	0.448	EEA (2023), Small Combustion, Table 3-7.
103A	Fly ash fossil	1A1a	010104	2.2%	0.0462	Assumed equal to coal. DCE assumption.
106A	BKB	1A2	03	6.4%	0.448	EEA (2023), Manufacturing Industries, Table 3-2.
106A	BKB	1A4a	0201	6.4%	0.448	EEA (2023), Small Combustion, Table 3-7.
106A	BKB	1A4b	0202	6.4%	0.448	EEA (2023), Small Combustion, Table 3-3.
106A	BKB	1A4c	0203	6.4%	0.448	EEA (2023), Small Combustion, Table 3-7.
107A	Coke oven coke	1A4b	0202	6.4%	0.448	EEA (2023), Small Combustion, Table 3-3.
107A	Coke oven coke	1A2	0301	6.4%	0.448	EEA (2023), Manufacturing Industries, Table 3-2.
110A	Petroleum coke	1A1a	0101	5.6%	0.168	EEA (2023), Energy Industries, Table 3-5 and Table 3-1.
110A	Petroleum coke	1A2	03	56.0%	1.68	EEA (2023), Manufacturing Industries, Table 3-4.
110A	Petroleum coke	1A4a	0201	56.0%	16.8	EEA (2023), Small Combustion, Table 3-9.
110A	Petroleum coke	1A4b	0202	8.5%	2.55	EEA (2023), Small Combustion, Table 3-5.
110A	Petroleum coke	1A4c	0203	56.0%	16.8	EEA (2023), Small Combustion, Table 3-9.
203A	Residual oil	1A1a	010101	5.6%	0.14	EEA (2023), Energy Industries, Table 3-5.
203A	Residual oil	1A1a	010102, 010103	5.6%	0.4424	EEA (2023), Energy Industries, Table 3-5.
203A	Residual oil	1A1a	0102	5.6%	0.14	EEA (2023), Energy Industries, Table 3-5.
203A	Residual oil	1A1b	010306	5.6%	1.96	EEA (2023), Energy Industries, Table 4-6.
203A	Residual oil	1A2	03	56.0%	2.688	EEA (2023), Manufacturing Industries, Table 3-4.
203A	Residual oil	1A4a	0201	56.0%	3.92	EEA (2023), Small Combustion, Table 3-9.
203A	Residual oil	1A4b	0202	8.5%	0.595	EEA (2023), Small Combustion, Table 3-5.
203A	Residual oil	1A4c	0203	56.0%	3.92	EEA (2023), Small Combustion, Table 3-9.
204A	Gas oil	1A1a	0101, 0102	33.5%	1.675	EEA (2023), Energy Industries, Table 3-7.
204A	Gas oil	1A1a	010104	33.5%	1.675	EEA (2023), Energy Industries, Table 3-20.
204A	Gas oil	1A1a	010105	78.0%	3.9	EEA (2023), Energy Industries, Table 3-21.
204A	Gas oil	1A1b	010306	33.5%	1.675	EEA (2023), Energy Industries, Table 4-7.
204A	Gas oil	1A1c	010500	33.5%	1.675	EEA (2023), Energy Industries, Table 3-20.
204A	Gas oil	1A2	03	56.0%	2.8	EEA (2023), Manufacturing Industries, Table 3-4.
204A	Gas oil	1A2	03 turbines	33.5%	1.675	EEA (2023), Energy Industries, Table 3-20.
204A	Gas oil	1A2	03 engines	78.0%	3.9	EEA (2023), Energy Industries, Table 3-21.
204A	Gas oil	1A4a	0201	56.0%	2.8	EEA (2023), Small Combustion, Table 3-9.
204A	Gas oil	1A4a	020105	78.0%	3.9	EEA (2023), Energy Industries, Table 3-21.
204A	Gas oil	1A4b	0202	3.9%	0.195	EEA (2023), Small Combustion, Table 3-18.
204A	Gas oil	1A4b	020204	78.0%	3.9	EEA (2023), Energy Industries, Table 3-21.
204A	Gas oil	1A4c	0203	56.0%	2.8	EEA (2023), Small Combustion, Table 3-9.
204A	Gas oil	1A4c	020304	78.0%	3.9	EEA (2023), Energy Industries, Table 3-21.

Fuel	Fuel	NFR	SNAP	BC share of $PM_{2.5}$	BC emission factor, g/GJ	Reference for BC share
206A	Kerosene	1A2	03	56.0%	2.8	EEA (2023), Manufacturing Industries, Table 3-4.
206A	Kerosene	1A4a	0201	56.0%	2.8	EEA (2023), Small Combustion, Table 3-9.
206A	Kerosene	1A4b	0202	8.5%	0.425	EEA (2023), Small Combustion, Table 3-5.
206A	Kerosene	1A4c	0203	56.0%	2.8	EEA (2023), Small Combustion, Table 3-9.
225A	Orimulsion	1A1a	010101	2.2%	0.0352	Assumed equal to coal. DCE assumption.
303A	LPG	1A1a	0101	2.5%	0.005	Assumed equal to natural gas. DCE assumption.
303A	LPG	1A1a	010104	2.5%	0.005	Assumed equal to natural gas. DCE assumption.
303A	LPG	1A1a	0102	2.5%	0.005	Assumed equal to natural gas. DCE assumption.
303A	LPG	1A2b	010306	2.5%	0.005	Assumed equal to natural gas. DCE assumption.
303A	LPG	1A2	03	4.0%	0.008	Assumed equal to natural gas. DCE assumption.
303A	LPG	1A4a	020100	4.0%	0.008	Assumed equal to natural gas. DCE assumption.
303A	LPG	1A4a	020105	4.0%	0.008	Assumed equal to natural gas. DCE assumption.
303A	LPG	1A4b	0202	5.4%	0.0108	Assumed equal to natural gas. DCE assumption.
303A	LPG	1A4c	0203	4.0%	0.008	Assumed equal to natural gas. DCE assumption.
308A	Refinery gas	1A2	03	18.4%	0.92	EEA (2023), Energy Industries, Table 4-4.
308A	Refinery gas	1A1a	010101	18.4%	0.92	EEA (2023), Energy Industries, Table 4-4.
308A	Refinery gas	1A1a	010203	18.4%	0.92	EEA (2023), Energy Industries, Table 4-4.
308A	Refinery gas	1A1b	0103	18.4%	0.92	EEA (2023), Energy Industries, Table 4-4.
301A	Natural gas	1A1a	0101	2.5%	0.0025	EEA (2019), Energy Industries, Table 3-4. The emission factor is not included in EEA (2023).
301A	Natural gas	1A1a	010104	2.5%	0.001275	EEA (2019), Energy Industries, Table 3-17. The emission factor is not included in EEA (2023), Table 3-19.
301A	Natural gas	1A1a	010105	2.5%	0.004025	EEA (2023), Energy Industries, Table 3-22.
301A	Natural gas	1A1a	010200	2.5%	0.0025	EEA (2019), Energy Industries, Table 3-4. The emission factor is not included in EEA (2023).
301A	Natural gas	1A1c	0105	2.5%	0.001275	EEA (2019), Energy Industries, Table 3-4. The emission factor is not included in EEA (2023).
301A	Natural gas	1A1c	010504	2.5%	0.001275	EEA (2019), Energy Industries, Table 3-17. The emission factor is not included in EEA (2023), Table 3-19.
301A	Natural gas	1A2	03	4.0%	0.004	EEA (2023), Manufacturing Industries, Table 3-3.
301A	Natural gas	1A2	03 turbines	2.5%	0.001275	EEA (2019), Energy Industries, Table 3-17. The emission factor is not included in EEA (2023), Table 3-19.
301A	Natural gas	1A2	03 engines	2.5%	0.004025	EEA (2023), Energy Industries, Table 3-22.
301A	Natural gas	1A4a	0201	4.0%	0.004	EEA (2023), Small Combustion, Table 3-8.
301A	Natural gas	1A4a	020104	2.5%	0.001275	EEA (2019), Energy Industries, Table 3-17. The emission factor is not included in EEA (2023), Table 3-19.
301A	Natural gas	1A4a	020105	2.5%	0.004025	EEA (2023), Energy Industries, Table 3-22.
301A	Natural gas	1A4b	0202	5.4%	0.0054	EEA (2023), Small Combustion, Table 3-16.
301A	Natural gas	1A4b	020204	2.5%	0.004025	EEA (2023), Energy Industries, Table 3-22.
301A	Natural gas	1A4c	020300	4.0%	0.004	EEA (2023), Small Combustion, Table 3-8.
301A	Natural gas	1A4c	020303	2.5%	0.001275	EEA (2019), Energy Industries, Table 3-17. The emission factor is not included in EEA (2023).
301A	Natural gas	1A4c	020304	2.5%	0.004025	EEA (2023), Energy Industries, Table 3-22.
114A	Waste	1A1a	0101	3.5%	0.01015	EEA (2023), Municipal waste Incineration, Table 3-1.
114A	Waste	1A1a	0102	3.5%	0.0735	EEA (2023), Municipal waste Incineration, Table 3-1.
114A	Waste	1A2	03	3.5%	0.0735	EEA (2023), Municipal waste Incineration, Table 3-1.
114A	Waste	1A4a	0201	3.5%	0.0735	EEA (2023), Municipal waste Incineration, Table 3-1.
115A	Industrial waste	1A2	03	3.5%	0.0735	EEA (2023), Municipal waste Incineration, Table 3-1.
111A	Wood	1A1a	0101	3.3%	0.0429	EEA (2023), Energy Industries, Table 3-8.

Fuel	Fuel	NFR	SNAP	BC share of $PM_{2.5}$	BC emission factor, g/GJ	Reference for BC share
111A	Wood	1A1a	0102	3.3%	0.33	EEA (2023), Energy Industries, Table 3-8.
111A	Wood	1A2	03	28.0%	2.8	EEA (2023), Manufacturing Industries, Table 3-5.
111A	Wood	1A4a	0201	28.0%	37.8	EEA (2023), Small Combustion, Table 3-10.
111A	Wood	1A4b	0202	-	19.4	See residential wood combustion, Chapter 6.13.
111A	Wood	1A4c	0203	28.0%	37.8	EEA (2023), Small Combustion, Table 3-10.
117A	Straw	1A1a	0101	3.3%	0.03663	EEA (2023), Energy Industries, Table 3-8.
117A	Straw	1A1a	0102	3.3%	0.396	EEA (2023), Energy Industries, Table 3-8.
117A	Straw	1A2	03	28.0%	3.36	EEA (2023), Manufacturing Industries, Table 3-5.
117A	Straw	1A4b	0202	28.0%	112.1	Time series based on DEPT (2022) and EEA (2019), Small Combustion, Table 3-10 (Assumed equal to agricultural plants).
117A	Straw	1A4c	020300	28.0%	112.1	Time series based on DEPT (2022) and EEA (2019), Small Combustion, Table 3-10 (Assumed equal to agricultural plants).
122A	Wood pellets	1A1a	0101	3.3%	0.0429	EEA (2023), Energy Industries, Table 3-8.
122A	Wood pellets	1A1a	0102	3.3%	0.33	EEA (2023), Energy Industries, Table 3-8.
122A	Wood pellets	1A2	0301	28.0%	2.8	EEA (2023), Manufacturing Industries, Table 3-5.
122A	Wood pellets	1A4a	0201	-	7	See residential wood combustion, Chapter 6.13.
122A	Wood pellets	1A4b	0202	-	7	See residential wood combustion, Chapter 6.13.
122A	Wood pellets	1A4c	0203	-	7	See residential wood combustion, Chapter 6.13.
215A	Bio oil	1A1a	0101	33.5%	1.675	Assumed equal to gas oil. DCE assumption.
215A	Bio oil	1A1a	010105	78.0%	3.9	Assumed equal to gas oil. DCE assumption.
215A	Bio oil	1A1a	0102	33.5%	1.675	Assumed equal to gas oil. DCE assumption.
215A	Bio oil	1A2	03	56.0%	2.8	EEA (2023), Manufacturing Industries, Table 3-4.
215A	Bio oil	1A2	03 engines	78.0%	3.9	Assumed equal to gas oil. DCE assumption.
215A	Bio oil	1A4a	020105	78.0%	3.9	Assumed equal to gas oil. DCE assumption.
215A	Bio oil	1A4b	020200	3.9%	0.295	Assumed equal to gas oil. DCE assumption.
215A	Bio oil	1A4b	020304	78.0%	3.9	Assumed equal to gas oil. DCE assumption.
309A	Biogas	1A1a	0101	3.3%	0.0495	Assumed % equal to wood. DCE assumption.
309A	Biogas	1A1a	010105	3.3%	0.006798	Assumed % equal to wood. DCE assumption.
309A	Biogas	1A1a	0102	3.3%	0.0495	Assumed % equal to wood. DCE assumption.
309A	Biogas	1A2	03	28.0%	0.42	Assumed % equal to wood. DCE assumption.
309A	Biogas	1A1c	010505	3.3%	0.006798	Assumed % equal to wood. DCE assumption.
309A	Biogas	1A4a	0201	28.0%	0.42	Assumed % equal to wood. DCE assumption.
309A	Biogas	1A4c	0203	28.0%	0.0054	Assumed % equal to wood. DCE assumption.
310A	Bio gasification gas	1A1a	010105	3.3%	0.006798	Assumed % equal to wood. DCE assumption.
310A	Bio gasification gas	1A2	03 engines	28.0%	0.05768	Assumed % equal to wood. DCE assumption.
310A	Bio gasification gas	1A4a	020105	3.3%	0.006798	Assumed % equal to wood. DCE assumption.
310A	Bio gasification gas	1A4c	020304	28.0%	0.05768	Assumed % equal to wood. DCE assumption.
315A	Biomethane	1A1a	0101, except engines	2.5%	0.0025	Assumed equal to natural gas. DCE assumption.
315A	Biomethane	1A1a	010105 Engines	2.5%	0.004025	Assumed equal to natural gas. DCE assumption.
315A	Biomethane	1A1a	0102	2.5%	0.0025	Assumed equal to natural gas. DCE assumption.
315A	Biomethane	1A1b	0103	2.5%	0.0025	Assumed equal to natural gas. DCE assumption.
315A	Biomethane	1A2	03	4.0%	0.004	Assumed equal to natural gas. DCE assumption.
315A	Biomethane	1A2	03, Engines	2.5%	0.004025	Assumed equal to natural gas. DCE assumption.
315A	Biomethane	1A4a	0201	4.0%	0.004	Assumed equal to natural gas. DCE assumption.
315A	Biomethane	1A4a	0201, engines	2.5%	0.004025	Assumed equal to natural gas. DCE assumption.
315A	Biomethane	1A4b	0202	5.4%	0.0054	Assumed equal to natural gas. DCE assumption.
315A	Biomethane	1A4b	0202, engines	2.5%	0.004025	Assumed equal to natural gas. DCE assumption.
315A	Biomethane	1A4c	0203	4.0%	0.004	Assumed equal to natural gas. DCE assumption.
315A	Biomethane	1A4c	0203, engines	2.5%	0.004025	Assumed equal to natural gas. DCE assumption.

7.12 Heavy metals emission factors

The heavy metal emission inventory has been documented in detail in Nielsen et al. (2013c).

The HM emission factors 2023 and references are shown in Table 68.

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, 2010).
- The EEA Guidebook (EEA, 2023).
- Struschka et al. (2008).
- Hedberg et al. (2002).

The time series are included in Annex 4. Time series have been estimated for:

- Coal combustion in electricity and district heat production plants.
- Waste incineration plants in public electricity and heat production.
- Waste incineration in other combustion plants.

Table 68 HM emission factors and references, 2023.

Fuel type	Fuel	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 (2023), 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 (2023), 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.
	BKB	1A4b i	Residential	0202	2.5	1.5	11.2	22.3	5.1	12.7	130	1.8	220	EEA (2023), 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 (2023), 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 (2023), 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 (2023), Tier 1, Energy Industries Table 3-6 (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 (2023), Tier 1, Energy Industries Table 3-6 (for heavy fuel oil).
	Gas oil	-	Engines	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.
	LPG	All	All	All	0.002	0.001	0.2	0.13	0.12	0.005	0.012	0.002	0.42	EEA (2023), Tier 1, Small Combustion Table 3-5 (for 1A4b, other liquid fuels).
	Refinery gas	1A1b	Petroleum refining	All	0.352	2.19	6.69	3.29	0.372	7.37	1.61	1.56	17.0	EEA (2023), Tier 1, Energy Industries, Table 4-2 (for refinery gas, 1A1b).
Gas	Natural gas	-	Engines	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). For Se: EEA (2023), 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).

Fuel type	Fuel	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
Biomass	Wood and wood pellets	-	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: Struschka et al. (2008). For Se: Hedberg et al. (2002).
		1A4b i	Residential	All	0.19	13	23	6	0.56	2	27	0.5	512	For As and Hg: Struschka et al. (2008). For Cd and Ni: Hedberg et al. (2002), Struschka et al. (2008), Lamberg et al. (2011). For Cr: Hedberg et al. (2002), Struschka et al. (2008). For Cu, Pb and Zn: Hedberg et al. (2002), Tissari et al. (2007), Struschka et al. (2008), Lamberg et al. (2011). For Se: Hedberg et al. (2002).
	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: Struschka et al. (2008) (see also EEA (2023), small combustion, Table 3-10).
		1A4b i	Residential	0202	0.19	13	23	6	0.56	2	27	0.5	512	EEA (2023), Tier 1, Small Combustion, Residential plants, Biomass, Table 3-6.
		1A4c i	Agriculture/ Forestry	0203	0.19	13	23	6	0.56	2	27	0.5	512	EEA (2023), Tier 1, Small Combustion, Residential plants, Biomass, Table 3-6.
	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.
		-	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 gasification 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.
	Biomethane	-	All except engines	All	0.119	0.00025	0.00076	0.000076	0.1	0.00051	0.0015	0.0112	0.0015	Assumed equal to natural gas.
			Engines	engines	0.05	0.003	0.05	0.01	0.1	0.05	0.04	0.01	2.9	Assumed equal to natural gas.

7.13 PAH emission factors

The PAH emission factors 2023 and references are shown in Table 69.

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 (2023).
- Nielsen et al. (2021b).

In general, emission factors for PAH are uncertain.

The time series are included in Annex 4. Time series have been estimated for:

- Residential wood combustion.
- Natural gas fuelled engines.
- Biogas-fuelled engines.

Table 69 PAH emission factors and references, 2023.

Fuel type	Fuel id	Fuel	NRF	SNAP	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 (2023). 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 (2023). Tier 1, Energy Industries Table 3-2
	106A	BKB	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	010500	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).
			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).

Fuel type	Fuel id	Fuel	NRF	SNAP	Benzo(a)-pyrene	Benzo(b)-fluoranthene	Benzo(k)-fluoranthene	Indeno-(1,2,3-c,d)-pyrene	Reference
				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	62554	62317	34806	34721	Nielsen et al. (2021b). Time series.
			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).
	122A	Wood pellets	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	03	6.46	1292.52	1292.52	11.56	Finstad et al. (2001).
			1A4a i	0201	900	1300	1300	1200	Nielsen et al. (2020).
			1A4b i	0202	900	1300	1300	1200	Nielsen et al. (2020).
	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 gasification gas	Engines	010105	2	2	2	2	Nielsen et al. (2010a).
	315A	Biomethane	1A4b i	0202	0.133	0.663	0.265	2.653	Jensen (2001).
			Gas turbines	-	1	1	2	3	Assumed equal to natural gas.
			Engines	-	1.2	9	1.7	1.8	Assumed equal to natural gas.

7.14 PCDD/F emission factors

The PCDD/F emission factors 2023 and references are shown in Table 70.

The emission factor for residential wood combustion refers to Nielsen et al. (2021b). The emission factor is based on technology specific emission factors, see chapter 6.13.

The emission factors for decentralised CHP plants[43] 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.

The time series are included in Annex 4. Time series have been estimated for:

- Residential wood combustion.
- Waste incineration plants.

[43] Natural gas fuelled engines, biogas fuelled engines, gas oil fuelled engines, engines fuelled by biomass gasification gas, CHP plants combusting straw or wood and waste incineration plants.

Table 70 Emission factors for PCDD/F, 2023.

Fuel type	Fuel id	Fuel	NFR	SNAP	PCDD/F, ng per GJ	Reference
Solid	102A	Anodic carbon	1A2g	0320	1.32	Henriksen et al., 2006
		Coal	1A1a	0101 and 0102	1.32	Henriksen et al., 2006
			1A2 a-g	03	1.32	Henriksen et al., 2006
			1A4c i	0203	300	Henriksen et al., 2006
	103A	Fly ash fossil	1A1a	0101	1.32	Henriksen et al., 2006
	106A	BKB	1A4b i	0202	800	Henriksen et al., 2006
	107A	Coke oven coke	1A2 a-g	03	1.32	Henriksen et al., 2006
			1A4c	0203	800	Henriksen et al., 2006
Liquid	110A	Petroleum coke	1A2 a-g	03	1.32	Henriksen et al., 2006
			1A4a i	0201	300	Henriksen et al., 2006
			1A4b i	0202	800	Henriksen et al., 2006
			1A4c i	0203	300	Henriksen et al., 2006
	203A	Residual oil	1A1a	All	0.882	Henriksen et al., 2006
			1A1b	010306	0.882	Henriksen et al., 2006
			1A2 a-g	03	0.882	Henriksen et al., 2006
			1A4a i	0201	10	Henriksen et al., 2006
			1A4b i	0202	10	Henriksen et al., 2006
			1A4c i	0203	10	Henriksen et al., 2006
	204A	Gas oil	1A1a	Not engines	0.882	Henriksen et al., 2006
				Engines	0.99	Nielsen et al., 2010a
			1A1b	010306	0.882	Henriksen et al., 2006
			1A1c	0105	0.882	Henriksen et al., 2006
			1A2 a-g	Not engines	0.882	Henriksen et al., 2006
				Engines	0.99	Nielsen et al., 2010a
			1A4a i	Not engines	10	Henriksen et al., 2006
				Engines	0.99	Nielsen et al., 2010a
			1A4b i	Not engines	10	Henriksen et al., 2006
				Engines	0.99	Nielsen et al., 2010a
			1A4c i	0203	10	Henriksen et al., 2006
	206A	Kerosene	1A2a-g	03	0.882	Henriksen et al., 2006
			1A4a i	0201	10	Henriksen et al., 2006
			1A4b i	0202	10	Henriksen et al., 2006
			1A4c i	0203	10	Henriksen et al., 2006
	303A	LPG	1A1a	0101 and 0102	0.025	Henriksen et al., 2006
			1A2a-g	03	0.025	Henriksen et al., 2006
			1A4a i	0201	2	Henriksen et al., 2006
			1A4b i	0202	2	Henriksen et al., 2006
			1A4c i	0203	2	Henriksen et al., 2006
	308A	Refinery gas	1A1b	0103	0.025	Henriksen et al., 2006
Gas	301A	Natural gas	1A1a	Not engines	0.025	Henriksen et al., 2006
				Engines	0.57	Nielsen et al., 2010a
			1A1b	0103	0.025	Henriksen et al., 2006
			1A1c	010504	0.025	Henriksen et al., 2006
			1A2 a-g	03, Not engines	0.025	Henriksen et al., 2006
				Engines	0.57	Nielsen et al., 2010a
			1A4a i	0201	2	Henriksen et al., 2006
				020105	0.57	Nielsen et al., 2010a
			1A4b i	0202	2	Henriksen et al., 2006
				020204	0.57	Nielsen et al., 2010a
			1A4c i	0203	2	Henriksen et al., 2006
				020304	0.57	Nielsen et al., 2010a
Waste	114A	Waste	1A1a	0101 and 0102	5	Nielsen et al., 2010a.

Fuel type	Fuel id	Fuel	NFR	SNAP	PCDD/F, ng per GJ	Reference
			1A4a i	0201	5	Nielsen et al., 2010a.
	115A	Industrial waste	1A2f	0316	5	Nielsen et al., 2010a.
Biomass	111A	Wood	1A1a	0101	14	Nielsen et al., 2010a.
				0102	1	Henriksen et al., 2006.
			1A2 a-g	03	1	Henriksen et al., 2006.
			1A4a i	0201	400	Henriksen et al., 2006.
			1A4b i	0202	766	Nielsen et al. (2021b).
			1A4c i	0203	400	Henriksen et al., 2006.
	117A	Straw	1A1a	0101	19	Nielsen et al., 2010a.
				0102	22	Henriksen et al., 2006.
			1A4b i	0202	500	Henriksen et al., 2006.
			1A4c i	0203	400	Henriksen et al., 2006.
	122A	Wood pellets	1A1a	0101	14	Nielsen et al., 2010a.
				0102	1	Henriksen et al., 2006.
			1A2 a-g	03	1	Henriksen et al., 2006.
			1A4a i	0201	333	Nielsen et al. (2021b).
			1A4b i	0202	333	Nielsen et al. (2021b).
			1A4c i	0203	333	Nielsen et al. (2021b).
	215A	Bio oil	1A1a	0101 and 0102	0.882	Henriksen et al., 2006.
			1A2 a-g	03	0.882	Henriksen et al., 2006.
			1A4b i	0202	10	Henriksen et al., 2006.
	309A	Biogas	1A1a	Engines	0.96	Nielsen et al., 2010a.
				Not engines	0.025	Henriksen et al., 2006.
			1A2a-g	Not engines	0.025	Henriksen et al., 2006.
				Engines	0.96	Nielsen et al., 2010a.
			1A4a i	Not engines	2	Henriksen et al., 2006.
				Engines	0.96	Nielsen et al., 2010a.
			1A4b	Not engines	2	Henriksen et al., 2006.
			1A4c i	Not engines	2	Henriksen et al., 2006.
				Engines	0.96	Nielsen et al., 2010a.
	310A	Bio gasification gas	1A1a	010105	1.7	Nielsen et al., 2010a.
	315A	Biomethane	1A1a	0101 and 0102	0.025	Assumed equal to natural gas.
			1A2a-g	03	0.025	Assumed equal to natural gas.
			1A4a	0201	2	Assumed equal to natural gas.
			1A4b	0202	2	Assumed equal to natural gas.
			1A4c	0203	2	Assumed equal to natural gas.
			All engines	Engines	0.57	Assumed equal to natural gas.

7.15 HCB emission factors

The HCB emission inventory has been documented in Nielsen et al. (2014b).

Table 71 shows the emission factors and references for the Danish emission factors.

Table 71 Emission factors for HCB, 2023.

Fuel	NFR (SNAP)	Emission factor, ng/GJ	Reference
Coal	1A1, 1A2	6,700	Grochowalski & Konieczyński (2008); EEA (2023) Energy Industries Table 3-2.
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 and wood pellets	1A1, 1A2	5,000	EEA (2023) Energy Industries Table 3-8.
Wood and wood pellets	1A4	5,000	EEA (2023) Small Combustion Table 3-8.
Straw	1A1, 1A2	113	Nielsen et al. (2010a).
Straw	1A4	5,000	EEA (2023) Energy Industries Table 3-8.
Biogas	1A1, 1A2, 1A4	190	Nielsen et al. (2010a).
Bio gasification gas	1A1, 1A2, 1A4	800	Nielsen et al. (2010a).
Biomethane	1A1, 1A2, 1A4	-	Negligible.

[1)] The emission factors for LPG and refinery gas are 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, 2023).

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 (2023) 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 (2023) emission factor is applied.

The emission factors for biogas and biomass gasification 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 %[44].

Table 72 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.

Table 72 Emission factors for ∑dl-PCB, stationary combustion, 2023.

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	2,075 (time series)	-	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).
Wood pellets	1A1, 1A2, 1A4a/c, 1A4b	465.5	-	Hedman et al. (2006).
Biogas	1A1, 1A2, 1A4	90	0.13	Nielsen et al. (2010a).
Bio gasification gas	1A1, 1A2, 1A4	144	0.17	Nielsen et al. (2010a).
Biomethane	1A1, 1A2, 1A4	-	-	Negligible.

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

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

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 73.

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 agree 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 73.

For wood pellets the emission factor for residential plants from Hedman et al. (2006) have been applied for all combustion of wood pellets.

Emission factor time series for waste incineration and for residential wood combustion are shown in Table 73.

Table 73 PCB emission factor time series for waste incineration and for residential wood combustion.

Year	Waste incineration ∑dl-PCB, ng/GJ	Residential wood combustion[1)] ∑dl-PCB, ng/GJ
1990	45671	6076
1991	38063	6000
1992	30433	5924
1993	22825	5849
1994	19773	5774
1995	16721	5701
1996	13690	5629
1997	10638	5560
1998	7586	5492
1999	5515	5425
2000	3423	5359
2001	3423	5293
2002	3423	5226
2003	3423	5162
2004	1766	4921
2005	109	4687
2006	109	4509
2007	109	4333
2008	109	4142
2009	109	3930
2010	109	3718
2011	109	3588
2012	109	3459
2013	109	3330
2014	109	3200
2015	109	3071
2016	109	2941
2017	109	2814
2018	109	2686
2019	109	2560
2020	109	2435
2021	109	2312
2022	109	2192
2023	109	2075

[1)] Wood pellets not included.

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 5. The implied emission factors are calculated as total emission divided by total fuel consumption.

8 Uncertainty

8.1 Uncertainty for greenhouse gases

Uncertainty estimates include uncertainty regarding the total emission inventory as well as uncertainty regarding trends.

8.1.1 Methodology

The uncertainty for greenhouse gas emissions has been estimated according to the IPCC Guidelines (IPCC, 2006). In later years the uncertainty has been estimated only by approach 1.

Approach 1 is based on a normal distribution and a confidence interval of 95 %.

The input data for the approach 1 are:

- Emission data for the base year (1990) and the latest year (2023).
- Uncertainties for emission factors.
- Uncertainty for fuel consumption rates.

The emission source categories applied are listed in Table 74.

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 and biomethane 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 2023 uncertainty levels have been applied in uncertainty calculation for trend.

Fuel consumption

The applied uncertainty rates for fuel consumption are shown below.

Table 74 Uncertainties for fuel consumption 2023.

IPCC Source category	2023	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	1.7%	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	1.6%	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	2.0%	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	1.2%	Estimated based on IPCC (2006) values.
1A1, 1A2, 1A4 St. comb., Gas oil, CO_2	1.9%	Estimated based on IPCC (2006) values.
1A1, 1A2, 1A4 St. comb., Kerosene, CO_2	2.6%	Estimated based on IPCC (2006) values.
1A1, 1A2, 1A4 St. comb., LPG, CO_2	1.8%	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	1.4%	Estimated based on IPCC (2006) values. Off-shore gas turbines not included in this category.
1A1c Offshore gas turbines, Natural gas, CO_2	0.5%	ETS data for 2021, 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	3.0%	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	3.0%	IPCC (2006).
1A4, Stationary Combustion, Residential wood combustion, CH_4	10.0%	DCE assumption.
1A4, Stationary Combustion, Residential and agricultural straw combustion, CH_4	10.0%	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).

IPCC Source category	2023	Reference
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	3.0%	DCE assumption.
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	3.0%	DCE assumption.
1A4b, Stationary Combustion, Residential wood combustion, N_2O	10.0%	DCE assumption.
1A4b/c, Stationary Combustion, Residential and agricultural straw combustion, N_2O	10.0%	DCE assumption.

Emission factors

Uncertainties for emission factors are shown in Table 75.

Table 75 Uncertainties for emission factors, 2023.

IPCC Source category	2023	Reference
1A1, 1A2, 1A4 St. comb. Coal, ETS data, CO_2	0.3%	ETS data, 2020 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	3.0%	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, 2020 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	1.3%	DCE estimate.
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	0.5%	1990: IPCC (2000), chapter 2.1.1.6. 2020: DCE assumption, 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 2020, 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.

IPCC Source category	2023	Reference
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). 2018: 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).
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

IPCC Source category	2023	Reference
		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

Approach 1 uncertainty estimates for stationary combustion emission inventories are shown in Table 76. Detailed calculation sheets are provided in Annex 7[45]. The uncertainty estimates are based on the methodology included in IPCC Guidelines (2006).

The uncertainty interval for the total greenhouse gas emission is estimated to be ±2.6 % and the trend in greenhouse gas emissions is -72.5 % ± 0.7 %-age points. The main sources of uncertainty for greenhouse gas emissions in 2023 are N_2O emission from biomass combusted in Energy industries (1A1), and N_2O emission from residential wood combustion. The main sources of uncertainty in the trend in greenhouse gas emission are also the N_2O emissions from biomass combusted in Energy industries (1A1) and the N_2O emission from residential wood combustion.

Table 76 Uncertainty estimates for the Danish GHG emission inventory, Approach 1, 2023.

Pollutant	Uncertainty Total emission, %	Trend 1990-2023, %	Uncertainty trend, %-age points
GHG	±2.6	-72.5	±0.7
CO_2	±0.8	-73.2	±0.3
CH_4	±39	+3.7	±43
N_2O	±179	-14.2	±187

8.2 Uncertainty for other pollutants

According to the EEA Guidelines (EEA, 2023), uncertainty estimates should be estimated. Uncertainty estimates include uncertainty with regard to the total emission inventory as well as uncertainty with regard to trends.

8.2.1 Methodology

The Danish uncertainty estimates are based on the Tier 1 approach.

The uncertainty estimates are based on emission data for the base year and year 2023 as well as on uncertainties for fuel consumption and emission

[45] Supporting Documentation Annex 3A Stationary combustion, Annex 3A-7.2

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 77.

The applied uncertainties for 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 78.

Table 77 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	10
1A4c_i Agriculture / forestry / fishing	3

Table 78 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 79. Detailed calculation sheets are provided in Annex 7.

The total emission uncertainty is 5.9 % for SO_2 and 9.6 % for NO_x.

Table 79 Uncertainty estimates, tier 1 approach, 2023.

Pollutant	Uncertainty Total emission, %	Trend 1990-2022, %	Uncertainty Trend, %-age points
SO_2	±5.9	-97	±0.1
NO_x	±9.6	-80	±1.5
NMVOC	±54	-44	±7.3
CO	±59	-55	±10.0
NH_3	±114	48	±112
TSP	±125	-41	±11.4
PM_{10}	±126	-41	±11.5
$PM_{2.5}$	±127	-40	±10.8
BC	±549	-12	±218
As	±70	-90	±6.1
Cd	±421	-54	±164
Cr	±239	-82	±42
Cu	±364	-88	±43
Hg	±43	-94	±1.9
Ni	±72	-94	±3.1
Pb	±207	-91	±19
Se	±41	-92	±1.3
Zn	±162	-45	±73
HCB	±758	-84	±26
PCDD/F	±471	-57	±171
Benzo(a)pyrene	±847	-64	±23
Benzo(b)fluoranthene	±799	-56	±35
Benzo(k)fluoranthene	±827	-69	±40
Indeno(1,2,3-c,d)pyrene	±832	-79	±15
PCB	±722	-74	±27

9 Sector specific QA/AC and verification

The quality work for the Danish GHG emission inventories is accounted for in *Quality manual for the Danish emission greenhouse gas inventory, Version 3* (Nielsen et al., 2020a). The quality manual outlines the quality work undertaken by the emission inventory group at the Department of Environmental Science, Aarhus University in connection with the preparation and reporting of the Danish greenhouse gas inventory.

The QA/QC defined in the Quality manual defines Critical control points (CCP) and a Points of measurement. Some points of measurement are sector specific whereas others are general. This chapter accounts for the sector specific QA/QC for stationary combustion.

Documentation concerning verification of the Danish emission inventories was published by Fauser et al. (2013).

This sector report has been reviewed by Peter Louring Nielsen from the Danish Energy Agency. Peter Louring Nielsen main focus was the chapters related to EU ETS data and CO_2 emission factors.

Former editions of the sector report for stationary combustion have been reviewed by other external experts in 2004, 2006, 2009, 2014, 2018 and 2021.

9.1 Sector specific points of measurement

Table 80 lists the sector specific points of measurement and specification about the points of measurement for stationary combustion.

Table 80 List of sectoral points of measurement, and QC for stationary combustion.

Level	CCP	Id	Description		Stationary combustion QC
Data Storage level 1	1. Accuracy	DS.1.1.1	General level of uncertainty for every dataset including the reasoning for the specific values.	Sectoral	Uncertainties are estimated and references given in chapter 8.1.
	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 values this is discussed in chapter 7.2 - 7.4. This documentation is improved annually based on reviews. At CRT 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 is shown and discussed below (Table 81).
	4.Consistency	DS.1.4.1	The original external data has to be archived with proper reference.	Sectoral	It is ensured that all original external data are archived. 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. All original data for stationary combustion are archived in the emission inventory archive: ST_ENVS-Luft-Emi/Inventory/(year)/1A1 1A2 and 1A4 Stationary combustion All original data for 1) the reference approach, 2) the comparison of EU ETS sum and CRT and 3) the comparison of Eurostat data and CRT are archived in the emission inventory archive: ST_ENVS-Luft-Emi/Inventory/(year)/1A Other Energy
	6.Robustness	DS.1.6.1	Explicit agreements between the external institution holding the data and AU, 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 2014. Most of the other external data sources are available due to legislation. See Table 81.
	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 81 below.
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 8.1.
	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 chapter 6.1.

Level	CCP	Id	Description		Stationary combustion QC
	3.Completeness	DP.1.3.1	Identification of data gaps with regard to data sources that could improve quantitative knowledge.	Sectoral	The energy statistics (the basic data sheet) is considered complete. Total fuel consumption is based on the energy statistics whereas other data sources are used for specification of technology, subsectors, plant specific data etc.
	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 Energy Producers Survey (plant specific fuel consumption data) from 1994 onwards and implementation of EU ETS data from 2006 onwards are discussed in chapter 6.5.
	5.Correctness	DP.1.5.2	Verification of calculation results using time series.	Sectoral	Time series for activity data on SNAP and CRT source category level are used to identify possible errors. Time series for emission factors and the emission from CRT 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. Except for 2016, 2022, and 2023 both differ less than 2.0 % in 1990-2023. The reference approach is included in chapter 12. The chapter gives an account of the differences between the national approach and the reference approach.
	7.Transparency	DP.1.7.1	The calculation principle, the equations used and the assumptions made must be described.	Sectoral	This is included in chapter 6.
		DP.1.7.2	Clear reference to dataset at Data Storage level 1.	Sectoral	This is included in chapter 6 and 7.
		DP.1.7.3	A manual log to collect information about recalculations.	Sectoral	A manual log is implemented in the emission database.
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.
Data Storage level 4	4.Consistency	DS.4.4.3	The IEFs from the CRT are checked both regarding 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 chapter 4 and 5.
	5. Correctness	DS.4.5.2	Check that additional information and information related to land-use changes has been correctly aggregated compared to the individual submissions of Denmark and Greenland.	Sectoral	(Not relevant for stationary combustion).

Table 81 List of external data sources for stationary combustion.

Dataset	Data reference	Contact(s)	Description	Years included	Data agreement/ Comment
Energy Producers Survey	The Danish Energy Agency (DEA)	Kaj Stærkind	Dataset for all plants producing electricity and district heating for the public grids. For each production unit, the dataset includes the consumption of each fuel, production of heat and electricity, technology and year of installation. The dataset is regarded as complete for fuel consumption since the plants are obliged to report the data to DEA.	1994 onwards	Data agreement 2014.
Gas consumption for gas engines and gas turbines 1990-1993	The Danish Energy Agency (DEA)	Kaj Stærkind	Historical dataset for gas engines and gas turbines. 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. The 1994 data were based on the Energy Producers Survey. DCE assesses that the DEA estimate is the best available data for 1990-1993.	1990-1993	No data agreement. Historical data.
Basic data	The Danish Energy Agency (DEA)	Carmela Moreno Jytte Boll Illerup Ali Zarnaghi	The Danish energy statistics. The dataset is applied for both the reference approach and the national approach. 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 dataset applied in the national approach.	1972 and 1975 onwards	Data agreement 2014. However, the dataset is also published as part of national energy statistics.
Energy statistics for industrial subsectors	The Danish Energy Agency (DEA)	Ali Zarnaghi	Disaggregation of the industrial fuel consumption. The data includes disaggregation of the fuel consumption for industrial plants. The dataset is estimated for the reporting to Eurostat. The data are included in the 2014 update of the agreement with DEA.		Included in data delivery agreement 2014.
Emission factors	See chapter regarding emission factors		Emission factors refer to a large number of sources. For specific references, see the Chapter 7.2 regarding emission factors. Some of the annually updated CO_2 emission factors are based on EU ETS data, see below.		Some of the annually updated CO_2 emission factors are based on EU ETS data and thus included in the data delivery agreement with DEA. For other emission factors there is no formal data delivery agreement.

Dataset	Data reference	Contact(s)	Description	Years included	Data agreement/ Comment
Annual environmental reports / environmental data / PRTR	Various plants		Emissions from plants defined as large point sources. Some large plants are obligated to report annual environmental data including emission data to PRTR. In addition, some plants publish annual environmental reports. And finally, some plant owners non-compulsory report annual emission data to DCE.		No data agreement. Some plants are obligated to report data (DEPA, 2010b; DEPA, 2015a) and data are published on the Danish EPA homepage.
EU ETS data	The Danish Energy Agency (DEA)	Rikke Brynaa Lintrup	Plant specific CO_2 emission factors and fuel consumption data. 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.		Plants are obligated by law. The availability of detailed information is part of the data agreement with DEA (2014 update).

9.2 Additional sector specific QC procedures

Some additional sector specific QC procedures are performed.

- 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 Chapter 7.
- Most country-specific emission factors are based on input from companies that have implemented some QA/QC work. The major power plant owner/operator in Denmark, Ørsted (former 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.

9.3 Sector specific verification

The IPCC reference approach for CO_2 emission is the primary verification of the CO_2 emission from the energy sector. The reference approach for the energy sector is shown in Chapter 10.

In addition, as part of the EU review of the reported GHG emission data, EU performs for each member state a comparison of Eurostat energy data in terms of TJ with energy data provided in the CRT. 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 latest comparison included comparisons of the reference approach (RA) and the sectoral approach (SA) for the years 2005 and 2008-2023. The comparison of fuel consumption data in CRT and energy statistics from Eurostat is shown in chapter 13. This chapter includes explanations for the differences.

Finally, a verification of the Danish GHG emission inventories has been published by Fauser et al. (2013).

9.4 National external review for stationary combustion

This sector report has been reviewed by Peter Louring Nielsen from the Danish Energy Agency. Peter Louring Nielsen main focus was the chapters related to EU ETS data and CO_2 emission factors.

The 2004, 2006, 2009, 2014, 2018 and 2021 updates of the sector report for stationary combustion have been reviewed by external experts (Nielsen & Illerup, 2004; Nielsen & Illerup, 2006; Nielsen et al., 2009, Nielsen et al., 2014a; Nielsen et al., 2018; Nielsen, 2021). The national external review forms a vital part of the QA activities for stationary combustion.

The 2004, 2006, 2009, 2014, 2018 and 2021 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, Vibeke Vestergaard Nielsen, AU DCE, energy statistics experts from the Danish Energy Agency and Jytte Boll Illerup, The Danish Environmental Protection Agency.

10 Source specific recalculations and improvements in the 2025 reporting

10.1 Greenhouse gases

Emission data for CO_2, CH_4 and N_2O reported this year have been compared to emissions reported last year. Table 82 shows recalculations for CO_2, CH_4 and N_2O. The recalculation of CO_2 emission from stationary combustion is +0.00 % for 1990 and -0.28 % for 2022. The recalculation of CH_4 emission from stationary combustion is +0.00 % for 1990 and -3.74 % for 2022. The recalculation of N_2O emission from stationary combustion is +0.00 % for 1990 and +0.96 % for 2022.

Sector specific recalculations for 1990 and 2022 are shown in Table 83 and Table 84. The main recalculations are discussed below the tables.

Table 82 Recalculations. GHG emissions reported in 2025 compared to emissions reported in 2024.

GHG	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	%	%	%	%	%	%	%	%	%	%
CO_2	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
CH_4	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
N_2O	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

GHG	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
	%	%	%	%	%	%	%	%	%	%
CO_2	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
CH_4	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
N_2O	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

GHG	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
	%	%	%	%	%	%	%	%	%	%
CO_2	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
CH_4	100.00	100.00	100.00	100.00	100.00	99.48	98.95	98.22	97.52	96.83
N_2O	100.00	100.00	100.00	100.00	100.00	99.99	100.00	100.00	100.00	100.00

GHG	2020	2021	2022
	%	%	%
CO_2	100.01	99.49	99.72
CH_4	96.05	96.48	96.26
N_2O	99.94	99.56	99.04

Table 83 Recalculations[46] for stationary combustion, 1990.

	CO_2, kt	CH_4, t	N_2O t	CO_2 %	CH_4, %	N_2O %
1A1 Energy industries	0.000	0.000	0.000	0.000	0.000	0.000
1A1a Public electricity and heat production	0.000	0.000	0.000	0.000	0.000	0.000
1A1b Petroleum refining	0.000	0.000	0.000	0.000	0.000	0.000
1A1c Oil and gas extraction	0.000	0.000	0.000	0.000	0.000	0.000
1A2 Industry	0.000	0.000	0.000	0.000	0.000	0.000
1A2a Iron and steel	0.000	0.000	0.000	0.000	0.000	0.000
1A2b Non-ferrous metals	0.000	0.000	0.000	-	-	-
1A2c Chemicals	0.000	0.000	0.000	0.000	0.000	0.000
1A2d Pulp, paper and print	0.000	0.000	0.000	0.000	0.000	0.000
1A2e Food processing, beverages and tobacco	0.000	0.000	0.000	0.000	0.000	0.000
1A2f Non-metallic minerals	0.000	0.000	0.000	0.000	0.000	0.000
1A2gviii Other manufacturing industry	0.000	0.000	0.000	0.000	0.000	0.000
1A4 Other sectors	0.011	-0.002	0.000	0.000	0.000	0.000
1A4ai Commercial/institutional: Stationary	0.000	0.000	0.000	0.000	0.000	0.000
1A4bi Residential: Stationary	0.011	-0.002	0.000	0.000	0.000	0.000
1A4ci Agriculture/Forestry/Fishing: Stationary	0.000	0.000	0.000	0.000	0.000	0.000
Stationary combustion	0.011	-0.002	0.000	0.000	0.000	0.000

Table 84 Recalculations[47] for stationary combustion, 2022.

	CO_2, kt	CH_4, t	N_2O t	CO_2 %	CH_4, %	N_2O %
1A1 Energy industries	-0.38	-185.06	0.06	0.00%	-4.75%	0.02%
1A1a Public electricity and heat production	-0.38	-185.06	0.06	-0.01%	-4.80%	0.02%
1A1b Petroleum refining	0.00	0.00	0.00	0.00%	0.00%	0.00%
1A1c Oil and gas extraction	0.00	0.00	0.00	0.00%	0.00%	0.00%
1A2 Industry	-5.28	-62.77	-4.51	-0.19%	-9.49%	-3.30%
1A2a Iron and steel	-0.08	0.00	0.00	-0.10%	-0.01%	-0.02%
1A2b Non-ferrous metals	0.00	0.00	0.00	-	-	-
1A2c Chemicals	-0.25	-6.23	-0.30	-0.13%	-12.91%	-3.70%
1A2d Pulp, paper and print	-0.03	-3.60	-2.29	-0.12%	-45.38%	-43.05%
1A2e Food processing, beverages and tobacco	0.17	-49.94	0.00	0.02%	-11.63%	0.02%
1A2f Non-metallic minerals	-0.70	0.00	0.00	-0.05%	0.00%	0.00%
1A2gviii Other manufacturing industry	-4.39	-2.99	-1.93	-1.16%	-10.80%	-11.64%
1A4 Other sectors	-30.43	-75.59	-0.87	-1.62%	-1.85%	-0.54%
1A4ai Commercial/institutional: Stationary	-27.64	-47.27	-0.87	-6.15%	-13.52%	-5.28%
1A4bi Residential: Stationary	1.23	1.22	0.02	0.12%	0.04%	0.01%
1A4ci Agriculture/Forestry/Fishing: Stationary	-4.02	-29.54	-0.02	-1.01%	-3.45%	-0.14%
Stationary combustion	-36.10	-323.42	-5.32	-0.28%	-3.74%	-0.96%

For stationary combustion plants, the emission estimates for the years 1990-2022 have been updated according to the latest energy statistics published by the Danish Energy Agency. The update included both end use and transformation and also a source category update. The changes in the energy statistics are largest for the years 2020, 2021 and 2022. The revisions

[46] The reporting in 2025 compared to the reporting in 2024.
[47] The reporting in 2025 compared to the reporting in 2024.

are shown in the energy statistics. The fuel consumptions have been revised for a large number of fuels for 2022, including natural gas[48], biomethane, bio oil, wood, wood pellets, gas oil and agricultural waste (straw).

The emission factor for CO_2 has been updated for wood for 2021-2022. This emission factor is aggregated based on different wood types with different CO_2 emission factors. The updated emission factors reflect the recalculations in the Danish energy statistics, whereas the CO_2 emission factors for the different wood types have not been changed.

The CH_4 emission factor for biogas fuelled engines have been updated for 2019-2022 according to a recent report (Kristensen, 2023).

The N_2O emission factors have not been revised since the reporting last year.

The emission factor for CO_2 has been updated for wood for 2021-2022. This emission factor is aggregated based on different wood types with different CO_2 emission factors. The updated emission factors reflect the recalculations in the Danish energy statistics, whereas the CO_2 emission factors for the different wood types have not been changed.

The CH_4 emission factor for biogas fuelled engines have been updated for 2019-2022 according to a recent report (Kristensen, 2023).

The N_2O emission factors have not been revised since the reporting last year.

The recalculations for fossil CO_2 emission in 2022 is related to the revised energy statistics and to a revised disaggregation between mobile sources and stationary combustion.

Revised energy statistics:

• Natural gas[1)]	-546 TJ	-30.8 kt CO_2
• Gas oil	+42 TJ	+3.1 kt CO_2

Revised disaggregation between mobile sources and stationary combustion:

• Gas oil	-112 TJ	-8.3 kt CO_2
• LPG	+0.013 TJ	+0.0 kt CO_2

[48] The energy statistics include a large recalculation for offshore gas turbines, but this recalculation is not reflected in the emission inventory because this fuel consumption is based on the EU ETS data in the emission inventory. Thus, the inaccuracy of the energy statistics from 2023 was never included in the emission inventory.

These updates cause lower fossil CO_2 emission for stationary combustion in 2022. The estimated fossil CO_2 emission for 2022 is 36 kt lower than reported last year.

The recalculation for the fossil CO_2 emission from stationary combustion in 1990 is related to the revised disaggregation between mobile sources and stationary combustion. The disaggregation has been revised for LPG and natural gas. For stationary combustion, the increase of LPG consumption in 1990 is 0.245 TJ corresponding to 0.016 kt CO_2. For stationary combustion, the decrease of natural gas consumption in 1990 is -0.266 TJ corresponding to -0.005 kt of CO_2.

The recalculation for CH_4-emission in 2022 is mainly related to the revised CH_4 emission factor for biogas engines. This causes a 313 kt decrease in the estimated emission in 2022. The remaining recalculation is a result of the revised energy statistics. The very small recalculation for 1990 is related revised disaggregation between mobile sources and stationary combustion for LPG and natural gas.

The recalculations for N_2O emission in 2022 are related to the revised energy statistics mentioned above. The recalculations for N_2O in 1990 are negligible.

10.1.1 Response to the review process

See below the comments and improvements related to the review *Report on the individual review of the annual submission of Denmark sub-mitted in 2022*.

E.1
NID chapter 3.2.6 now further clarify the information on EFs for both waste and industrial waste, the fossil and biomass part of the fuels, and the use of confidential EU ETS data for industrial waste in the cement industry.

E.6
Information has been added in NID Chapter 3.2.1.

All pipeline compressors on the natural gas grid are electric compressors. Hence fuel consumption and emissions are NO in the sector 1A3e i Pipeline transport. The fuel consumption in the Danish gas treatment plant is included in sector 1A1cii Oil and gas extraction.

10.2 Other pollutants

Recalculations for stationary combustion are shown in Table 85.

For SO_2 the recalculation for stationary combustion is below ±0.15 % for 1990-2022. The small recalculations for 2022 are related to the revised energy statistics (DEA, 2024a) and updated data for disaggregation to industrial subsectors (DEA, 2024c). The largest recalculation for 2022 is the lower consumption of wood chips in industrial plants in the updated energy statistics.

For NO_x, the recalculation is below ±0.4% for 1990-2022. The recalculation for 2022 is -0.4 %. The recalculation for 2022 is related to the revision of the energy statistics, mainly the lower consumption of wood chips in industrial plants and the lower consumption of natural gas and biomethane in commercial/institutional plants[49].

For NMVOC, the recalculation is below ±0.4% for 1990-2022. The recalculation for 2022 is -0.4 %. This recalculation is related to the lower consumption of wood chips in industrial plants in the updated energy statistics. In addition, the emission factor for NMVOC for wood applied in industrial plants has been revised for 2021-2022.

For CO, the recalculation for stationary combustion is below ±0.3% for 1990-2022. The recalculation for 2022 is -0.3 %. The recalculation for 2022 is related to the revised energy statistics, mainly the lower consumption of wood chips in industrial plants.

For NH_3, the recalculations are below ±0.1 %in 1990-2022. The recalculation for 2022 is -0.1 %. The recalculation for 2022 is related to the revised energy statistics, mainly the lower consumption of wood chips in industrial plants and the lower consumption of firewood in residential plants.

The recalculations for PMs are below ±0.2 % for 1990-2022. The recalculation for emission of $PM_{2.5}$ in 2022 is -0.14 %. The recalculations for 2022 are related to the revised energy statistics, mainly the lower consumption of wood in industrial plants, residential plants and commercial/institutional plants.

The recalculations for BC are below ±0.3 % for 1990-2022. The recalculations are related to the revised energy statistics.

For HMs, the reported emissions 1990-2022 are below ±0.4 % for 1990-2022. The recalculations are related to the revised energy statistics.

The recalculations for PCDD/F below ±0.07 % to for 1990-2022. The recalculations are related to the revised energy statistics.

For PAHs the recalculations for stationary combustion are in the interval -0.5 % to +0.01 %.

[49] The energy statistics sectors Wholesale, Retail trade, Private service and Public service.

For HCB the recalculation is below ±0.3 % and for PCB the recalculations are below ±0.6 %.

Table 85 Recalculations for stationary combustion. Emissions reported in 2025 compared to emissions reported in 2024.

	1990	1995	2000	2005	2010	2015	2020	2021	2022
					Percent				
SO_2	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.9
NO_x	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.7	99.6
NMVOC	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.8	99.6
CO	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.7
TSP	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.8
PM_{10}	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.8
$PM_{2.5}$	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9
BC	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.8
NH_3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9
As	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.8
Cd	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Cr	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.8
Cu	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.6
Hg	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.8
Ni	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9
Pb	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.8
Se	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9
Zn	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
HCB	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.7
PCDD/F	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9
Benzo(a)pyrene	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.5
Benzo(b)fluoranthene	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.6
Benzo(k)fluoranthene	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.7
Indeno(123cd)pyrene	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.6
PCB	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.8	99.4

Energy statistics

For stationary combustion plants, the emission estimates for the years 1990-2022 have been updated according to the latest energy statistics published by the Danish Energy Agency. The update included both end use and transformation and also a source category update. The changes in the energy statistics are largest for the years 2020, 2021 and 2022. The revisions are shown in the energy statistics. The fuel consumption has been revised for a large number of fuels for 2022, including natural gas[50], biomethane, bio oil, wood, wood pellets, gas oil and agricultural waste (straw).

Revised estimates for combustion of gas-/diesel oil, LPG and natural gas in mobile sources have resulted in revised split between stationary combustion and mobile sources.

[50] The energy statistics include a large recalculation for offshore gas turbines, but this recalculation is not reflected in the emission inventory because this fuel consumption is based on the EU ETS data in the emission inventory. Thus, the inaccuracy of the energy statistics from 2023 was never included in the emission inventory.

Emission factors

For large plants, some additional plant specific emission data for 2022 became available during 2024. These data have been implemented.

The emission factors for NMVOC have been revised for industrial combustion of wood for the years 2021-2022.

11 Planned improvements

11.1 GHG

The CO_2 emission factor for waste will be updated next year. The update will include the emission factors for both fossil and biomass CO_2.

The Danish Energy Agency will implement some improvements of the energy statistics next year. These will be reflected in the emission inventory.

A tier 2 emission factor for N_2O from residential wood combustion will be implemented.

11.2 Other pollutants

Plant specific emission data for 2023 available after December 2023 will be implemented.

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

In addition to the sector specific CO_2 emission inventories (the sectoral approach - SA), the CO_2 emission from the energy sector[51] is also estimated using the reference approach (RA) 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.

12.1 Methodology and data input

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, 2024a). 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 include a comparison of the sectoral 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 (2D Non-energy products from fuels and solvent use) in the Danish sectoral approach. Three fuels are used for non-energy purposes: lubricants, bitumen and white spirit. The total consumption for non-energy purposes is relatively low, in 2023 the consumption was 7.9 PJ.

The CO_2 emission from oxidation of lube oil during use was 31.7 kt in 2023 and this emission is reported in the sector Non-energy products from fuels and solvent use (sector 2D). The reported emission corresponds to 20 % of the CO_2 emission from lube oil consumption assuming full oxidation. This agrees with the methodology for lube oil emissions in the 2006 IPCC Guidelines (IPCC, 2006). Methodology and emission data for lube oil are shown in the National Inventory Document (Nielsen et al., 2025a), Chapter 4.5.3.

The CO_2 emissions from bitumen and white spirit are indirect and the emission data for non-energy use of these fuels are included the National Inventory Document (Nielsen et al., 2025a), Chapter 10.

[51] Including energy consumption in mobile sources.

12.2 Reference approach results and comparison to the national approach

The sectoral approach and the reference approach have been compared and the differences between the two approaches are shown in Table 86 below.

Table 86 Differences between sectoral approach and reference approach.

Year	Difference Energy consumption [%]	Difference CO_2 emission [%]
1990	0.28	-0.21
1991	-0.55	-0.86
1992	-0.02	-0.53
1993	-0.40	-0.90
1994	-0.31	-0.79
1995	-0.56	-0.84
1996	-0.49	-0.66
1997	-0.03	-0.02
1998	1.50	1.43
1999	-0.58	-0.76
2000	0.27	0.19
2001	0.75	0.73
2002	0.05	-0.05
2003	0.10	0.00
2004	0.00	-0.09
2005	-0.88	-0.80
2006	-0.69	-0.80
2007	-0.96	-0.99
2008	-0.21	-0.33
2009	-1.67	-1.72
2010	0.12	-0.17
2011	-0.99	-1.07
2012	-1.54	-1.86
2013	-0.79	-1.09
2014	-1.41	-1.62
2015	-1.49	-1.77
2016	-2.77	-3.30
2017	-0.65	-0.84
2018	-1.06	-1.20
2019	-0.56	-0.85
2020	-0.13	-0.74
2021	-0.53	-1.07
2022	-1.85	-2.39
2023	-2.23	-2.66

The comparison of the sectoral approach and the reference approach is illustrated in Figure 87. In 2023, the fuel consumption rates in the two approaches differ by 2.23 % and the CO_2 emission differs by 2.66 %. Both the fuel consumption and the CO_2 emission differ by less than 2 % for all years except 2016, 2022 and 2023. The high difference for CO_2 emission in 2016 is mainly related to solid and liquid fuels. The high differences for 2022 and 2023 might be lower in the next inventory due to annual recalculation of the energy statistics for the latest two years.

The fluctuations in Figure 87 follow the fluctuations of the statistical difference in the Danish energy statistics shown in Figure 88. The large differences in certain years, e.g. in 1998 and 2016 are due to high statistical differences in the Danish energy statistics in these years.

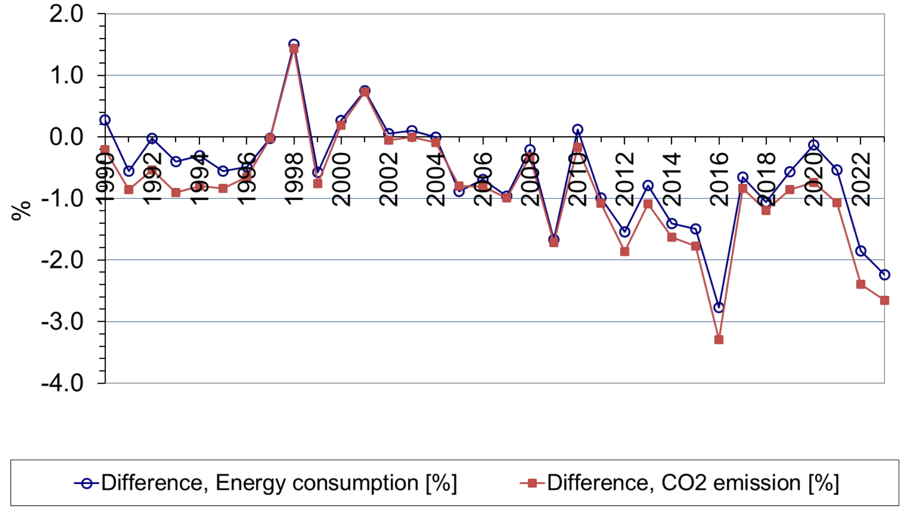


Figure 87 Comparison of the reference approach and the sectoral approach.

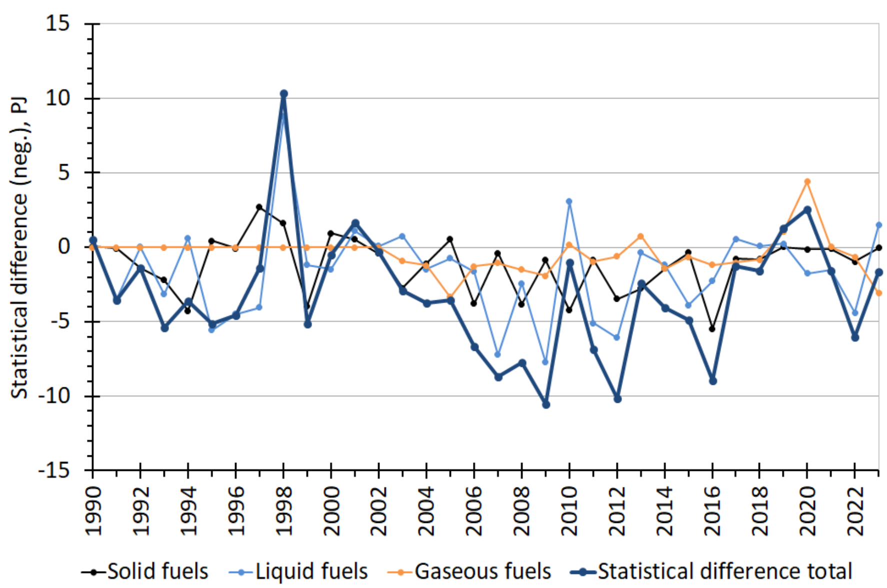


Figure 88 Statistical difference in the Danish energy statistics (DEA, 2024a).

The difference between SA and RA for CO_2-emission is above 2 % for 2016, 2022 and 2023. The reason for these differences has been further analysed.

The large differences between RA and SA in 2016, 2022 and 2023 are mainly related to differences in fuel consumption data. The fuel consumption applied in the SA was higher than in the RA for all fuel categories for 2016, 2022 and 2023.

12.3 Analysis of the differences between the sectoral approach and the reference approach for each of the fuel categories

The difference between the sectoral approach and the reference approach is above 2 % for 2016, 2022 and 2023. The sources causing the differences for 2016, 2022 and 2023 have been analysed for each of the fossil fuel categories.

12.3.1 Solid fuels

The difference for solid fuels in 2016 is 6.2 % or 5.5 PJ. The statistical difference for solid fuels in the Danish energy statistics is 5.5 PJ for 2016. This difference mainly relates to coal (5.5 PJ).

The difference for solid fuels in 2022 is 2.6 % or 1.1 PJ. The statistical difference for solid fuels in the Danish energy statistics is 1.0 PJ for 2022. This difference mainly relates to coal (1.0 PJ).

The difference for solid fuels in 2023 is 0.3 % or 0.1 PJ. Thus, the difference for solid fuels is relatively low for 2023.

The difference between approaches for solid fuels are a result of the statistical difference in the energy statistics. A time series for the difference of solid fuel consumption is shown in Figure 89.

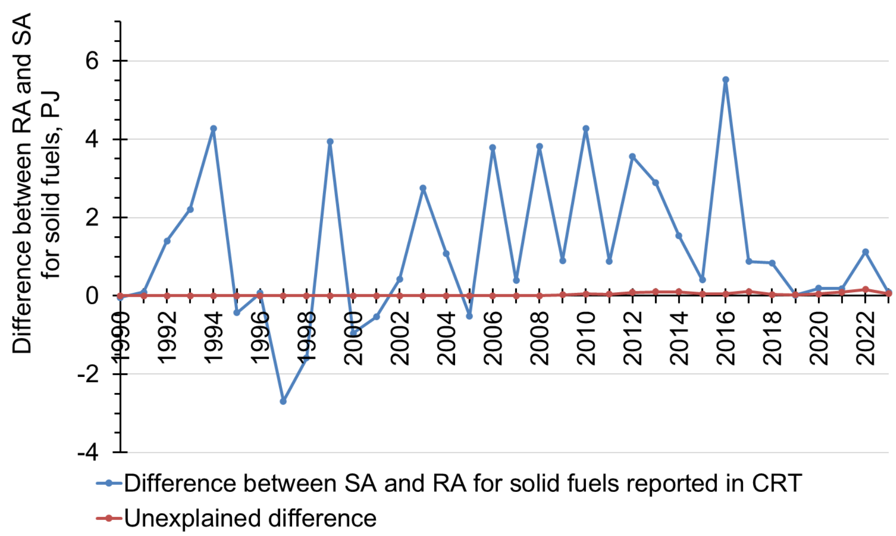


Figure 89 Difference between RA and SA for solid fuels reported in CRT and the difference not explained by statistical difference of the Danish energy statistics.

12.3.2 Liquid fuels

The differences for liquid fuels for the years 2016, 2022 and 2023 are 2.0 %, 1.9 % and 1.5 % or 4.7 PJ, 4.3 PJ and 3.4 PJ, respectively. This difference has been further analysed and several sources identified.

- The statistical differences for liquid fuels in the Danish energy statistics are -2.3 PJ for 2016, -4.4 PJ for 2022 and +1.5 PJ for 2023. These differences mainly relate to crude oil, motor gasoline and gas-/diesel oil.
- The Danish energy statistics includes data for net input of blends. The net input was 0.2 PJ, for the years 2016, 2022 and 2023.
- In the Danish energy statistics, the fuel input to refineries is not equal to the fuel output added to fuel consumption. The differences were 2.7 PJ in 2016, 1.1 PJ in 2022 and 5.4 PJ in 2023.
- For refinery gas, the fuel consumption applied in the SA is based on EU ETS data rather than the energy statistics (see Chapter 6.7). The fuel consumption in EU ETS for 2016 (applied in SA) is 0.7 TJ higher than the data from the energy statistics. In 2022 and 2023 the consumption is 0.8 PJ and 0.2 PJ lower than the data in the energy statistics.

The explained differences for liquid fuels add up to 5.4 PJ, 4.5 PJ and 3.6 PJ for 2016, 2022 and 2023, respectively. Thus, less than 0.7 PJ difference is not explained.

The time series for reported difference for liquid fuels between SA and RA for 1990-2023 is shown in Figure 90 below. In the figure, the estimated difference taking into account the four known sources explained above, is also shown.

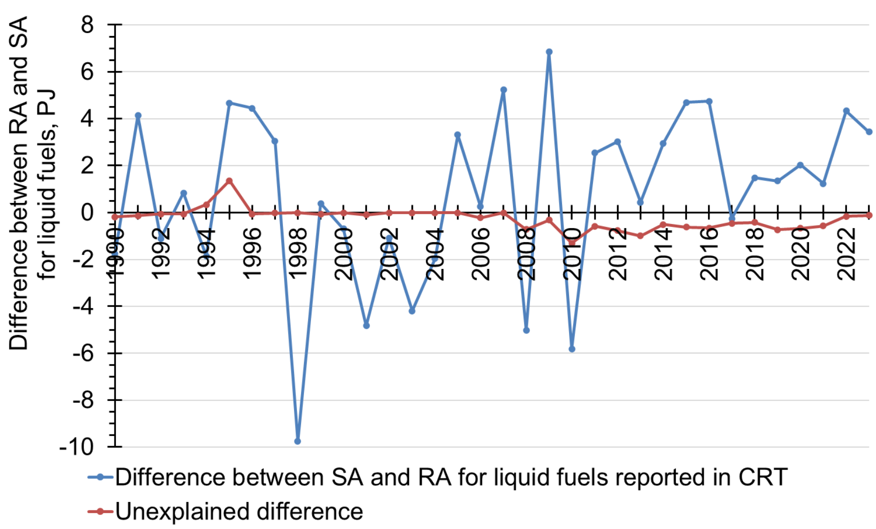


Figure 90 Difference between RA and SA for liquid fuels reported in CRT and the difference not explained by four known sources.

12.3.3 Gaseous fuels

The differences for gaseous fuels for the years 2016, 2022 and 2023 are 1.7 %, 1.3 % and 5.6 % or 2.1 PJ, 0.8 PJ and 3.3 PJ, respectively. The statistical differences for gaseous fuels in the Danish energy statistics are 1.2 PJ for 2016, 0.7 PJ in 2022 and 3.1 PJ in 2023. For offshore gas turbines the fuel consumption applied in the sectoral approach is based on EU ETS data rather than the energy statistics (see chapter 6.6). For 2016, the consumption in EU ETS that are applied in SA was 1.0 PJ higher than the data from the energy statistics. For 2021-2023, the data from EU ETS have been implemented as part of the input data for the energy statistics and the two data sets agree. The difference between SA and RA for gaseous fuels is shown in Figure 91 below.

The remarkable difference for 2020 is related to a large statistical difference for gaseous fuels in 2020.

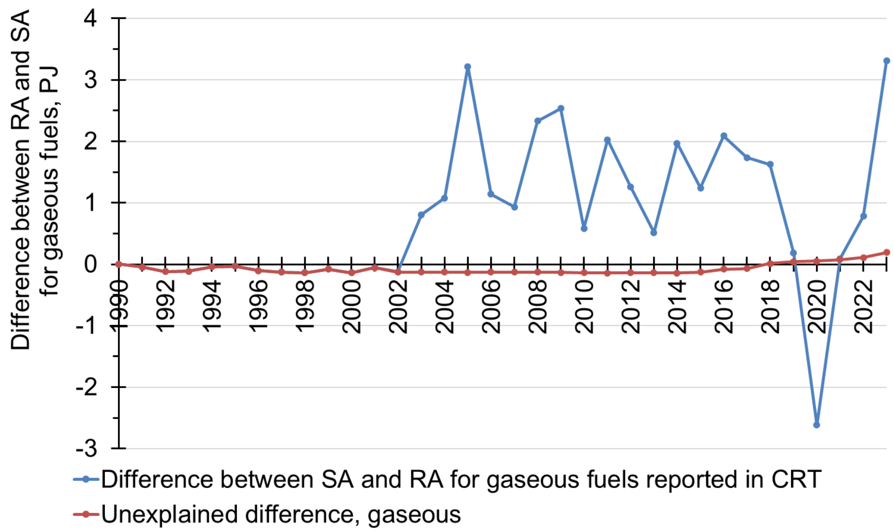


Figure 91 Difference between RA and SA for gaseous fuels reported in CRT and the difference not explained by three known sources.

12.3.4 Other fossil fuels

The differences for other fossil fuels (fossil waste) for the years 2016, 2022 and 2023 are 3.8 %, 2.1 % and 3.0 % or 0.7 PJ, 0.4 PJ and 0.5 PJ, respectively.

The statistical difference for fossil waste in the Danish energy statistics is 0.0 PJ for 2016, 2022 and 2023. The fossil part of waste applied in the Danish cement production plant is higher than for other waste applied in Danish incineration plants. The higher fossil part of the energy content of waste applied in the cement production plant have been implemented in the SA but not in the RA. This corresponds to a 0.5 PJ difference for 2016, 0.4 PJ in 2022 and 0.5 PJ in 2023. In addition, the combustion of waste in individual plants implemented in the SA for 2016 added up to a higher total than included in the energy statistics. This difference corresponds to a difference of 0.2 PJ fossil waste.

The higher waste consumption based on the plant specific data than included the energy statistics is related to the applied fuel group for some specific biomass waste fractions. The recent implementation of EU ETS data as a data source for the industrial subsectors has improved transparency and the agreement between the two data sets.

A time series for the fuel consumption difference for other fossil fuels (fossil waste) is shown in Figure 92.

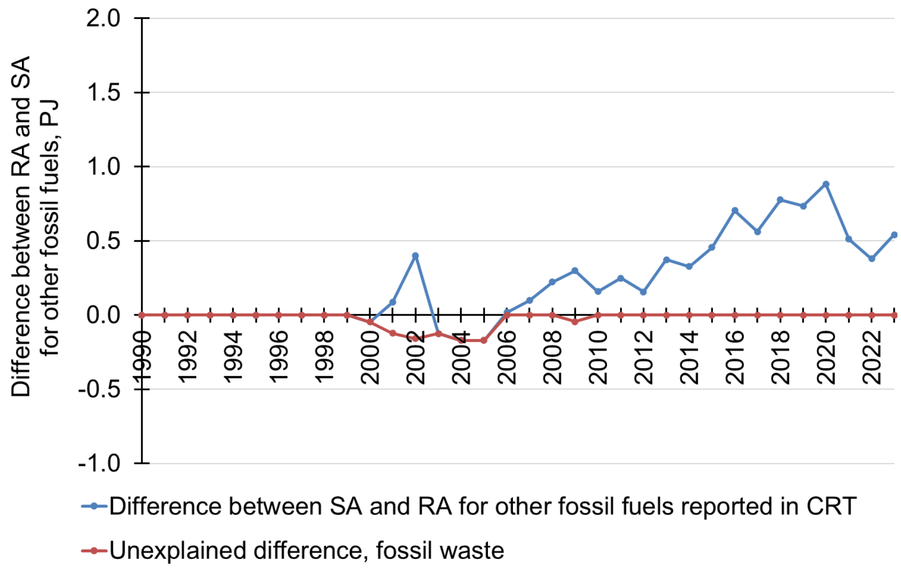


Figure 92 Difference between RA and SA for other fossil fuels reported in CRT and the difference not explained by four known sources.

12.4 Recalculations and improvements for the reference approach

Data for both reference approach and national approach have been updated according to the latest energy statistics.

Response to the review process

One issue is from the review process is relevant for the reference approach. The issue (E5) has been solved in the 2024 and 2025 reporting.

Ensure consistent reporting between CRF tables 1.D and 1.A(b) for jet kerosene consumed in international aviation bunkers (1990–2000) and for residual fuel oil consumed in international navigation bunkers.

This is not an issue for the reporting for Denmark, i.e. the EU submission, but relates to the lack of the reference approach for the Faroe Islands. It is corrected for the 2024 and 2025 submission.

12.5 Planned improvements for the reference approach

The differences mentioned above are part of the ongoing dialogue with the Danish Energy Agency.

13 Verification based on data from Eurostat

As part of the EU review of the reported GHG emission data, EU performs for each member state a comparison of Eurostat energy data in terms of TJ with energy data provided in the CRT. 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 includes comparisons of the reference approach (RA) and the sectoral approach (SA) for the years 2005 and 2008-2023.

In Denmark, the emission inventory is based on the energy statistics published by the Danish Energy Agency (DEA). DEA is responsible for the reporting to Eurostat.

13.1 Reference approach, comparison of fuel consumption data in CRT and in the Eurostat data

The apparent fuel consumption reported in the CRT reference approach has been compared to data aggregated from Eurostat as part of the EU internal review for the EU-GHG inventory. The results are shown in Table 87. Fuel consumption differences for all years (2005 and 2008-2023) are shown in Table 88.

The fossil fuel consumption stated in CRT for 2023 differs 3634 TJ or 1.1 % from the fossil fuel consumption based on the Eurostat data. The differences are -1524 TJ (-5.2 %) for solid fuels, 5517 TJ (2.5 %) for liquid fuels, -360 TJ (-0.6 %) for gaseous fuels, and 0 TJ for fossil waste (0.0 %).

The differences between fuel consumption data in CRT and Eurostat are explained below. However, the causes of some minor differences between the Danish energy statistics[52] and the Eurostat data are still unknown. These differences are part of an ongoing dialogue with the Danish Energy Agency (DEA).

13.1.1 Solid fuels

The apparent consumption differs -1524 TJ for solid fuels, 2023. The difference occurs for Other bituminous coal. For import and export, the difference in data is low for 2005-2018, but for 2019 onwards, the difference is higher. The Danish energy statistics include two different types of coal in the fuel category Other bituminous coal: Electricity plant coal and Other hard coal. The differences in import and export are related to differences in NCV values in the Danish energy statistics and in the Eurostat data.

[52] The CRT fuel consumption data are based on the Danish energy statistics from DEA.

Data for stock change differs for 2016 onwards. This is part of the ongoing dialogue with DEA.

13.1.2 Liquid fuels

The apparent consumption differs 5517 TJ for liquid fuels, 2023. The fuels with large differences are gas-/diesel oil (3504 TJ), residual fuel oil (1347 TJ), and jet kerosene (666 TJ). In addition, the apparent consumption of white spirit (383 TJ) has been included in the fuel category Other liquid in the Danish CRT whereas the consumption has been included in Other oil in the EU compare file.

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, a considerable difference between CRT and Eurostat data all years is related to the fuel consumption to/from Greenland or the Faroe Islands. The consumption of jet kerosene between Denmark, Greenland and the Faroe Islands was 665 TJ in 2023. The difference for consumption of jet kerosene was 666 TJ in the 2023 data set.

For non-bio diesel oil, the difference between the apparent consumption in the two data sets is 3504 TJ for 2023.

- The fuel consumption to/from Greenland or the Faroe Islands was 391 TJ in 2023. This difference in the two data sets is intentional.
- Large differences occur for import in 2007-2012 and 2022-2023. The differences are between the two data sets from the Danish Energy Agency: DEA basic data and DEA international reporting. The import of biodiesel has not been reported in the international reporting.
- Data for export is in agreement for 2021-2023. The difference is 837 TJ for 2020, but for the years 2014-2019 data are in agreement. The difference for 2020 is between the two data sets from the Danish Energy Agency: DEA basic data and DEA international reporting. For some years between 2003 and 2010 the differences are considerable. These differences also originate from differences between the two DEA data sets.
- Data for international bunkers (almost) agree all years.
- Data for stock change differ 829 TJ for 2023. Data differ for the years 2011 onwards and the differences originate from a difference in the two DEA data sets: DEA basic data and DEA international reporting. The Danish Energy Agency have earlier stated that biodiesel was included in the reported data for stock change and that the Eurostat data would be corrected (Zarnaghi, 2021). However, the difference still seems to exist.

For residual oil, the difference between the two data sets is 1347 TJ for 2023. The data for import, export and stock change agree. For 2020-2023, the difference in data for international bunkers is equal to the fuel consumption to/from Greenland or Faroe Islands. Thus, this is an intentional difference. For the years before 2020, the largest part of the differences is also related to the fuel consumption to/from Greenland/Faroe Islands, but in addition data for import, export and stock changes also differ.

For gasoline, the apparent fuel consumption differs less than 0.1 TJ for 2016-2023, and below 30 TJ for 2008 onwards except for 2011 (818 TJ). The large difference in 2011 is related to a difference between the two data set from the Danish Energy Agency for stock change.

For crude oil, the relatively large difference in 2005 (326 TJ) is due to implementation of waste oil in the fuel category crude oil in the CRT reference approach. The consumption of waste oil was lower in 2008-2023.

DCE reports white spirit in the CRT fuel category Other liquid fossil, whereas the aggregation based on data from Eurostat includes white spirit in the fuel category Other oil.

13.1.3 Gaseous fuels

Differences in apparent consumption are below 5 TJ for gaseous fuels all years except 2021 and 2023. The difference in 2021 is related to a difference for stock change. The difference for 2023 is related to differences for import and stock change.

13.1.4 Waste

The data for waste are equal in the two data sets.

13.1.5 Biomass

Data for apparent consumption of solid biomass are almost equal for 2008-2023. However, for 2005 the difference between the data in CRT and Eurostat is 760 TJ. The Eurostat data for primary production of solid biofuels 2005 include production of bio oil. This inconsistency is part of the ongoing dialogue with the DEA.

For liquid biomass the difference between the two data sets is below 8 TJ for 2014-2023. For 2005 and 2008-2013, the differences are 78 - 513 TJ.

Data for apparent consumption of gaseous biomass do not differ considerably. The difference is below 6 TJ all years.

For Other biomass the difference is below 1 TJ all years.

Table 87 Comparison of apparent consumption in 2023 (EU, 2025).

CRT Fuel Group	CRT Fuel Name	2023 Eurostat, TJ	2023 CRT, TJ	2023 Difference, TJ	2023 Difference, %
Solid	Anthracite	- -	- -	0	0.0%
Solid	BKB and patent fuel	- -	- -	0	0.0%
Solid	Coal tar	- -	- -	0	0.0%
Solid	Coke oven/gas coke	258	258	0	0.0%
Solid	Coking coal	- -	- -	0	0.0%
Solid	Lignite	- -	- -	0	0.0%
Solid	Oil shale and tar sand	- -	- -	0	0.0%
Solid	Other bituminous coal	29,164	27,640	-1,524	-5.2%
Solid	Other solid	- -	- -	0	0.0%
Solid	Sub-bituminous coal	- -	- -	0	0.0%
Solid	Total solid	29,422	27,898	-1,524	-5.2%
Liquid	Bitumen	5,427	5,427	0	0.0%
Liquid	Crude oil	321,614	321,615	1	0.0%
Liquid	Ethane	- -	- -	0	0.0%
Liquid	Gas/diesel oil	-7,955	-4,451	3,504	-44.0%
Liquid	Gasoline	-34,382	-34,382	0	0.0%
Liquid	Jet kerosene	-4,764	-4,098	666	-14.0%
Liquid	Liquefied petroleum gas (LPG)	634	634	0	0.0%
Liquid	Lubricants	2,150	2,150	0	0.0%
Liquid	Naphta	- -	- -	0	0.0%
Liquid	Natural gas liquids	- -	- -	0	0.0%
Liquid	Orimulsion	- -	- -	0	0.0%
Liquid	Other kerosene	- -	- -	0	0.0%
Liquid	Other liquid	- -	383	383	0.0%
Liquid	Other oil	383	- -	-383	-100.0%
Liquid	Petroleum coke	3,827	3,827	0	0.0%
Liquid	Refinery feedstocks	-1,483	-1,483	0	0.0%
Liquid	Residual fuel oil	-60,790	-59,443	1,347	-2.2%
Liquid	Shale oil	- -	- -	0	0.0%
Liquid	Total liquid	224,663	230,180	5,517	2.5%
Gaseous	Natural gas	55,626	55,266	-360	-0.6%
Gaseous	Other gaseous	- -	- -	0	0.0%
Gaseous	Total gaseous	55,626	55,266	-360	-0.6%
Waste	Waste	17,349	17,349	0	0.0%
Biomass	Solid biomass	31,739	31,739	0	0.0%
Biomass	Liquid biomass	9,372	9,372	0	0.0%
Biomass	Gas biomass	21,205	21,205	0	0.0%
Biomass	Other biomass	129,339	129,339	0	0.0%
Biomass	Total biomass	191,654	191,655	0	0.0%
All fossil	**Total fossil**	327,060	330,693	3,634	1.1%

Table 88 Comparison of apparent consumption (EU, 2025).

CRT Fuel Name	2005 Differ-ence, TJ	2008 Difference TJ	2009 Difference TJ	2010 Difference TJ	2011 Difference TJ	2012 Difference TJ	2013 Difference TJ	2014 Difference TJ	2015 Difference TJ	2016 Difference TJ	2017 Difference TJ	2018 Difference TJ	2019 Difference TJ	2020 Difference TJ	2021 Difference TJ	2022 Difference TJ	2023 Difference TJ
Anthracite	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BKB and patent fuel	-6	-6	-7	-9	2	-3	0	0	-1	0	0	0	0	0	0	0	0
Coal tar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coke oven/gas coke	6	15	-10	23	-25	-17	10	-2	0	0	0	0	0	0	0	0	0
Coking coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lignite	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil shale and tar sand	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other bituminous coal	10	29	1	-11	-23	2	-48	-20	0	-934	1054	101	-2491	-951	-2347	-2144	-1524
Other solid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-bituminous coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total solid	11	39	-16	3	-46	-18	-38	-22	-1	-934	1054	101	-2491	-951	-2347	-2144	-1524
Bitumen	7	17	-37	-15	1	-8	20	-17	-1	0	0	0	0	0	0	0	0
Crude oil	326	88	42	-8	60	71	38	-46	37	19	19	3	3	2	1	2	1
Ethane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas/diesel oil	248	-1625	-7293	-379	-2206	-5508	224	-238	332	183	925	402	555	545	3201	1225	3504
Gasoline	-197	13	-1	8	-818	-21	-11	-28	-16	0	0	0	0	0	0	0	0
Jet kerosene	731	658	541	508	489	502	458	407	412	435	536	623	653	337	383	610	666
Liquefied petroleum gas (LPG)	-25	-40	-79	32	46	-121	2	145	0	0	0	0	0	0	0	0	0
Lubricants	-37	31	-8	13	13	13	13	13	0	0	0	0	0	0	0	0	0
Naphta	-3	70	8	-23	-22	0	0	0	0	0	0	0	0	0	0	0	0
Natural gas liquids	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Orimulsion	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other kerosene	0	0	0	0	0	0	0	0	0	18	19	0	0	0	0	0	0
Other liquid	849	351	407	382	383	411	452	358	319	357	269	261	331	350	461	252	383
Other oil	-870	-348	-392	-392	-392	-392	-479	-348	-319	-357	-269	-261	-331	-350	-461	-252	-383
Petroleum coke	5	-20	29	-3	-2	30	-48	-8	13	0	0	0	0	0	0	0	0
Refinery feedstocks	-390	36	29	-27	17	-112	-819	40	7	0	0	0	0	0	0	0	0
Residual fuel oil	1151	1217	1289	1281	1300	1441	2183	1289	1230	1278	1762	1531	1041	1291	1254	1338	1347
Shale oil	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total liquid	1794	447	-5465	1380	-1129	-3694	2035	1568	2014	1933	3261	2558	2250	2174	4838	3174	5517
Natural gas	-3	-3	-2	0	-2	-2	2	0	4	2	3	2	4	4	5291	0	-360
Other gaseous	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total gaseous	-3	-3	-2	0	-2	-2	2	0	4	2	3	2	4	4	5291	0	-360
Waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solid biomass	-760	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0
Liquid biomass	200	484	411	513	78	210	239	0	-4	0	-4	-3	-2	0	0	0	0
Gas biomass	0	0	4	0	0	0	0	0	0	0	6	0	0	0	0	0	0
Other biomass	0	0	0	0	0	0	0	0	-1	0	1	0	0	-1	0	1	0
Total biomass	-560	484	415	513	79	211	239	0	-4	0	3	-3	-2	-1	0	1	0
Other fossil fuels	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Peat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total fossil	1802	483	-5483	1382	-1177	-3714	1998	1546	2017	1001	4318	2662	-236	1227	7782	1030	3634

13.2 Sectoral approach, comparison of fuel consumption data in CRT and in the Eurostat data

The difference between the fuel consumption in the national approach of CRT have been compared to fuel consumption data from Eurostat for 2005 and 2008-2023.

Table 89 shows the fuel consumptions and differences between fuel consumption data from CRT and Eurostat for 2023. Table 90 shows the differences between the fuel consumption data in CRT and Eurostat for 2005 and 2008-2023.

The 2023 fossil fuel consumption is 16739 TJ (4.82 %) lower in CRT than the data aggregated based on the Eurostat data. The difference in fossil fuel consumption is below 5 % for 2005 and 2008-2023. For 2005 and 2008-2019, the fuel consumption reported in CRT is higher than the Eurostat fuel consumption data. This is due to the inclusion of fuel consumption to/from Greenland or Faroe Islands in domestic consumption in CRT. For 2020-2023, the fossil fuel consumption reported in CRT are lower than the Eurostat data. This is due to inclusion of biomethane in the fuel category (fossil) gaseous fuels in the Eurostat data. The biomethane part of the gridded gas has increased in later years.

The 2023 fuel consumption for solid fuels is 7 TJ higher in the CRT data than in the Eurostat data, corresponding to 0.03%.

The 2023 fuel consumption for liquid fuels is 8563 TJ higher in CRT than in the Eurostat data, corresponding to 3.9% higher.

For liquid fuels, the domestic consumption jet kerosene, gas / diesel oil and residual oil reported to Eurostat is lower than in CRT. 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. In 2023, this causes a 1347 TJ difference for fuel oil, a 391 TJ difference for diesel oil, and a 665 TJ difference for jet kerosene.

The CRT data are based on fuel sold in Denmark. This agrees with the reporting guidelines. The Danish energy statistics data for fuel consumption in road transport are for fuel applied in Denmark, and thus the border trade have been added to fuel sold in the fuel consumption data. In 2023, 9379 TJ diesel oil was sold in Denmark, but applied abroad, and 1334 TJ motor gasoline was bought abroad but applied in Denmark. This causes a higher fuel consumption included in CRT than in the fuel consumption data of the Danish energy statistics and the Eurostat fuel consumption data for road transport.

Finally, the consumption of refinery gas in the Danish energy statistics is higher for 2023 than the consumption in the two Danish refineries. This additional consumption has not been included in CRT because it is considered an inaccuracy in the energy statistics. The energy statistics is usually revised two years back and thus the inaccuracy when comparing to EU ETS data is likely to be lower in the next version of the Danish energy statistics.

For gaseous fuels, the 2023 fuel consumption in CRT is 25851 TJ lower than the Eurostat data, corresponding to 30.6 %. The Eurostat data for gaseous fuels includes biogas upgraded for distribution in the natural gas grid (bio natural gas or biomethane). The consumption of this fuel added up to 25980 TJ in 2023. In CRT, this fuel consumption is included in the fuel category biomass. In addition, the gaseous fuel consumption for offshore gas turbines is 21 TJ higher in CRT than in the Eurostat data.

For fossil waste, the 2023 consumption in the CRT data are 542 TJ or 3.1 % higher than in the Eurostat data. The fossil part of waste is plant-specific for some plants in the CRT data whereas a fixed fossil energy part is applied in the energy statistics. The fossil part of waste applied in the cement production plant differ from the fossil part of municipal waste applied in Denmark.

For biomass, the 2023 consumption in the CRT data are 24990 TJ or 15.1 % higher than in the Eurostat data. Biomethane has been reported in the fuel category biomass in CRT whereas it has been included in gaseous fuels in the Eurostat data. This causes a 25980 TJ lower fuel consumption in the 2023 Eurostat data. The large increase of biomethane in the gridded gas in Denmark is reflected in the time series in Table 90. In addition, the biogenic part of waste is plant-specific for some plants in the CRT data whereas a fixed fossil energy part is applied in the energy statistics.

Table 89 Total fuel consumption, sectoral approach, 2023 (EU, 2025).

	Fuel Eurostat, TJ	Fuel CRT, TJ	Difference, TJ	Difference, %
Solid	27,981	27,988	7	0.03%
Liquid	217,414	225,977	8,563	3.94%
Gaseous	84,424	58,574	-25,851	-30.62%
Other fossil	17,349	17,891	542	3.12%
Biomass	165,523	190,513	24,990	15.10%
Fossil fuels	347,169	330,429	-16,739	-4.82%

Table 90 Fuel consumption difference between CRT national approach and Eurostat data (EU, 2025).

	2005	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Solid, TJ	131	104	44	58	24	119	73	117	49	79	146	37	25	-226	-211	-188	7
Liquid, TJ	2212	1890	2537	2499	1737	9191	9773	10592	6005	7753	11153	11024	11384	10357	9951	8732	8563
Gaseous, TJ	10	1065	843	956	1199	785	1394	266	-1139	-1715	-5919	-6279	-8216	-11727	-19608	-22674	-25851
Other, TJ	-172	221	297	159	248	155	373	326	455	705	563	776	734	884	512	380	542
Biomass, TJ	-385	221	64	324	-216	-384	-556	-433	134	2401	4221	5981	8307	12259	18762	21927	24990
Fossil, TJ	2182	3280	3721	3673	3208	10250	11613	11301	5370	6822	5943	5559	3928	-712	-9357	-13750	-16739
Fossil, %	0.3%	0.5%	0.6%	0.6%	0.6%	2.0%	2.2%	2.4%	1.2%	1.5%	1.3%	1.3%	1.0%	-0.2%	-2.4%	-3.7%	-4.8%

14 Sum of EU ETS data compared to CRT data

Consistency of data reported under Directive 2003/87/EC with the inventory.

The annual reporting of GHGs to EU includes a comparison of the CRT data and the total verified emissions reported under the EU ETS Directive 2003/87/EC. The comparison of CRT data and EU ETS data sum is shown in Table 91 below.

The comparison is based on an ETS data extract from June 2024. The data extract from 10-01-2025 shows a 0.01 % lower emission.

14.1 Results and comments

The EU ETS data sum for CO_2 emissions adds up to 34.0 % of the total GHG emissions (total GHG emissions without LULUCF and excluding emissions from domestic aviation).

The EU ETS data sum for CO_2 emissions adds up to 36.0 % of the total CO_2 emissions (total CO_2 emissions without LULUCF and excluding CO_2 emissions from domestic aviation).

Biomethane part of the distributed gas

Gas distributed in the Danish gas distribution system consists of (fossil) natural gas and biomethane. In the emission inventory (CRT), the biomethane part has been assumed equal for all appliances in Denmark, except for offshore consumption. This assumption is in agreement with the Danish energy statistics (DEA, 2024) and with the IPCC Guidelines (2006). According to IPCC Guidelines (2006) the GHG emission inventories should be based on physical data, and thus the trading of certificates is not included in the inventories. In 2023, 36.7 % of the energy content in distributed gas was biomethane (DEA, 2024).

In the EU ETS data system, trading of biomethane certificates has been included in the fuel consumption data for 2021 and onwards. This agrees with the EU Guidance document for biomass issues in the EU ETS (EU 2022[53]), see *Chapter 5.3 Biogas in natural gas grids* that specifies the system requirements for the purchase of biomethane certificates. In the EU ETS data set for Denmark, all distributed gas is considered (fossil) natural gas if no biomethane certificates have been purchased.

The differences regarding biomethane cause some differences when comparing CO_2 emission data in CRT and the sum of EU ETS emission data.

The EU ETS data for 1A2c, 1A2f and 1A2g include data based on biomethane certificates.

[53] EUROPEAN COMMISSION, Guidance Document, Biomass issues in the EU ETS, MRR Guidance document No. 3, Updated Version of 17 October 2022.

The EU ETS verified CO_2 emission data are higher than the emissions reported in CRF for the sectors 1A1b, 1A2a and 1A2d. This is due to the higher biomethane part of the distributed gas assumed in the Danish emission inventories.

Table 91 EU ETS data sum compared to the CRT reporting, 2023.

ANNEX XII	
Reporting on consistency of reported emissions with data from EU Emissions Trading System pursuant to Article 14	
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:	2025
Basis for data: verified ETS emissions and greenhouse gas emissions as reported in inventory submission for the year X-2	

	Total emissions (CO_{2-eq})			
	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)**
Greenhouse gas emissions (for GHG inventory: total GHG emissions, including indirect CO_2 emissions if reported, without LULUCF, and excluding emissions from domestic aviation; for Directive 2003/87/EC: GHG emissions from stationary installations under Article 2(1) of Directive 2003/87/EC)	**27,161.5**	**9,245.1**	**34.0%**	
CO_2 emissions (for GHG inventory: total CO_2 emissions, including indirect CO_2 emissions if reported, without LULUCF, and excluding CO_2 emissions from domestic aviation; for Directive 2003/87/EC: CO_2 emissions from stationary installations under Article 2(1) of Directive 2003/87/EC)	**25,668.3**	**9,245.1**	**36.0%**	

	CO_2 emissions			
	Greenhouse gas inventory emissions [kt] (3)	**Verified emissions under Directive 2003/87/EC [kt] (3)**	**Ratio in % (Verified emissions/ inventory emissions (3)**	**Comment (2)**
1.A Fuel combustion activities, total	**24,274.0**	**8,115.9**	**33.4%**	
1.A Fuel combustion activities, stationary combustion	**10,368.6**	**8,115.9**	**78.3%**	
1.A.1 Energy industries	**6,390.0**	**6,316.8**	**98.9%**	
1.A.1.a Public electricity and heat production	4,659.5	4,566.0	98.0%	

1.A.1.b Petroleum refining	898.8	918.6	102.2%	In the emission inventory (CRT), the consumption of distributed gas has been split between natural gas and biomethane according to the national average for distributed gas in 2023. In the EU ETS data, the consumption of distributed gas is considered (fossil) natural gas, except if biomethane certificates have been purchased. The CO2-emission from the combustion of biomethane in the two refineries (CRF data) was 19 kt in 2023.
1.A.1.c Manufacture of solid fuels and other energy industries	831.7	832.1	100.0%	
Iron and steel (for GHG inventory combined CRT categories 1.A.2.a + 2.C.1 + 1.A.1.c and other relevant CRT categories that include emissions from iron and steel (e.g. 1A1a, 1B1) (4)	77.3	107.8	139.4%	In the emission inventory (CRT), the consumption of distributed gas has been split between natural gas and biomethane according to the national average for distributed gas in 2023. In the EU ETS data, the consumption of distributed gas is considered (fossil) natural gas, except if biomethane certificates have been purchased. The CO2-emission from the combustion of biomethane in sector 1A2a (CRT data) was 38 kt in 2023.
1.A.2 Manufacturing industries and construction	**2,974.6**	**1,795.2**	**60.4%**	
1.A.2.a Iron and steel	77.3	107.8	139.4%	In the emission inventory (CRT), the consumption of distributed gas has been split between natural gas and biomethane according to the national average for distributed gas in 2023. In the EU ETS data, the consumption of distributed gas is considered (fossil) natural gas, except if biomethane certificates have been purchased. The CO2-emission from the combustion of biomethane in sector 1A2a (CRF data) was 38 kt in 2023.
1.A.2.b Non-ferrous metals	NO	NO	NO	
1.A.2.c Chemicals	174.4	105.1	60.3%	The EU ETS data include biomethane certificates.

1.A.2.d Pulp, paper and print	27.1	34.1	126.0%	In the emission inventory (CRT), the consumption of distributed gas has been split between natural gas and biomethane according to the national average for distributed gas in 2023. In the EU ETS data, the consumption of distributed gas is considered (fossil) natural gas, except if biomethane certificates have been purchased. The CO_2 emission from the combustion of biomethane in sector 1A2d (CRT data) was 6 kt in 2023.
1.A.2.e Food processing, beverages and tobacco	665.7	589.2	88.5%	
1.A.2.f Non-metallic minerals	1,024.2	936.0	91.4%	The EU ETS data include biomethane certificates.
1.A.2.g Other	1,005.9	22.9	2.3%	The EU ETS data include biomethane certificates.
1.A.3 Transport	**11,724.8**	**0.0**	**0.0%**	
1.A.3.e Other transportation (pipeline transport)	NO	NO	NO	
1.A.4 Other sectors	**2,921.7**	**4.0**	**0.1%**	
1.A.4.a Commercial/institutional	593.9	2.6	0.4%	
1.A.4.b Agriculture/Forestry/Fisheries	1,384.7	1.4	0.1%	
1.B Fugitive emissions from Fuels	**87.8**	**86.0**	**98.0%**	
1.C CO_2 Transport and storage	**NO**	**NO**	**NO**	
1.C.1 Transport of CO_2	NO	NO	NO	
1.C.2 Injection and storage	NO	NO	NO	
1.C.3 Other	NO	NO	NO	
2.A Mineral products	**1,111.7**	**1,041.9**	**93.7%**	
2.A.1 Cement production	981.5	981.6	100.0%	
2.A.2 Lime production	59.8	7.1	11.8%	
2.A.3 Glass production	10.3	10.3	100.0%	
2.A.4 Other process uses of carbonates	60.1	43.0	71.5%	
2.B Chemical industry	**1.5**	**0.0**	**0.0%**	
2.B.1 Ammonia production	NO	NO	NO	
2.B.3 Adipic acid production (CO_2)	NO	NO	NO	
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	NO	NO	NO	
2.B.5 Carbide production	NO	NO	NO	
2.B.6 Titanium dioxide production	NO	NO	NO	

2.B.7 Soda ash production	NO	NO	NO	
2.B.8 Petrochemical and carbon black production	NO	NO	NO	
2.C Metal production	**0.1**	**0.0**	**0.0%**	
2.C.1 Iron and steel production	NO	NO	NO	
2.C.2 Ferroalloys production	NO	NO	NO	
2.C.3 Aluminium production	NO	NO	NO	
2.C.4 Magnesium production	NO	NO	NO	
2.C.5 Lead production	0.1	0.0	0.0%	
2.C.6 Zinc production	NO	NO	NO	
2.C.7 Other metal production	NO	NO	NO	

	N_2O emissions			
	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.B.2 Nitric acid production	NO	NO	NO	
2.B.3 Adipic acid production	NO	NO	NO	
2.B.4 Caprolactam, glyoxal and glyoxylic acid production	NO	NO	NO	

	PFC emissions			
	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	NO	NO	NO	

Notation: x = reporting year

Notes:

(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 CRT 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.

(3) Data to be reported up to one decimal point for kt and % values.

(4) The be filled on the basis of combined CRT categories pertaining to 'Iron and Steel', to be determined individually by each Member State; the stated formula is for illustration purposes only.

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Annex 1 Correspondence list between SNAP and CRT/NFR source categories

Table 1.1 Correspondence list between SNAP and CRT/NFR source categories for stationary combustion.

	SNAP name	CRT id	CRF/NFR 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 equipment	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 equipment (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 equipment	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

	SNAP name	CRT id	CRF/NFR name
030106	Other stationary equipment	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
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 equipment	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 equipment	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 equipment	1A2c	Chemicals
030700	Non-Metallic Minerals	1A2f	Non-metallic minerals
030701	Mineral wool	1A2f	Non-metallic minerals
030702	Glass	1A2f	Non-metallic minerals
030703	Tile	1A2f	Non-metallic minerals
030704	Gas turbines	1A2f	Non-metallic minerals
030705	Stationary engines	1A2f	Non-metallic minerals
030706	Other non-metallic minerals	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 equipment	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 equipment	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 equipment	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 equipment	1A2d	Pulp, Paper and Print
031200	Transport Equipment	1A2g viii	Other manufacturing industry
031201	Combustion plants >= 300 MW (boilers)	1A2g viii	Other manufacturing industry

	SNAP name	CRT id	CRF/NFR name
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 equipment	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
031305	Stationary engines	1A2g viii	Other manufacturing industry
031306	Other stationary equipment	1A2g viii	Other manufacturing industry
031400	Wood and Wood Products	1A2g viii	Other manufacturing industry
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 equipment	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 equipment	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 equipment	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 rates

Table 2.1 Fuel consumption rate for stationary combustion plants 1990-2023, PJ.

Sum of Fuel_rate_PJ			Year									
Fuel type	**Fuel_id**	**Fuel**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
SOLID	101A	Other solid fossil										
	102A	Coal	253.4	344.3	286.8	300.8	323.4	270.3	371.9	276.3	234.3	196.5
	103A	Fly ash (fossil)										
	106A	BKB	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	37.0	37.3	32.5	46.6	33.3	38.1	26.7	29.5	23.0
	204A	Gas oil	73.5	76.8	67.3	73.1	64.2	64.3	67.9	61.1	57.8	56.8
	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	2.5	2.6	2.6	2.8	3.1	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	Industrial waste										
BIOMASS	111A	Wood	16.7	17.9	18.6	20.1	19.7	19.5	20.7	20.5	19.7	20.3
	117A	Straw	12.5	13.3	13.9	13.4	12.7	13.1	13.5	13.9	13.9	13.7
		Wood pellets	1.6	2.1	2.5	2.1	2.1	2.3	2.7	2.9	3.2	4.0
	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 gasification gas					0.1	0.0	0.0	0.0	0.0	0.0
	315A	Biomethane										
Total			511.0	620.3	560.1	591.5	633.8	611.2	767.1	662.9	624.1	595.0

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	Other solid fossil										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	Fly ash (fossil)										
	106A	BKB	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	18.0	20.2	24.8	27.3	23.5	21.1	25.4	19.3	15.3	14.2
	204A	Gas oil	50.0	52.2	47.1	47.1	44.0	40.0	35.3	30.9	30.4	32.5
	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	2.1	2.0	2.1	2.1	2.1	2.2	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	37.8	38.9	40.1	38.1
	115A	Industrial waste	0.5	1.4	1.9	1.5	2.0	2.0	0.6	0.9	1.4	1.2
BIOMASS	111A	Wood	22.3	23.7	23.7	29.1	31.1	33.7	36.5	43.8	45.1	45.9
	117A	Straw	12.2	13.7	15.7	16.9	17.9	18.5	18.5	18.8	15.9	17.4
		Wood pellets	5.1	7.1	7.9	9.8	12.8	16.1	15.6	16.5	18.5	20.1
	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 gasification gas	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3
	315A	Biomethane										
Total			**552.3**	**578.5**	**576.2**	**635.6**	**576.4**	**540.0**	**626.0**	**567.5**	**539.9**	**532.3**

Continued

Sum of Fuel_rate_PJ			Year									
fuel_type	**fuel_id**	**fuel_gr_abbr**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
SOLID	101A	Other solid fossil	0.0	0.0	0.0	0.0						
	102A	Coal	163.0	135.5	106.2	135.0	107.0	76.0	88.2	65.8	67.2	37.8
	103A	Fly ash (fossil)		0.0	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.0
	106A	BKB	0.0	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	0.3	0.3	0.4	0.3
LIQUID	110A	Petroleum coke	5.1	6.5	6.7	6.1	6.6	6.6	7.6	7.9	6.9	7.7
	203A	Residual oil	12.8	7.8	7.2	5.5	4.5	4.2	4.1	4.1	3.2	3.0
	204A	Gas oil	31.8	25.5	21.7	20.0	13.1	13.9	14.0	12.1	13.5	10.4
	206A	Kerosene	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2
	225A	Orimulsion										
	303A	LPG	1.6	1.5	1.7	1.6	1.3	1.8	2.1	2.3	2.3	2.3
	308A	Refinery gas	14.3	13.7	14.8	14.8	15.4	16.2	14.4	15.6	15.0	16.1
GAS	301A	Natural gas	185.7	157.3	147.1	139.3	119.3	120.6	122.5	116.5	113.1	105.5
WASTE	114A	Waste	37.2	37.1	36.1	35.9	37.1	37.7	37.8	38.1	37.1	38.4
	115A	Industrial waste	0.9	1.3	1.2	1.6	1.6	2.2	2.6	2.7	3.4	3.1
BIOMASS	111A	Wood	51.3	48.8	48.6	46.4	45.0	50.1	51.6	51.6	52.7	52.3
	117A	Straw	23.3	20.2	18.3	20.3	18.6	19.8	19.7	20.2	17.6	18.0
	122A	Wood pellets	29.9	30.0	33.2	35.0	36.3	36.5	44.3	57.4	55.2	53.3
	215A	Bio oil	2.0	0.8	1.1	0.9	0.7	0.6	0.3	0.2	0.2	0.1
	309A	Biogas	4.3	4.1	4.4	4.6	5.2	5.3	5.9	5.8	6.3	6.9
	310A	Bio gasification gas	0.2	0.3	0.4	0.1	0.4	0.5	0.5	1.0	1.4	1.5
	315A	Biomethane					0.3	1.0	3.1	5.2	7.1	9.4
Total			**564.3**	**491.3**	**449.5**	**467.6**	**413.2**	**393.6**	**419.0**	**407.0**	**402.8**	**366.5**

Sum of Fuel_rate_PJ			Year			
fuel_type	**fuel_id**	**fuel_gr_abbr**	**2020**	**2021**	**2022**	**2023**
SOLID	101A	Other solid fossil				
	102A	Coal	33.2	44.3	43.5	27.7
	103A	Fly ash (fossil)	0.0	0.1	0.1	0.0
	106A	BKB				
	107A	Coke oven coke	0.3	0.3	0.4	0.3
LIQUID	110A	Petroleum coke	7.9	6.9	7.3	4.0
	203A	Residual oil	3.1	2.7	3.1	2.1
	204A	Gas oil	9.5	11.6	16.8	12.8
	206A	Kerosene	0.0	0.0	0.0	0.0
	225A	Orimulsion				
	303A	LPG	2.3	2.7	3.4	3.6
	308A	Refinery gas	15.3	15.7	14.7	15.1
GAS	301A	Natural gas	85.3	85.6	61.2	58.1
WASTE	114A	Waste	38.2	37.4	37.0	36.3
	115A	Industrial waste	3.4	2.8	2.5	2.2
BIOMASS	111A	Wood	57.6	62.8	60.3	61.9
	117A	Straw	18.9	21.6	21.2	21.7
	122A	Wood pellets	47.2	66.2	47.1	43.9
	215A	Bio oil	0.1	0.2	0.1	0.2
	309A	Biogas	6.7	6.5	6.2	5.8
	310A	Bio gasification gas	1.6	1.7	1.7	1.9
	315A	Biomethane	13.5	19.6	22.5	25.7
Total			**344.2**	**388.7**	**349.0**	**323.1**

Table 2.2 Detailed fuel consumption data for stationary combustion plants, 1990-2023, PJ.

This table is available in Annex 3A at: https://envs.au.dk/en/research-areas/air-pollution-emissions-and-effects/air-emissions/greenhouse-gases/supporting-documentation

Annex 3 Default Net Calorific Value (NCV) of fuels and fuel correspondence list

Table 3.1 Time series for calorific values of fuels (DEA, 2024a).

		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										
Natural Gas, North Sea	GJ per 1000 Nm^3										
Gas Works Gas	GJ per 1000 m^3	39.00	39.00	39.00	39.30	39.30	39.30	39.30	39.60	39.90	40.00
Liquefied Natural 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										
Brown Coal Briquettes	GJ per tonne	31.80	29.30	29.30	29.30	29.30	29.30	29.30	29.30	29.30	29.30
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 tonne	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 tonne	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
Wood Waste	GJ per 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 1000 m^3								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
Natural Gas, North Sea	GJ per 1000 Nm^3										
Gas Works 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
Liquefied Natural Gas	GJ per 1000 m^3										
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 tonne	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 tonne	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
Wood Waste	GJ per 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 1000 m^3	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	2016	2017	2018	2019
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	27.65	27.65	27.65	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	39.46	39.51	39.55	38.99	39.53	39.64	39.63	39.66	39.59	38.81
Natural Gas, North Sea	GJ per 1000 Nm^3										
Gas Works Gas	GJ per 1000 m^3	21.35	21.37	19.30	19.31	20.20	19.80	20.28	20.80	20.82	20.80
Liquefied Natural Gas	GJ per 1000 m^3						26.50	26.50	26.50	26.50	26.50
Electricity Plant Coal	GJ per tonne	24.44	24.38	24.23	24.49	24.70	24.10	24.29	24.33	24.13	23.89
Other Hard Coal	GJ per tonne	24.44	24.38	24.23	24.49	24.70	24.10	26.10	26.88	26.64	24.17
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 tonne	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 tonne	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70
Wood Waste	GJ per 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 1000 m^3	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	10.60	10.60	10.60	10.60	10.60	10.60	10.60
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	37.50	37.50	37.50	37.50	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	37.20	37.20	37.20	37.20

Continued		2020	2021	2022	2023
Crude Oil, Average	GJ per tonne	43.00	43.00	43.00	43.00
Crude Oil, Golf	GJ per tonne	41.80	41.80	41.80	41.80
Crude Oil, North Sea	GJ per tonne	43.00	43.00	43.00	43.00
Refinery Feedstocks	GJ per tonne	42.70	42.70	42.70	42.70
Refinery Gas	GJ per tonne	52.00	52.00	52.00	52.00
LPG	GJ per tonne	46.00	46.00	46.00	46.00
Naphtha (LVN)	GJ per tonne	44.50	44.50	44.50	44.50
Motor Gasoline	GJ per tonne	43.80	43.80	43.80	43.80
Aviation Gasoline	GJ per tonne	43.80	43.80	43.80	43.80
JP4	GJ per tonne	43.80	43.80	43.80	43.80
Other Kerosene	GJ per tonne	43.50	43.50	43.50	43.50
JP1	GJ per tonne	43.50	43.50	43.50	43.50
Gas/Diesel Oil	GJ per tonne	42.70	42.70	42.70	42.70
Fuel Oil	GJ per tonne	40.65	40.65	40.65	40.65
Orimulsion	GJ per tonne	27.65	27.65	27.65	27.65
Petroleum Coke	GJ per tonne	31.40	31.40	31.40	31.40
Waste Oil	GJ per tonne	41.90	41.90	41.90	41.90
White Spirit	GJ per tonne	43.50	43.50	43.50	43.50
Bitumen	GJ per tonne	39.80	39.80	39.80	39.80
Lubricants	GJ per tonne	41.90	41.90	41.90	41.90
Natural Gas	GJ per 1000 Nm^3	36.70	36.62	37.41	38.03
Natural Gas, North Sea	GJ per 1000 Nm^3		40.94	41.65	38.54
Gas Works Gas	GJ per 1000 m^3	20.78	20.84	20.84	20.84
Liquefied Natural Gas	GJ per 1000 m^3	26.50	26.50	26.50	26.50
Electricity Plant Coal	GJ per tonne	24.09	23.96	23.75	23.49
Other Hard Coal	GJ per tonne	25.63	25.42	26.03	23.86
Coke	GJ per tonne	29.30	29.30	29.30	29.30
Brown Coal Briquettes	GJ per tonne	18.30	18.30	18.30	18.30
Straw	GJ per tonne	14.50	14.50	14.50	14.50
Wood Chips	GJ per m^3	2.80	2.80	3.13	3.13
Wood Chips	GJ per tonne	9.30	9.30	10.40	10.40
Firewood, Hardwood	GJ per m^3	10.40	10.40	10.40	10.40
Firewood, Conifer	GJ per tonne	7.60	7.60	7.60	7.60
Wood Pellets	GJ per tonne	17.50	17.50	17.50	17.50
Wood Waste	GJ per tonne	14.70	14.70	14.70	14.70
Wood Waste	GJ per m^3	3.20	3.20	3.20	3.20
Biogas	GJ per 1000 m^3	23.00	23.00	23.00	23.00
Wastes	GJ per tonne	10.60	10.60	10.60	10.60
Bioethanol	GJ per tonne	26.70	26.70	26.70	26.70
Liquid Biofuels	GJ per tonne	37.50	37.50	37.50	37.50
Bio Oil	GJ per tonne	37.20	37.20	37.20	37.20

Table 3.2 Fuel category correspondence list, DEA, DCE and Climate Convention reporting (CRT).

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	BKB	Solid
-	Other solid fossil	Solid
-	Fly ash fossil	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
Gas Works Gas	Natural gas	Gas
Natural Gas	Natural gas	Gas
Straw	Straw	Biomass
Wood Waste	Wood	Biomass
Wood Pellets	Wood pellets	Biomass
Wood Chips	Wood	Biomass
Firewood	Wood	Biomass
Wastes, Renewable	Municipal wastes	Biomass
Biooil	Liquid biofuels	Biomass
Biogas	Biogas	Biomass
(Wood applied in gas engines)	Biomass gasification gas	Biomass
Bio methane	Biomethane	Biomass
Biogas distributed in the town gas grid	Biogas	Biomass
Wastes, Non-renewable	Fossil waste	Other fuel

Annex 4 Emission factors

Table 4.1 CO_2 emission factors, 2023.

Fuel	Emission factor, kg per GJ		Reference type	IPCC fuel category
	Biomass	Fossil fuel		
Coal	-	95.11 1)	Country specific	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)	-	94.51	Country specific	Solid
Petroleum coke	-	93 3)	Country-specific	Liquid
Residual oil	-	78.95 1)	Country-specific	Liquid
Gas oil	-	74.1 1)	Country-specific	Liquid
Kerosene	-	71.9	IPCC (2006)	Liquid
Orimulsion	-	80 2)	Country-specific	Liquid
LPG	-	64.8	Country-specific	Liquid
Refinery gas	-	56.280	Country-specific	Liquid
Natural gas, offshore gas turbines	-	57.522	Country-specific	Gas
Natural gas, other 7)	-	57.14	Country-specific	Gas
Waste	59.2 3)4)	+ 42.5 1)3)4)	Country-specific	Biomass and Other fuels
Industrial waste	59.2 3)4)	+ 42.5 1)3)4)	Country-specific	Biomass and Other fuels
Straw	100	-	Country-specific	Biomass
Wood (national average 2023 for fire-wood, wood chips and wood waste)	103.254	-	Country-specific	Biomass
Wood pellets	97.4	-	Country-specific	Biomass
Bio oil	70.8	-	IPCC (2006)	Biomass
Biogas	81.9	-	Country-specific	Biomass
Biomass gasification gas	142.9 5)	-	Country-specific	Biomass
Biomethane 7)	54.9	-	Country-specific	Biomass

1) Plant specific data from EU ETS incorporated for individual plants.
2) Not applied in 2023. 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 (42.5+59.2) 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 CRT. The corresponding fossil CO_2 emission factor for Other fuels is 94.4 kg CO_2 per GJ fossil waste and 107.6 kg biomass CO_2 per GJ biomass waste.
5) Includes a high content of CO_2 in the gas.
6) Anodic carbon. Not applied in Denmark in 2014-2023.
7) Gas distributed in the gas grid consist of a mixture of two fuels: Biomethane and (fossil) natural gas. The two fuels are treated as separate fuels in the emission inventories, see also Chapter 6.8.

Time series for CO_2 emission factors have been estimated for:

- Coal
- Residual oil
- Refinery gas
- Natural gas applied in offshore gas turbines
- Natural gas, other
- Waste, fossil part
- Wood

For all other fuels the same emission factor has been applied for 1990-2023.

Table 4.2 CO_2 emission factors, time series.

Year	Coal, kg per GJ	Residual oil, kg per GJ	Refinery gas, kg per GJ	Natural gas, offshore gas turbines, kg per GJ	Natural gas, other, kg per GJ	Waste, fossil part kg fossil CO_2 per GJ waste	Wood, kg per GJ
1990	94	78.7	57.6	57.469	56.9	37	99.785
1991	94	78.7	57.6	57.469	56.9	37	99.661
1992	94	78.7	57.6	57.469	56.9	37	99.718
1993	94	78.7	57.6	57.469	56.9	37	99.691
1994	94	78.7	57.6	57.469	56.9	37	99.802
1995	94	78.7	57.6	57.469	56.9	37	99.819
1996	94	78.7	57.6	57.469	56.9	37	99.897
1997	94	78.7	57.6	57.469	56.9	37	99.894
1998	94	78.7	57.6	57.469	56.9	37	100.081
1999	94	78.7	57.6	57.469	56.9	37	100.057
2000	94	78.7	57.6	57.469	57.1	37	99.948
2001	94	78.7	57.6	57.469	57.25	37	100.009
2002	94	78.7	57.6	57.469	57.28	37	100.161
2003	94	78.7	57.6	57.469	57.19	37	100.583
2004	94	78.7	57.6	57.469	57.12	37	100.615
2005	94	78.7	57.6	57.469	56.96	37	100.448
2006	94.4	78.6	57.812	57.879	56.78	37	100.490
2007	94.3	78.5	57.848	57.784	56.78	37	100.293
2008	94.0	78.5	57.948	56.959	56.77	37	100.658
2009	93.6	78.9	56.817	57.254	56.69	37	100.955
2010	93.6	79.2	57.134	57.314	56.74	37	101.041
2011	94.73	79.25	57.861	57.379	56.97	37.5	101.299
2012	94.25	79.21	58.108	57.423	57.03	40.0	101.512
2013	93.95	79.28	58.274	57.295	56.79	42.5	101.275
2014	94.17	79.49	57.620	57.381	56.95	42.5	101.481
2015	94.46	79.17	57.508	57.615	57.06	42.5	101.277
2016	94.95	79.29	57.335	57.704	57.01	42.5	101.537
2017	94.37	79.19	57.109	57.628	57.00	42.5	102.088
2018	94.04	79.42	56.144	57.639	56.89	42.5	102.492
2019	94.13	79.32	56.452	57.588	56.54	42.5	102.793
2020	94.20	79.03	56.813	57.456	55.52	42.5	103.115
2021	93.94	79.15	56.486	57.356	55.47	42.5	103.380
2022	94.51	78.94	56.554	57.443	56.38	42.5	103.331
2023	95.11	78.95	56.280	57.522	57.14	42.5	103.254

Table 4.3 CH_4 emission factors and references, 2023.

Fuel group	Fuel	CRT source category	CRT 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)]
	BKB	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	0105	0.9	IPCC (2006), Tier 3, Table 2-6, Utility, gas oil, boilers.
		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).

Fuel group	Fuel	CRT source category	CRT source category	SNAP	Emission factor, g per GJ	Reference
		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.
				020204	24	Nielsen et al. (2010a)
		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	03	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 020105	1 481	IPCC (2006), Tier 3, Table 2-10, Commercial, natural gas boilers. Nielsen et al. (2010a).
		1A4b i	Residential	0202	37.5	Schweitzer, 2020.
				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).

Fuel group	Fuel	CRT source category	CRT source category	SNAP	Emission factor, g per GJ	Reference
				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	83.8	DCE estimate based on technology distribution, Nielsen et al. (2021b) [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).
				0102	30	IPCC (2006), Tier 1, Table 2-2, Energy industries, other primary solid biomass.
		1A4b i	Residential	0202	276	DCE estimate based on DEPA (2022) and IPCC (2006). A time series has been estimated.
		1A4c i	Agriculture/ Forestry	020300	276	DCE estimate based on DEPA (2022) and IPCC (2006). A time series has been estimated.
				020302	30	IPCC (2006), Tier 1, Table 2-2, Energy industries, other primary solid biomass (large agricultural plants considered equal to this plant category).
	Wood pellets	1A1a	Public electricity and heat production	0101	3.1	Nielsen et al. (2010a).
				0102	3	Paulrud et al. (2005).
		1A2 a-g	Industry	03	3	Paulrud et al. (2005).
		1A4a	Commercial/ Institutional	0201	3	Paulrud et al. (2005).
		1A4b i	Residential	0202	3	Paulrud et al. (2005).
		1A4c i	Agriculture/ Forestry	0203	3	Paulrud et al. (2005).
	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	369	Kristensen (2023).
				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	369	Kristensen (2023)
		1A4a	Commercial/ Institutional	0201	5	IPCC (2006), Tier 1, Table 2-4, Commercial, other biogas.
				020105	369	Kristensen (2023).
		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	369	Kristensen (2023).
	Bio gasification 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).
	Biomethane	1A1a	Public electricity and heat production	0101 0102	1	Assumed equal to natural gas.

Fuel group	Fuel	CRT source category	CRT source category	SNAP	Emission factor, g per GJ	Reference
				Tur-bines	1.7	Assumed equal to natural gas.
				Engines	481	Assumed equal to natural gas.
		1A1b	Petroleum refining	0103	1	Assumed equal to natural gas.
		1A2 a-g	Industry	03	1	Assumed equal to natural gas.
				Tur-bines	1.7	Assumed equal to natural gas.
				Engines	481	Assumed equal to natural gas.
		1A4a	Commercial/ Institu-tional	0201	1	Assumed equal to natural gas.
				Engines	481	Assumed equal to natural gas.
		1A4b	Residential	0202	37.5	Assumed equal to natural gas.
				Engines	481	Assumed equal to natural gas.
		1A4c	Agriculture/ Forestry	0203	1	Assumed equal to natural gas.
				Engines	481	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 (Nielsen et al., 2021b) and technology specific emission factors that refer to Paulrud et al. (2005), Johansson et al. (2004) and Olsson & Kjällstrand (2005). The emission factor is within the IPCC (2006) interval for residential wood combustion (100-900 g per GJ).

In general, the same CH_4 emission factors have been applied for 1990-2023. However, time series have been estimated for both natural gas fuelled engines and biogas fuelled engines, residential wood combustion, combustion of straw in residential and agricultural plants, natural gas fuelled gas turbines[54] and waste incineration plants.

[54] A minor emission source.

Table 4.4 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 tur-bines, g per GJ	Straw, residential and agricultural plants, g per GJ
1990	266	239	327	0.59	1.5	300
1991	309	251	321	0.59	1.5	300
1992	359	264	314	0.59	1.5	300
1993	562	276	308	0.59	1.5	300
1994	623	289	302	0.59	1.5	300
1995	632	301	296	0.59	1.5	300
1996	616	305	289	0.59	1.5	300
1997	551	310	283	0.59	1.5	300
1998	542	314	276	0.59	1.5	300
1999	541	318	270	0.59	1.5	300
2000	537	323	263	0.59	1.5	300
2001	522	342	256	0.59	1.5	300
2002	508	360	248	0.59	1.6	300
2003	494	379	240	0.59	1.6	300
2004	479	397	227	0.51	1.7	300
2005	465	416	215	0.42	1.7	300
2006	473	434	206	0.34	1.7	300
2007	481	434	197	0.34	1.7	300
2008	481	434	188	0.34	1.7	300
2009	481	434	178	0.34	1.7	300
2010	481	434	167	0.34	1.7	300
2011	481	434	160	0.34	1.7	300
2012	481	434	152	0.34	1.7	300
2013	481	434	145	0.34	1.7	300
2014	481	434	138	0.34	1.7	300
2015	481	421	131	0.34	1.7	300
2016	481	408	124	0.34	1.7	300
2017	481	395	117	0.34	1.7	300
2018	481	382	111	0.34	1.7	300
2019	481	369	105	0.34	1.7	300
2020	481	369	99	0.34	1.7	300
2021	481	369	94	0.34	1.7	300
2022	481	369	88.5	0.34	1.7	288
2023	481	369	83.8	0.34	1.7	276

Table 4.5 N_2O emission factors and references, 2023.

Fuel group	Fuel	CRT source category	CRT 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].
	BKB	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.
			Industry – mineral wool	030701	46	Emission factor based on plant specific data for the mineral wool industry, 2023.
		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.
				031600	1.5	-
		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 010105	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).

Fuel group	Fuel	CRT source category	CRT source category	SNAP	Emission factor, g per GJ	Reference
				0102	0.4	IPCC (2006), Tier 3, Table 2-6, Utility, gas oil boilers.
		1A1b	Petroleum refining	010306	0.6	IPCC (2006), Tier 1, Table 2-2, Energy industries, gas oil.
		1A1c	Oil and gas extraction	010500	0.4	IPCC (2006), Tier 3, Table 2-6, Utility, gas oil boilers.
		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. (2010a).
			Industry – mineral wool	030701	46	Emission factor based on plant specific data for the mineral wool industry, 2023.
		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, Residen-tial, gas oil.
				Engines	2.1	Nielsen et al. (2010a).
		1A4c	Agriculture/ Forestry	0203	0.4	IPCC (2006), Tier 3, Table 2-10, Commercial, gas oil boilers[1)].
				Engines	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.
			Industry – mineral wool	030701	46	Emission factor based on plant specific data for the mineral wool industry, 2023.
		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. (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.
		1A1b	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).

Fuel group	Fuel	CRT source category	CRT source category	SNAP	Emission factor, g per GJ	Reference
		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).
			Industry – mineral wool	030701	46	Emission factor based on plant specific data for the mineral wool industry, 2023.
		1A4a	Commercial/ Institutional	020100 020103	1	IPCC (2006), Tier 3, Table 2-10, Commercial, natural gas boilers.
				Engines	0.58	Nielsen et al. (2010a).
		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.
	Industrial 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	7	IPCC (2006), Table 2-7 Industrial source emission factors, wood / wood waste boilers.
		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 biomass.
		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.
	Wood pellets	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	Agriculture/ Forestry	0203	4	IPCC (2006), Tier 1, Table 2-4, Commercial, wood.

Fuel group	Fuel	CRT source category	CRT source category	SNAP	Emission factor, g per GJ	Reference
	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	0.4	Assumed equal to gas oil.
		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 gasification gas	1A1a	Public electricity and heat production	010101	0.1	Assumed equal to biogas.
				010105	2.7	Nielsen et al. (2010a).
		1A4a	Commercial/ Institutional	020105	2.7	Nielsen et al. (2010a).
	Biomethane	1A1a	Public electricity and heat production	0101 or 0102	1	Assumed equal to natural gas.
				Engines	0.58	Assumed equal to natural gas.
		1A1b	Petroleum refining	0103	1	Assumed equal to natural gas.
		1A2 a-g	Industry	03	1	Assumed equal to natural gas.
				Engines	0.58	Assumed equal to natural gas.
		1A2 f	Industry – mineral wool	030701	46	Emission factor based on plant specific data for the mineral wool industry, 2023.
		1A4a	Commercial/ Institutional	0201	1	Assumed equal to natural gas.
				Engines	0.58	Assumed equal to natural gas.
		1A4b	Residential	0202	1	Assumed equal to natural gas.
				Engines	0.58	Assumed equal to natural gas.
		1A4c	Agriculture/ Forestry	0203	1	Assumed equal to natural gas.
				Engines	0.58	Assumed equal to natural gas.

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

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 1990-2023.

Table 4.6 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
1990-2000	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
2007-2023	1.0	1.0

Table 4.7 Technology specific CH_4 emission factors for residential wood combustion.

Technology	Emission factor, g per GJ	Reference
Stoves (-1989)	430	Methane emissions from residential biomass combustion, Paulrud et al. (2005) (SMED report, Sweden).
Stoves (1990-2007)	215	Assumed ½ the emission factor for stoves (-1989).
Stoves (2008-2014)	125	Estimated based on the emission factor for stoves (1990-2007) and the emission factors for NMVOC.
Stoves (2015-2016)	125	Same as stoves (2008-2014).
Stoves (2017-)	125	Same as stoves (2008-2014).
Eco labelled stoves / new advanced stoves (-2014)	2	Low emissions from wood burning in an ecolabelled residential boiler. Olsson & Kjällstrand (2005).
Eco labelled stoves / new advanced stoves (2015-2016)	2	Same as advanced/ecolabelled stoves.
Eco labelled stoves / new advanced stoves (2017-)	2	Same as advanced/ecolabelled stoves.
Open fireplaces and similar	430	Assumed equal to stoves (-1989).
Masonry heat accumulating stoves and similar	215	Assumed equal to stoves (1990-2007).
Boilers with accumulation tank (-1979)	211	Methane emissions from residential biomass combustion, Paulrud et al. (2005) (SMED report, Sweden).
Boilers without accumulation tank (-1979)	256	Methane emissions from residential biomass combustion, Paulrud et al. (2005) (SMED report, Sweden).
Boilers with accumulation tank (1980-)	50	Emission characteristics of modern and old-type residential boilers fired with wood logs and wood pellets. Johansson et al. (2004).
Boilers without accumulation tank (1980-)	50	Emission characteristics of modern and old-type residential boilers fired with wood logs and wood pellets. Johansson et al. (2004).

Table 4.8 SO_2 emission factors time series, g per GJ for the years 1990 to 2023.
This table is available at: https://envs.au.dk/en/research-areas/air-pollution-emissions-and-effects/air-emissions/air-pollutants/supporting-documentation

Table 4.9 NO_x emission factors time series, g per GJ for the years 1990 to 2023.
This table is available at: https://envs.au.dk/en/research-areas/air-pollution-emissions-and-effects/air-emissions/air-pollutants/supporting-documentation

Table 4.10 NMVOC emission factors time series, g per GJ for the years 1990 to 2023.
This table is available at: : https://envs.au.dk/en/research-areas/air-pollution-emissions-and-effects/air-emissions/air-pollutants/supporting-documentation

Table 4.11 CO emission factors time series, g per GJ for the years 1990 to 2023.
This table is available at: : https://envs.au.dk/en/research-areas/air-pollution-emissions-and-effects/air-emissions/air-pollutants/supporting-documentation

Table 4.12 NH_3 emission factors time series, g per GJ for the years 1990 to 2023.
This table is available at: : https://envs.au.dk/en/research-areas/air-pollution-emissions-and-effects/air-emissions/air-pollutants/supporting-documentation

Table 4.13 TSP emission factors, time series, g per GJ for the years 1990 to 2023.
This table is available at: : https://envs.au.dk/en/research-areas/air-pollution-emissions-and-effects/air-emissions/air-pollutants/supporting-documentation

Table 4.14 PM_{10} emission factors, time series, g per GJ for the years 1990 to 2023.
This table is available at: : https://envs.au.dk/en/research-areas/air-pollution-emissions-and-effects/air-emissions/air-pollutants/supporting-documentation

Table 4.15 $PM_{2.5}$ emission factors, time series, g per GJ for the years 1990 to 2023.
This table is available at: : https://envs.au.dk/en/research-areas/air-pollution-emissions-and-effects/air-emissions/air-pollutants/supporting-documentation

Table 4.16 BC emission factors, time series, g per GJ for the years 1990 to 2023.
This table is available at: : https://envs.au.dk/en/research-areas/air-pollution-emissions-and-effects/air-emissions/air-pollutants/supporting-documentation

Table 4.17 As emission factors time series, mg per GJ, for the years 1990 to 2023.
This table is available at : https://envs.au.dk/en/research-areas/air-pollution-emissions-and-effects/air-emissions/air-pollutants/supporting-documentation

Table 4.18 Cd emission factors time series, mg per GJ, for the years 1990 to 2023.
This table is available at: : https://envs.au.dk/en/research-areas/air-pollution-emissions-and-effects/air-emissions/air-pollutants/supporting-documentation

Table 4.19 Cr emission factors time series, mg per GJ, for the years 1990 to 2023.
This table is available at : https://envs.au.dk/en/research-areas/air-pollution-emissions-and-effects/air-emissions/air-pollutants/supporting-documentation

Table 4.20 Cu emission factors time series, mg per GJ, for the years 1990 to 2023.
This table is available at : https://envs.au.dk/en/research-areas/air-pollution-emissions-and-effects/air-emissions/air-pollutants/supporting-documentation

Table 4.21 Hg emission factors time series, mg per GJ, for the years 1990 to 2023.
This table is available at: : https://envs.au.dk/en/research-areas/air-pollution-emissions-and-effects/air-emissions/air-pollutants/supporting-documentation

Table 4.22 Ni emission factors time series, mg per GJ, for the years 1990 to 2023.
This table is available at: : https://envs.au.dk/en/research-areas/air-pollution-emissions-and-effects/air-emissions/air-pollutants/supporting-documentation

Table 4.23 Pb emission factors time series, mg per GJ, for the years 1990 to 2023.
This table is available at : https://envs.au.dk/en/research-areas/air-pollution-emissions-and-effects/air-emissions/air-pollutants/supporting-documentation

Table 4.24 Se emission factors time series, mg per GJ, for the years 1990 to 2023.
This table is available at : https://envs.au.dk/en/research-areas/air-pollution-emissions-and-effects/air-emissions/air-pollutants/supporting-documentation

Table 4.25 Zn emission factors time series, mg per GJ, for the years 1990 to 2023.
This table is available at: : https://envs.au.dk/en/research-areas/air-pollution-emissions-and-effects/air-emissions/air-pollutants/supporting-documentation

Table 4.26 PAH emission factors time series, µg pr GJ for the years 1990 to 2023.
This table is available at: : https://envs.au.dk/en/research-areas/air-pollution-emissions-and-effects/air-emissions/air-pollutants/supporting-documentation

Table 4.27 HCB emission factors time series, ng per GJ for the years 1990 to 2023.
This table is available at : https://envs.au.dk/en/research-areas/air-pollution-emissions-and-effects/air-emissions/air-pollutants/supporting-documentation

Table 4.28 PCDD/F emission factors time series, ng per GJ for the years 1990 to 2023.
This table is available at: : https://envs.au.dk/en/research-areas/air-pollution-emissions-and-effects/air-emissions/air-pollutants/supporting-documentation

Table 4.29 PCB emission factors time series, ng per GJ for the years 1990 to 2023. This table is available at : https://envs.au.dk/en/research-areas/air-pollution-emissions-and-effects/air-emissions/air-pollutants/supporting-documentation

Annex 5 Large point sources

Table 5.1 Large point sources, 2023 (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
Dalum Kraftvarmevaerk
Danisco Grindsted Dupont
DanSteel
DTU
Duferco Danish Steel
Esbjergvaerket
Faxe Kalk
Fjernvarme Fyn, Centrum Varmecentral
Frederikshavn Affaldskraftvarmevaerk
Fynsvaerket
H.C.Oerstedsvaerket
Haldor Topsoee
Hammel Fjernvarmeselskab
Helsingoer Kraftvarmevaerk
Herningvaerket
Hilleroed Kraftvarmevaerk
Hjoerring Varmeforsyning
Horsens Kraftvarmevaerk
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
Kyndbyvaerket
L90 Affaldsforbraending
LECA Danmark
Maricogen
Masnedoevaerket
Maabjergvaerket
Nordic Sugar Nakskov
Nordic Sugar Nykoebing
Nordjyllandsvaerket
Nybro Gasbehandlingsanlaeg
Odense Kraftvarmevaerk
Oestkraft
Randersvaerket Verdo
Rensningsanlaegget Lynetten

Continued

Rockwool A/S Doense
Rockwool A/S Vamdrup
Saint-Gobain Isover A/S
Shell Raffinaderi
Silkeborg Kraftvarmevaerk
Skaerbaekvaerket
Soenderborg Kraftvarmevaerk
Special Waste System
Statoil Raffinaderi
Studstrupvaerket
Svanemoellevaerket
Svendborg Kraftvarmevaerk
Viborg Kraftvarme
Vordingborg Kraftvarme
Aalborg Portland
AarhusKarlshamn Denmark A/S

Table 5.2 Large point sources, aggregated fuel consumption in 2023.

NFR	Fuel id	Fuel	Fuel, TJ
1A1a	102A	COAL	24356
	103A	SUB-BITUMINOUS	44
	111A	WOOD	28927
	114A	WASTE	35563
	117A	STRAW	5674
	122A	Wood Pellets	29877
	203A	RESIDUAL OIL	665
	204A	GAS OIL	443
	215A	BIO OIL	14
	301A	NATURAL GAS	3731
	303A	LPG	1
	309A	BIOGAS	99
	315A	BIONATGAS	2162
1A1a Total			131555
1A1b	203A	RESIDUAL OIL	0
	204A	GAS OIL	162
	301A	NATURAL GAS	597
	303A	LPG	0
	308A	REFINERY GAS	15055
	315A	BIONATGAS	346
1A1b Total			16160
1A1c	204A	GAS OIL	3
	301A	NATURAL GAS	323
	315A	BIONATGAS	0
1A1c Total			326
1A2a	204A	GAS OIL	0
	301A	NATURAL GAS	1194
	303A	LPG	1
	315A	BIONATGAS	692
1A2a Total			1887
1A2c	204A	GAS OIL	104
	301A	NATURAL GAS	634
	303A	LPG	11
	315A	BIONATGAS	367
1A2c Total			1116
1A2e	102A	COAL	62
	107A	COKE OVEN COKE	121
	111A	WOOD	642
	203A	RESIDUAL OIL	1371
	204A	GAS OIL	718
	215A	BIO OIL	100
	301A	NATURAL GAS	14
	303A	LPG	38
	309A	BIOGAS	93
	315A	BIONATGAS	8
1A2e Total			3168
1A2f	102A	COAL	2496
	107A	COKE OVEN COKE	160
	110A	PETROLEUM COKE	4001
	111A	WOOD	1910
	114A	WASTE	191
	115A	INDUSTR. WASTES	2224
	203A	RESIDUAL OIL	24
	204A	GAS OIL	82
	301A	NATURAL GAS	802
	303A	LPG	224
	315A	BIONATGAS	465
1A2f Total			12578
1A4a i	111A	WOOD	215
	114A	WASTE	0
	309A	BIOGAS	0
1A4a i Total			215
Grand Total			167005

Table 5.3 Large point sources, plant specific emissions[1].

Year	2023																				
NFR	**LPS name**	**SO_2**	**NO_x**	**NMVOC**	**CO**	**NH_3**	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**BC [2]**	**As**	**Cd**	**Cr**	**Cu**	**Hg**	**Ni**	**Pb**	**Se**	**Zn**	**PCDD/F**	**PCB**
1A1a	AffaldPlus+, Naestved Forbraendingsanlaeg	x	x	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	x		x			x					x	
1A1a	Affaldscenter aarhus - Forbraendsanlaegget	x	x				x	x	x	x					x					x	
1A1a	Affaldsforbraendingsanlaeg I/S REFA														x						
1A1a	Amagerforbraending	x	x	x	x	x	x	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	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	x	x	x		x			x					x	
1A1a	Bofa I/S	x	x		x						x	x	x	x	x	x	x			x	
1A1a	DTU		x		x																
1A1a	Esbjergvaerket	x	x		x		x	x	x	x	x	x	x	x	x	x	x	x	x		
1A1a	Fjernvarme Fyn, Centrum Varmecentral		x																		
1A1a	Frederikshavn Affaldskraftvarmevaerk	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x			x	
1A1a	Fynsvaerket	x	x				x	x	x	x	x	x	x	x	x	x	x	x	x		
1A1a	H.C.Oerstedsvaerket		x	x	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	
1A1a	I/S Kara Affaldsforbraendingsanlaeg	x	x		x		x	x	x	x					x					x	
1A1a	I/S Nordforbraending		x																		
1A1a	I/S Reno Nord	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			x	x
1A1a	I/S Reno Syd	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	
1A1a	Koege Kraftvarmevaerk		x																		
1A1a	Kolding Forbraendingsanlaeg TAS	x	x	x	x	x	x	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	x	x	x	x	x	x			x	
1A1a	Maabjergvaerket		x																		
1A1a	Nordjyllandsvaerket	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x		
1A1a	Odense Kraftvarmevaerk	x	x				x	x	x	x										x	
1A1a	Oestkraft	x	x				x	x	x	x											
1A1a	Silkeborg Kraftvarmevaerk		x																		
1A1a	Skaerbaekvaerket		x	x	x																

Year	2023																				
NFR	**LPS name**	**SO_2**	**NO_x**	**NMVOC**	**CO**	**NH_3**	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**BC [2)]**	**As**	**Cd**	**Cr**	**Cu**	**Hg**	**Ni**	**Pb**	**Se**	**Zn**	**PCDD/F**	**PCB**
1A1a	Soenderborg Kraftvarmevaerk	x	x		x															x	
1A1a	Studstrupvaerket	x	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			x	
1A1a	Viborg Kraftvarme		x																		
1A1a	Vordingborg Kraftvarme	x	x																		
1A1a	Dalum Kraftvarmevaerk	x	x				x	x	x	x											
1A1a	Randersvaerket Verdo	x	x				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																		
1A2a	Duferco Danish Steel		x																		
1A2c	Cheminova																				
1A2c	Haldor Topsoee		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	Ardagh Glass Holmegaard A/S		x																		
1A2f	Faxe Kalk	x	x																		
1A2f	Rockwool A/S Doense	x	x												x		x				
1A2f	Rockwool A/S Vamdrup		x																		
1A2f	Saint-Gobain Isover A/S		x																		
1A2f	Aalborg Portland	x	x		x	x	x	x	x	x					x						
1A2f	LECA Danmark		x		x	x									x						
1A4a i	Rensningsanlaegget Lynetten	x	x		x		x	x	x	x		x			x		x			x	
Total		**2083**	**9568**	**28**	**6160**	**66**	**190**	**155**	**120**	**10**	**20**	**14**	**41**	**26**	**95**	**36**	**38**	**171**	**82**	**511**	**-**
Total emission from stationary combustion		4569	23305	9606	71082	986	7757	7307	7091	1024	111	493	1029	438	170	802	1399	327	17190	20346	298328
Share of total emission from stationary combustion based on plant specific data, %		46%	41%	0.3%	9%	6.7%	2%	2%	2%	1.0%	18%	2.8%	4%	6%	56%	5%	3%	52%	0.5%	2.5%	-

1) Emissions of the pollutants marked with “x” are plant specific. Emissions of other pollutants are 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, 2024a).

		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	38.6	48.2	42.3	44.6	48.1	44.9	57.9	48.1	44.1	40.9
Adjusted CO_2 emission	1 000 000 tonnes	44.9	46.6	45.2	45.6	44.3	44.2	44.9	42.1	40.5	39.0
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	3273	3271	3261	3224	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	36.9	38.5	38.0	42.8	36.8	33.1	40.8	35.4	32.5	31.7
Adjusted CO_2 emission	1 000 000 tonnes	37.6	38.1	36.4	36.0	34.6	34.2	35.2	34.6	33.7	32.0
Continued		**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Actual Degree Days	Degree days	3742	2970	3234	3207	2664	2921	2998	2970	2900	2847
Normal Degree Days	Degree days	3171	3156	3166	3155	3131	3112	3070	3057	3041	3030
Net electricity import	PJ	-4.1	4.7	18.8	3.9	10.3	21.3	18.2	16.4	18.8	20.9
Actual CO_2 emission	1 000 000 tonnes	32.1	27.4	23.8	25.8	21.5	18.9	20.2	17.7	17.5	14.2
Adjusted CO_2 emission	1 000 000 tonnes	31.2	28.4	28.0	26.4	23.3	22.5	23.3	20.4	20.5	17.4
Continued		**2020**	**2021**	**2022**	**2023**						
Actual Degree Days	Degree days	2715	3098	2834	2864						
Normal Degree Days	Degree days	3021	3012	3003	2989						
Net electricity import	PJ	24.8	17.5	4.9	11.3						
Actual CO_2 emission	1 000 000 tonnes	12.5	13.5	12.6	10.4						
Adjusted CO_2 emission	1 000 000 tonnes	15.9	15.7	13.2	10.4						

Annex 7 Uncertainty estimates

Table 7.1 Uncertainty estimation, approach 1, GHG

This table is available in Annex 3A at: https://envs.au.dk/en/research-areas/air-pollution-emissions-and-effects/air-emissions/greenhouse-gases/supporting-documentation

Table 7.2 Uncertainty estimation, approach 1, CO_2

This table is available in Annex 3A at: https://envs.au.dk/en/research-areas/air-pollution-emissions-and-effects/air-emissions/greenhouse-gases/supporting-documentation

Table 7.3 Uncertainty estimation, approach 1, CH_4

This table is available in Annex 3A at: https://envs.au.dk/en/research-areas/air-pollution-emissions-and-effects/air-emissions/greenhouse-gases/supporting-documentation

Table 7.4 Uncertainty estimation, approach 1, N_2O

This table is available in Annex 3A at: https://envs.au.dk/en/research-areas/air-pollution-emissions-and-effects/air-emissions/greenhouse-gases/supporting-documentation

Table 7.5 Uncertainty estimates for air pollutants.

This table is available at: : https://envs.au.dk/en/research-areas/air-pollution-emissions-and-effects/air-emissions/air-pollutants/supporting-documentation

Annex 8 Emission inventory 2023 based on SNAP sectors

Table 8.1 Emission inventory 2023 based on SNAP sectors, GHGs.

CRT	SNAP	CO_2, kt	CH_4, t	N_2O, t
1A1a	010100	0.0	0.0	0.0
	010101	2449.6	114.3	45.3
	010102	1010.4	61.9	45.5
	010103	423.0	11.2	16.0
	010104	298.0	43.0	18.3
	010105	133.9	2647.2	11.1
	010200	0.0	0.0	0.0
	010201	0.0	0.0	0.0
	010202	33.0	1.0	0.8
	010203	311.5	370.3	93.5
	010205	0.0	0.0	0.0
1A1a Total		4659.5	3248.8	230.5
1A1b	010304	111.4	3.4	2.0
	010306	787.4	14.5	2.3
1A1b Total		898.8	17.9	4.3
1A2	030104	0.0	0.0	0.0
	030105	0.0	0.0	0.0
	030106	3.2	0.1	0.1
	030400	9.1	0.1	0.0
	030402	68.3	1.9	1.9
	030500	0.0	0.0	0.0
	030600	130.3	7.7	6.3
	030602	24.7	0.7	0.7
	030603	0.0	0.0	0.0
	030604	19.4	0.9	0.4
	030605	0.0	22.7	0.1
	030700	187.1	4.0	4.0
	030701	38.9	1.9	32.1
	030702	25.0	0.7	0.7
	030703	6.4	0.7	0.1
	030705	0.0	0.0	0.0
	030706	44.1	9.4	1.5
	030800	123.9	4.8	3.9
	030900	481.0	18.5	11.8
	030902	102.9	8.6	7.8
	030903	78.3	2.4	4.2
	030904	0.0	0.0	0.0
	030905	3.6	313.5	1.2
	031000	12.0	0.4	0.4
	031005	0.0	0.0	0.0
	031100	27.1	0.8	0.8
	031102	0.0	0.0	0.0
	031103	0.0	0.0	0.0
	031104	0.0	0.0	0.0
	031200	9.6	0.5	0.4
	031205	0.0	0.0	0.0
	031300	135.2	2.8	2.7
	031305	0.0	0.0	0.0
	031400	9.8	1.0	1.3
	031403	0.0	1.9	1.2
	031405	0.1	1.7	0.0
	031500	17.8	0.4	0.3
	031600	722.8	120.8	31.4
	031604	0.0	0.0	0.0
	031605	0.0	0.0	0.0
	032000	21.3	4.8	0.9
	032002	0.0	0.0	0.0
	032004	0.0	0.0	0.0
	032005	0.1	1.0	0.0
1A2 Total		2301.7	534.7	116.3
1A1c_ii	010500	35.0	0.4	0.2
	010503	18.7	0.3	0.3
	010504	778.0	23.0	13.5

Continued

	010505	0.0	0.0	0.0
1A1c_ii Total		831.7	23.7	14.0
1A4a_i	020100	421.0	18.3	13.7
	020103	1.1	2.6	0.9
	020105	1.7	266.2	1.1
1A4a_i Total		423.8	287.1	15.8
1A4b_i	020200	915.7	2872.1	138.2
	020202	1.5	1.9	0.1
	020204	1.0	13.9	0.0
1A4b_i Total		918.3	2887.8	138.3
1A4c_i	020300	329.5	555.1	11.2
	020302	0.0	0.0	0.0
	020303	0.0	0.0	0.0
	020304	5.3	217.0	0.7
	020305	0.0	0.0	0.0
1A4c_i Total		334.8	772.0	12.0
Grand Total		10368.6	7772.0	531.2

Table 8.2 Emission inventory 2023 based on SNAP sectors, air pollutants.

This table is available at : https://envs.au.dk/en/research-areas/air-pollution-emissions-and-effects/air-emissions/air-pollutants/supporting-documentation

Annex 9 EU ETS data for coal

EU ETS data are available for the years 2006-2023. Corresponding values for net calorific value (NCV) and implied emission factor (IEF) for CO_2 for 2006-2009 are shown in Figure 9.1. The IEF factors include the oxidation factors.

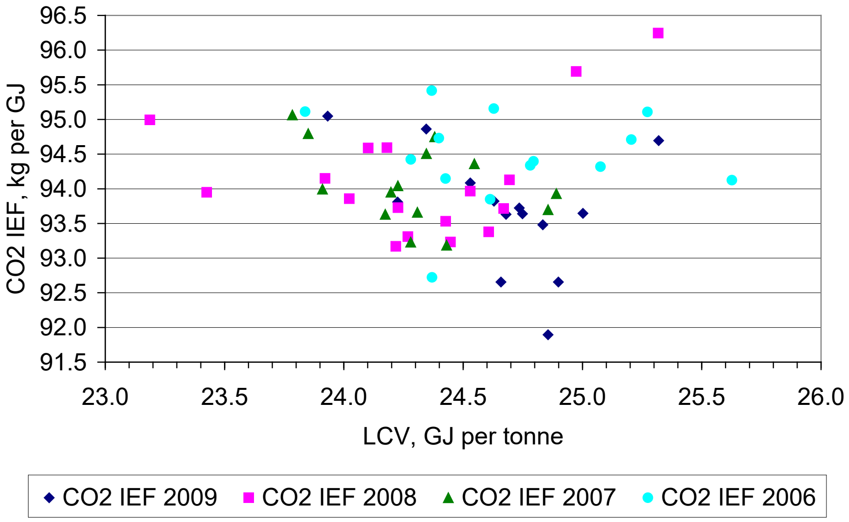

Figure 9.1 EU ETS data for NCV and CO_2 IEF (including oxidation factor) for coal. Data for the years 2006-2009.

Annex 10 Implied emission factors for power plants and municipal waste incineration plants

Table 10.1 Implied emission factors for municipal waste incineration plants 2023.

Pollutant	Implied emission factor	Unit
SO_2	4.7	g /GJ
NO_x	83	g / GJ
TSP	0.36	g / GJ
PM_{10}	0.35	g / GJ
$PM_{2.5}$	0.34	g / GJ
As	0.41	mg / GJ
Cd	0.36	mg / GJ
Cr	1.26	mg / GJ
Cu	1.12	mg / GJ
Hg	1.22	mg / GJ
Ni	2.94	mg / GJ
Pb	3.60	mg / GJ
Se	1.18	mg / GJ
Zn	2.69	mg / GJ

Table 10.2 Implied emission factors for power plants combusting coal, 2023.

Pollutant	Implied emission factor	Unit
SO_2	11.8	g / GJ
NO_x	16.9	g / GJ
TSP	2.64	g / GJ
PM_{10}	2.29	g / GJ
$PM_{2.5}$	1.85	g / GJ
As	0.60	mg / GJ
Cd	0.06	mg / GJ
Cr	1.03	mg / GJ
Cu	0.43	mg / GJ
Hg	1.21	mg / GJ
Ni	0.99	mg / GJ
Pb	0.72	mg / GJ
Se	9.08	mg / GJ
Zn	1.41	mg / GJ

Annex 11 Description of the Danish energy statistics

This description of the Danish energy statistics has been prepared by Denmark's National Environmental Research Institute, NERI (now DCE) in cooperation with the Danish Energy Agency (DEA) as background information to the Danish National Inventory Report (NIR).

The Danish energy statistics system

DEA is responsible for the Danish energy balance. Main contributors to the energy statistics outside DEA are Statistics Denmark and Danish Energy Association (before Association of Danish Energy Companies). The statistics is performed using an integrated statistical system building on an Access database and Excel spreadsheets.

The DEA follows the recommendations of the International Energy Agency as well as Eurostat.

The national energy statistics is updated annually, and all revisions are immediately included in the published statistics, which can be found on the DEA homepage. It is an easy task to check for breaks in a series because the statistics is 100 % time-series oriented.

The national energy statistics do not include Greenland and Faroe Islands.

For historical reasons, DEA receive monthly information from the Danish oil companies regarding Danish deliveries of oil products to Greenland and Faroe Islands. However, the monthly (MOS) and annual (AOS) reporting of oil statistics to Eurostat and IEA exclude Greenland and Faroe Islands. For all other energy products, the Danish figures are also excluding Greenland and Faroe Islands.

Reporting to the Danish Energy Agency

The Danish Energy Agency receives monthly statistics for the following fuel groups:

- Crude oil and oil products.
  - Monthly data from 46 oil companies, the main purpose is monitoring oil stocks according to the oil preparedness system.
- Natural gas.
  - Fuel/flare from platforms in the North Sea.
  - Natural gas balance from the regulator Energinet.dk (National monopoly).
- Coal and coke.
  - Power plants (94 %).
  - Industry companies (4 %).
  - Coal and coke traders (2 %).
- Electricity.
  - Monthly reporting by e-mail from the regulator Energinet.dk (National monopoly).
  - The statistics covers:
    - Production by type of producer.
    - Own use of electricity.
    - Import and export by country.
    - Domestic supply (consumption + distribution loss).
- Town gas (quarterly) from two town gas producers.

- The large central power plants also report monthly consumption of biomass.

Annual data includes renewable energy including waste. The DEA conducts a biannual survey on wood pellets and wood fuel. Statistics Denmark conducts biannual surveys on the energy consumption in the service and industrial sectors. Statistics Denmark prepares annual surveys on forest (wood fuel) & straw.

Other annual data sources include:

- DEA:
  - Survey on production of electricity and heat and fuels used.
  - Survey on end use of oil.
  - Survey on end use of natural gas.
  - Survey on end use of coal and coke.
- DCE (former NERI), Aarhus University.
  - Energy consumption for domestic air transport.
- Danish Energy Association (Association of Danish Energy companies).
  - Survey on electricity consumption.
- Ministry of Taxation.
  - Border trade.
- Centre for Biomass Technology.
  - Annual estimates of final consumption of straw and wood chips.

Annual revisions

In general, DEA follows the same procedures as in the Danish national account. This means that normally only figures for the last two years are revised.

Aggregating the energy statistics on SNAP level

The sectors used in the official energy statistics have been mapped to SNAP categories, used in the Danish emission database. DCE aggregates the official energy statistics to SNAP level based on a source correspondence table.

In cooperation between DEA and DCE, a fuel correspondence table has been developed mapping the fuels used by the DEA in the official energy statistics with the fuel codes used in the Danish national emission database. The fuel correspondence table between fuel categories used by the DEA, DCE and NFR is presented in Annex 3.

The mapping between the energy statistics and the SNAP and fuel codes used by DCE can be seen in the table below.

Table 11.1 Correspondence between the Danish national energy statistics and the SNAP nomenclature (only stationary combustion part shown).

Unit: TJ	End-use			Transformation 1980-1993	
	SNAP	Fuel (in Danish)	Fuel-code	SNAP	Fuel-code
Foreign Trade					
- Border Trade					
- - Motor Gasoline					
- - Gas-/Diesel Oil					
- - Petroleum Coke	0202	Petrokoks	110A		
Vessels in Foreign Trade					
- International Marine Bunkers					
- - Gas-/Diesel Oil					
- - Fuel Oil					
- - Lubricants					
Energy Sector					
Extraction and Gasification					
- Extraction					
- - Natural Gas	010504	Naturgas	301A		
- Gasification					
- - Biogas, Landfill	091006	Biogas	309A		
- - Biogas, Other	091006	Biogas	309A		
Refineries					
- Own Use					
- - Refinery Gas	010306	Raffinaderigas	308A		
- - LPG	010306	LPG	303A		
- - Gas-/Diesel Oil	010306	Gas & Dieselolie	204A		
- - Fuel Oil	010306	Fuelolie & Spildolie	203A		
Transformation Sector					
Large-scale Power Units					
- Fuels Used for Power Production					
- - Gas-/Diesel Oil				0101	204A
- - Fuel Oil				0101	203A
- - Electricity Plant Coal				0101	102A
- - Straw				0101	117A
Large-Scale CHP Units					
- Fuels Used for Power Production					
- - Refinery Gas				0103	308A
- - LPG				0101	303A
- - Naphtha (LVN)				0101	210A
- - Gas-/Diesel Oil				0101	204A
- - Fuel Oil				0101	203A
- - Petroleum Coke				0101	110A
- - Orimulsion				0101	225A
- - Natural Gas				0101	301A
- - Electricity Plant Coal				0101	102A
- - Straw				0101	117A
- - Wood Chips				0101	111A
- - Wood Pellets				0101	111A
- - Wood Waste				0101	111A
- - Biogas, Landfill				0101	309A
- - Biogas, Others				0101	309A
- - Waste, Non-renewable				0101	114A
- - Wastes, Renewable				0101	114A
- Fuels Used for Heat Production					
- - Refinery Gas				0103	308A
- - LPG				0101	303A
- - Naphtha (LVN)				0101	210A
- - Gas-/Diesel Oil				0101	204A
- - Fuel Oil				0101	203A
- - Petroleum Coke				0101	110A
- - Orimulsion				0101	225A
- - Natural Gas				0101	301A
- - Electricity Plant Coal				0101	102A
- - Straw				0101	117A
- - Wood Chips				0101	111A
- - Wood Pellets				0101	111A

Unit: TJ	End-use			Transformation 1980-1993	
	SNAP	Fuel (in Danish)	Fuel-code	SNAP	Fuel-code
- - Wood Waste				0101	111A
- - Biogas, Landfill				0101	309A
- - Biogas, Other				0101	309A
- - Waste, Non-renewable				0101	114A
- - Wastes, Renewable				0101	114A
Small-Scale CHP Units					
- Fuels Used for Power Production					
- - Gas-/Diesel Oil				0101	204A
- - Fuel Oil				0101	203A
- - Natural Gas				0101	301A
- - Hard Coal				0101	102A
- - Straw				0101	117A
- - Wood Chips				0101	111A
- - Wood Pellets				0101	111A
- - Wood Waste				0101	111A
- - Biogas, Landfill				0101	309A
- - Biogas, Other				0101	309A
- - Waste, Non-renewable				0101	114A
- - Wastes, Renewable				0101	114A
- Fuels Used for Heat Production					
- - Gas-/Diesel Oil				0101	204A
- - Fuel Oil				0101	203A
- - Natural Gas				0101	301A
- - Coal				0101	102A
- - Straw				0101	117A
- - Wood Chips				0101	111A
- - Wood Pellets				0101	111A
- - Wood Waste				0101	111A
- - Biogas, Landfill				0101	309A
- - Biogas, Other				0101	309A
- - Waste, Non-renewable				0101	114A
- - Wastes, Renewable				0101	114A
District Heating Units					
- Fuels Used for Heat Production					
- - Refinery Gas				0103	308A
- - LPG				0102	303A
- - Gas-/Diesel Oil				0102	204A
- - Fuel Oil				0102	203A
- - Waste Oil				0102	203A
- - Petroleum Coke				0102	110A
- - Natural Gas				0102	301A
- - Electricity Plant Coal				0102	102A
- - Coal				0102	102A
- - Straw				0102	117A
- - Wood Chips				0102	111A
- - Wood Pellets				0102	111A
- - Wood Waste				0102	111A
- - Biogas, Landfill				0102	309A
- - Biogas, Sludge				0102	309A
- - Biogas, Other				0102	309A
- - Waste, Non-renewable				0102	114A
- - Wastes, Renewable				0102	114A
- - Fish Oil				0102	215A
Autoproducers, Electricity Only					
- Fuels Used for Power Production					
- - Natural Gas				0320	301A
- - Biogas, Landfill				0320	309A
- - Biogas, Sewage Sludge				0320	309A
- - Biogas, Other				0320	309A
Autoproducers, CHP Units					
- Fuels Used for Power Production					
- - Refinery Gas				0103	308A
- - Gas-/Diesel Oil				0320	204A
- - Fuel Oil				0320	203A

Unit: TJ	End-use SNAP	Fuel (in Danish)	Fuel-code	Transformation 1980-1993 SNAP	Fuel-code
- - Waste Oil				0320	203A
- - Natural Gas				0320	301A
- - Coal				0320	102A
- - Straw				0320	117A
- - Wood Chips				0320	111A
- - Wood Pellets				0320	111A
- - Wood Waste				0320	111A
- - Biogas, Landfill				0320	309A
- - Biogas, Sludge				0320	309A
- - Biogas, Other				0320	309A
- - Fish Oil				0320	215A
- - Waste, Non-renewable				0320	114A
- - Wastes, Renewable				0320	114A
- Fuels Used for Heat Production					
- - Refinery Gas				0103	308A
- - Gas-/Diesel Oil				0320	204A
- - Fuel Oil				0320	203A
- - Waste Oil				0320	203A
- - Natural Gas				0320	301A
- - Coal				0320	102A
- - Wood Chips				0320	111A
- - Wood Waste				0320	111A
- - Biogas, Landfill				0320	309A
- - Biogas, Sludge				0320	309A
- - Biogas, Other				0320	309A
- - Waste, Non-renewable				0320	114A
- - Wastes, Renewable				0320	114A
Autoproducers, Heat Only					
- Fuels Used for Heat Production					
- - Gas-/Diesel Oil				0320	204A
- - Fuel Oil				0320	203A
- - Waste Oil				0320	203A
- - Natural Gas				0320	301A
- - Straw				0320	117A
- - Wood Chips				0320	111A
- - Wood Chips				0320	111A
- - Wood Waste				0320	111A
- - Biogas, Landfill				0320	309A
- - Biogas, Sludge				0320	309A
- - Biogas, Other				0320	309A
- - Waste, Non-renewable				0102	114A
- - Wastes, Renewable				0102	114A
Town Gas Units	030106	Naturgas	301A		
- Fuels Used for Production of District Heating	030106	Kul (-83) / Gasolie (84-)	102A / 204A		
Transport sector					
Military Transport					
- Aviation Gasoline					
- Motor Gasoline					
- JP4					
- JP1					
- Gas-/Diesel Oil					
Road					
- LPG					
- Motor Gasoline					
- Other Kerosene	0202	Petroleum	206A		
- Gas-/Diesel Oil					
- Fuel Oil					
Rail					
- Motor Gasoline					
- Other Kerosene					
- Gas-/Diesel Oil					
- Electricity					
Domestic Sea Transport					

Unit: TJ	End-use SNAP	 Fuel (in Danish)	 Fuel-code	Transformation 1980-1993 SNAP	 Fuel-code
- LPG					
- Other Kerosene					
- Gas-/Diesel Oil					
- Fuel Oil					
Air Transport, Domestic					
- LPG					
- Aviation Gasoline					
- Motor Gasoline					
- Other Kerosene	0201	Petroleum	206A		
- JP1					
Air Transport, International					
- Aviation Gasoline					
- JP1					
Agriculture and Forestry					
- LPG					
- Motor Gasoline					
- Other Kerosene	0203	Petroleum	206A		
- Gas-/Diesel Oil					
- Fuel Oil	0203	Fuelolie & Spildolie	203A		
- Petroleum Coke	0203	Petrokoks	110A		
- Natural Gas	0203	Naturgas	301A		
- Coal	0203	Kul	102A		
- Brown Coal Briquettes	0203	Brunkul	106A		
- Straw	0203	Halm	117A		
- Wood Chips	0203	Træ	111A		
- Wood Waste	0203	Træ	111A		
- Biogas, Other	0203	Biogas	309A		
Horticulture					
- LPG					
- Motor Gasoline					
- Gas-/Diesel Oil					
- Fuel Oil	0203	Fuelolie & Spildolie	203A		
- Petroleum Coke	0203	Petrokoks	110A		
- Natural Gas	0203	Naturgas	301A		
- Coal	0203	Kul	102A		
- Wood Waste	0203	Træ	111A		
Fishing					
- LPG					
- Motor Gasoline					
- Other Kerosene					
- Gas-/Diesel Oil					
- Fuel Oil					
Manufacturing Industry					
- Refinery Gas	0320	Raffinaderigas	308A		
- LPG					
- Naphtha (LVN)					
- Motor Gasoline					
- Other Kerosene	0320	Petroleum	206A		
- Gas-/Diesel Oil					
- Fuel Oil	0320	Fuelolie & Spildolie	203A		
- Waste Oil	0320	Fuelolie & Spildolie	203A		
- Petroleum Coke	0320	Petrokoks	110A		
- Natural Gas	0320	Naturgas	301A		
- Coal	0320	Kul	102A		
- Coke	0320	Koks	107A		
- Brown Coal Briquettes	0320	Brunkul	106A		
- Wood Pellets	0320	Træ	111A		
- Wood Waste	0320	Træ	111A		
- Biogas, Landfill	0320	Biogas	309A		
- Biogas, Other	0320	Biogas	309A		
- Wastes, Non-renewable	0320	Affald	114A		
- Wastes, Renewable	0320	Affald	114A		
- Town Gas	0320	Naturgas	301A		

Unit: TJ	End-use			Transformation 1980-1993	
	SNAP	Fuel (in Danish)	Fuel-code	SNAP	Fuel-code
Construction					
- LPG	0320	LPG	303A		
- Motor Gasoline					
- Other Kerosene	0320	Petroleum	206A		
- Gas-/Diesel Oil					
- Fuel Oil	0320	Fuelolie & Spildolie	203A		
- Natural Gas	0320	Naturgas	301A		
Wholesale					
- LPG	0201	LPG	303A		
- Motor Gasoline	0201	Petroleum	206A		
- Other Kerosene	0201	Gas & Dieselolie	204A		
- Gas-/Diesel Oil	0201	Fuelolie & Spildolie	203A		
- Petroleum Coke	0201	Petrokoks	110A		
- Natural Gas	0201	Naturgas	301A		
- Wood Waste	0201	Træ	111A		
Retail Trade					
- LPG	0201	LPG	303A		
- Other Kerosene	0201	Petroleum	206A		
- Gas-/Diesel Oil	0201	Gas & Dieselolie	204A		
- Fuel Oil	0201	Fuelolie & Spildolie	203A		
- Petroleum Coke	0201	Petrokoks	110A		
- Natural Gas	0201	Naturgas	301A		
Private Service					
- LPG	0201	LPG	303A		
- Other Kerosene	0201	Petroleum	206A		
- Gas-/Diesel Oil	0201	Gas & Dieselolie	204A		
- Fuel Oil	0201	Fuelolie & Spildolie	203A		
- Waste Oil	0201	Fuelolie & Spildolie	203A		
- Petroleum Coke	0201	Petrokoks	110A		
- Natural Gas	0201	Naturgas	301A		
- Wood Chips	0201	Træ	111A		
- Wood Waste	0201	Træ	111A		
- Biogas, Landfill	0201	Biogas	309A		
- Biogas, Sludge	0201	Biogas	309A		
- Biogas, Other	0201	Biogas	309A		
- Wastes, Non-renewable	0201	Affald	114A		
- Wastes, Renewable	0201	Affald	114A		
- Town Gas	0201	Naturgas	301A		
Public Service					
- LPG	0201	LPG	303A		
- Other Kerosene	0201	Petroleum	206A		
- Gas-/Diesel Oil	0201	Gas & Dieselolie	204A		
- Fuel Oil	0201	Fuelolie & Spildolie	203A		
- Petroleum Coke	0201	Petrokoks	110A		
- Natural Gas	0201	Naturgas	301A		
- Coal	0201	Kul	102A		
- Brown Coal Briquettes	0201	Brunkul	106A		
- Wood Chips	0201	Træ	111A		
- Wood Pellets	0201	Træ	111A		
- Town Gas	0201	Naturgas	301A		
Single Family Houses					
- LPG	0202	LPG	303A		
- Motor Gasoline					
- Other Kerosene	0202	Petroleum	206A		
- Gas-/Diesel Oil	0202	Gas & Dieselolie	204A		
- Fuel Oil	0202	Fuelolie & Spildolie	203A		
- Petroleum Coke	0202	Petrokoks	110A		
- Natural Gas	0202	Naturgas	301A		
- Coal	0202	Kul	102A		
- Coke	0202	koks	107A		
- Brown Coal Briquettes	0202	Brunkul	106A		
- Straw	0202	Halm	117A		
- Firewood	0202	Træ	111A		
- Wood Chips	0202	Træ	111A		

Unit: TJ	End-use			Transformation 1980-1993	
	SNAP	Fuel (in Danish)	Fuel-code	SNAP	Fuel-code
- Wood Pellets	0202	Træ	111A		
- Town Gas	0202	Naturgas	301A		
Multi-family Houses					
- LPG	0202	LPG	303A		
- Other Kerosene	0202	Petroleum	206A		
- Gas-/Diesel Oil	0202	Gas & Dieselolie	204A		
- Fuel Oil	0202	Fuelolie & Spildolie	203A		
- Petroleum Coke	0202	Petrokoks	110A		
- Natural Gas	0202	Naturgas	301A		
- Coal	0202	Kul	102A		
- Coke	0202	Koks	107A		
- Brown Coal Briquettes	0202	Brunkul	106A		
- Town Gas	0202	Naturgas	301A		

DANISH EMISSION INVENTORIES FOR STATIONARY COMBUSTION PLANTS

Inventories until 2023

Emission inventories for stationary combustion plants are presented and the methodologies and assumptions used for the inventories are described. The pollutants considered are CO_2, CH_4, N_2O, SO_2, NO_x, NMVOCs, CO, NH_3, particulate matter, black carbon, heavy metals, PCDD/Fs, HCB, PCBs and PAHs. The CO_2 emission from stationary combustion was 73.2 % lower in 2023 than in 1990 and the total greenhouse gas emission was 72.5 % 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 PM emissions increased until 2007 and decreased after 2007. The increase until 2007 was caused by the increased wood combustion in residential plants. The decrease after 2007 is caused by installation of modern stoves and boilers with lower emissions. The PCDD/F emission decreased until 1999 due to improved flue gas cleaning on waste incineration plants. In recent years, residential wood combustion is the largest emission source.

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