

THE DANISH EMISSION INVENTORY FOR FUGITIVE EMISSIONS FROM FUELS

Inventories until 2024

Scientific Report from DCE – Danish Centre for Environment and Energy No. 718 2026

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Data sheet

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Abstract: The Danish Centre for Environment and Energy (DCE), Aarhus University prepares the national inventories of emissions to the air for greenhouse gases and air pollutants and reports to the UN and EU according to the national obligations.
In line with the international reporting guidelines, the Danish emission inventories cover five main sectors. This report documents the methodologies used in the emission inventory for sector "Fugitive emissions from fuels", which is a subsector in the Energy sector, including information on activity data, emission factors and emissions for the time series 1990-2024. The fugitive sector covers emissions from extraction, handling, storage, and transport of solid, liquid, and gaseous fuels, and from venting and flaring.
The fugitive sector includes emissions of the greenhouse gases CO_2, CH_4 and N_2O, and the fugitive sector account for 0.6 % of the national total GHG emissions.
The air pollution inventory for the fugitive emissions sector includes emissions of SO_2, NO_x, NMVOC, CO, particulate matter, BC, heavy metals, and POPs, and the sector contributes 17.7 %, 4.4 % and 0.3 % to the national total emissions of SO_2, NMVOC and BC, respectively. For the remaining pollutants, the fugitive sector contributed only little to the national total (< 0.1 %).

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Preface

The Danish Centre for Environment and Energy (DCE), Aarhus University prepares the national inventories of emissions to the air and carries out the reporting to the UNFCCC (United Nations Framework Convention on Climate Change) and to the UNECE CLRTAP (United Nations Economic Commission for Europe Convention on Long-range Transboundary Pollutants) on an annual basis. Furthermore, the greenhouse gas emission inventory is reported to the EU Governance Regulation (Regulation on the Governance of the Energy Union and Climate Action) and the Paris Agreement, while the air pollution inventory forms the basis of the reporting under the NEC directive (National Emission Ceilings Directive for certain atmospheric pollutants).

This report summarizes the methods and the data used for quantification of fugitive emissions from fuels, and updates the earlier version published in 2021 (Plejdrup et al., 2021). The report includes the latest updates and improvements to the emission inventory of fugitive emissions. Data given in this report is based on the national emission inventory reported in 2026 covering the years 1990-2024, which is described in full in Denmark's National Inventory Document (Nielsen et al., 2026a) and Denmark's Informative Inventory Report (Nielsen et al., 2026b).

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Summary

The Danish Centre for Environment and Energy (DCE), Aarhus University prepares the national inventories of emissions to the air and carries out the reporting to the UNFCCC (United Nations Framework Convention on Climate Change) and to the UNECE CLRTAP (United Nations Economic Commission for Europe Convention on Long-range Transboundary Pollutants) on an annual basis. Furthermore, the greenhouse gas emission inventory is reported to the EU Governance Regulation (Regulation on the Governance of the Energy Union and Climate Action) and the Paris Agreement, while the air pollution inventory forms the basis of the reporting under the NEC directive (National Emission Ceilings Directive for certain atmospheric pollutants).

The national emission inventories cover five sectors as defined in the international guidelines and reporting templates (IPCC, 2006; IPCC, 2019; EMEP/EEA, 2023). "Fugitive emissions from fuels" is a subsector in the Energy sector. This report documents the methodologies used in the emission inventory for fugitive emissions from fuels, including information on activity data, emission factors and emissions for the time series 1990-2024. This report updates the version published in 2021 (Plejdrup et al., 2021). The fugitive sector covers emissions from extraction, handling, storage, treatment, transmission and distribution of solid, liquid, and gaseous fuels, and from venting and flaring. Among the major sources in the fugitive sector are offshore installations in upstream oil and gas production, and refineries.

The total Danish GHG emission in 2024 is 36 354 kt CO_2 equivalents (CO_2 eqv.) including Land use, Land use change and forestry (LULUCF) and indirect CO_2 emissions. In the same year, the GHG emission from the energy sector is 22 718 kt CO_2 eqv., corresponding to 62 %. The majority of the GHG emissions in the energy sector stem from fuel combustion in energy industries and in transport. The GHG emission from the fugitive sector is 211 kt CO_2 eqv. in 2024, which corresponds 0.6 % of the national total GHG emission.

Besides the greenhouse gases carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) the inventory of fugitive emissions from fuels includes emissions of sulphur dioxide (SO_2), nitrogen oxide (NO_x), non-methane volatile organic compounds (NMVOC), carbon monoxide (CO), particulate matter (PM), black carbon (BC), heavy metals (HM), and persistent organic pollutants (POPs).

Emissions of particulate matter are estimated in three size fractions; total suspended particulate matter (TSP) and particles with an aerodynamic diameter less than 10 µm (PM_{10}) and less than 2.5 µm ($PM_{2.5}$).

The fugitive sector contributes 17.7 %, 4.4 % and 0.3 % to the national total emissions of SO_2, NMVOC and BC, respectively. For the remaining pollutants, the fugitive sector contributed only little to the national total (< 0.1 %).

Sammenfatning

DCE – Nationalt Center for Miljø og Energi ved Aarhus Universitet udarbejder de nationale opgørelser af emissioner til luft og står for den årlige rapportering til UNFCCC (FN's rammekonvention om klimaændringer) og UNECE CLRTAP (FN's Økonomiske Kommission for Europas konvention om grænseoverskridende luftforurening over lange afstande). Derudover rapporteres drivhusgasopgørelsen til EU's Forvaltnings Forordning (Forordning om forvaltning af energiunionen og klimaindsatsen) og til Parisaftalen, mens luftforureningsopgørelsen danner grundlag for rapporteringen under NEC-direktivet (direktivet om nationale emissionslofter for visse luftforurenende stoffer).

De nationale emissionsopgørelser omfatter fem sektorer som er defineret i de internationale retningslinjer og rapporteringsskabeloner (IPCC, 2006; IPCC, 2019; EMEP/EEA, 2023). "Flygtige emissioner fra brændsler" (Flygtige emissioner) udgør en delsektor under energisektoren. Denne rapport dokumenterer de metoder, der anvendes i emissionsopgørelsen for Flygtige emissioner, herunder oplysninger om aktivitetsdata, emissionsfaktorer og emissioner for tidsserien 1990-2024. Rapporten opdaterer den version, der blev offentliggjort i 2021 (Plejdrup et al., 2021).

Sektoren Flygtige emissioner omfatter emissioner fra udvinding, håndtering, lagring, behandling, transmission og distribution af faste, flydende og gasformige brændsler samt fra udluftning (venting) og afbrænding (flaring). Blandt de væsentligste kilder i den flygtige sektor er offshoreinstallationer til olie- og gasproduktion samt raffinaderier.

Den samlede danske udledning af drivhusgasser i 2024 er 36.354 kt CO_2-ækvivalenter (CO_2-ækvivalent) inklusive emissioner fra sektoren Arealanvendelse, ændringer i arealanvendelse og skovbrug (LULUCF) og indirekte CO_2-emissioner. Samme år udgør drivhusgasudledningen fra energisektoren 22.718 kt CO_2-ækvivalent, svarende til 62 % af den samlede udledning. Størstedelen af drivhusgasudledningerne fra energisektoren stammer fra forbrænding af brændsler i energiproducerende anlæg og i transportsektoren. Drivhusgasudledningen fra sektoren Flygtige emissioner er 211 kt CO_2-ækvivalent, i 2024, hvilket svarer til 0,6 % af den samlede danske drivhusgasudledning.

Ud over drivhusgasserne kuldioxid (CO_2), metan (CH_4) og lattergas (N_2O) omfatter opgørelsen over flygtige emissioner fra brændsler også emissioner af svovldioxid (SO_2), kvælstofoxider (NO_x), flygtige organiske forbindelser uden metan (NMVOC), kulilte (CO), partikler (PM), sorte kulstofpartikler (BC), tungmetaller (HM) og persistente organiske miljøgifte (POP'er).

Partikelemissioner beregnes i tre størrelsesfraktioner: total emission af partikler (TSP), partikler med en aerodynamisk diameter under 10 µm (PM_{10}) og partikler med en aerodynamisk diameter under 2,5 µm ($PM_{2,5}$).

Den flygtige sektor bidrager med 17,7 %, 4,4 % og 0,3 % af de nationale samlede emissioner af henholdsvis SO_2, NMVOC og BC. For de øvrige forurenende stoffer er sektorens bidrag til de nationale samlede emissioner meget begrænset (< 0,1 %).

1 Introduction

The Danish emission inventories follow the IPCC Guidelines (IPCC, 2006; IPCC, 2019). The inventories are based on the European programme for emission inventories, the CORINAIR system, which includes methodology, structure and software. The methodology is outlined in the EMEP/EEA Guidebook (EMEP/EEA, 2023). The emission data are stored in a MS Access database, from where it is transferred to the reporting formats.

In the national inventory, the emissions are organised in six categories, according to the reporting formats for the Convention on Long-range Transboundary Pollutants (UNECE CLRTAP) and the United Nations Framework Convention on Climate Change (UNFCCC). These categories cover emissions from Energy, Industrial Processes and Product Use (IPPU), Agriculture, Land use - Land use change and forestry (LULUCF), Waste, and Other. The Danish emission database is organized according to the Selected Nomenclature for Air Pollution (SNAP) as defined in the CORINAIR system. The emission inventories are prepared from a complete emission database based on the SNAP sectors. Aggregation to the sector codes used for both the CLRTAP in accordance with the Nomenclature for Reporting (NFR) and the UNFCCC in accordance with the Common Reporting Tables (CRT) is based on a correspondence list between SNAP and NFR or CRT sectors. Data presented in the present report are based on the Danish emission inventories 2026 including emissions for the year 2024.

Documentation reports for the National Emission Inventory 2026 are published on the homepage for The Danish Centre for Environment and Energy (DCE), Aarhus University, as are annual updated figures on emissions and emission factors:
https://envs.au.dk/en/research-areas/air-pollution-emissions-and-effects/air-emissions/

Furthermore, the data and reports reported can be found on the EIONET homepage:

UNFCCC reporting:
https://unfccc.int/ghg-inventories-annex-i-parties/2026

EU Governance regulation:
https://cdr.eionet.europa.eu/dk/eu/govreg/inventory/

CLRTAP reporting:
https://cdr.eionet.europa.eu/dk/un/clrtap/inventories/

NECD reporting: https://cdr.eionet.europa.eu/dk/eu/nec_revised/

1.1 Total Danish emissions

The national Danish emissions in 2024 as reported to the conventions are summarised in Table 1.1, Table 1.2, Table 1.3 and Table 1.4. The emissions are aggregated on sector level according to the reporting formats.

Table 1.1 GHG emission 2024 as reported to UNFCCC (Nielsen et al., 2026a).

Sector	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3	Total GHG
	kt CO_2 equivalents							
Energy	21 996	313	409					22 718
Industrial Processes and Product Use	1 034	2	51	269	0	12	NO	1 369
Agriculture	185	6 950	4 218					11 353
Land Use, Land-Use Change and Forestry	-572	422	44					-106
Waste	12	837	171					1 021
Denmark Total excl. LULUCF	23 228	8 101	4 849	269	0	12	0	36 460
Denmark Total incl. LULUCF	22 656	8 523	4 893	269	0	12	0	36 354

NO: Not occurring.

Table 1.2 Danish emissions of other air pollutants in 2024 as reported to CLRTAP (Nielsen et al., 2026b).

Sector	NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
					kt				
Energy	60.97	21.34	6.27	1.54	8.45	9.73	11.11	1.42	161.49
Industrial Processes and Product Use	0.04	37.50	0.65	0.38	0.64	2.28	5.53	0.01	1.58
Agriculture	18.35	45.77	0.01	67.50	1.03	8.01	62.84	0.01	0.86
Waste	0.15	0.50	0.34	0.56	0.29	0.30	0.31	0.02	2.36
Other	NO	NO	NO	0.56	NO	NO	NO	NO	NO
Denmark Total	79.50	105.11	7.26	70.54	10.41	20.32	79.79	1.45	166.29

NO: Not occurring.

Table 1.3 Danish emissions of other air pollutants in 2024 as reported to CLRTAP (Nielsen et al., 2026b).

Sector	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
					kt				
Energy	9.85	0.52	0.19	0.14	2.44	66.55	4.13	0.36	47.38
Industrial Processes and Product Use	1.79	0.02	0.01	0.05	0.16	1.89	0.15	0.03	1.67
Agriculture	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Waste	1.73	0.01	0.00	0.00	0.01	0.06	0.01	0.00	6.87
Other	NO	NO	NO	NO	NO	NO	NO	NO	NO
Denmark Total	13.37	0.55	0.20	0.19	2.62	68.49	4.29	0.39	55.93

NO: Not occurring.

Table 1.4 Danish emissions of other air pollutants in 2024 as reported to CLRTAP (Nielsen et al., 2026b).

Sector	Dioxin	Benzo(a)-pyrene	Benzo(b)-fluoranthene	Benzo(k)-fluoranthene	Indeno-(1,2,3-cd)-pyrene	HCB	PCB
				t			
Energy	20.05	1.16	1.28	0.71	0.70	1.64	0.28
Industrial Processes and Product Use	0.08	0.01	0.00	0.00	0.00	0.00	0.04
Agriculture	0.02	0.01	0.01	0.01	0.01	0.31	0.00
Waste	4.15	0.07	0.09	0.05	0.09	0.01	0.03
Other	NO	NO	NO	NO	NO	NO	NO
Denmark Total	24.30	1.24	1.39	0.77	0.80	1.97	0.35

NO: Not occurring.

2 Fugitive emissions from fuels (sector 1B)

2.1 Overview of the sector

The Danish emission inventory for the sector Fugitive emissions from fuels includes emissions from production, storage, refining, transport, venting and flaring of coal, oil and gas. The relevant CRT categories for the Danish fugitive sector are:

- 1B1a Coal mining and handling
- 1B2a Oil
- 1B2b Natural gas
- 1B2c Venting and flaring

Coal mining is not occurring in Denmark for the entire time series, and there are no solid fuel transformation processes such as coke or charcoal production in Denmark. Consequently, the only fugitive emissions related to solid fuels are emissions in connection with the storage and handling.

Denmark has a large domestic production of oil and gas, all production taking place offshore in the North Sea west of Jutland. In addition to the offshore activities, there are two operating refineries in Denmark (a third refinery closed in 1996). Town gas is used to a limited extent in Denmark and today consists of diluted natural gas.

Fuel consumption in the Danish gas treatment plant used for gas heating and drying is included under category 1A1cii (Oil and gas extraction).

All pipeline compressors on the natural gas grid are electric compressors and hence the fuel consumption and emissions, which belong in category 1A3e i Pipeline transport, are not occurring (NO).

Post-meter emissions from start-stop losses from gas engines are included in the stationary combustion sector.

Fugitive emissions from non-fuel sources, e.g. handling of mineral products and agricultural operations, belong in the IPPU sector and the Agriculture sector, and are therefore not included in the fugitive sector.

2.1.1 Greenhouse gas emissions

The total Danish GHG emission in 2024 is 36 354 kt CO_2 eqv. including Land use, Land use change and forestry (LULUCF) and indirect CO_2 emissions. The fugitive sector is a rather small sector in Denmark contributing only little to the national total greenhouse gas emissions. To give an impression of the quantities of the GHG emissions on both national and sectoral level, the fugitive emissions of CO_2, CH_4 and N_2O are given in Table 2.1 as well as the national total GHG emission. Furthermore, the percentage of the national total is included in the table.

Table 2.1 National and fugitive emissions of CO_2, CH_4 N_2O and GHG in 2024, and the fugitive emissions share of national total emissions (Nielsen et al., 2026a).

	National emission kt CO_2 equivalents	Fugitive emission kt CO_2 equivalents	Fugitive/national emission %
CO_2	22 947	111	0.5
CH_4	8 523	100	1.2
N_2O	4 893	0.1	0.0
GHG*	36 354	211	0.6

*Including LULUCF and indirect CO^2.

Fugitive emissions from fuels is a subsector in the energy sector, accounting for 0.6 % of the national total GHG emissions including LULUCF and indirect CO_2 in 2024. The majority of the GHG emissions in the energy sector stem from fuel combustion in energy industries and transport (Table 2.2). Fugitive emissions from fuels arise from extraction, handling, storage, transmission and distribution of solid, liquid, and gaseous fuels. Also, flaring is an important source for fugitive emissions from fuels. Among the facilities that contribute to the fugitive emissions are the oil and gas production facilities in the North Sea, gas storage and treatment plants and refineries. Furthermore, transmission pipelines, distribution networks and gas post-meter emissions are sources of fugitive emissions.

Table 2.2 Emissions of greenhouse gases in the Energy sector in 2024 (Nielsen et al., 2026a).

CRF category		CO_2		CH_4		N_2O		GHG	
		kt	% of total	t	% of total	t	% of total	kt CO_2 eqv.	% of total
1A1	Energy industries	5 959.20	27.1	88.84	28.4	67.94	16.6	6 115.99	26.9
1A2	Manufacturing industries	2 629.51	12.0	14.82	4.7	39.76	9.7	2 684.08	11.8
1A3	Transport	10 544.86	47.9	6.96	2.2	251.17	61.4	10 803.00	47.6
1A4	Other sectors	2 594.97	11.8	101.46	32.4	48.01	11.7	2 744.44	12.1
1A5	Other	157.12	0.7	0.21	0.1	2.12	0.5	159.45	0.7
1B1	Fugitive emissions from solid fuels	NO		NO		NO		NO	
1B2	Fugitive emissions from oil and gas	110.62	0.5	100.42	32.1	0.07	0.0	211.11	0.9
	Sum	21 996.28		312.71		409.07		22 718.06	

NO: Not occurring.

Regarding CRT category 1B1, CH_4 emission from post-mining of coal (storage and transport) should be accounted for in the emission inventory of the mining countries according to the IPCC Guidelines and is therefore not included in the Danish emission inventory.

Emissions of F-gases (HFCs, PFCs, SF_6, and NF_3) are only applicable to the Industrial Processes and Product Use (IPPU) sector, and therefore the total fugitive GHG emission from fuels, expressed as CO_2 eqv., refers to the sum of CO_2, CH_4 and N_2O emissions multiplied by their individual global warming potentials (GWP) of 1, 28 and 265, respectively, as given in the Working Group I Report of IPCC Fifth Assessment Report (IPCC, 2013).

Flaring, the largest contribution being flaring offshore in upstream oil and gas production, is by far the major source of CO_2 in the fugitive sector. The CO_2 emission from offshore flaring in 2024 makes up 84 % of the total GHG emission in the fugitive sector.

The major sources of fugitive emissions of CH_4 are extraction of oil and gas, gas transmission and distribution, flaring in oil and gas extraction, refining of oil, venting in gas storage, and storage of crude oil. The CH_4 emission makes up 45 % of the total GHG emission in the fugitive sector in 2024.

Fugitive emissions of N_2O are dominated by flaring in oil and gas extraction and flaring in refineries, both making up 50 % of the total fugitive N_2O emission in 2024, respectively. The N_2O emission is minor making up 0.04 % of the total GHG emission in the fugitive sector.

2.1.2 Air pollution emissions

The inventory on fugitive emissions from fuels includes emissions of sulphur dioxide (SO_2), nitrogen oxide (NO_x), non-methane volatile organic compounds (NMVOC), carbon monoxide (CO), particulate matter (PM), black carbon (BC), heavy metals (HM), and persistent organic pollutants (POPs). Emissions of particulate matter are estimated in three size fractions; total suspended particulate matter (TSP) and particles with an aerodynamic diameter less than 10 µm (PM_{10}) and less than 2.5 µm ($PM_{2.5}$).

To illustrate the quantities of emissions of air pollutants on both national and sector level, the emissions of SO_2, NO_x, CO, NMVOC, $PM_{2.5}$ and BC are given in Table 2.3. Furthermore, the percentage of the national total is included in the table. The fugitive sector has only minor emissions of NO_x, CO, and PM compared to the total Danish emissions of these components.

Table 2.3 Emissions of selected air pollutants in the fugitive sector and national total emission in 2024, and the share of fugitive to national total emissions (Nielsen et al., 2026b).

	National emission Kt	Fugitive emission kt	Fugitive/national emission %
SO_2	7	1.29	17.7
NO_x	105	0.05	0.0
CO	166	0.10	0.1
NMVOC	105	4.66	4.4
$PM_{2.5}$	10	0.00	0.0
BC	1	0.00	0.3

Refining of oil products (Sulphur recovery) is the major source of fugitive emissions of SO_2, while NO_x and CO mainly come from flaring in upstream oil and gas production and in refineries. The fugitive emissions of NMVOC originate predominantly from refining of oil products, production of oil and natural gas, service stations and storage of crude oil. The major source of TSP emissions in the fugitive sector is storage of solid fuels, due to dust from stockpiles of coal for use in power and heating plants, while $PM_{2.5}$ emissions owe mainly to storage of coal (50 %) and flaring in oil and gas extraction (42 %).

Fugitive emissions are important contributors of SO_2 and NMVOC to the Energy sector (Table 2.4). The main sources for NMVOC in the fugitive sector are refining of oil products contributing 41 %, extraction of oil and gas contributing 33 % and storage of crude oil contributing 5 %. Fugitive SO_2 emissions are predominantly from sulphur recovery (81 %) and flaring in refineries (19 %). Storage of coal is the major source of fugitive emissions of TSP, PM_{10} and BC (80 %, 78 % and 97 %, respectively).

Table 2.4 Emissions of selected air pollutants in the Energy sector in 2024 and share of the total emissions for the Energy sector (Nielsen et al., 2026b).

NFR category		SO_2		NO_x		NMVOC		BC	
		kt	% of total	kt	% of total	kt	% of total	kt	% of total
1A1	Energy Industries	2.73	43.5	13.71	22.5	0.97	4.6	0.03	1.9
1A2	Manufacturing industries and Construction	0.73	11.7	7.02	11.5	1.22	5.7	0.08	5.9
1A3	Transport	0.31	5.0	28.10	46.1	4.76	22.3	0.26	18.6
1A4	Other Sectors	1.15	18.3	11.28	18.5	9.49	44.5	1.03	72.2
1A5	Other	0.06	0.9	0.81	1.3	0.24	1.1	0.02	1.1
1B1	Fugitive Emissions from fuels, Solid fuels	NO		NO		NO		0.00	0.3
1B2	Fugitive Emissions from fuels, Oil and Natural gas	1.29	20.5	0.05	0.1	4.66	21.8	0.00	0.0
Sum		6.27		60.97		21.34		1.42	

NO: Not occurring

2.2 Source category description

According to the IPCC sector definitions the category *fugitive emissions from fuels* is a subcategory under the main category Energy. The category *fugitive emissions from fuels* (Sector 1B) is segmented into subcategories covering emissions from solid fuels *(*coal mining and handling (1B1a), solid fuel transformation (1B1b) and other (1B1c)), oil (1B2a), natural gas (1B2b), venting and flaring *(1B2c)* and other *(1B2d)*. The subcategories relevant for the Danish emission inventory are shortly described below according to Danish conditions:

1B1a Fugitive emission from solid fuels: Coal mining is not occurring in Denmark. Accordingly, only emissions from storage in coal piles are included in the emission inventory.

1B2a Fugitive emissions from oil include emissions from exploration, storage and transmission of crude oil, distribution of oil products, fugitive emissions from refining and from abandoned wells. Emission from oil production is included in gas production in category 1B2b.

1B2b Fugitive emissions from natural gas include emissions from exploration and production of natural gas, transmission and distribution of natural gas, biomethane and town gas, and post-meter emissions.

1B2c Venting and flaring include activities onshore and offshore. Flaring occurs both offshore in upstream oil and gas production, and onshore in gas treatment and storage facilities, in refineries and in natural gas transmission and distribution. Venting occurs in gas treatment and storage facilities. Venting of gas is assumed negligible in oil and gas production and in refineries, as controlled venting enters the gas flare system.

Activity data, emission factors and emissions are stored in the Danish emission database on SNAP categories (Selected Nomenclature for Air Pollution). In Table 2.5 the corresponding SNAP codes and IPCC sectors relevant to

fugitive emissions are shown. Further, the table holds the SNAP names for the SNAP codes and the overall activity (e.g. oil and natural gas).

Table 2.5 Overview of the SNAP codes and the corresponding IPCC sources relevant for fugitive emissions.

SNAP code	SNAP name	NFR code	NFR name	CRT code	CRT name	Activity
040101	Petroleum products processing	1B2a iv	Refining / storage	1B2a4	Refining/storage	Oil
040103	Sulphur recovery plants	1B2a iv	Refining / storage	1B2a4	Refining/storage	Oil
040104	Storage and handling of petroleum production in refinery	1B2a iv	Refining / storage	1B2a4	Refining/storage	Oil
040105	Other	1B2a iv	Refining / storage	1B2a4	Refining/storage	Oil
050103	Storage of solid fuel	1B1a	Coal mining and handling	1B1a	Coal mining and handling	Coal
050204	Exploration of oil	1B2a i	Exploration, production, transport	1B2a1	Exploration	Oil
050206	Offshore loading of oil	1B2a i	Exploration, production, transport	1B2a3	Transport	Oil
050207	Onshore loading of oil	1B2a i	Exploration, production, transport	1B2a3	Transport	Oil
050208	Storage of crude oil	1B2a i	Exploration, production, transport	1B2a4	Refining/storage	Oil
050210	Abandoned wells	1B2a i	Exploration, production, transport	1B2a6i	Other	Oil
050304	Exploration of gas	1B2b	Fugitive emissions from natural gas	1B2b1	Exploration	Gas
050305	Production of gas	1B2b	Fugitive emissions from natural gas	1B2b2	Production	Gas
050503	Service stations (including refuelling of cars)	1B2a v	Distribution of oil products	1B2a5	Distribution of oil products	Oil
050601	Natural gas transmission	1B2b	Fugitive emissions from natural gas	1B2b4	Transmission and storage	Gas
050603	Natural gas distribution	1B2b	Fugitive emissions from natural gas	1B2b5	Distribution	Gas
050604	Town gas distribution	1B2b	Fugitive emissions from natural gas	1B2b5	Distribution	Gas
050606	Post-meter - industrial and power plants	1B2b	Fugitive emissions from natural gas	1B2b6i	Other	Gas
050607	Post-meter - commercial and residential	1B2b	Fugitive emissions from natural gas	1B2b6i	Other	Gas
050608	Post-meter - natural gas fired vehicles	1B2b	Fugitive emissions from natural gas	1B2b6i	Other	Gas
050699	Venting in gas storage	1B2c	Venting and flaring (oil, gas, combined oil and gas)	1B2c1ii	Venting, gas	Venting
090203	Flaring in oil refinery	1B2c	Venting and flaring (oil, gas, combined oil and gas)	1B2c2i	Flaring, oil	Flaring
090206	Flaring in gas and oil extraction	1B2c	Venting and flaring (oil, gas, combined oil and gas)	1B2c2iii	Flaring, combined	Flaring
090298	Flaring in gas storage	1B2c	Venting and flaring (oil, gas, combined oil and gas)	1B2c2ii	Flaring, gas	Flaring
090299	Flaring in gas transmission and distribution	1B2c	Venting and flaring (oil, gas, combined oil and gas)	1B2c2ii	Flaring, gas	Flaring

CRT sector, NFR sector and activity are only given for categories included in the Danish emission inventory.

Table 2.6 summarizes the Danish fugitive emissions in 2024 for selected pollutants. The methodologies, activity data and emission factors used for calculation are described in the following chapters.

Table 2.6 Summary of the Danish fugitive emissions in 2024.

IPCC category	Sector	Pollutant	Emission [t]	Share of total fugitive [%]
1B1a	Storage of solid fuel	TSP	6.40	80.33%
1B1a	Storage of solid fuel	PM_{10}	5.63	78.23%
1B1a	Storage of solid fuel	$PM_{2.5}$	1.54	49.50%
1B1a	Storage of solid fuel	BC	4.26	97.90%
1B2a i	Offshore loading of oil	NMVOC	58.27	1.25%
1B2a i	Offshore loading of oil	CH_4	14.57	<0.01 %
1B2a i	Onshore loading of oil	NMVOC	9.60	<0.01 %
1B2a i	Onshore loading of oil	CH_4	2.40	<0.01 %
1B2a i	Storage of crude oil	NMVOC	211.14	4.53%
1B2a i	Storage of crude oil	CH_4	149.69	4.17%
1B2a i	Storage of crude oil	CO_2	1.44	<0.01 %
1B2a i	Abandoned wells	CH_4	<0.01	<0.01 %
1B2a iv	Petroleum products processing	NMVOC	1 913.00	41.06%
1B2a iv	Petroleum products processing	CH_4	250.00	6.97%
1B2a iv	Sulphur recovery plants	SO_2	1 037.71	80.61%
1B2a iv	Other	CO_2	107.00	<0.01 %
1B2a v	Service stations (including refuelling of cars)	NMVOC	617.00	13.24%
1B2b	Production of gas	NMVOC	1 549.18	33.25%
1B2b	Production of gas	CH_4	1 752.42	48.86%
1B2b	Production of gas	CO_2	39.36	<0.01 %
1B2b	Natural gas transmission	NMVOC	33.12	0.71%
1B2b	Natural gas transmission	CH_4	159.35	4.44%
1B2b	Natural gas transmission	CO_2	9.54	<0.01 %
1B2b	Natural gas distribution	NMVOC	114.85	2.46%
1B2b	Natural gas distribution	CH_4	553.24	15.43%
1B2b	Natural gas distribution	CO_2	33.15	<0.01 %
1B2b	Town gas distribution	NMVOC	22.22	<0.01 %
1B2b	Town gas distribution	CH_4	27.01	0.75%
1B2b	Town gas distribution	CO_2	1.62	<0.01 %
1B2b	Post-meter - industrial and power plants	NMVOC	0.01	<0.01 %
1B2b	Post-meter - industrial and power plants	CH_4	2.75	<0.01 %
1B2b	Post-meter - industrial and power plants	CO_2	<0.01	<0.01 %
1B2b	Post-meter - commercial and residential	NMVOC	7.08	<0.01 %
1B2b	Post-meter - commercial and residential	CH_4	71.47	1.99%
1B2b	Post-meter - commercial and residential	CO_2	0.69	<0.01 %
1B2b	Post-meter - natural gas fired vehicles	NMVOC	0.01	<0.01 %
1B2b	Post-meter - natural gas fired vehicles	CH_4	0.20	<0.01 %
1B2b	Post-meter - natural gas fired vehicles	CO_2	<0.01	<0.01 %
1B2c	Venting in gas storage	NMVOC	50.48	1.08%
1B2c	Venting in gas storage	CH_4	242.09	6.75%
1B2c	Venting in gas storage	CO_2	14.50	<0.01 %
1B2c	Flaring in oil refinery	SO_2	249.40	19.37%
1B2c	Flaring in oil refinery	NO_X	10.54	20.26%
1B2c	Flaring in oil refinery	NMVOC	21.66	<0.01 %
1B2c	Flaring in oil refinery	CH_4	5.14	<0.01 %

Continued

1B2c	Flaring in oil refinery	CO	37.69	39.55%
1B2c	Flaring in oil refinery	CO_2	16 076.73	14.53%
1B2c	Flaring in oil refinery	N_2O	0.13	49.85%
1B2c	Flaring in oil refinery	TSP	0.25	3.17%
1B2c	Flaring in oil refinery	PM_{10}	0.25	3.51%
1B2c	Flaring in oil refinery	$PM_{2.5}$	0.25	8.13%
1B2c	Flaring in oil refinery	BC	0.06	1.40%
1B2c	Flaring in gas and oil extraction	SO_2	0.17	<0.01 %
1B2c	Flaring in gas and oil extraction	NO_X	40.86	78.50%
1B2c	Flaring in gas and oil extraction	NMVOC	50.82	1.09%
1B2c	Flaring in gas and oil extraction	CH_4	350.79	9.78%
1B2c	Flaring in gas and oil extraction	CO	56.80	59.61%
1B2c	Flaring in gas and oil extraction	CO_2	93 177.53	84.22%
1B2c	Flaring in gas and oil extraction	N_2O	0.13	49.53%
1B2c	Flaring in gas and oil extraction	TSP	1.30	16.27%
1B2c	Flaring in gas and oil extraction	PM_{10}	1.30	18.01%
1B2c	Flaring in gas and oil extraction	$PM_{2.5}$	1.30	41.78%
1B2c	Flaring in gas and oil extraction	BC	0.03	0.69%
1B2c	Flaring in gas storage	SO_2	0.01	<0.01 %
1B2c	Flaring in gas storage	NO_X	0.63	1.20%
1B2c	Flaring in gas storage	NMVOC	0.69	<0.01 %
1B2c	Flaring in gas storage	CH_4	5.06	<0.01 %
1B2c	Flaring in gas storage	CO	0.78	0.81%
1B2c	Flaring in gas storage	CO_2	1 136.20	1.03%
1B2c	Flaring in gas storage	N_2O	<0.01	0.60%
1B2c	Flaring in gas storage	TSP	0.02	<0.01 %
1B2c	Flaring in gas storage	PM_{10}	0.02	<0.01 %
1B2c	Flaring in gas storage	$PM_{2.5}$	0.02	0.57%
1B2c	Flaring in gas storage	BC	<0.01	<0.01 %
1B2c	Flaring in gas transmission and distribution	SO_2	<0.01	<0.01 %
1B2c	Flaring in gas transmission and distribution	NO_X	0.02	<0.01 %
1B2c	Flaring in gas transmission and distribution	NMVOC	0.02	<0.01 %
1B2c	Flaring in gas transmission and distribution	CH_4	0.17	<0.01 %
1B2c	Flaring in gas transmission and distribution	CO	0.03	<0.01 %
1B2c	Flaring in gas transmission and distribution	CO_2	36.73	<0.01 %
1B2c	Flaring in gas transmission and distribution	N_2O	<0.01	<0.01 %
1B2c	Flaring in gas transmission and distribution	TSP	<0.01	<0.01 %
1B2c	Flaring in gas transmission and distribution	PM_{10}	<0.01	<0.01 %
1B2c	Flaring in gas transmission and distribution	$PM_{2.5}$	<0.01	<0.01 %
1B2c	Flaring in gas transmission and distribution	BC	<0.01	<0.01 %

3 Methodology

The following chapters give descriptions on the methods of calculation used in the Danish emission inventory.

3.1 Fugitive emissions from solid fuels

The emissions of PM and BC from storage of coal are estimated based on the imported amount of coal and emission factors for TSP, PM_{10}, $PM_{2.5}$ and BC (Equation 1).

Equation 1

$$E_{coal\ storage} = EF_{coal\ storage} \cdot AD_{coal}$$

where $EF_{coal\ storage}$ is the emission factor for storage of coal in coal piles and AD_{coal} is the amount of coal imported in the actual year.

3.2 Fugitive emissions from oil

The fugitive emissions from oil derive from exploration, refining, storage and handling of oil, and from abandoned oil/gas wells (Equation 2). Emissions from offshore activities include emissions from exploration, abandoned wells and offshore loading of ships. Transport and storage cover emissions from the crude oil terminal, onshore loading of ships at the harbour terminal and a small number of abandoned wells. Service stations are a source of emissions from reloading of tanker trucks and refuelling of vehicles. The emissions from refineries include fugitive losses from the petroleum products processing. Emissions from oil production is included in gas production in category 1B2b (see Chapter 3.3.2). The offshore production sites all produce both oil and gas, and therefore it is not possible to split the production emissions between oil and gas. Emissions from flaring in refineries and in oil production are included in the Chapter 3.4. The total fugitive emission from oil can be expressed as:

Equation 2

$$E_{oil} = E_{exploration} + E_{loading\ of\ ships} + E_{oil\ terminal} + E_{servive\ stations} + E_{refineries} + E_{abandoned\ wells}$$

where $E_{oil\ terminal}$ covers the emissions from transport in pipelines and storage in tanks at the crude oil terminal and where $E_{refineries}$ does not include emissions from flaring.

3.2.1 Exploration of oil

Exploration of oil and gas in the North Sea involves the drilling and preparing of exploration and appraisal wells (E/A wells), which leads to fugitive emissions. The oil and gas operators provide information to the Danish Energy Agency (DEA) for each exploration drilling, including volume of oil and gas extracted. All oil and gas from exploration drilling is flared on-site. Oil and gas composition is available for most E/A wells. As calorific values and densities are not available per drilling, data from a gas test in 1992 are applied.

3.2.2 Production of oil

Emissions from production of oil are included in the category Production of gas (see Chapter 3.3.2).

3.2.3 Loading of ships

Fugitive emissions of CH_4 and NMVOC from loading of ships include the transfer of oil from storage tanks or directly from the well into ships. The activity also includes losses during transport. When oil is loaded, hydrocarbon vapour will be displaced by oil, and new vapour will be formed, both leading to emissions. Vapour recovery units might be installed to reduce the emissions, which is reflected in the applied emission factors. The emissions from ships are calculated by Equation 3.

Equation 3

$$E_{loading} = EF_{offshore\ loading} \cdot AD_{offshore\ loading} + EF_{onshore\ loading} \cdot AD_{onshore\ loading}$$

where EF is the emission factor for loading of ships and AD is the amount of oil loaded.

3.2.4 Crude oil terminal

Crude oil produced in the North Sea is transported to the Danish crude oil terminal via pipeline and the remaining part is loaded to ships offshore. Pipeline transport accounted for 48 % of the production in 2024, while pipeline oil made up more that 80 % of the oil production before 2021. The CH_4 and NMVOC emissions from the crude oil terminal, covering storage and handling of crude oil, are given in annual reports for the crude oil terminal from DONG Oil Pipe A/S until 2017. Data for 2018 and onwards are collected via personal communication, as annual reports are no longer prepared. An implied emission factor is calculated for use in the reporting template based on the amount of oil transported in pipelines according to Equation 4.

Equation 4

$$IEF_{oil\ terminal} = \frac{E_{oil\ terminal}}{AD_{pipeline\ oil}}$$

where $IEF_{oil\ terminal}$ is the implied emission factor for storage of crude oil in tanks, $E_{oil\ terminal}$ is the emission, and $AD_{pipeline\ oil}$ is the amount of oil transported by in the pipeline from the offshore production sites to the crude oil terminal.

3.2.5 Service stations

NMVOC emissions from service stations are estimated as outlined in Equation 5.

Equation 5

$$E_{service\ stations} = (EF_{reloading} + EF_{refueling}) \cdot AD_{gasoline}$$

where $EF_{reloading}$ is the emission factor for reloading of tankers to storage tanks at the service stations, $EF_{refuelling}$ is the emission factor for refuelling of vehicles, and $AD_{gasoline}$ is the amount of gasoline used for road transport. The emission

calculation is dependent on true vapour pressure (TVP), which again depends on the Reid vapour pressure (RVP) and the temperature (T), according to Equation 6.

Equation 6

$$TVP = \mathrm{RVP} \cdot 10^{AT+B}$$

where $A = 0.000007047 \cdot \mathrm{RVP} + 0.0132$, $B = 0.0002311 \cdot \mathrm{RVP} - 0.5236$, T is the temperature in °C, and RVP is the Reid Vapour Pressure in kPa. The parameters refer to the 2023 EMEP/EEA Guidebook.

3.2.6 Oil refining

When oil is processed in refineries, part of the volatile organic compounds (VOC) is emitted to the atmosphere. VOC emissions from the oil refinery process include non-combustion emissions from handling and storage of feedstock (crude oil), from the petroleum product processing and from handling and storage of products. VOC emissions are provided by the refineries. Only one of the two refineries has made a split between NMVOC and CH_4. For the other refinery it is assumed that 10 % of the VOC emission is CH_4 (Hjerrild & Rasmussen, 2014).

Both the non-combustion processes, including product processing, and the sulphur recovery plants emit SO_2. The SO_2 emissions are calculated by the refineries based on oil balance, measured sulphur content in products and fuels, flow measurements in sulphur recovery plants and key figures in environmental approvals.

Emissions from flaring in refineries are included in the category venting and flaring (Chapter 3.4). Emissions related to process furnaces in refineries are included in the stationary combustion sector (Nielsen, 2026).

3.2.7 Abandoned wells

Most Danish abandoned wells are located offshore and have been plugged. Numbers of abandoned wells abandoned are provided by the DEA including information about onshore/offshore and plugged/unplugged. The total fugitive emission from abandoned wells can be expressed as:

Equation 7

$$E_{abandoned\ wells} = E_{onshore\ plugged} + E_{onshore\ unplugged} + E_{offshore\ plugged} + E_{offshore\ unplugged}$$

3.3 Fugitive emissions from gas

The emissions from gas derive from offshore activities in gas production, transmission of natural gas and biomethane, distribution of natural gas, biomethane and town gas and gas post-meter emissions (Equation 8). Emissions from venting and flaring in gas transmission and distribution and venting and flaring in gas treatment and storage are included in the category Venting and flaring (Chapter 3.4). The total emission can be expressed as:

Equation 8

$$E_{gas} = E_{exploration} + E_{production} + E_{transmission} + E_{distribution} + E_{post-meter}$$

3.3.1 Exploration of gas

Exploration of oil and gas in the North Sea involves the drilling and preparation of E/A wells, which leads to fugitive emissions. The oil and gas operators provide information to the DEA for each exploration drilling, including volume of oil and gas extracted. Oil and gas from exploration drilling is flared on-site or lead to existing production facilities. Oil and gas composition is available for most drillings. As calorific values and densities are not available per drilling, data from a gas test in 1992 are applied.

3.3.2 Production of gas

Production of oil and gas takes place offshore in the Danish part of the North Sea. All offshore production facilities produce both oil and gas. As the equipment leaks are related to both oil and gas production it is not possible to split the emissions between production of oil and gas, respectively. Estimation of emissions from oil and gas production is based on information from the Danish operators, e.g. company inventories, LDAR reports and information from measurement campaigns. Production figures are published by the Danish energy agency on facility level.

3.3.3 Transmission of gas

The fugitive emission from transmission and storage of natural gas and biomethane is based on information from the gas transmission company. Gas transmission is handled by one company, which provides data on the transported amount, the length and material of the pipeline system, flared amounts, fugitive losses from pipelines and emissions from the storage and treatment plants.

The annual average gas quality for pipeline gas transmitted in Denmark is published by Energinet.dk. The calculations account for the share of admixed biomethane.

3.3.4 Distribution of gas

The fugitive emission from distribution of natural gas, biomethane and town gas is based on information from the gas distribution companies. Natural gas distribution is handled by one company (a fusion in the later years of the four previous distribution companies). Town gas distribution is handled by two companies (in earlier years another two companies handled town gas distribution). All distribution companies deliver data on the transported amount, the length and material of the pipeline systems and gas amounts flared.

The fugitive losses from pipelines are only given for some companies. The available distribution data are used for the remaining companies too. Emissions are calculated from the fugitive losses from the distribution pipelines and the annual average gas quality for pipeline gas transmitted in Denmark measured and published by Energinet.dk according to the calculated weight percent of CH_4 and NMVOC. The same approach is used for town gas, which is natural gas admixed ~ 50 % ambient air. Town gas makes only a small contribution to the total gas distribution (less than 1 % of the total distribution in energy units). The calculations account for the share of admixed biomethane.

Calculations of emissions from distribution of town gas are based on data from the companies on distribution losses. At present, there are two areas

with town gas distribution having separate distribution companies. Two other companies in different areas were closed in 2004 and 2006, and it has therefore not been possible to collect data for all years in the time series. The emissions have been calculated for the years with available data and the distribution loss for the first year with data has been applied for the previous years in the time series. Data are missing for the later years (1996-2003) for one of the distribution companies. The distribution amount is assumed to decrease linearly to zero over these years, and the ratio "distribution loss/distribution amount" is assumed equal to the value for 1995. The calculations account for the share of admixed biomethane.

3.3.5 Post-meter emissions

Post-meter emissions include three categories: Industry and power plants, Residential and commercial appliances, and Natural gas fired vehicles. Activity data are the annual sectoral gas consumptions according to the energy statistics and the annual numbers of natural gas fired vehicles in accordance with the numbers used in the emission inventory for mobile sources. Post-meter emissions for appliances and power plants include leakage emissions beyond gas meters, such as internal piping and end-of-pipe appliances (e.g. boilers and stoves). Emissions from start-stop losses from gas engines are included in the stationary combustion sector. Post-meter emissions for natural gas-fueled vehicles include releases from dead volumes during fueling, venting of high-pressure interim storage units, gas discharge during pressure testing and release from vehicles' gas tanks for pressure tests or decommissioning.

3.4 Venting and flaring

Venting and flaring occur in oil and gas production, at oil refineries and in connection with treatment, transmission and distribution of natural gas (Equation 9). Flaring is used for safety reasons on offshore oil and gas production sites, in refineries and at the natural gas treatment plant. Venting occurs at the two underground natural gas storage facilities. The total emission can be expressed as:

Equation 9

$$E = E_{venting} + E_{flaring\ in\ refinery} + E_{flaring\ in\ oil/gas\ production} + E_{flaring\ in\ gas\ handling\ and\ transport}$$

Emissions from flaring are estimated from the amount of gas flared offshore (7 fields), in gas treatment and storage plants (1 and 2 plants, respectively), in refineries (2 plants), and in gas transmission (1 company), storage (1 company), and distribution (1 company), combined with corresponding emission factors. From 2006 data on flaring in upstream oil and gas production is given in the reports for the European Union Greenhouse Gas Emission Trading System (EU ETS) and thereby flaring can be split to the individual production units. Before 2006 only the total flared amount is available from DEA. Flaring in refineries and in gas transmission, storage and distribution are given in annual environmental reports from the relevant companies and plants or collected via personal communication with the companies.

3.5 Use of EU-ETS data

Reporting to the European Union Greenhouse Gas Emission Trading System (EU ETS), concerning fugitive emissions, is available in the annual EU ETS reports for upstream oil and gas extraction facilities, refineries and the natural

gas treatment plant. EU ETS data are only included in the national emission inventory if higher tier methodologies are applied, which is the case for all EU ETS reports relevant for the refineries and for offshore facilities. The EU ETS data used are fully in line with the requirements in the IPCC Guidelines and are considered the best data source on CO_2 emission factors due to the legal obligation for the relevant companies to make the accounting following the Commission Implementing Regulation on the monitoring and reporting of greenhouse gas emissions (European Commission, 2025). The EU ETS data are thereby a source of consistent data with low uncertainties. Unfortunately, corresponding data do not exist before the commencement of EU ETS in 2006 and therefore it is not possible to set up time series based only on EU ETS. Appropriate methods from the IPCC Guidelines have been selected to ensure time series consistency and described in the chapters for the specific sources. Further information on EU ETS is included in the following sections.

3.5.1 EU ETS reports for refineries

Activity data are measured with flow meters and rates are reported with high accuracy using the Tier 4 methodology (uncertainty ±1.5 %) for large sources and Tier 3 (uncertainty ±2.5 %) or Tier 2 (uncertainty ±5 %) for small sources. The oxidation factor is set to 1, corresponding the Tier 1 methodology.

CO_2 emission factors for fuel combustion follow the Tier 3 methodology (uncertainty ±2.5 %) is applied for most sources including all major sources, and the Tier 2a and 2b methodology (uncertainty ±5 %) is applied only for some minor or insignificant sources using diesel or butane. CO_2 emission factors for flaring follow the Tier 3 methodology (uncertainty ±2.5 %) and the Tier 2b (uncertainty ±5 %) methodology (uncertainty ±5 %). Few insignificant sources (pilot gas and KCP off gas) use a lower Tier methodology than required due to unreasonable costs to comply with the requirements. The oxidation factor is set to 1, corresponding the Tier 1 methodology.

3.5.2 EU ETS reports for offshore installations

Activity data for fuel combustion are measured with flow meters and rates are reported with high accuracy. The Tier 4 methodology (uncertainty ±1.5 %) is required, but for some sources, including few larger sources, a lower Tier methodology is used due to unreasonable costs to comply with the requirements. Activity data for flaring are required to use Tier 3 methodology (uncertainty ±7.5 %), but for some sources, a lower Tier methodology is used as it is not technical feasible to comply with 7.5 % uncertainty or due to unreasonable costs to comply with the requirements. CO_2 emission factors for fuel combustion follow the Tier 3 methodology, which is activity specific, for gas, while the country specific Tier 2a methodology is applied for diesel. CO_2 emission factors for flaring are calculated using the Tier 2b methodology. The oxidation factor is set to 1, corresponding the Tier 1 methodology.

4 Activity data, emission factors and emissions

The following paragraphs describe the methodology for emission calculation for fugitive sources, including activity data, emission factors and annual emissions. The order follows the reporting structure (1B1 Solid fuels, 1B2a Oil, 1B2b Natural gas, 1B2c Venting and flaring), with the exception that exploration of gas are included in the paragraph for exploration of oil, due to similar methodologies and data providers, and that production of oil are included in the paragraph for production of gas as the emissions cannot be split because all Danish offshore facilities produce both oil and gas.

4.1 Fugitive emissions from solid fuels (1B1)

- *Storage of solid fuel: snap 050103, NFR 1B1a, CRT 1B1a*

Coal mining is not occurring in Denmark, and emissions from solid fuels only include particulate matter and black carbon from storage of coal in piles.

4.1.1 Activity data

Coal production is not occurring in Denmark. The annual total amount of coal used is included in the import statistics provided by the Danish Energy Agency (2025b). Coal is primarily (>90 %) used in power plants, and the annual fluctuations in the import rates mainly owe to variations in electricity import/export and temperature variations. The time series shows a decreasing trend due to a shift of fuels in power and heat production from coal and oil to natural gas, waste and biomass (Figure 4.1.1). The increase in 2022 owes to Danish policy regarding energy security, where the Danish government allowed two power plants to burn coal and oil.

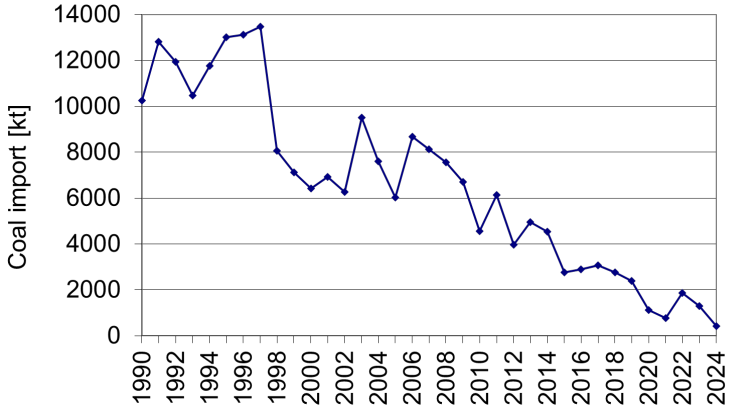


Figure 4.1.1 Import of coal.

4.1.2 Emission factors

The emission factors are listed in Table 4.1. Emissions of particulate matter (PM) from coal storage are estimated using emission factors from the Coordinated European Particulate Matter Emission Inventory Program, CEPMEIP (Visschedijk et al., 2004). Abatement technologies are used to reduce the dust from coal storage, e.g. wind protection and spraying of water with or without additives. According to the Integrated Pollution Prevention and Control

Reference Document on Best Available Techniques on Emissions from Storage July 2006 (European Commission, 2006) the abatement efficiency is 80-95 % for spraying with water without additives and 90-99 % for spraying with water with additives. The US-EPA (1996) include efficiency of using water sprays and chemical stabilizer or wetting agents, respectively, both given as 40 % for $PM_{2.5}$. The abatement efficiencies of 90 % for TSP and 40 % for $PM_{2.5}$ are used in the Danish emission inventory and 78 % is applied for PM_{10} (average of the efficiencies for TSP and $PM_{2.5}$).

Denmark has a long tradition for environmental awareness and regulation. There has been focus on dust from coal storage as early as in the 1980s because most of the large coal piles are in or near urban areas, where the large harbours and coal-fired plants are located. Because of the early awareness and regulation, the emission reducing due to use of abatement technologies are applied for the years 1990 forward.

The BC emission factor is estimated as a fraction of the TSP emission factor, based on characteristics for other bituminous coal included in the 2006 IPCC Guidelines Volume 2, Chapter 1 (Equation 10).

Equation 10

$$EF_{BC} = EF_{TSP} \cdot C \cdot H \cdot 0.001$$

where EF_{BC} is the emission factor for BC [g/Mg], EF_{TSP} is the emission factor for TSP [g/Mg], C is the carbon content [kg C/GJ], and H is the heating value [GJ/Mg]. The EF_{BC} estimation is based on C = 25.8 kg C/GJ and H = 25.8 GJ/Mg, as given for other bituminous coal in IPCC (2006).

The estimated BC emission factor exceeds the $PM_{2.5}$ and the PM_{10} emission factors as coal dust for the major part consist of larger particles. For combustion sources, the BC emission factor does not exceed the $PM_{2.5}$ emission factor. While coal dust is not BC in the traditional sense (from incomplete combustion), it is carbon that is primarily dark black in colour and absorbs across the visible spectrum (Khan et al., 2017). According to the Reporting Guidelines (UNECE, 2015), BC is defined as follows: " "Black carbon" (BC), which means carbonaceous particulate matter that absorbs light".

The same abatement efficiency is applied for BC as for TSP, as the BC emission factor is based on the TSP emission factor.

Table 4.1 Emission factors used to estimate particulate emissions from coal storage.

	TSP	PM_{10}	$PM_{2.5}$	BC
Emission factor, unabated [g/Mg]	150	60	6	100
Abatement efficiency [%]	90	78	40	90
Emission factor, abated [g/Mg]	15	13,2	3,6	10

4.1.3 Emissions

Emissions from coal storage (Figure 4.1.2) are proportional to the import rates. The causes of the variations are described above.

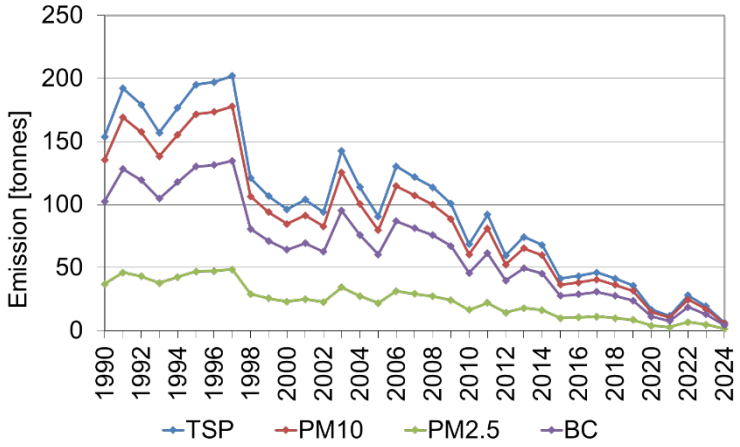


Figure 4.1.2 Emissions from coal storage.

4.2 Fugitive emissions from oil (1B2a)

The emissions from oil derive from exploration, production, onshore and offshore loading of ships, onshore crude oil tanks, service stations and refineries. Exploration of gas is included in the description in this paragraph, while the methodology for production of oil is included in Chapter 4.3.2 with the methodology for production of gas.

Oil and natural gas production take place offshore in the Danish part of the North Sea. Most of the oil and gas produced at the North Sea are brought ashore by pipeline; gas is led to the Nybro gas terminal and oil is led to the terminal in Fredericia (Figure 4.2.1). Oil is brought ashore by ship from the Siri platform.

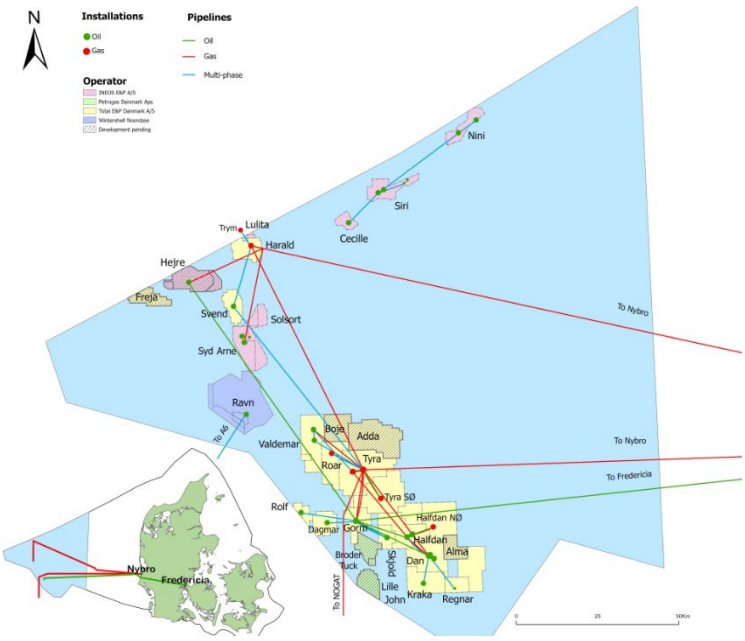


Figure 4.2.1 Production facilities in the North Sea (Danish Energy Agency, 2025c).

4.2.1 Exploration of oil

- *Snap 050204, NFR 1B2ai, CRF 1B2a1*

Activity data

Activity data for oil and gas exploration are provided annually by the Danish Energy Agency. Exploration of oil and gas is given separately for each exploration drilling and fluctuate significantly over the time series. The largest gas exploration rates are seen for 1990, 2002 and 2005, while relatively large oil exploration rates are seen for more years of the time series. In 2002 there were three E/A wells of which one had a large gas exploration amount of 8.4 million Nm^3. Even though the Svane-1 well encountered large gas deposits, this has not been been extracted due to the extreme environment of the high-depth and high-pressure deposit. Explored rates are shown in Figure 4.2.2.

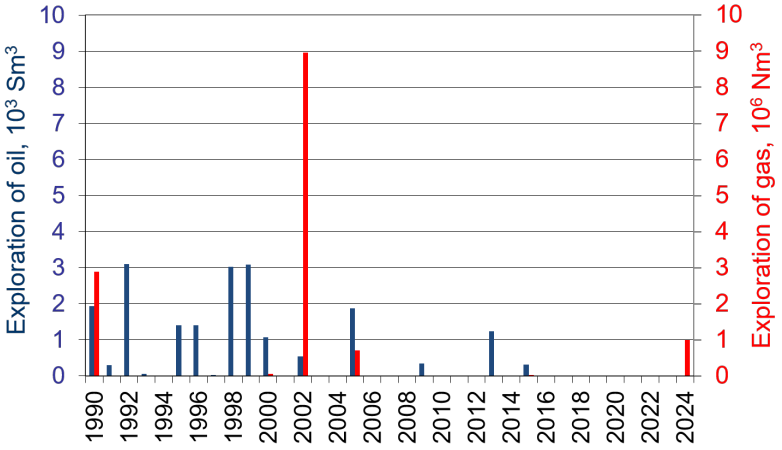


Figure 4.2.2 Exploration of oil and gas.

Emission factors

Year specific CO_2 emission factors are based on composition data, calorific values and densities for explored oil and gas provided by the Danish Energy Agency. Composition data are available for the E/A wells separately, except for a few E/A wells, for which the compositions for the previous E/A well are used for emission calculation. As calorific values and densities are not available per drilling, data from a gas test in 1992 are used. CO_2 emission factors are listed in Table 4.2.

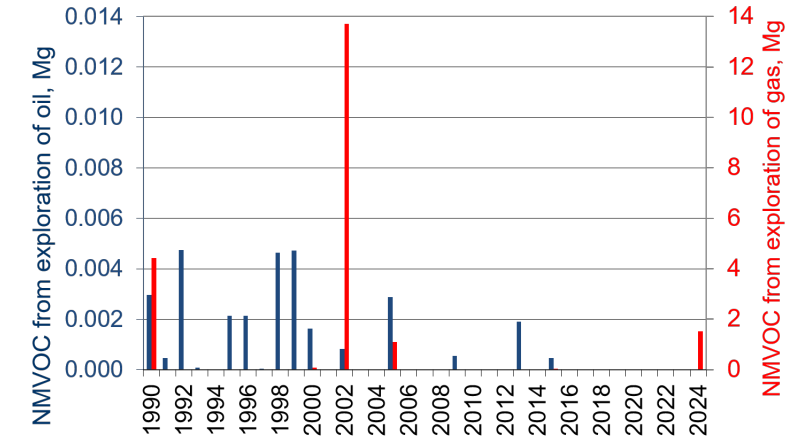
Emission of other pollutants are calculated from the same emission factors that are used for flaring in upstream oil and gas production. Further description on the emission factors, which are based on the Danish EPA (2008) and EMEP/EEA (2023), is included in Chapter 4.4.3, and the emission factors are listed in Table 4.2.

Table 4.2 Annual CO_2 emission factors for years with exploration of oil and gas.

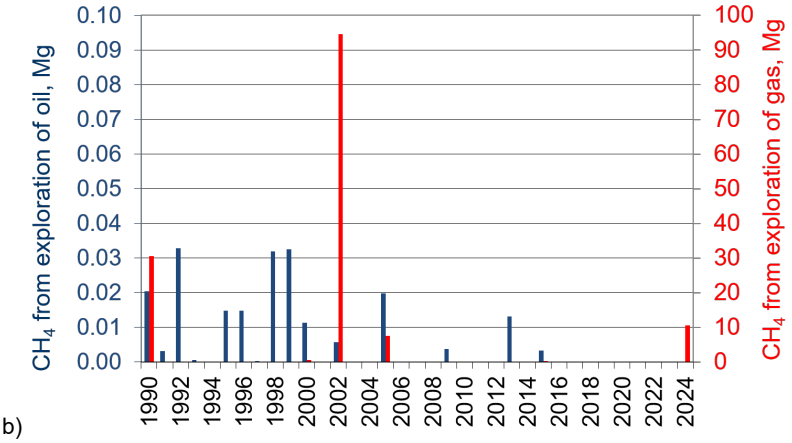
	1990	1991	1992	1993	1994	1995	1996	1997
EF(CO_2), exploration of oil, kg/Sm^3	2433	2437	2441	2441	2437	2449	2449	2449
EF(CO_2), exploration of gas, kg/Nm^3	2.85	2.81	2.84	2.93	2.81	2.94	2.94	2.94
continued	1998	1999	2000	2002	2005	2009	2013	2015
EF(CO_2), exploration of oil, kg/Sm^3	2445	2449	2449	2442	2444	2449	2449	2449
EF(CO_2), exploration of gas, kg/Nm^3	2.93	2.94	2.94	2.92	2.89	2.82	2.82	2.82

Emissions

Calculated NMVOC and CH_4 emissions from exploration of oil and gas are shown in Figure 4.2.3. There is no correlation between emissions from oil and gas, as the individual exploration drillings have different ratios between oil and gas rates.



a)



b)

Figure 4.2.3 NMVOC (a) and CH_4 (b) emissions from exploration of oil and gas.

4.2.2 Production of oil

- *Snap 050205, NFR 1B2ai, CRT 1B2a2*

Emissions from production of oil are included in production of gas, because emissions from production of oil and gas cannot be split as all Danish offshore facilities produce both oil and gas. See Chapter 4.3.2.

4.2.3 Loading of ships

- *Offshore loading: Snap 050206, NFR 1B2ai, CRT 1B2a3*
- *Onshore loading: Snap 050207, NFR 1B2ai, CRT 1B2a3*

Fugitive emissions of oil transport include loading of ships from storage tanks or directly from the production sites.

Activity data

Activity data for loading offshore and onshore are provided by the DEA (Danish Energy Agency, 2025a) and from the annual self-regulating reports and supporting information from Danish Oil Pipe A/S (Boesen, 2025), respectively.

The rates of oil loaded offshore to ships roughly follow the trend of the oil production (Figure 4.2.4). Offshore loading of ships was introduced in 1999. In earlier years, the produced oil was transported to land via pipeline.

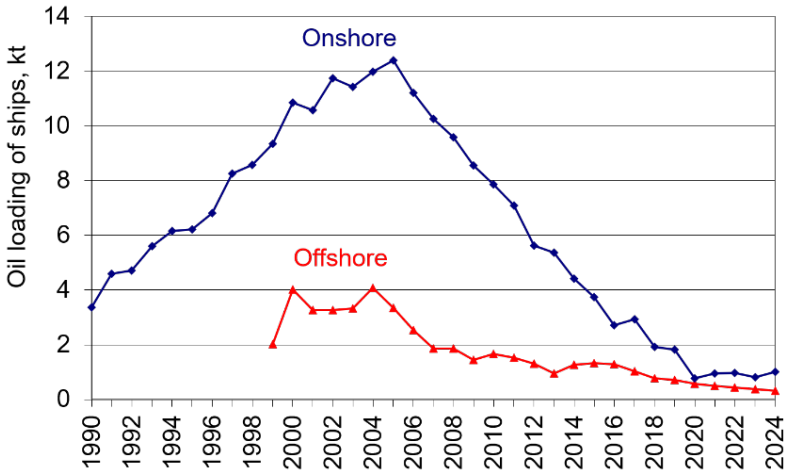


Figure 4.2.4 Onshore and offshore loading of ships.

Emission factors

Emissions from offshore loading are based on the default emission factors for offshore loading of ships from the 2019 IPCC Refinement (IPCC, 2019). A 50/50 split between loading with/without VRU is assumed in the emission calculations, with a change to 100 % VRU from 2021 according to the operator.

Emission factors for onshore loading are based on annual reports from the Harbour Terminal for the years 2012 onwards; A/S Dansk Shell 2013-2021 and Crossbridge 2022-2025 (Table 4.3), which include loaded amounts, standard NMVOC emission factors and emissions of NMVOC (2013-2017) or VOC (2019-2020). The emission factor for 2012 is applied for the earlier years in the time series. The NMVOC emission factor shows a significant decrease from 2016 to 2019 due to installation of a new vapour recovery unit (VRU) during 2017. No emissions were reported for 2018 and has thus been estimated according to the environmental approval for VRU2 (Danish EPA, 2017), which include a requirement of 85 % emission reduction of the VRU2. For years with only VOC emission data, NMVOC and CH_4 emissions assume that NMVOC make up 80 % of VOC, in accordance with the annual reports for the harbour terminal. Emission factors for loading of ships offshore and onshore are listed in Table 4.3

Table 4.3 Emission factors for loading of ships offshore and onshore.

Source	Pollutant	Emission factor	Unit	Reference
Ships offshore, 1990-2020	NMVOC	0.63	Mg/1000 m3 oil loaded	IPCC, 2019
Ships offshore, 2021 onwards	NMVOC	0.16	Mg/1000 m3 oil loaded	IPCC, 2019
Ships onshore, 1985-2012	NMVOC	584	g/ton oil loaded	A/S Dansk Shell - Havneterminalen, 2013
Ships onshore, 2013	NMVOC	587	g/ton oil loaded	A/S Dansk Shell - Havneterminalen, 2014
Ships onshore, 2014-2016	NMVOC	584	g/ton oil loaded	A/S Dansk Shell - Havneterminalen, 2015, 2016, 2017
Ships onshore, 2017	NMVOC	334	g/ton oil loaded	A/S Dansk Shell - Havneterminalen, 2018
Ships onshore, 2018	NMVOC	88	g/ton oil loaded	A/S Dansk Shell - Havneterminalen, 2019 Danish EPA, 2017
Ships onshore, 2019	NMVOC	7	g/ton oil loaded	A/S Dansk Shell - Havneterminalen, 2020
Ships onshore, 2020	NMVOC	8	g/ton oil loaded	A/S Dansk Shell - Havneterminalen, 2021
Ships onshore, 2021	NMVOC	10	g/ton oil loaded	Crossbridge - Havneterminalen, 2022
Ships onshore, 2022	NMVOC	10	g/ton oil loaded	Crossbridge - Havneterminalen, 2023
Ships onshore, 2023	NMVOC	7	g/ton oil loaded	Crossbridge - Havneterminalen, 2024
Ships onshore, 2024	NMVOC	10	g/ton oil loaded	Crossbridge - Havneterminalen, 2025
Ships offshore, 1990-2020	CH_4	0.0525	Mg/1000 m3 oil loaded	IPCC, 2019
Ships offshore, 2021 onwards	CH_4	0.04	Mg/1000 m3 oil loaded	IPCC, 2019
Ships onshore, -2012	CH_4	146	g/ton oil loaded	A/S Dansk Shell - Havneterminalen, 2013
Ships onshore, 2013	CH_4	147	g/ton oil loaded	A/S Dansk Shell - Havneterminalen, 2014
Ships onshore, 2014-2016	CH_4	146	g/ton oil loaded	A/S Dansk Shell - Havneterminalen, 2015, 2016, 2017
Ships onshore, 2017	CH_4	84	g/ton oil loaded	A/S Dansk Shell - Havneterminalen, 2018
Ships onshore, 2018	CH_4	22	g/ton oil loaded	A/S Dansk Shell - Havneterminalen, 2019 Danish EPA, 2017
Ships onshore, 2019	CH_4	1.8	g/ton oil loaded	A/S Dansk Shell - Havneterminalen, 2020
Ships onshore, 2020	CH_4	2.1	g/ton oil loaded	A/S Dansk Shell - Havneterminalen, 2021
Ships onshore, 2021	CH_4	2.6	g/ton oil loaded	Crossbridge - Havneterminalen, 2022
Ships onshore, 2022	CH_4	2.4	g/ton oil loaded	Crossbridge - Havneterminalen, 2023
Ships onshore, 2023	CH4	2.1	g/ton oil loaded	Crossbridge - Havneterminalen, 2024
Ships onshore, 2024	CH_4	2.4	g/ton oil loaded	Crossbridge - Havneterminalen, 2025

Emissions

NMVOC emissions from loading of ships offshore and onshore are shown in Figure 4.2.5. Emissions from offshore loading fluctuates with the amount of oil, while emissions from onshore loading also reflect the technological improvements (VRU) at the harbour terminal.

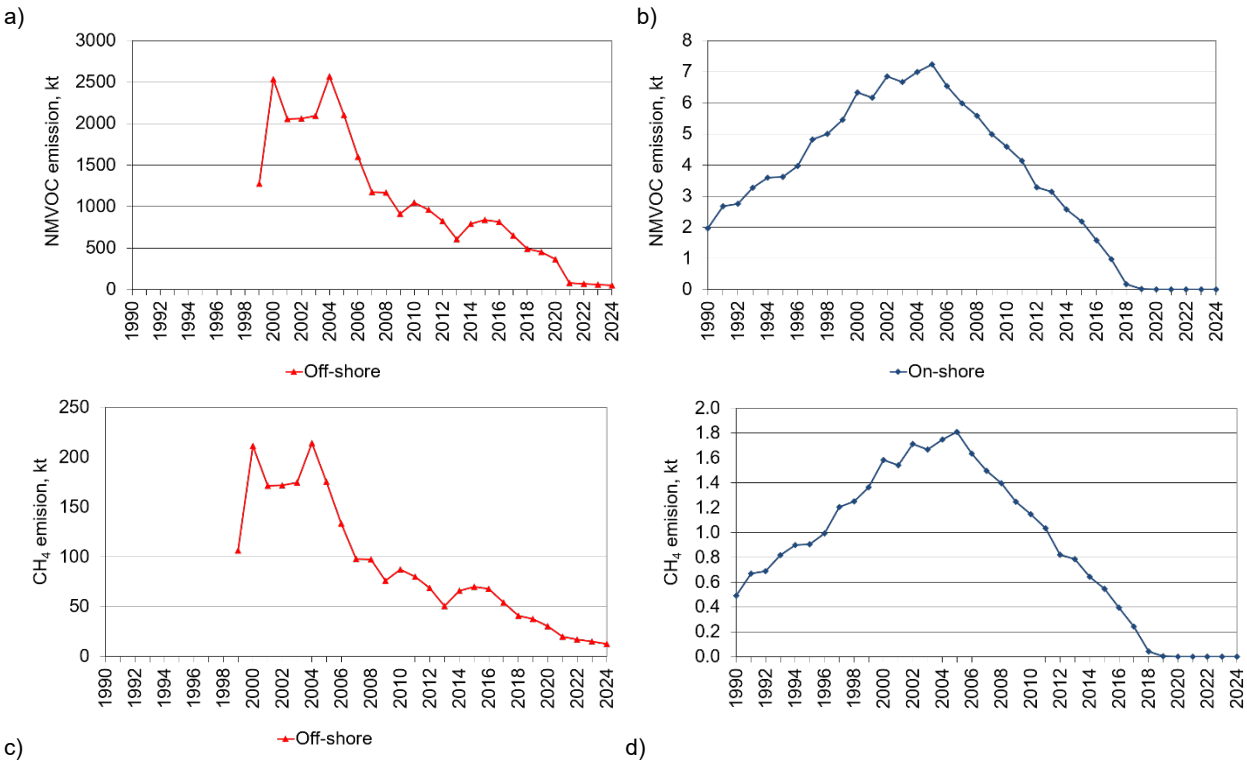


Figure 4.2.5 NMVOC emissions from a) offshore and b) onshore loading of ships, and CH_4 emissions from c) offshore and d) onshore loading of ships.

4.2.4 Storage of crude oil

- *Snap 050208, NFR 1B2ai, CRT 1B2a4*

Activity data

Activity data and annual emissions from storage and handling at the crude oil terminal are provided in the annual self-regulating reports and supporting information from Danish Oil Pipe A/S (Boesen, 2025).

Emission factors

Emissions of CH_4 and NMVOC from storage tanks at the crude oil terminal are provided annually by Danish Oil Pipe A/S. According to the environmental approval, measurements of fugitive emissions should be made every fifth year. DIAL measurement campaigns were made in 2002, 2009 and 2015, and VOC emissions are calculated annually based on the measurement results. Emissions of CO_2 are calculated using the default emission factor from the IPCC (2019) (Table 4.4).

Table 4.4 Default IPCC (2019) CO2 emission factor for the crude oil terminal.

Source	Pollutant	Emission factor	Unit
Crude oil terminal	CO_2	4.9E-07	kt/1000m^3 oil transported by pipeline

Emissions

Emissions of CH_4 and NMVOC from storage tanks at the crude oil terminal are provided annually by Danish Oil Pipe A/S. During 2009, new emission reducing technologies (degassing units) were installed at the crude oil terminal, leading to a significant decrease of the emissions (Figure 4.2.6). Differential Absorption Lidar (DIAL) measurements carried out in 2009 show reduced emissions especially for NMVOC compared to results from the previous measurement campaign in 2002. Emission levels and CH_4/NMVOC ratios are

linked to the operation mode, filling operation being the most critical condition for the emissions.

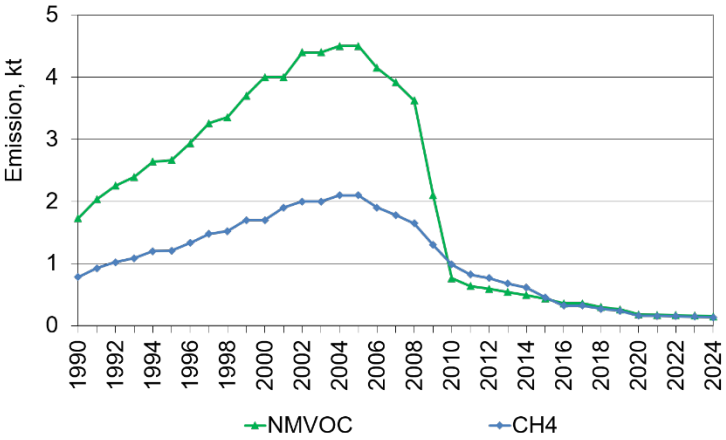


Figure 4.2.6 CH_4 and NMVOC emissions from the crude oil terminal.

4.2.5 Refining and storage

- *Petroleum products processing: Snap 040101, NFR 1B2ai, CRT 1B2a4*
- *Sulphur recovery plants: Snap 040103, NFR 1B2ai, CRT 1B2a4*
- *Storage and handling of petroleum products in refinery: Snap 040104, NFR 1B2ai, CRT 1B2a4*
- *Other (catalytic regeneration): Snap 040105, NFR 1B2ai, CRT 1B2a4*

Activity data

Emissions from the oil refineries include non-combustion emissions from handling and storage of feedstock (crude oil), from the petroleum product processing, from catalytic regeneration and from handling and storage of products. Emissions from flaring in refineries are included in Chapter 4.4.2. Emissions related to process furnaces in refineries are included in stationary combustion. The EMEP/EEA Guidebook lists potential emissions from catalytic cracking unit regenerators with partial burn and without a CO boiler and from fluid coking units. These processes are not used in Denmark due to plant complexity, environmental requirements and economic considerations. Instead, visbreaking (a thermal cracking process) is used at the relatively small Danish refineries. No information on emissions from this process is available from the reporting by the Danish refineries, and as no method is included in the EMEP/EEA Guidebook, this source is not included in the emission inventory.

Rates of crude oil processed in the two Danish refineries are given in their annual environmental report (Crossbridge, 2025 and Kalundborg Refinery, 2025). Until 1996 a third refinery was in operation, leading to a decrease in the crude oil rate from 1996 to 1997. Activity data is shown in Figure 4.2.7.

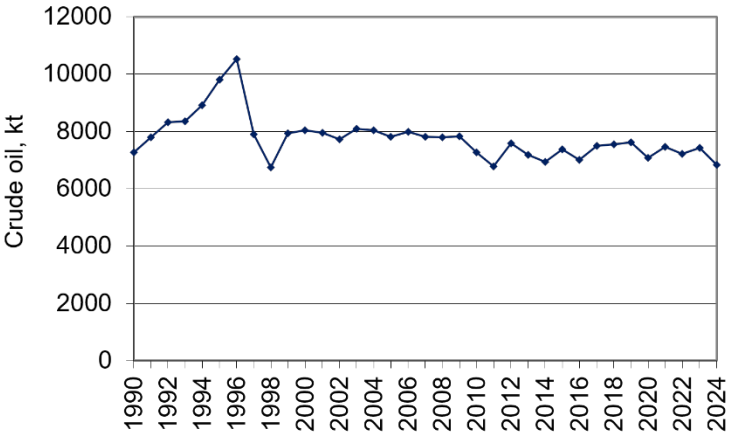


Figure 4.2.7 Crude oil processed in Danish refineries.

Emission factors

Emissions of SO_2 and VOC are given by the refineries. Only one of the two refineries has made a split between NMVOC and CH_4. For the other refinery, it is assumed that 10 % of the VOC emission is CH_4 and the remaining 90 % is NMVOC (Hjerrild & Rasmussen, 2014). Both the non-combustion processes including product processing and sulphur recovery plants emit SO_2.

CO_2 emissions from catalytic regeneration are included in the refineries' annual EU-ETS reports.

The standard CO_2 emission factor for oil transport from the 2019 IPCC Refinement (IPCC, 2019) is used to calculate emissions from storage and handling at the crude oil terminal.

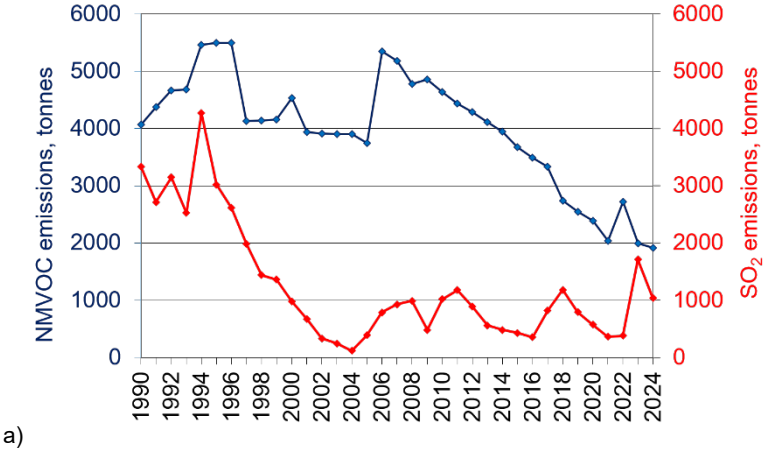
Emissions

Refineries are a significant source to fugitive emissions of SO_2, the most important activities being sulphur recovery and flaring. In 1990-1993, emissions from petroleum product processing were included in emissions from flaring in refineries (NFR category 1B2c). From 1994 the data delivery format was changed, which made it possible to split the emissions between from flaring and processing, respectively. Emissions from processing are included in NFR category 1B2aiv from 1994 and forward.

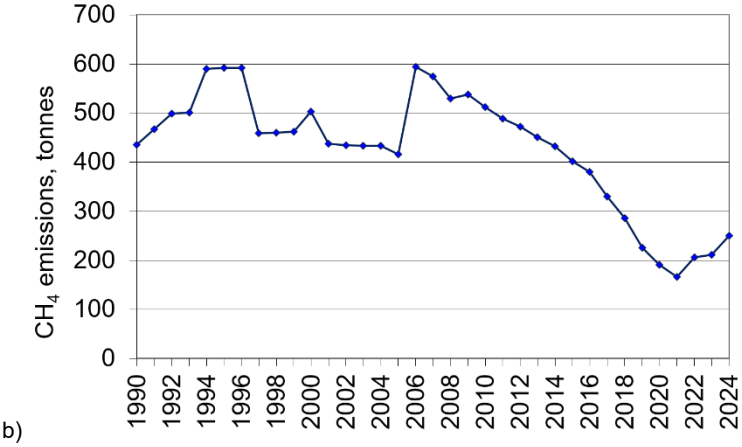
SO_2, NMVOC and CH_4 emissions are shown in Figure 4.2.8. One refinery was shut down in 1996 leading to a decrease of the emissions from 1996 to 1997. Technical improvements of the sulphur recovery system at one of the two Danish refineries lead to a decrease of the SO_2 emissions from 1996-1998. The large emissions from 2005 and onwards owe to shutdowns due to maintenance and incidents. Further, construction and initialisation of new facilities and problems related to the ammonium thiosulphate (ATS) plant at the one refinery has led to increased emissions. In 2007, the capacity of the ATS plant was increased followed by commissioning difficulties. In 2023, there were unusually many days with downtime of the CLAUS and/or SCOT plant, and the gas stream bypass of the CLAUS/SCOTT plant was led to the hydrogen sulphide flare, either from the Amino Di-Isopropanol Process (ADIP) plant or from the sour water stripper (SWS). In the hydrogen sulphide flare, hydrogen sulphide is burned to sulphur dioxide to avoid odour nuisance.

The increase of NMVOC and CH_4 emissions from 2005 to 2006 owes to a new measurement campaign at one refinery, which showed larger emissions than the previous measurement campaign (Figure 4.2.8). According to the

environmental department at the refinery, fugitive emissions from oil processing in refineries do not correlate to any measured parameters but are expected to follow a more random pattern. The refinery has chosen to report the latest measured emission for the years between measurement campaigns, and as no better methodology is available, the same approach is used in the national emission inventories.



a)



b)

Figure 4.2.8 SO_2 and NMVOC (a) and CH_4 (b) emissions from crude oil processing including sulphur recovery in Danish refineries.

4.2.6 Service stations

- *Snap 050503, NFR 1B2av, CRT 1B2a5*

Activity data

Calculations of emissions from service stations are based on gasoline sales figures from the Danish Energy statistics (Danish Energy Agency, 2025b). The gasoline sales increases from 1990-1998 and shows a decreasing trend from 1999 onwards as shown in Figure 4.2.9.

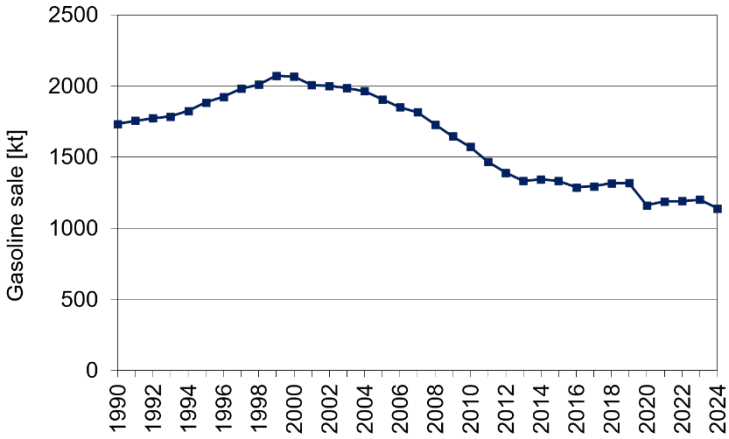


Figure 4.2.9 Gasoline sales in Denmark.

Emission factors

The NMVOC emission from service stations is calculated by use of different emission factors for the time series as shown in Table 4.5.

In 1994, the emission factors for NMVOC from service stations were investigated by Fenhann and Kilde (1994) for 1990 and 1991, individually. The emission factors reported for reloading for 1990 are used for the years 1985-1990, while the emission factor for 1991 is used for 1991 only. In 1995, Stage I (emissions reduction from storage at terminals and refuelling of storage tanks at service stations) was made obligatory, and the emission factor from the EMEP/EEA Guidebook (EMEP/EEA, 2023) is applied from 1997 and onwards. Linear interpolation is applied for the years 1995-1996.

Fenhann & Kilde (1994) also include NMVOC emission factors for refuelling for the years 1990, 1991, 1992, and 1993. The same value is given for these years. From 1994, the refuelling emission factor is based on the EMEP/EEA Guidebook (EMEP/EEA, 2023). An abatement rate of Stage II (petrol vapour recovery during refuelling of motor vehicles at service stations) of 85 % is given in the 2023 EMEP/EEA Guidebook, while 60 % were given in the 2006 EMEP/EEA Guidebook (EMEP/EEA, 2006). The Danish requirement is 85 % abatement under optimal conditions, but 70 % in practice (Danish Ministry of the Environment, 1994). Based on this, 70 % abatement is applied in the emission calculations.

Table 4.5 Emission factors used for estimating NMVOC from service stations.

Year	Reloading of tankers [kg NMVOC per tonnes gasoline]	Refuelling of vehicles [kg NMVOC per tonnes gasoline]	Sum of reloading and refuelling [kg NMVOC per tonnes gasoline]	Source - reloading	Source - refuelling
1985-1990	1.28	1.52	2.8	Fenhann & Kilde, 1994	Fenhann & Kilde, 1994
1991	0.64	1.52	2.16	Fenhann & Kilde, 1994	Fenhann & Kilde, 1994
1992	0.519	1.52	2.039	Interpolation	Fenhann & Kilde, 1994
1993	0.397	1.004	1.401	Interpolation	Fenhann & Kilde, 1994
1994	0.276	0.488	0.764	MST, 1994	EMEP/EEA 2023 with 70 % efficiency (national regulation)
1995	0.202	0.488	0.69	Interpolation	EMEP/EEA 2023 with 70 % efficiency (national regulation)
1996	0.127	0.488	0.615	Interpolation	EMEP/EEA 2023 with 70 % efficiency (national regulation)
1997 onwards	0.053	0.488	0.541	EMEP/EEA 2023	EMEP/EEA 2023 with 70 % efficiency (national regulation)

Emissions

Emissions from service stations are shown in Figure 4.2.10. The decrease from 1990 to 1999 owes to decreasing emission factors due to technological improvements. From 1999 to 2005, the decrease owes to a combination of decreasing gasoline sales and decreasing emission factors. Since 2005, the decreasing trend is less pronounced and only varies with the gasoline sales, which show a slight decreasing trend.

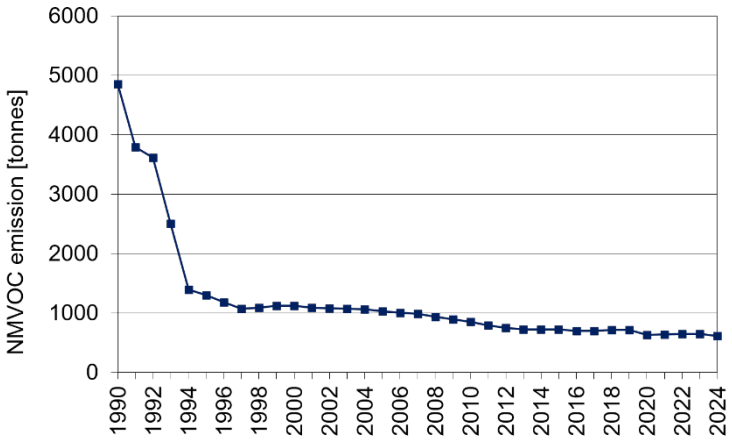


Figure 4.2.10 NMVOC emissions from service stations.

4.2.7 Abandoned wells

- *Snap 050210, NFR 1B2ai, CRT 1B2a6*

Activity data

The Danish Environmental Agency provide information about the number of abandoned wells and time for abandonment. The abandoned wells are categorised into onshore and offshore wells and further into the status categories "abandoned" and "plugged and abandoned". The numbers of abandoned wells are shown in Figure 4.2.11.

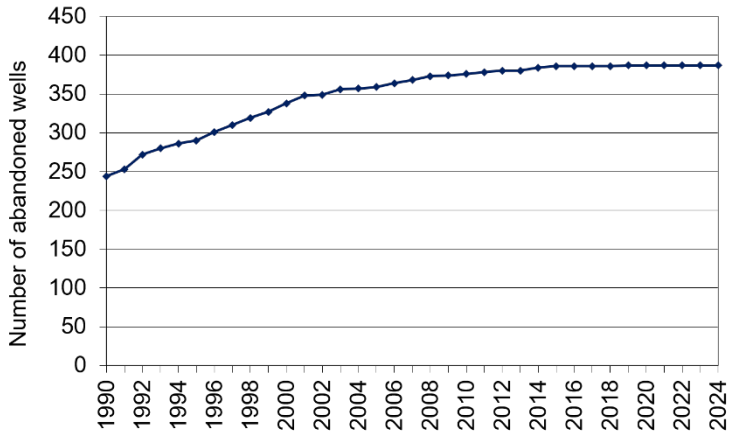


Figure 4.2.11 Number of abandoned wells.

Emission factors

The standard emission factors for abandoned oil wells from the IPCC (2019) are used to calculate emissions from all abandoned wells in accordance with the Guidebook, which states that available information on abandoned oil and gas wells does not indicate a clear distinction between abandoned oil wells and abandoned gas wells regarding practices or emission factor (Table 4.6).

Table 4.6 Default 2019 IPCC Refinement emission factors for abandoned wells.

		CH_4	CO_2	NMVOC	N_2O	unit
Onshore	Plugged	2.00E-05	NA	NA	NA	t/abandoned well
	Unplugged	8.80E-02	NA	NA	NA	t/abandoned well
Offshore	Plugged	3.50E-07	NA	NA	NA	t/abandoned well
	Unplugged	1.80E-03	NA	NA	NA	t/abandoned well

4.3 Fugitive emissions from natural gas (1B2b)

The emissions from natural gas derive from exploration, transmission, storage and distribution. Description of exploration of natural gas is included in Chapter 4.2.1 covering exploration of oil.

4.3.1 Exploration of gas

- *Snap 050304, NFR 1B2b, CRT 1B2b1*

See Chapter 4.2.1

4.3.2 Production of gas

- *Snap 050305, NFR 1B2b, CRT 1B2b2*

Activity data

Activity data used for oil and gas production are provided by the DEA (Danish Energy Agency, 2025a). As seen in Figure 4.3.1, the production of oil and gas in the North Sea has generally increased in the years 1990-2004, and since 2004, the production has decreased. Commissioning of five major platforms in the period 1997-1999 is the main reason for the great increase in the oil production in the years 1998-2000.

The Tyra platforms were closed in the period between September 2019 and March 2024 due to redevelopment. The recommissioning that started ultimo March 2024, was expected to last around four months, where the capacity slowly increased from 0 to full capacity. The commissioning and ramp-up of Tyra II production was impacted by weather conditions and minor operational occurrences and by the end of February 2025 Tyra II was back in full operation. The Tyra platforms have for 30 years been processing most of the Danish natural gas production, and the redevelopment ensures continued production from Denmark's largest producing gas field.

The gas produced in the North Sea and transported by pipeline to the treatment gas plant Nybro is dry and with low H_2S content. Therefore, the gas does not need any processing that causes fugitive emissions, before going into the transmission network. The environmental approval from 2009 for Nybro states that gas processing equipment is in place, and that some parts have never been used, and others have been mothballed or phased out. It has been verified by the senior operations supporter at Nybro that these conditions are still applicable (Korshøj, 2023).

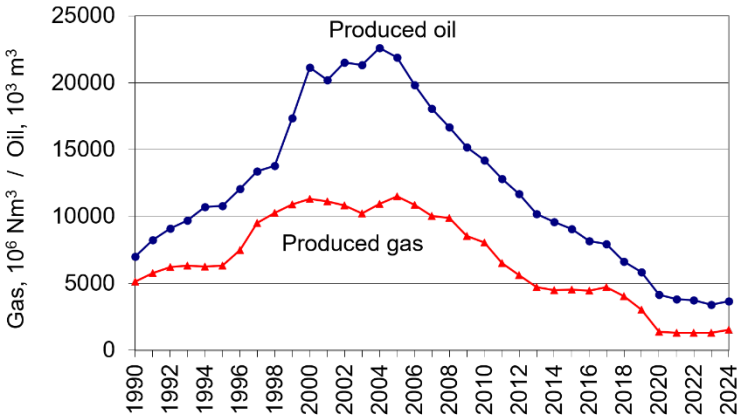


Figure 4.3.1 Production of oil and gas.

Emission factors

A Tier 2 methodology is applied, using country specific emission factors. Development of the country specific emission factors has been made in close corporation with the industry association for the Danish offshore sector (Danish Offshore) and the Danish operators TotalEnergies and INEOS Energy. The operators are providing data and information about emissions and related issues for the offshore production facilities. The Danish operators have made drone measurements, some carried out by the independent company Explicit ApS, who have also contributed to the improvement work providing information about the measurements, including details about the state-of-the-art ISO/IEC 17025 accredited drone-flux method (DFM) developed by Explicit.

The country specific emission factors are based on company emission inventories for the larger operator (TotalEnergies), information from the operators' LDAR programmes, results from drone measurements, and supporting information regarding national circumstances in the offshore oil and gas production industry.

Annual emission inventories for the years 2019 to 2023 have been provided by the larger operator, including emission estimates on installation level based on the methodology in the company's guidelines. Installation specific activity data and gas composition information, and company specific emission factors are used for calculation. The emission factors, which are developed by the company's international headquarters based on experience in measurements and operating practices within the company, apply to all the company's oil and gas production operations worldwide, and are subject to annual data reporting audits by third parties. The inventory includes emissions from unburnt gas for the unlit flares (cold vents), process vents (glycol units), oily water treatment, centrifugal compressors, and reciprocating compressors.

The operators provide information about leak detection and repair (LDAR). The operators are highly aware of leaks due to the safety of the personnel and the environmental and safety regulations for offshore facilities. There are gas detectors all over the offshore process facilities, which will react in case of a leak. Following, the gas leak amounts are very small. Detected leaks are registered, including type of leak, estimates of the leaked amounts, actions required, and how the leak was or will be rectified.

In 2022, drone measurements were carried out, and the results have been provided by the operators for seven fields. The first drone measurements used

the Airborne Ultralight Spectrometer for Environmental Applications (AUSEA) technology. The newest measurements were done using the DFM technique. The DFM method is distinguished by simultaneous measurements of wind parameters using 3D ultrasonic anemometers, which significantly improves the accuracy of identifying emission sources. The DFM method allows for a split of the emissions on source level, e.g. flare, platform structure and wellhead platform.

The fugitive emissions based on the DFM results are significantly lower than estimates in the operator emission inventories. For one of the fields the DFM measurements find site emissions around 2 kg/h while the corresponding estimate based on the company reporting guidelines is around 28 kg/h. This might be because emission factors in the company reporting guidelines mainly are based on conditions for American facilities and partly for onshore facilities, which might be subject to less strict regulation than Danish offshore facilities, e.g. due to the higher safety risk offshore.

Data from the operator do not split emissions between oil and gas production, respectively, as all the Danish facilities produce both oil and gas and thus equipment leaks are related to both oil and gas production.

Annual production data of oil and natural gas and data from the operator's inventories, LDAR programmes and drone measurements include emissions on field level. This allows for setting up a time series for the country specific emission factors, considering the distribution of the production between the fields. Thereby differences in the emission level between the fields are reflected in the calculated emissions.

The country specific tier 2 emission factors (Table 4.7) are expressed as emission per gas production, which is in accordance with API (2021), who suggest using emission factors for gas production for facilities that produce both oil and gas.

Table 4.7 Country specific (CS) emission factors for 2024.

	CH_4	NMVOC	CO_2	N_2O	unit
Oil production offshore*	IE	IE	IE	NA	
Gas production offshore	1.15 E-03	1.02E-03	2.58E-05	NA	$Gg/10^6$ m^3 gas produced

*Emissions from oil production are included in the country specific emission factors for gas production.

Emissions

Calculated NMVOC and CH_4 emissions from oil and gas production are shown in Figure 4.3.2 for selected years. The annual variations follow the production rates.

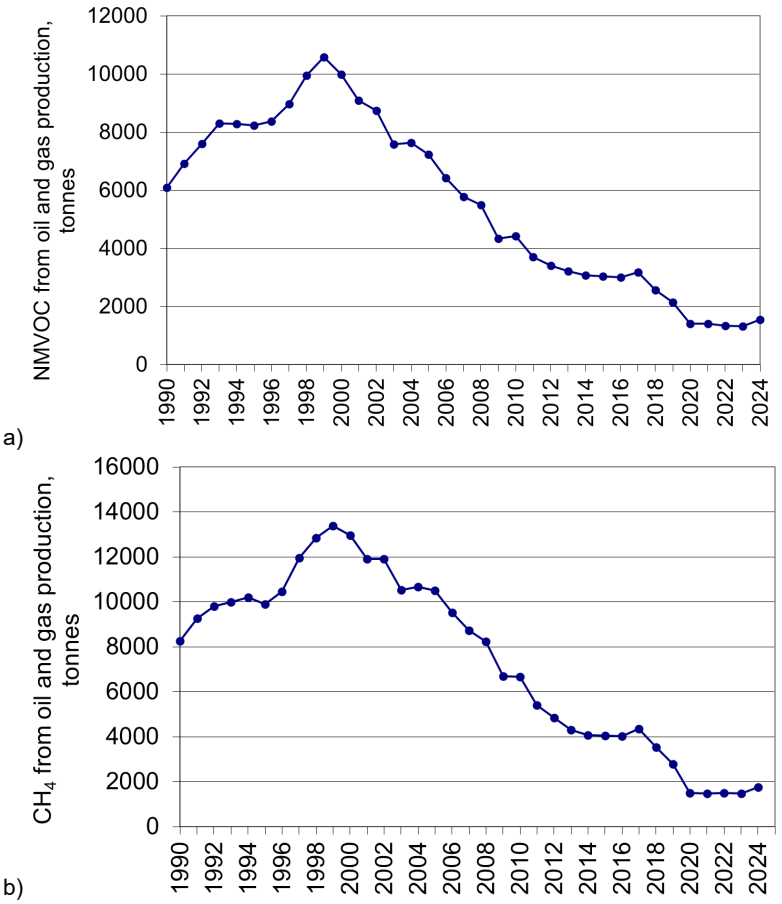


Figure 4.3.2 NMVOC (a) and CH_4 (b) emissions from production of oil and gas.

4.3.3 Transmission and storage of gas

- *Snap 050601, NFR 1B2b, CRT 1B2b4*

Gas transmission and storage cover the Danish gas pipeline system, the gas treatment plant Nybro (including the receiving terminals for the gas pipelines from the Danish production facilities in the North Sea and the gas pipeline Baltic Pipe running from Norway via Denmark to Poland), and two underground gas storage sites. Fuel consumption in the Danish gas treatment plant used for gas heating and drying is included under category 1A1cii (Oil and gas extraction). All pipeline compressors on the natural gas grid are electric compressors. Hence fuel consumption and emissions are not occurring (NO) in the sector 1A3ei Pipeline transport. The fuel consumption in the Danish gas treatment plant is included in sector 1A1cii Oil and gas extraction.

Activity data

The fugitive emissions from transmission and storage of gas are based on information from the gas transmission companies, which provide data on transport rate, pipeline losses, and length and material of the pipeline systems. The combined length of the transmission pipelines is approximately 1000 km.

The activity data used in the calculation of the emissions from gas transmission are shown in Figure 4.3.3. Transmission rates for 1990-1998 refer to annual environmental reports of DONG Energy. In 1999-2006, transmission rates refer to the Danish Gas Technology Centre (Karll 2002, 2003, 2004, 2005, Oertenblad 2006, Oertenblad 2007). From 2008 onwards, transmission rates

refer to Energinet.dk (2025b). Transmission losses for 1991-1999 are based on an annual environmental report by DONG Energy. The average for 1991-1995 is applied for 1990. From 2005 onwards, transmission losses are given by Energinet.dk. The average for 2005-2010 is applied for the years 2000-2004.

The variation over the time series owes mainly to variations in the winter temperature and to the variation of import/export of electricity from Norway and Sweden. The transmission rate is for most years less than the production rate, as part of the produced natural gas is exported through the Northern Offshore Gas Transport (NOGAT) pipeline system to the Netherlands. The increase in 2023 is due to commissioning of the new gas pipeline, Baltic Pipe, which transport Norwegian natural gas from the North Sea via Denmark to Poland. A new receiving plant is constructed at the gas treatment plant for the Danish natural gas from the North Sea, and the Danish gas transmission network has been expanded with approximately 210 km pipeline. The pipeline runs through a new compressor station in Zealand. The full annual capacity of the Baltic Pipe is 10 billion cubic meters gas.

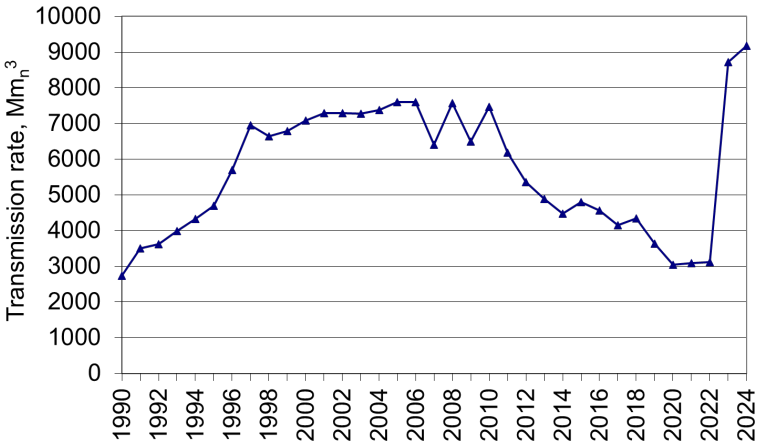


Figure 4.3.3 Rates for transmission of natural gas.

Emission factors

The fugitive emissions from transmission and storage of gas are based on data on gas losses from the companies and on the average annual natural gas composition given by Energinet.dk (2025c). Gas composition data for selected years are listed in Table 4.8. Biomethane has been added to the transmission gas since 2018, which is taken into account in the emission calculations for the relevant years.

Table 4.8 Annual gas composition, lower heating value and density for Danish natural gas (Energinet.dk, 2025c).

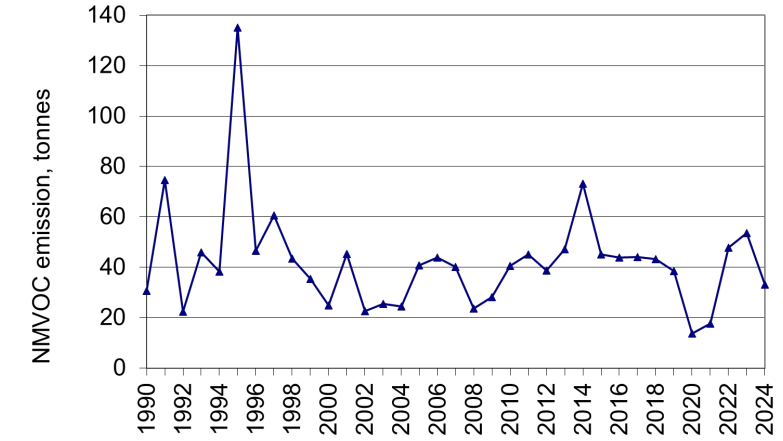
		Unit	1990	2000	2010	2020	2023	2024
Methane	CH_4	molar-%	90.92	86.97	89.95	95.9	88.06	88.35
Ethane	C_2H_6	molar-%	5.08	6.88	5.71	3.05	7.28	7.20
Propane	C_3H_8	molar-%	1.89	3.17	2.19	0.18	1.39	1.26
i-Butane	i-C_4H_{10}	molar-%	0.36	0.43	0.37	0.05	0.13	0.12
n-Butane	n-C_4H_{10}	molar-%	0.50	0.61	0.54	0.03	0.18	0.17
i-Petane	i-C_5H_{12}	molar-%	0.14	0.11	0.13	0.01	0.03	0.03
n-Petane	n-C_5H_{12}	molar-%	0.10	0.08	0.08	0.01	0.02	0.02
n-Hexane and heavier hydrocarbons	C^{6+}	molar-%	0.09	0.06	0.06	0.02	0.02	0.02
Nitrogen	N_2	molar-%	0.31	0.34	0.31	0.31	0.97	0.89
Carbon dioxide	CO_2	molar-%	0.60	1.35	0.66	0.44	1.93	1.93
Lower heating value	H_n	MJ/m^3_n	39.176	40.154	39.461	36.700	38.026	37.949
Density	ρ	kg/m^3_n	0.808	0.846	0.816	0.749	0.818	0.815

Emissions

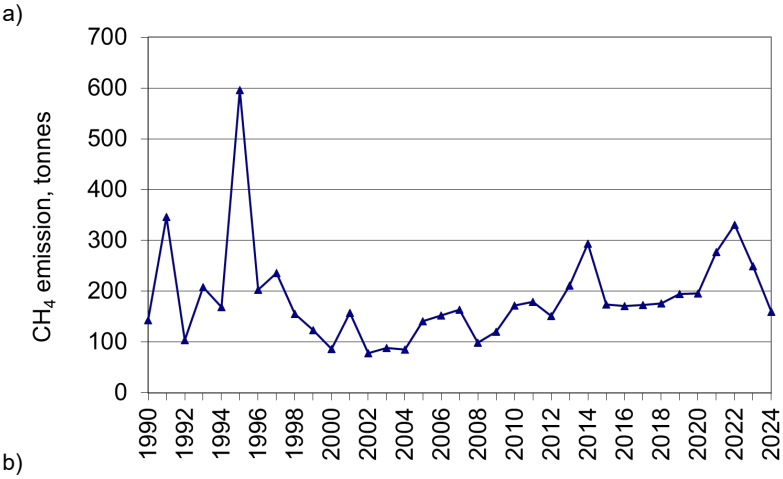
Emissions of NMVOC and CH_4 from transmission of natural gas are shown in Figure 4.3.4. Emissions of CO_2 from transmission and storage are very limited and not included in the figure.

The gas transmission company reports emissions of CH_4 for the years 1999 and onwards, based on registered loss in the transmission grid and the emission from the natural gas consumption in the pressure regulating stations. For the years 1991-1998, the CH_4 emissions for transmission are estimated based on the registered loss provided by the transmission company and the annual composition of Danish natural gas given by Energinet.dk. Transmission loss is not available for 1990, and therefore the average for 1991-1995 is applied.

As the pipelines in Denmark are relatively new and made of plastic, most emissions are due to leaks during construction and maintenance. This leads to large annual fluctuations in emissions, which are not correlated with the transmission rates. E.g. the large emission in 1995 owes to large construction works on four different locations. The increase in 2011 owes to venting for drainage of the pipes in preparation for construction work on a new compressor station, and the increase in 2014 owes to the construction of a new major railway line. The increase in 2021 and 2022 owes to increased focus from the transmission company on improvement of the data foundation. Further, there have been more construction work than in the previous years, e.g. activities related to two biomethane systems and the Baltic pipe. The transmission loss has decreased from 2022 to 2024 due to the completion of the work on the Baltic Pipe. The difference in trend for CH_4 and NMVOC for 2022-2024 owe to variations of the gas loss amounts, gas composition and biomethane content in the transmitted gas.



a)



b)

Figure 4.3.4 NMVOC (a) and CH_4 (b) emissions from transmission of natural gas.

4.3.4 Distribution of gas

- *Snap 050603, NFR 1B2b, CRT 1B2b5*

Gas distribution covers the Danish distribution pipeline systems for natural gas and town gas, and gas post-meter emissions from "industrial and power plants", from "commercial and residential plants" and from natural gas fired vehicles. Danish town gas is a mix of natural gas and air or natural gas, bio-methane and air, with approximately 50 % air.

Activity data

Natural gas distribution rates for 1990-1998 are estimated from the Danish energy statistics. Distribution rates are assumed to equal the total Danish consumption rate minus the consumption rates of sectors that receive the gas at high pressure. The following consumers are assumed to receive high pressure gas: town gas production companies, production platforms, and power plants. Distribution rates for 1999-2006 refer to DONG Energy, the Danish Gas Technology Centre or the Danish gas distribution companies. Since 2007, the distribution rates have been given by the companies. The fugitive losses from distribution of natural gas are only given for some companies. The average of the available "loss/distribution" ratios is used for the remaining companies.

Activity data for distribution of town gas are rather scarce, especially for the early part of the timeseries, and calculations are based on the available data from the town gas distribution companies on losses from the pipelines. At present, there are two areas with town gas distribution (Greater Copenhagen and Aalborg) and correspondingly two distribution companies. Two other companies in other areas (Svendborg and Kolding) were closed in 2004 and

2006, and it has not been possible to collect data for all years in the time series. The emissions have been calculated for the years with available data and the distribution loss for the first year with data has been applied for the previous years in the time series. Data are missing for the later years (1996-2003) for one of the distribution companies. The distribution rate is assumed to decrease linearly to zero over these years, and the rate "distribution loss/distribution amount" is assumed equal to the value for 1995.

Data on the distribution network are given by Energinet.dk, Danish Gas Technology Centre (DGC) and the distribution companies concerning length and material. The length of the distribution network is around 20 000 km. The distribution network in Denmark is relatively new and most of the pipelines are made of plastic (approximately 90 %). For this reason, the fugitive emission is negligible under normal operating conditions, as the distribution system is basically airtight with only minor fugitive losses. However, the plastic pipes are vulnerable and therefore most of the fugitive emissions from the pipes are caused by losses due to excavation damages and to construction and maintenance activities performed by the gas companies. These losses are either measured or estimated by calculation in each case by the gas companies. About 5 % of the distribution network is used for town gas. This part of the network is older, and the fugitive losses are larger. The fugitive losses from this network are associated with more uncertainty, as it is estimated as a percentage (15 %) of the meter differential. This assumption is based on expert judgement from one of the town gas companies (Jensen, 2008). Distribution rates are shown in Figure 4.3.5.

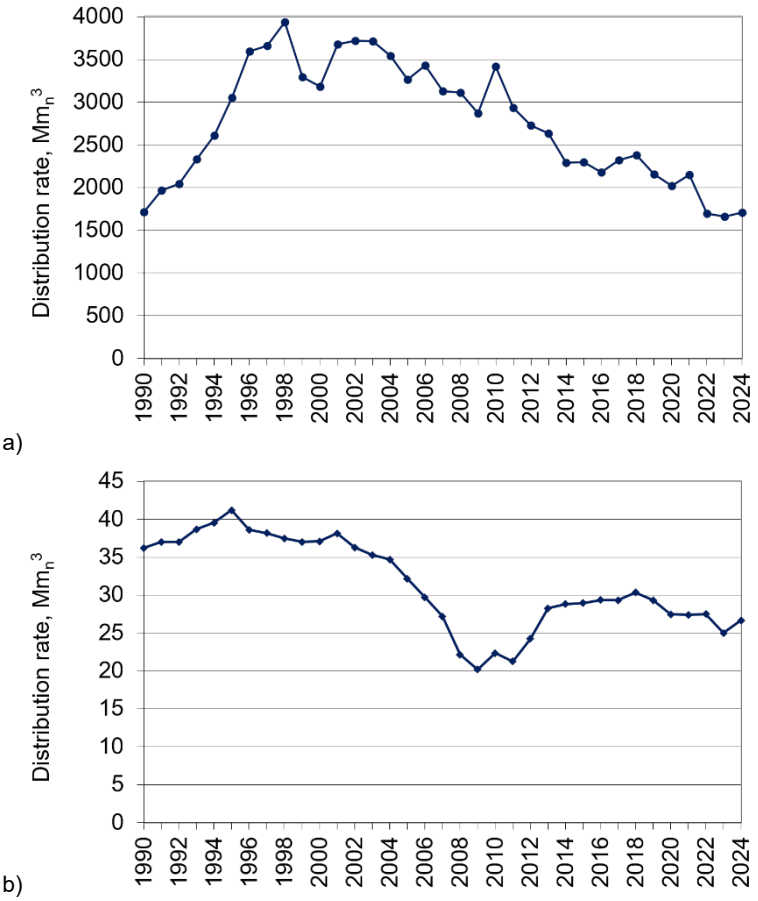


Figure 4.3.5 Distribution rates of a) natural gas and b) town gas.

Emission factors

Emissions from natural gas distribution are calculated from the fugitive losses from pipelines and the gas quality measured by Energinet.dk (Table 4.8). The same approach is used for town gas, which is natural gas admixed ~ 50 % ambient air. Biomethane has been added to the distribution gas since 2014, which is considered in the emission calculations for the relevant years.

In 2014, one town gas distribution company started to admix biomethane. In 2014, the share of biomethane was 10 %, which has increased to 66 % in 2024. The gas composition of biomethane is given in Table 4.9.

Table 4.9 Composition of biomethane admixed to town gas (Jeppesen, 2014; Ea Energianalyse, 2014).

Methane	molar-%	60.98
Nitrogen	molar-%	0.001
Carbon dioxide	molar-%	39.02
Lower heating value	MJ/m^3_n	21.53
Density	kg/m^3_n	0.808

The distribution companies provide emissions of CH_4 for 1997 and onwards. For 1995-1996, emissions are calculated from the registered loss from distribution and the annual composition of Danish natural gas given by Energinet.dk. As distribution losses are not available for the years 1990-1994, the percentage loss for 1995 is used.

Emissions

Emissions of NMVOC and CH_4 from distribution of natural gas and town gas are shown in Figure 4.3.6.

In the later years large emissions from natural gas distribution owe to excavation damages, especially in connection with expansion of district heating. In areas where district heating substitutes naturals gas, the pipelines are almost in the same place, and the gas is not disconnected until the construction work is finalized. The relatively low NMVOC emissions in 2020-2021 owe to variations in the gas quality, with higher CH_4 content in those years.

The decreasing trend for town gas owe to phase-out of town gas distribution in two areas (Svendborg and Kolding). Further relining of old pipelines has reduced the gas loss from town gas distribution. The NMVOC emissions are reduced from 2014 onwards due to admix of biomethane, which does not contain NMVOC.

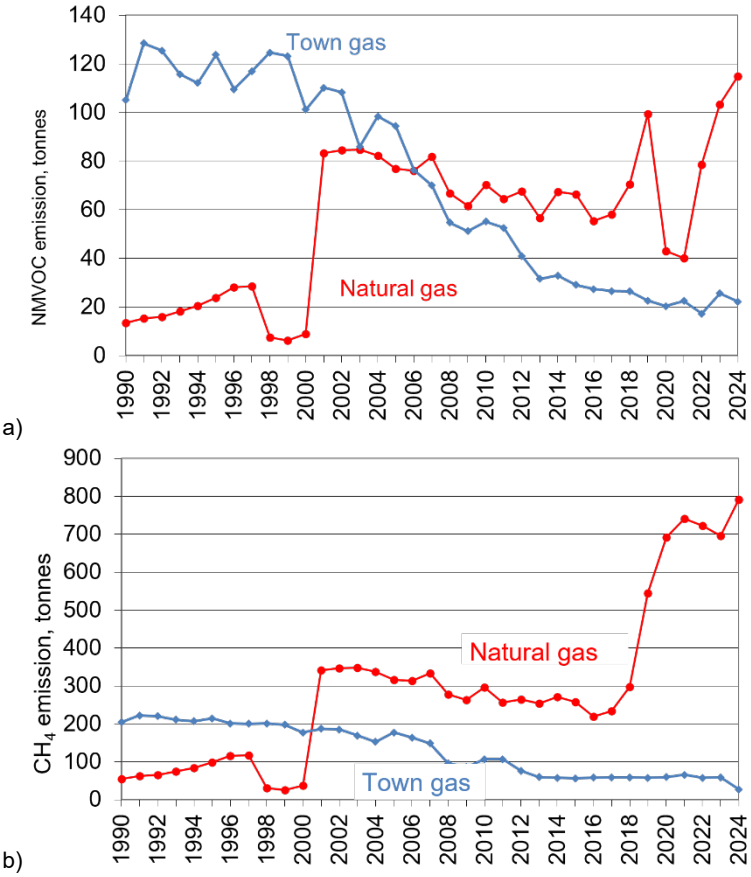


Figure 4.3.6 NMVOC (a) and CH_4 (b) emissions from distribution of natural gas.

4.3.5 Gas post-meter

- *Post-meter - industrial and power plants: Snap 050606, NFR 1B2b, CRT 1B2b6*
- *Post-meter - commercial and residential: Snap 050607, NFR 1B2b, CRT 1B2b6*
- *Post-meter - natural gas fired vehicles: Snap 050608, NFR 1B2b, CRT 1B2b6*

Gas post-meter covers emissions due to leakages after the gas meter from industrial appliances and power plants, from commercial and residential plants, and from natural gas-fired vehicles.

Activity data

Activity data for gas post-meter emissions is natural gas consumption in industry and power plants, in the residential and commercial sector and the number of natural gas-fired vehicles. Natural gas consumptions are based on the energy statistics, and the number of natural gas-fired vehicles are in accordance with the numbers used in the Danish national emission inventory for mobile sources. Activity data for post-meter emissions are included in Figure 4.3.7.

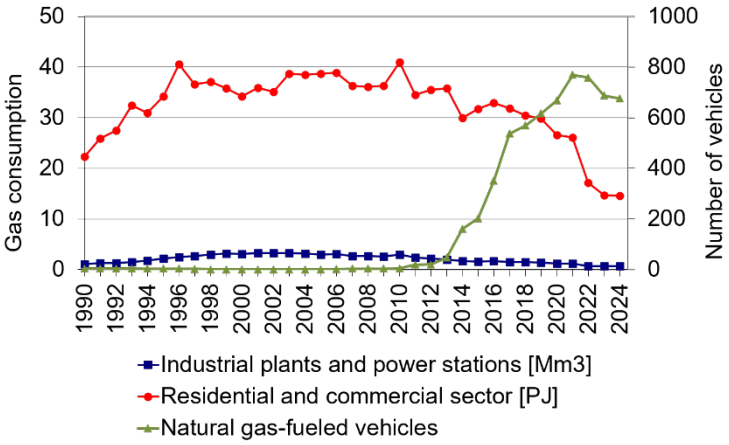


Figure 4.3.7 Activity data for gas post-meter emissions.

Emission factors

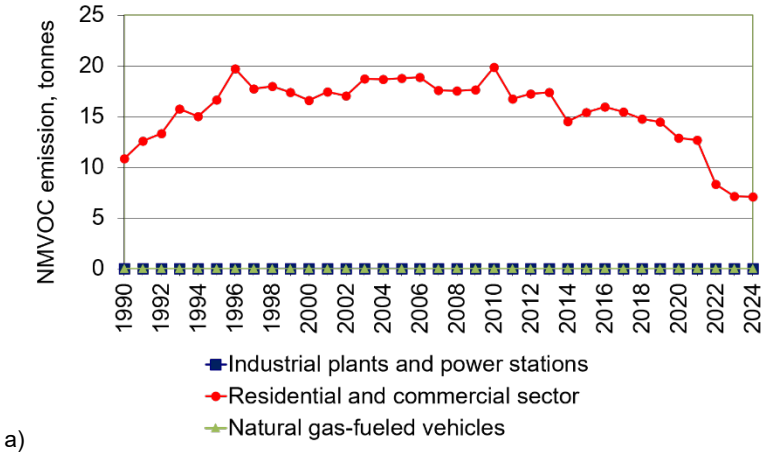
Emission factors for post-meter emissions for industrial appliances and power plants and for natural gas fired vehicles are Tier 1 emission factors from the 2019 IPCC Refinement. Emission factors for residential and commercial appliances are calculated with country specific emission factors based on Merrin & Francisco (2019) and country specific number of appliances per type provided by the Danish gas distribution company Evida. The emission factors for post-meter emissions are included in Table 4.10.

Table 4.10 Emission factors for post-meter emissions.

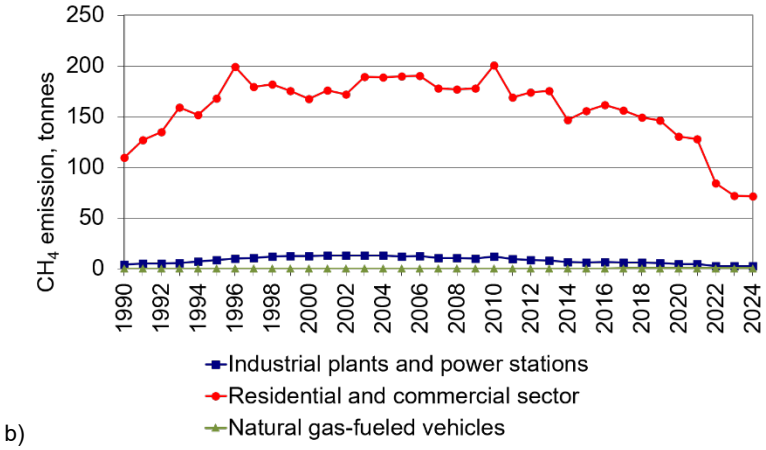
	Unit	CH_4	NMVOC	CO_2	N_2O
Appliances in industrial plants and power stations	kg/Mm^3 gas consumed	4	8.00E-06	2.3E-03	NA
Appliances in the residential and commercial sector	g/GJ	4.899	0.485	0.047	NA
Natural gas fired vehicles	t/vehicle	3.0E-04	8.00E-06	2.3E-06	NA

Emissions

Gas post-meter CH_4 and NMVOC emissions are shown in Figure 4.3.8. The annual variation depends on the natural gas consumption in power plants and in industrial, residential and commercial plants. Emissions from natural gas fired vehicles is minor due to the small number of vehicles.



a)



b)

Figure 4.3.8 Gas post-meter emissions of a) NMVOC and b) CH_4.

4.4 Fugitive emissions from venting and flaring (1B2c)

Venting occurs in the two Danish natural gas storage facilities. Flaring takes place in refineries, in oil and gas production, in gas treatment and storage facilities, and in gas transmission and distribution.

4.4.1 Venting

- *Snap 050699, NFR 1B2c, CRT 1B2c1ii*

Activity data

The natural gas storage facilities make environmental reports on annual basis, including data on venting. Venting of gas is assumed not to be occurring in extraction and in refineries, as controlled venting enters the gas flare system. Venting rates in gas storage facilities are shown in Figure 4.4.1. Data are not available for the years 1990-1994 for the one gas storage facility that was in operation over the entire time series, and the average for 1995-1998 is applied. The second gas storage facility was opened in 1994, leading to increasing venting rates. The increase in 2024 owe to extraordinary venting in relation to coil tubing at one gas storage, where twelve production wells were cleaned in 1500 m depth.

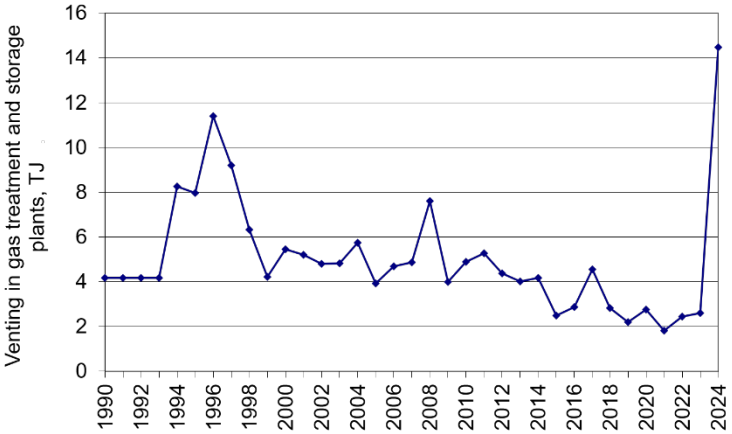


Figure 4.4.1 Venting rates in gas storage facilities.

Emission factors

Emissions of CH_4 and NMVOC from venting are given in the environmental reports for the gas storage facilities (Energinet.dk, 2025a). CO_2 emissions from venting are calculated from country specific emission factors based on annual natural gas composition published by Energinet.dk (Table 4.8).

Emissions

Venting is limited to the gas storage facilities, and the emissions are of minor importance to the total fugitive emissions. Venting emissions are included in Figure 4.4.2.

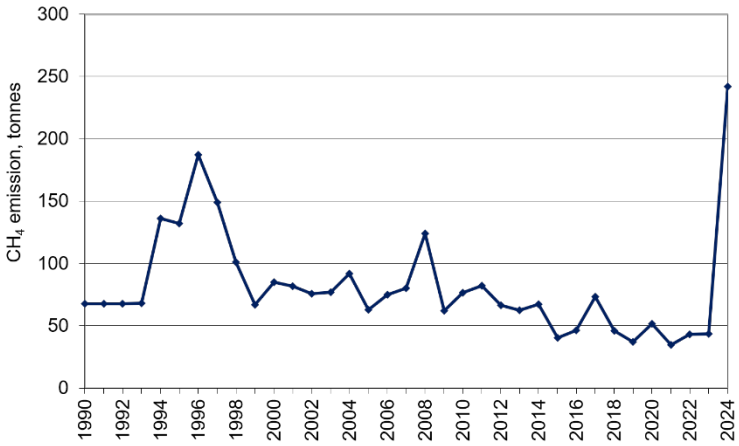


Figure 4.4.2 CH_4 emissions from venting in gas storage facilities.

4.4.2 Flaring in refineries

- *Snap 090203, NFR 1B2c, CRT 1B2c2i*

Activity data

Flaring rates for the two Danish refineries are given in their environmental reports and in additional data provided by the refineries directly to DCE. From 2006, flaring rates are given in the EU ETS reporting. Data are not available for the years 1990-1995, why the flaring rate for 1996 has been adopted for the previous years. Flaring rates are shown in Figure 4.4.3.

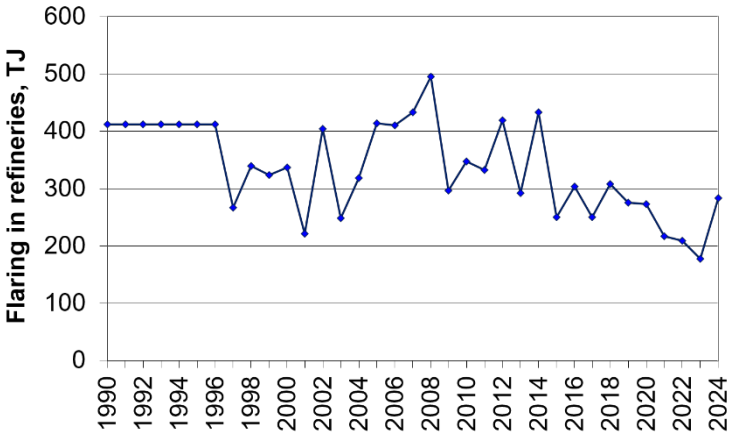


Figure 4.4.3 Flaring rates in refineries.

Emission factors

SO_2 emissions are provided annually by the refineries, and NO_x emissions are provided annually by only one refinery. The composition of refinery gas is given for 2008 by one of the two refineries. As the composition for refinery gas is very different from the composition of natural gas, the 2008 refinery gas composition is used in calculations for both Danish refineries. The NMVOC and CH_4 emission factors based on the 2008 refinery gas composition are applied for both refineries for the entire time series. The CO_2 emission factor is based on the refineries reporting to the EU ETS from the years 2006 and onwards. Before 2006, corresponding data are not available, and the average of CO_2 emission factors for 2007-2011 for each refinery is applied. The emission factor applied for N_2O is based on OLF (1993) for flaring in oil and gas extraction, as no values are given for flaring in refineries in the 2006 IPCC Guidelines. Emissions of the remaining pollutants are based on standard emission factors from the 2023 EMEP/EEA Guidebook. Emission factors for selected pollutants are listed in Table 4.11.

Table 4.11 Emission factors for flaring in refineries.

Pollutant	Emission factor	Unit
NO_x	29.2	g/GJ
NMVOC	76.45	g/GJ
CO	133	g/GJ
TSP	0.89	g/GJ
PM_{10}	0.89	g/GJ
$PM_{2.5}$	0.89	g/GJ
BC	0.21	g/GJ
CH_4	18.1	g/GJ
CO_2 *	55.02 / 59.02	kg/GJ
N_2O	0.47	g/GJ

*The CO_2 emission factors are plant specific and based on the refineries' reports for EU ETS. The values in the table are for year 2024.

Emissions

Emissions of NMVOC, SO_2, CH_4 and CO_2 are shown in Figure 4.4.4. The variation over the time series mainly reflects the annual variation in the activity rate for flaring, with small variations for CO_2 from 2006 onwards, when annual plant specific CO_2 emission factors became available via the EU ETS reporting. SO_2 in the early years of the time series is very uncertain, as one refinery is closed, and as only very scarce information is available. It has not been possible to get further verification of the data for 1990-1994.

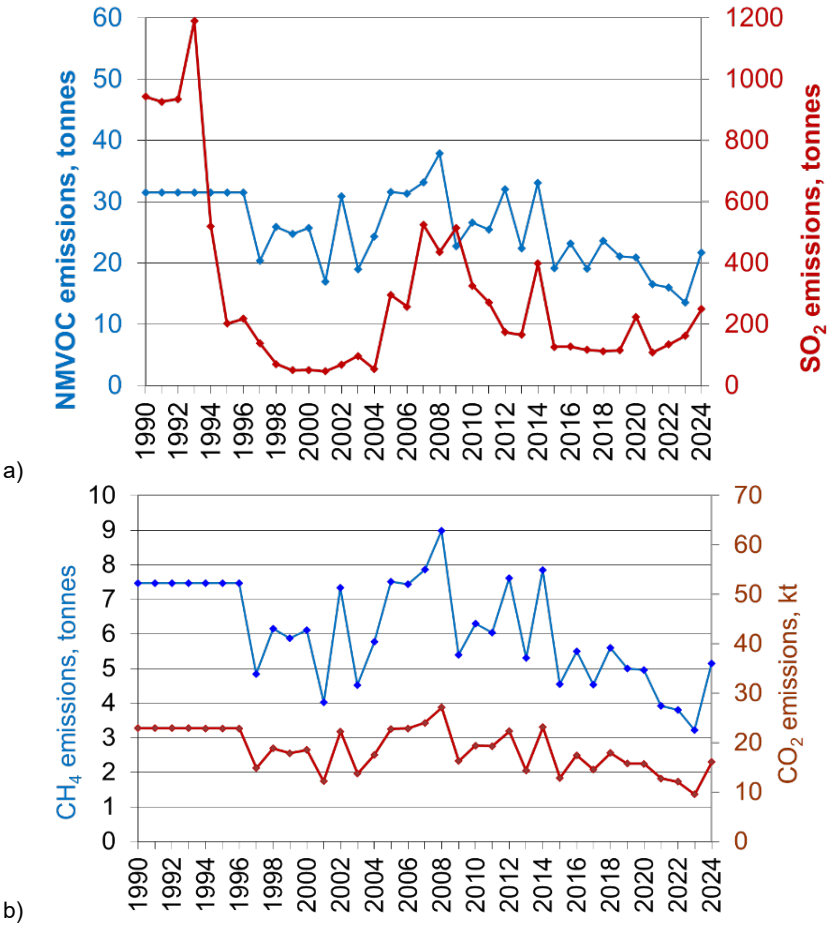


Figure 4.4.4 Emissions of (a) NMVOC and SO_2 and (b) CH_4 and CO_2 emissions from flaring in refineries.

4.4.3 Flaring in upstream oil and gas production

- *Snap 090206, NFR 1B2c, CRT 1B2c2iii*

Activity data

From 2006, data on flaring in upstream oil and gas production is given in the reports submitted under the EU ETS and thereby emission calculation can be made for the individual production units. Before 2006, only the total flared amount is available in the annual reports "Denmark's oil and gas production" published by the Danish Energy Agency. Flaring rates are shown in Figure 4.4.5. Flaring rates in upstream oil and gas production have been decreasing over the last 10 years period in accordance with the decrease in production as seen in Figure 4.4.5. Further, for environmental reasons there is focus on reduction of the amount being flared.

The Tyra platforms were closed in the period between September 2019 and March 2024 due to redevelopment. The recommissioning that started ultimo March 2024, was expected to last around 4 months, where the capacity slowly increased from 0 to full capacity. The commissioning and ramp-up of Tyra II production was impacted by weather conditions and minor operational occurrences and by the end of February 2025 Tyra II was back in full operation. The Tyra platforms have for 30 years been processing most of the Danish natural gas production, and the redevelopment ensures continued production from Denmark's largest producing gas field.

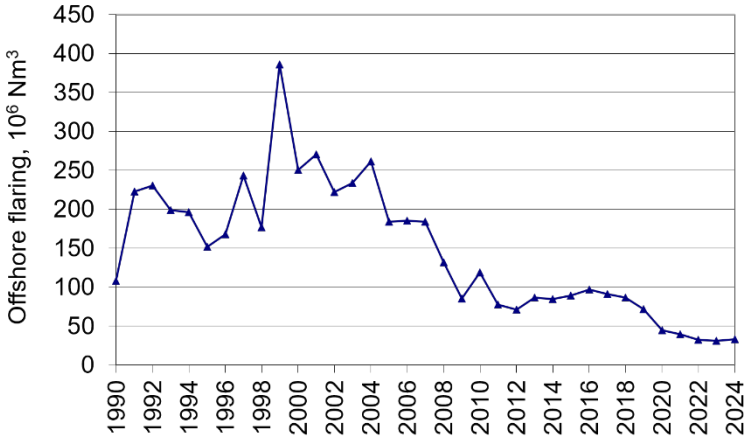


Figure 4.4.5 Flaring rates in upstream oil and gas production.

Emission factors

The emission factors for flaring in upstream oil and gas production are shown in Table 4.12. The NO_x emission factor is based on the conclusion in a Danish study of NO_x emissions from offshore flaring carried out by the Danish Environmental Protection Agency (Danish EPA, 2008). The recommended NO_x emission factor (31 008 g per GJ or 0.0015 tonnes NO_x per tonnes gas) corresponded well with the emission factors used to estimate NO_x emission in other countries with oil production in the North Sea (Netherlands: approximately 0.0014 tonnes NO_x per tonnes gas and United Kingdom: approximately 0.0013 tonnes NO_x per tonnes gas). Since 2006, the CO_2 emission factors are calculated according to the reporting for EU ETS. As corresponding data are not available for earlier years, the average CO_2 EF for the years 2008-2012 is applied for the years 1990-2007. The emission factor for CH_4 is estimated from flare gas quality data for one offshore production platform, assuming a flare efficiency of 98 % in agreement with IPCC (2019) and API (2009). Emission factors for N_2O are based on IPCC (2019) and annual Danish production and flaring rates. Emission factors for all other pollutants are based on standard Tier 1 emission factors for stationary combustion of gaseous fuels in energy industries from the 2023 EMEP/EEA Guidebook (EMEP/EEA, 2023).

Table 4.12 Emission factors for flaring in upstream oil and gas production.

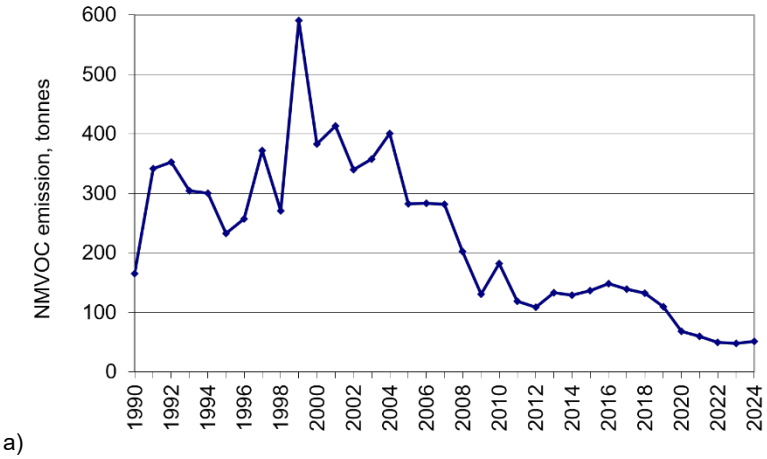
Pollutant	Emission factor,	Unit
SO_2	0.005	g/Nm^3 flared
NO_x	1.23	g/Nm^3 flared
NMVOC	1.53	g/Nm^3 flared
CO	2.81	g/Nm^3 flared
TSP	0.039	g/Nm^3 flared
PM_{10}	0.039	g/Nm^3 flared
PM2.5	0.039	g/Nm^3 flared
BC	0.0009	g/Nm^3 flared
CH_4	10.56	g/Nm^3 flared
CO_2	2.46	kg/Nm^3 flared
N_2O	0.004	g/Nm^3 flared

Emissions

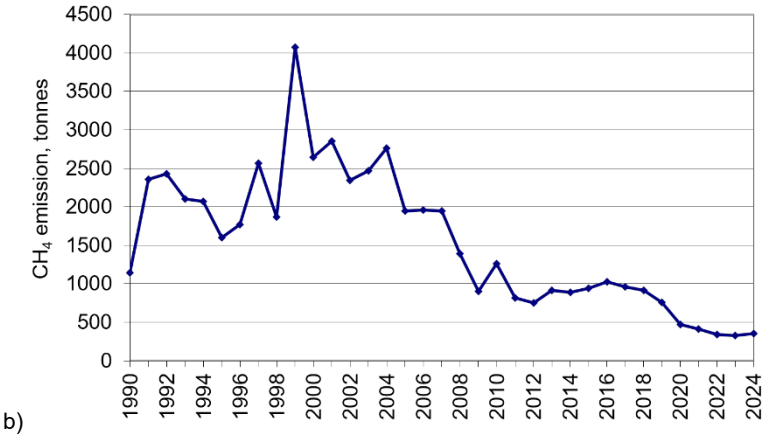
The time series for the emission of CO_2 from flaring in upstream oil and gas production fluctuates primarily due to the fluctuations in the flaring rate and to a minor degree due to the CO_2 emission factor. Emissions of other pollutants from flaring in upstream oil and gas production are estimated

from the same emission factors for all years in the time series, and the variations reflect only the variations in the flared amounts.

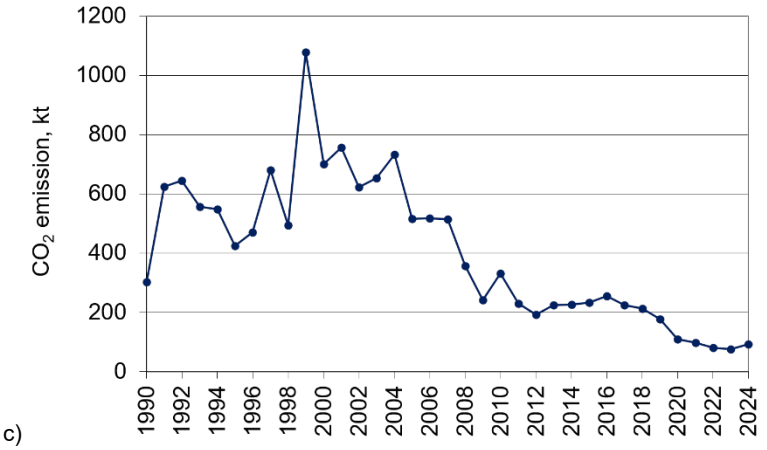
As shown in Figure 4.4.6, there was a marked increase in the rate of flaring in upstream oil and gas production in 1997 and especially in 1999. The increase in 1997 was due to the new Dan field and the commissioning of the Harald field. The increase in 1999 was due to the opening of the three new fields Halfdan, Siri, and Syd Arne.



a)



b)



c)

Figure 4.4.6 NMVOC (a), CH_4 (b) and CO_2 (c) emissions from flaring in upstream oil and gas production.

4.4.4 Flaring in treatment and storage facilities

- *Snap 090298, NFR 1B2c, CRT 1B2c2ii*

Activity data

Activity data for flaring at the gas treatment facility are given in environmental reports (1994-2005) and in the EU-ETS reports (2006 onwards) and for gas storage facilities in environmental reports (Energinet.dk, 2025a). Flaring rates in gas treatment and gas storage facilities are not available before 1994. The mean value for 1994-1998 has been adopted as basis for the emission calculation for the years 1990-1993 (Figure 4.4.7). Note that one of the two gas storage facilities was not opened before 1994.

The large amount of gas flared in 2007 owes to extensive maintenance work being done at the gas treatment plant. The increase in 2017 owe to increased flaring amount at the gas treatment plant. The increase in 2022 owe to the emissions from the receiving terminal for Baltic Pipe, which is a gas pipeline that provides Denmark and Poland with a direct access to Norway's gas fields. The receiving terminal is an expansion of the existing receiving terminal Nybro, which receives gas from the Danish production facilities in the North Sea. Baltic Pipe was in full operation from ultimo November 2022.

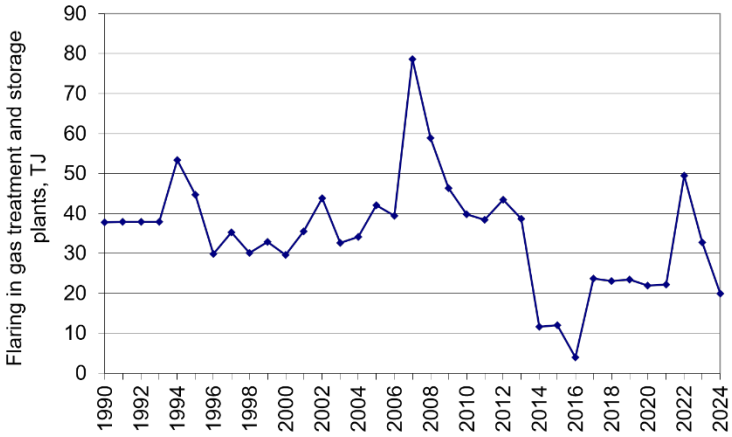


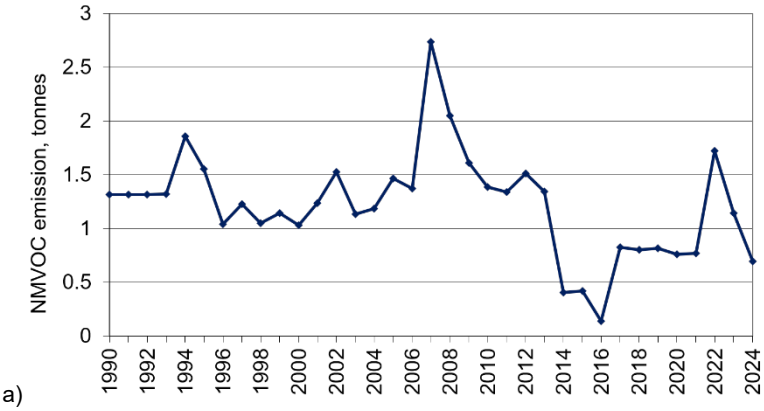
Figure 4.4.7 Flaring in gas treatment and storage facilities.

Emission factors

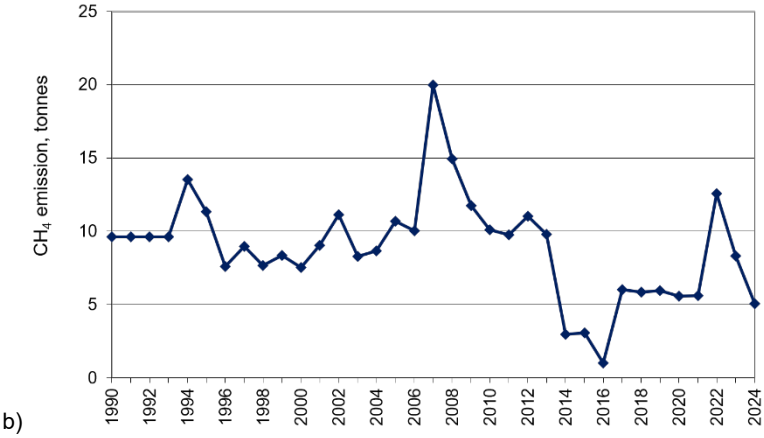
NMVOC emissions from flaring in gas treatment and storage facilities are provided for the relevant treatment and storage facilities. Emissions of other pollutants are calculated from the same emission factors, which are used for flaring in upstream oil and gas production (Table 4.12), except for CO_2. The natural gas flared in the treatment and storage facilities are natural gas with the same composition as natural gas distributed in Denmark, and the CO_2 emission factors are based on the gas composition given by Energinet.dk (Table 4.8).

Emissions

Emissions from flaring in gas treatment and storage facilities are of minor importance to the total fugitive emissions. Emissions from flaring in gas storage and treatment facilities are minor and the annual variation follows the activity data (Figure 4.4.8).



a)



b)

Figure 4.4.8 NMVOC (a) and CH_4 (b) emissions from flaring in gas treatment and storage facilities.

4.4.5 Flaring in gas transmission and distribution

- *Snap 090299, NFR 1B2c, CRT 1B2c2ii*

Activity data

The Danish gas transmission company acquired a mobile flare, which has been used during large maintenance work since 2013. Also, flaring has occurred in gas distribution since 2011. Flaring rates are provided by the relevant companies. Total flaring amounts in gas transmission and distribution are shown in Figure 4.4.9.

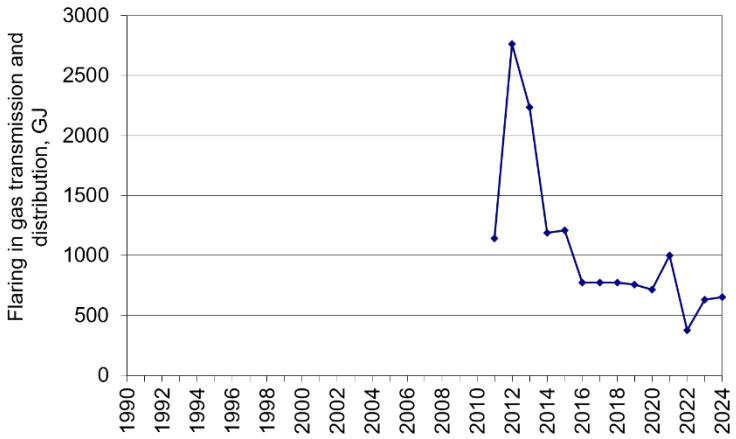


Figure 4.4.9 Flaring rates in gas transmission and distribution.

Emission factors

Emissions from flaring in gas transmission and distribution are for most pollutants calculated from the same emission factors, which are used for flaring in upstream oil and gas production (Table 4.12). The SO_2 emission factor is the same as used for stationary combustion and is based on data from the Danish electricity and gas network operator Energinet. The deviation owes to adding odorants to the gas for transmissions and distribution due to safety reasons. The CO_2 emission factor is based on average annual natural gas composition (Table 4.8) given by Energinet.dk (2025c). Emission factors for SO_2 and CO_2 are listed in Table 4.13.

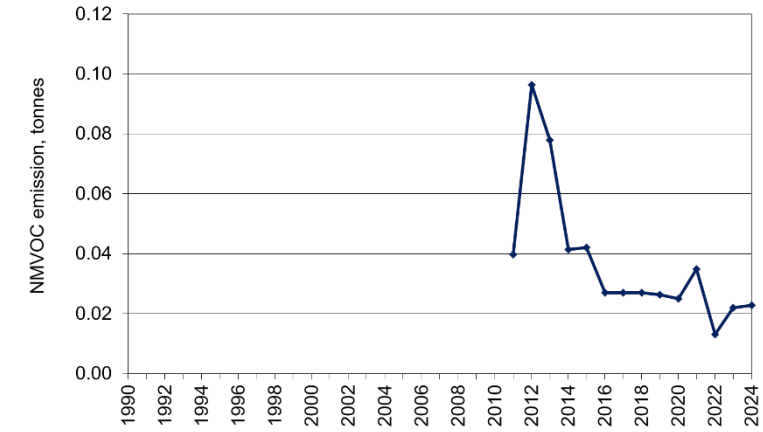
Table 4.13 Emission factors for flaring in gas transmission and distribution.

Pollutant	Emission factor,	Unit
SO_2	0.43	g/GJ
CO_2^*	57.1	kg/GJ

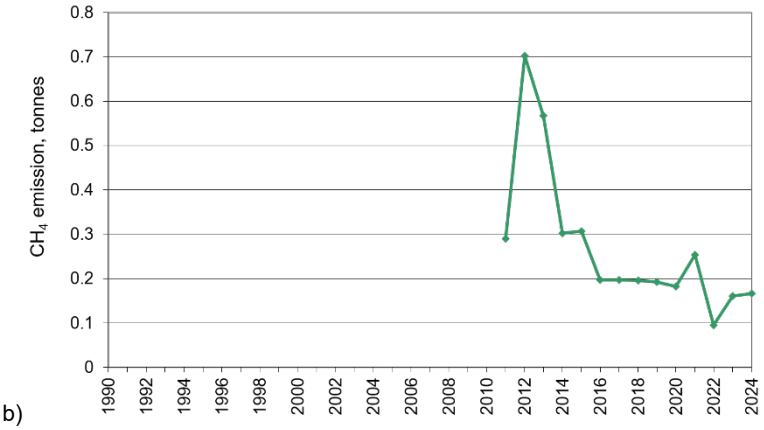
* The CO_2 emission factor is year specific and the value in the table refers to the year 2024.

Emissions

Emissions from flaring in gas transmission and distribution are of minor importance to the total fugitive emissions (Figure 4.4.10).



a)



b)

Figure 4.4.10 NMVOC (a) and CH_4 (b) emissions from flaring in gas transmission and distribution.

5 Uncertainties and time series consistency

5.1 Air pollutants

The applied methodology for uncertainty estimates refers to Pulles & Aardenne (2004). The Danish uncertainty estimates are based on approach 1, as described in the 2006 IPCC Guidelines (IPCC, 2006).

5.1.1 Input data

The uncertainty estimates are based on the calculated emissions for the base year and for the latest inventory year, and on the uncertainty rates for both activity data and emission factors. Data are aggregated for the NFR category 1B - Fugitive Emissions from Fuels. Base year refers to 1990 for all pollutants. Emission data, activity data and emission factors are described in Chapter 4.

For each pollutant the primary emission source/sources are the determinants for the overall uncertainty level. Uncertainty levels are based on the IPCC Guidelines, the EMEP/EEA Guidebook, reports under the EU ETS and DCE assumptions. Uncertainty levels for activity data and emission factors are listed in Table 5.1.

Table 5.1 Uncertainty levels for activity rates and emission factors for NFR category 1B - Fugitive Emissions from Fuels.

Pollutant	Activity data uncertainty level, %	Emission factor uncertainty level, %
SO_2	10	25
NO_x	7.5	125
NMVOC	2	125
CO	7.5	125
TSP	2	50
PM_{10}	2	50
$PM_{2.5}$	2	50
BC	2	100
As	7.5	500
Cd	7.5	500
Cr	7.5	500
Cu	7.5	500
Hg	7.5	500
Ni	7.5	500
Pb	7.5	500
Se	7.5	500
Zn	7.5	500
PCDD/F	7.5	500
Benzo(b)fluoranthene	7.5	500
Benzo(k)fluoranthene	7.5	500
Benzo(a)pyrene	7.5	500
Indeno(1,2,3-cd)pyrene	7.5	500

5.1.2 Results

The uncertainty model estimates uncertainties for both the emission level and the trend. The uncertainty on the emission level for SO_2, NO_x, NMVOC and

CO is 27 %, 125 %, 125 % and 125 %, respectively. For PM, the uncertainty is 50 %, for BC, the uncertainty is 100 % and for HM and PAHs, the uncertainty is 500 %.

The individual uncertainty estimates for the fugitive emission inventory are shown in Table 5.2. The trend refers to the years 1990-2024 for all pollutants and shows a decreasing trend for all pollutants between -96 % and -31 %.

Table 5.2 Estimated uncertainty levels for emissions and trends for fugitive emissions.

Pollutant	Emission level uncertainty [%]	Trend [%]	Trend uncertainty [%]
SO_2	27	-70	4
NO_x	125	-65	4
NMVOC	125	-76	1
CO	125	-61	4
TSP	50	-95	0,1
PM_{10}	50	-95	0,1
$PM_{2.5}$	50	-93	0,2
BC	100	-96	0,1
As	500	-62	4
Cd	500	-31	7
Cr	500	-31	7
Cu	500	-31	7
Hg	500	-61	4
Ni	500	-31	7
Pb	500	-32	7
Se	500	-34	7
Zn	500	-31	7
PCDD/F	500	-67	4
Benzo(b) fluoranthene	500	-66	4
Benzo(k) fluoranthene	500	-68	3
Benzo(a)pyrene	500	-66	4
Indeno (1,2,3-cd) pyrene	500	-68	3

5.2 Greenhouse gases

The uncertainty models follow the methodology in the 2006 IPCC Guidelines (IPCC, 2006). Approach 1 is based on the simplified uncertainty analysis (error propagation method) and Approach 2 is based on Monte Carlo simulations. Since the 2017 submission, the Approach 2 uncertainty estimation has not been carried out due to a lack of resources.

Uncertainty estimates are made for total emissions in the latest inventory year and for the emission trends for the corresponding time series. Uncertainty estimates are made for the CO_2, CH_4 and N_2O separately and summarized.

5.2.1 Input data

The Approach 1 uncertainty model is based on emission data, uncertainty levels for activity data and uncertainty levels for emission factors for base year and latest inventory year. Emission data, activity data and emission factors are described in Chapter 4.

The uncertainty levels used in the uncertainty models are based on different sources, e.g. the 2006 IPCC Guidelines, EMEP/EEA Guidebook, and reports under the EU ETS. Further, several of the uncertainty levels are given as DCE assumptions. DCE assumptions are based on source and/or plant specific uncertainty levels for part of the SNAP category and assumptions for the remaining sources and/or plants in the category.

Input data are aggregated on SNAP level. Estimates are made for the greenhouse gases CO_2, CH_4 and N_2O both separately and summarized (GHG). Uncertainty levels for activity data and emission factors are listed in Table 5.3.

Table 5.3 Uncertainty levels for activity rates and emission factors.

Pollutant	CRT category	Source	Activity data uncertainty level, %	Emission factor uncertainty level, %
CO_2	1.B.2.a.1	Exploration	2 A	10 A
CO_2	1.B.2.a.4	Refining/storage	2 A	40 S
CO_2	1.B.2.a.6	Abandoned wells	1 A	120 R
CO_2	1.B.2.b.1	Exploration	2 A	10 A
CO_2	1.B.2.b.2	Production	2 A	70 A
CO_2	1.B.2.b.4	Transmission and storage	15 G	2 Q
CO_2	1.B.2.b.5	Distribution	25 G, A	10 Q, A
CO2	1.B.2.b.6	Post-meter	15 G	60 R
CO_2	1.B.2.c.1.ii	Venting	15 G, A	2 Q
CO_2	1.B.2.c.2.i	Flaring, oil	11 E	2 E
CO_2	1.B.2.c.2.ii	Flaring, gas	7.5 E	2 E
CO_2	1.B.2.c.2.iii	Flaring, combined	7.5 E	2 E
CH_4	1.B.2.a.1	Exploration	2 A	125 A
CH_4	1.B.2.a.3	Transport	2 A	50 R
CH_4	1.B.2.a.4	Refining/storage	1 E, A	200 A
CH_4	1.B.2.a.6	Abandoned wells	1 A	120 R
CH_4	1.B.2.b.1	Exploration	2 A	125 A
CH_4	1.B.2.b.2	Production	2 A	130 A
CH_4	1.B.2.b.4	Transmission and storage	15 G	2 Q
CH_4	1.B.2.b.5	Distribution	25 G, A	10 Q, A
CO2	1.B.2.b.6	Post-meter	15 G	60 R
CH_4	1.B.2.c.1.ii	Venting	15 G, A	2 Q
CH_4	1.B.2.c.2.i	Flaring, oil	11 E	15 H, A
CH_4	1.B.2.c.2.ii	Flaring, gas	7.5 E	2 A
CH_4	1.B.2.c.2.iii	Flaring, combined	7.5 E	125 G
N_2O	1.B.2.a.1	Exploration, oil	2 A	1000 A
N_2O	1.B.2.c.2.i	Flaring, oil	11 E	1000 I
N_2O	1.B.2.c.2.ii	Flaring, gas	7.5 E	1000 I
N_2O	1.B.2.c.2.iii	Flaring, combined	7.5 E	1000 I

A: DCE assumption.
E: EU Emission Trading Scheme (EU ETS).
G: EMEP/EEA Guidebook, 2009.
H: Holst, 2009 and Statoil A/S, 2010.
I: IPCC Good Practice Guidance (default value).
Q: Annual gas quality, Energinet.dk
R: 2019 IPCC Refinement.
S: Statistisk Sentralbyrå, Statistics Norway, 2008.

The CO_2 emission factors for flaring in upstream oil and gas production and in refineries and the CO_2 and CH_4 emission factors for natural gas transmission, distribution and venting, are the most accurate as they are calculated on basis of gas composition measurements. Emission factors for flare gas are available in the EU ETS reporting while emission factors for natural gas are published by Energinet.dk.

The calculation of CO_2 emissions from exploration of oil and gas is based on information on oil and gas quality for most drillings. As the uncertainty levels of the measurements are not available, the double of the uncertainty for flaring in oil and gas extraction (before EU ETS standards) has been used.

The CO_2 emission factor for abandoned oil/gas wells is based on standard emission factors from IPCC (2019) and the corresponding uncertainties of 120 % are applied in the uncertainty analysis.

The CH_4 and CO_2 emission factors for production of oil and gas are based on data from the Danish operators and estimated uncertainties of 130 % and 70 %, respectively, is applied in the uncertainty analysis.

The uncertainty level for the emission factor for fugitive CH_4 emissions from refineries is dominated by a large uncertainty for one refinery. Further, measurements of fugitive emissions from the refineries are only available for one and two years, respectively, and these measurements indicate larger emissions than earlier estimates. As more measurements become available, the uncertainty level is expected to decrease.

The emission factors for onshore loading of ships are based on data for the Danish harbour terminal, and the uncertainty is expected to be relatively low, as annual calculations are based on results from measurement campaigns. The uncertainty for the CH_4 emission factors for offshore loading of ships in the 2019 IPCC Refinement (IPCC, 2019) is ±50 %. Following, an uncertainty level of 50 % is used for CRT 1B2a3 Oil transport.

For onshore activities, the emission factor uncertainty corresponds to the uncertainty for onshore loading by Statistics Norway (2008), and the same uncertainty level is assumed for the CH_4 emission factor for onshore activities.

According to IPCC (2006) the emission factor for N_2O is the least reliable, and the uncertainty interval for the N_2O emission factors given for flaring in oil and gas production is -10 % to +1 000 %. An uncertainty level of 1 000 % is adopted in the Danish uncertainty model for all fugitive sources in the Danish inventory (exploration and flaring of oil and gas).

5.2.2 Results

The results of the Approach 1 uncertainty model are shown in Table 5.4. N_2O has the largest uncertainty for both the total emission and the trend followed by CH_4 and CO_2. The estimated uncertainty for the total GHG emission is 30 %, and the GHG emission trend is -69 % ±5 %-point.

Table 5.4 Uncertainty estimates for total emissions and emission trends from the Approach 1 uncertainty model.

	1990 emission, kt CO_2 eqv.	2024 emission, kt CO_2 eqv.	Uncertainty, % lower and upper (±)	Trend 1990-2024, %	Uncertainty, % lower and upper (±)
CO_2	341	111	7	-68	3
CH_4	329	100	69	-69	9
N_2O	0.17	0,07	703	-58	111
GHG	670	211	33	-69	5

5.2.3 Source specific QA/QC and verification

The elaboration of a formal QA/QC plan started in 2004 and was updated in 2013 (Nielsen et al., 2013) and latest in 2020 (Nielsen et al., 2020). The plan describes the concepts of quality work and definitions of sufficient quality,

Critical Control Points (CCP) and a list of Points of Measuring (PM) (Figure 5.2.1).

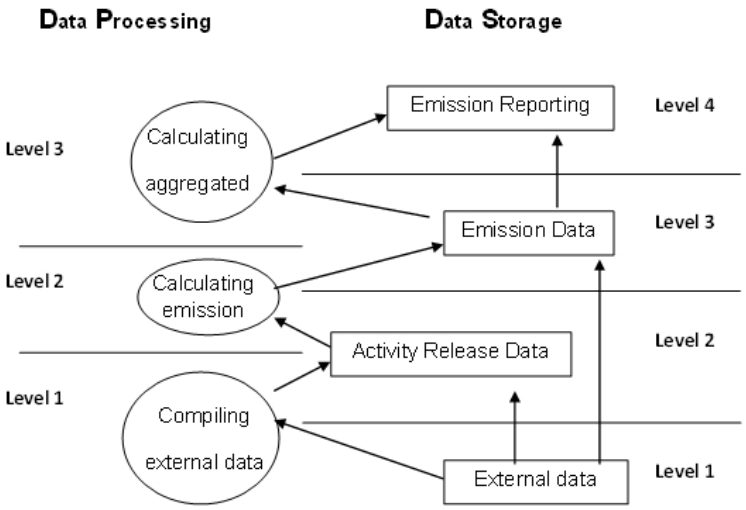


Figure 5.2.1 The general data structure for the Danish emission inventory (Nielsen et al., 2020).

Data storage level 1

Data storage level 1 refers to the data collected by DCE before any processing or preparing. Table 5.5 lists the external data deliveries used for the inventory of fugitive emissions. Further, the table holds information on the contacts at the data delivery companies.

Table 5.5 List of external data sources.

Category	Data description	Data type	Reference	Contact(s)	Data agreement /comment
Exploration of oil and gas	Dataset for exploration of oil and gas, including rates and composition.	Activity data	The Danish Energy Agency	Kirsten Lundt Erichsen	Data agreement
Abandoned oil/gas wells	Number, date and location for abandoned wells	Activity data	The Danish Energy Agency	Kirsten Lundt Erichsen	No formal data agreement
Production of oil and gas	Gas and oil production. Dataset, including rates of offshore loading of ships.	Activity data	The Danish Energy Agency	Kirsten Lundt Erichsen	Not necessary due to obligation by law
	Company emission inventory data, LDAR information and drone measurement results.	Emission data and supporting information	TotalEnergies, INEOS Energy	Karina Gil Tabita Hylkjær	No formal data agreement.
Offshore flaring	Flaring in upstream oil and gas production (EU ETS data)	Activity data	The Danish Energy Agency	Rikke Brynaa Lintrup	Data agreement
Service stations	Data on gasoline sales from the Danish energy statistics.	Activity data	The Danish Energy Agency	Jytte Illerup, Ali A. Zarnaghi	Data agreement
Gas transmission	Natural gas transmission rates from the transmission company, sales and losses.	Activity data	Energinet.dk	Frederikke Byrial Zilstorff	Not necessary due to obligation by law
Onshore activities	Rates of oil transport in pipeline and onshore loading to ships. Emissions from storage of raw oil in the terminal.	Activity data and emission data	Ørsted	Søren Boesen	No formal data agreement.
Gas distribution	Natural gas and town gas distribution rates from the distribution company, sales and losses (meter differences)	Activity data	Evida	Per Gravers Kristensen	No formal data agreement.
Emissions from refinery	Fuel consumption and emission data.	Activity data and emission data	Kalundborg Refinery, Crossbridge	Anette Holst, Trine Bjerre Kristiansen	No formal data agreement.
Treatment and storage of gas	Environmental reports and supplemental data from plants defined as large point sources (Lille Torup, Stenlille)	Activity data and emission data	Energinet.dk	Christian Guldager Cordon	No formal data agreement.
Onshore loading	Annual report for the harbour terminal.	Activity data and emission data	Crossbridge	Trine Bjerre Kristiansen	No formal data agreement.
CO_2 emission factors for different sources	Reports according to the CO_2 emission trading scheme (EU ETS)	Activity data	Various plants		Not necessary due to obligation by law
Emission factors	Emission factors originating from many sources	Emission factors	See Chapter 4		

The following section lists the CCPs and the PMs in the Danish QA/QC plan, relevant for the emission inventory for the fugitive sector.

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

The uncertainty for every dataset included in the inventory of fugitive emissions are evaluated and included in the Tier 1/Approach 1 uncertainty calculations with short descriptions of the reasoning behind the specific values. The general levels of uncertainty are relatively low. The largest uncertainties are expected for emissions from refineries and distribution of town gas, the latter being of minor importance to the total fugitive emissions. For further comments regarding uncertainties, see Chapter 5.

Level	CCP	PM	Description
Data Storage level 1	2.Comparability	DS.1.2.1	Comparability of the emission factors/calculation parameters with data from international guidelines, and evaluation of major discrepancies

Systematic inter-country comparison has only been made on Data Storage Level 4. Further information is available in Nielsen et al. (2026a).

Level	CCP	PM	Description
Data Storage level 1	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

External data include energy statistics from the Danish Energy Agency, EU ETS reports and annual environmental reports from several plants and companies. Further, supplementary information is gathered annually from some companies. Only one national data set is found for most fugitive sources, and all data sets are expected to be complete and include all activities/emissions form the sources. Data on flaring in upstream oil and gas production, in refineries and in gas treatment and storage facilities are available both in annual environmental reports and in EU ETS reports. Data are compared and if any differences occur, this is checked with the data suppliers. Minor differences may owe to the allocation of fuels, e.g. if pilot gas is included in the flare gas or the fuel gas rate.

Energy statistics

The Danish Energy Agency reports fuel consumption statistics on the SNAP level based on a correspondence table developed in co-operation with DCE. Both traded and non-traded fuels are included in the Danish energy statistics. Data on production and flaring in upstream oil and gas production, and gasoline sales are used for estimation of fugitive emissions.

Environmental reports

Many plants are obligated by law to publish an environmental report annually with information on e.g. fuel consumption and emissions. DCE compares data with those from previous years, discrepancies are checked, and large fluctuations are verified.

Reports for the European Union Greenhouse Gas Emission Trading System (EU ETS)

CO_2 emission factors for offshore in upstream oil and gas production and in refineries have been taken from the EU ETS reports since 2006, when the EU ETS reports became available. EU ETS reports are available individually for the Danish oil/gas production fields and refineries.

Emission factors from a wide range of sources

For specific references, see Chapter 4.

Level	CCP	PM	Description
Data Storage level 1	4.Consistency	DS.1.4.1	The original external data has to be archived with proper reference

All external data are stored in the inventory file system and are accessible for all inventory staff members. Data processing is carried out in separate spread

sheets to ensure that the external data are always available in the original form. Data sources are referenced in the spread sheets. Further information is available in Nielsen et al. (2026a).

Level	CCP	PM	Description
Data Storage level 1	6.Robustness	DS.1.6.1	Explicit agreements between the external institution holding the data and DCE about the conditions of delivery

Formal agreements are made with the Danish Energy Agency. Annual environmental reports are available due to legal requirements. The remaining data are published or delivered by the companies on voluntary basis (Table 5.5).

Level	CCP	PM	Description
Data Storage level 1	7.Transparency	DS.1.7.1	Listing of all archived datasets and external contacts

See DS 1.3.1 and (Table 5.5).

Data Processing Level 1

Level	CCP	PM	Description
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

Further information is available in Nielsen et al. (2026a).

Level	CCP	PM	Description
Data Processing level 1	2.Comparability	DP.1.2.1	The methodologies have to follow the international guidelines suggested by UNFCCC and IPCC

The methodologies in the inventory follow the principles in international guidelines by the UNFCCC and the IPCC.

Level	CCP	PM	Description
Data Processing level 1	3.Completeness	DP.1.3.1	Identification of data gaps with regard to data sources that could improve quantitative knowledge

Data gaps are found for distribution of town gas, as multiple companies closed before this source was included in the Danish inventory. Town gas distribution emissions, which account for only a limited part of the total fugitive emissions, are calculated on a scarce data foundation.

Further information regarding VOC emissions from refineries would be preferred but are not available. In 2022, one refinery revised its inventory methodology, resulting in a higher estimated SO_2 emission. Direct measurement data from five furnaces are now incorporated. The SO_2 concentration in the flue gas is derived from hydrogen sulfide, mercaptans, and other sulfur-containing compounds and is expressed on a standard dry flue gas basis. According to the refinery, the revised methodology cannot be applied retrospectively and consequently, a discontinuity is introduced into the time series.

Level	CCP	PM	Description
Data Processing level 1	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

Since 2006, the EU ETS data have been available for several sources. In all cases, the new data replace usage of data assumed to be less accurate. Therefore, the CO_2 emission factors have been updated for all years, and no methodological change has occurred in the time series.

A change in the calculating procedure would entail elaboration of an updated description in Chapter 4.

Level	CCP	PM	Description
Data Processing level 1	5.Correctness	DP.1.5.2	Verification of calculation results using time series

Time series for activity data, emission factors and emissions on source and/or SNAP level are used to identify possible errors in the calculation procedure.

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

For fugitive sources, only one data set is available for calculation, and no verification using other measures are possible. For sources where activity data is available in more data sources (e.g. in both EU ETS and annual reports), data are compared and the reasons for any differences are clarified.

Level	CCP	PM	Description
Data Processing level 1	7.Transparency	DP.1.7.1	The calculation principle, the equations used and the assumptions made must be described

Descriptions are included in Chapter 4.

Level	CCP	PM	Description
Data Processing level 1	7.Transparency	DP.1.7.2	Clear reference to dataset at Data Storage level 1

Notes on data sources are included in the calculation files for all input data.

Level	CCP	PM	Description
Data Processing level 1	7.Transparency	DP.1.7.3	A manual log to collect information about recalculations

A log holding information on recalculations are included in the national inventory system. Further, a log is prepared annually holding information on status of the inventory work and recalculations for each source in the fugitive sector.

Data storage level 2

Level	CCP	PM	Description
Data Storage level 2	5.Correctness	DS.2.5.1	Check if a correct data import to level 2 has been made

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

Data storage level 4

Level	CCP	PM	Description
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

Time series for IEFs are checked to identify large fluctuations, which are afterwards investigated and explained. The levels of the IEFs are compared to other relevant EFs, e.g. standard EFs in guidebooks and guidelines.

Other QC procedures

A list of QA/QC tasks are performed directly in relation to the fugitive emission part of the Danish emission inventories. The following procedures are carried out to ensure the data quality:

- The emission from the large point sources (refineries, gas treatment and gas storage facilities) is compared with the emission reported the previous year.
- Annual environmental reports are kept for subsequent control of plant-specific emission data.
- Checks of data transfer are incorporated in the fugitive emission models, e.g. sum checks.
- Verification of activity data from external data when data are available through more data sources (production and flaring rates in upstream oil and gas production).
- Data sources are incorporated in the fugitive emission models.
- A manual log table in the emission databases is applied to collect information about recalculations.
- Comparison with the inventory of the previous year. Any major changes are verified.
- Total emission, when aggregated to reporting tables, is compared with totals based on SNAP source categories (control of data transfer).
- Checking of time series in the CRT and SNAP source categories. Significant dips and jumps are controlled and explained.

5.3 International inventory review

The Danish emission inventories for greenhouse gases are reported to the United Nations Framework Convention on Climate Change (UNFCCC) and to the EU effort sharing regulation (Regulation (EU) 2018/842) (ESR), and the Danish emission inventories for air pollution are reported to the UNECE Convention on Long-Range Transboundary Air Pollution (LRTAP) and to the

Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants (NECD). The reports are reviewed regularly. The reviews are conducted by teams of international experts, and include automatic checks, initial assessment, desk reviews and in-country reviews.

The latest UNFCCC review of the Danish 2025 submission took place as an in-country review from 28 April to 2 May 2025. The 2025 UNFCCC review was the technical expert review of the first biennial transparency report of Denmark submitted on 23 December 2024, covering the years 1990-2022. The review team did not include any findings for the fugitive emissions sector in the review report. The outcome of the review is available in the review report (UNFCCC 2025a, UNFCCC 2025b).

The latest review of the Danish greenhouse gas inventory under the EU ESR was conducted in 2025 for the 2025 reporting covering the years 1990-2023, The review reports are published by the European Commission (2025a).

The latest review of the air pollution inventory was conducted in 2025. The review report is not yet completed, but the 2024 review report is published by the European Commission (2025b). The 2025 NECD review include periodically review of projections, emissions from large point sources (LPS) and gridded emissions. The review team did not include any findings for the fugitive emissions sector in the review report.

Observations and recommendations from the international experts following the international reviews are a vital part of the QA and improvement work for the emission inventory.

5.4 External sectoral review

The first documentation report for the sector "Fugitive emissions from fuels" was published in 2009 (Plejdrup et al., 2009). The 2009 report was reviewed by an external expert not involved in the preparation of the inventory to allow for an independent peer review as part of the QA activities. The expert was Anette Holst from Statoil Refinery, Kalundborg, Denmark.

In 2015, an updated documentation report for the sector "Fugitive emissions from fuels" was published, including detailed information on the methodology used in the emission inventories for greenhouse gases and air pollution (Plejdrup et al., 2015). The report was reviewed by the external expert Glen Thistlethwaite from Ricardo Energy & Environment, Oxfordshire, UK.

The previous version from 2021 (Plejdrup et al., 2021) was reviewed by Jesper Werner Løhndorf Christensen, the Danish Energy Agency, Centre for Subsoil Resources and Risk Preparedness.

The present report has been reviewed by Christian Böttcher, Umweltbundesamt (Federal Environment Agency), Germany.

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THE DANISH EMISSION INVENTORY FOR FUGITIVE EMISSIONS FROM FUELS

Inventories until 2024

The Danish Centre for Environment and Energy (DCE), Aarhus University prepares the national inventories of emissions to the air for greenhouse gases and air pollutants and reports to the UN and EU according to the national obligations.

In line with the international reporting guidelines, the Danish emission inventories cover five main sectors. This report documents the methodologies used in the emission inventory for sector "Fugitive emissions from fuels", which is a subsector in the Energy sector, including information on activity data, emission factors and emissions for the time series 1990-2024. The fugitive sector covers emissions from extraction, handling, storage, and transport of solid, liquid, and gaseous fuels, and from venting and flaring.

The fugitive sector includes emissions of the greenhouse gases CO_2, CH_4 and N_2O, and the fugitive sector account for 0.6 % of the national total GHG emissions.

The air pollution inventory for the fugitive emissions sector includes emissions of SO_2, NO_x, NMVOC, CO, particulate matter, BC, heavy metals, and POPs, and the sector contributes 17.7 %, 4.4 % and 0.3 % to the national total emissions of SO_2, NMVOC and BC, respectively. For the remaining pollutants, the fugitive sector contributed only little to the national total (< 0.1 %).

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