National Institute for Public Health
and the Environment
Ministry of Health, Welfare and Sport

Greenhouse gas emissions
in the Netherlands 1990-2023

National Inventory Document 2025

RIVM report 2025-0005

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Colophon

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Synopsis

Greenhouse gas emissions in the Netherlands 1990–2023

Total greenhouse gas (GHG) emissions in the Netherlands decreased by 6.8 per cent in 2023, compared to the 2022 emissions. This decrease was mainly the result of lower coal and natural gas consumption in the electricity sector. In addition, more renewable energy resources were used in 2023, such as solar and wind energy. In total this share was 17 per cent of the total energy consumption in the Netherlands. In 2022, this share was 15 per cent.

The total amount of GHG emissions is expressed in CO_2-equivalents and are compared with emissions in the base year 1990. Emissions are converted into CO_2-equivalents to be able to add up the impact of the various greenhouse gases. The total GHG emissions expressed in CO_2-equivalents amounted to 146.4 Mton CO_2-eq in 2023. Emissions decreased by 35.6 percent compared to the base year, in which the emissions were 227.5 Mton CO_2-eq. Thanks to this emission reduction, the Netherlands amply met the Urgenda target. According to this target, greenhouse gas emissions must be at least 25 percent less than in 1990.

The CO_2 emissions were 28.1 per cent less than the level in the base year. The emissions of the other greenhouse gases (methane, nitrous oxide and fluorinated gases) were reduced by 56.8 per cent since 1990.

These figures are derived from the final inventory of greenhouse gas emissions in 2023, which is yearly reported by RIVM at the request of the Ministry of Climate Policy and Green Growth (KGG). With this, the Netherlands complies with the national reporting obligations for 2025 set out by the United Nations Framework Convention on Climate Change (UNFCCC), the Paris Agreement and the Governance Regulation of the Energy Union (EU 2018/1999) and implementing regulations. In the autumn of 2024, the preliminary emission figures for 2023 were published.

The report also contains an analysis on GHG emission trends between 1990 and 2023. It also includes an assessment of the main sources of GHGs (key sources) and a description of the uncertainty in the emissions estimates. In addition, the inventory sets out the calculation methods and data sources used. Finally, the inventory contains a general description of the quality assurance system and the way verification activities are performed on the data by the Dutch Emission Inventory.

Keywords: greenhouse gases, emissions, trends, methodology, climate, renewable energy sources, international

Publiekssamenvatting

Emissies van broeikasgassen tussen 1990 en 2023

In 2023 zijn in Nederland in totaal 6,8 procent minder broeikasgassen naar de lucht uitgestoten dan in 2022. Deze daling komt vooral doordat de elektriciteitssector minder steenkool en aardgas gebruikte. In 2023 zijn ook meer hernieuwbare energiebronnen gebruikt, zoals zonne- en windenergie. In totaal is dit 17 procent van het energieverbruik in Nederland. In 2022 was dit 15 procent.

De totale hoeveelheid uitgestoten broeikasgassen wordt uitgedrukt in CO_2-equivalenten en vergeleken met het basisjaar 1990. De uitstoot wordt omgerekend naar CO_2-equivalenten om de invloed van de verschillende broeikasgassen te kunnen optellen. De totale uitstoot van broeikasgassen in CO_2-equivalenten was in 2023 146,4 megaton. De uitstoot daalde met 35,6 procent ten opzichte van het basisjaar, waarin de uitstoot van 227,5 megaton CO_2-equivalenten was. Met deze daling is het zogeheten Urgenda-doel ruim gehaald. Volgens dit doel moet de uitstoot van broeikasgassen minimaal 25 procent lager zijn dan in 1990.

De uitstoot van het broeikasgas CO_2 is 28,1 procent lager dan die in het basisjaar. De uitstoot van de andere broeikasgassen (methaan, distikstofoxide en gefluoreerde gassen) is sinds 1990 met 56,8 procent gedaald.

Deze gegevens komen uit de definitieve inventarisatie van broeikasgasemissies in 2023 die het RIVM elk jaar op verzoek van het ministerie van Klimaat en Groene Groei (KGG) maakt. Hiermee voldoet Nederland aan de nationale rapportageverplichtingen voor 2025 van het Klimaatverdrag van de Verenigde Naties (UNFCCC), van het Akkoord van Parijs en van de Europese verordening (2018/1999) over de governance van de energie-unie en de klimaatactie. In het najaar van 2024 zijn de voorlopige emissiecijfers over 2023 gepubliceerd.

De inventarisatie geeft ook inzicht in ontwikkelingen in de uitstoot van broeikasgassen tussen 1990 en 2023. Verder is er een analyse van de belangrijkste bronnen die broeikasgassen uitstoten. Ook is de onzekerheid in de berekening van deze uitstoot beschreven. Daarnaast zijn de gebruikte berekeningsmethoden en databronnen beschreven. Ten slotte geeft de inventarisatie een overzicht van het kwaliteitssysteem en de manier waarop de Nederlandse Emissieregistratie de berekeningen controleert.

Kernwoorden: broeikasgassen, emissies, trends, methodiek, klimaat, hernieuwbare energiebronnen, internationaal

Contents

Executive summary

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

This report documents the Netherlands' annual submission of its greenhouse gas (GHG) emissions inventory for 2025, in line with the annual reporting requirements under the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement (PA). It contributes to fulfilling the reporting requirements under the Governance Regulation of the Energy Union (EU 2018/1999) and implementing regulations.
The report has been prepared in line with the reporting guidelines provided in Decisions by the UNFCCC Conference of the Parties (COP) and the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement (CMA).

Note that this report provides no specific information on government policies for reducing GHG emissions. Such information can be found, for example, in the Netherlands State of the Environment Report 2023 (PBL, 2023) (biennial edition; in Dutch: *Balans van de Leefomgeving*) prepared by the Netherlands Environmental Assessment Agency (PBL), in the 1st Biennial Transparency Report of the Netherlands under the Paris Agreement (RVO, 2024), in the Climate and Energy Outlook 2024 (PBL, TNO, Statistics Netherlands and RIVM, 2024) and in the updated National Energy and Climate Plan 2021-2030 (EZK, 2024).

The Enhanced Transparency Framework (ETF) tooling and corresponding Common Reporting Tables (CRT), containing data on emissions, activity data and implied emission factors (IEFs), accompany this report. The complete set of CRT tables, as well as the NID 2025 in PDF format, are also available on http://english.rvo.nl/nie.

Please note that a detailed description of calculation methods for the various CRT sectors can be found in the corresponding methodology reports. In these methodology reports, the calculation methods are described, adjusted and updated every year according to the most recent scientific insights. Although these are separate documents containing detailed information, both the CRT and the methodology reports form an integral part of the inventory.

Institutional arrangements for inventory preparation
The GHG emissions inventory process of the Netherlands is an integral part of the national Pollutant Release and Transfer Register (NL-PRTR). Figure ES.1 shows the structure of the inventory process and the bodies responsible for each stage.

The Ministry of Infrastructure and Water Management and the Ministry of Climate Policy and Green Growth (KGG) have contracted the National Institute for Public Health and the Environment (RIVM) to compile and maintain the PRTR and to coordinate the annual preparation of the NID and the completion of the CRT tables.

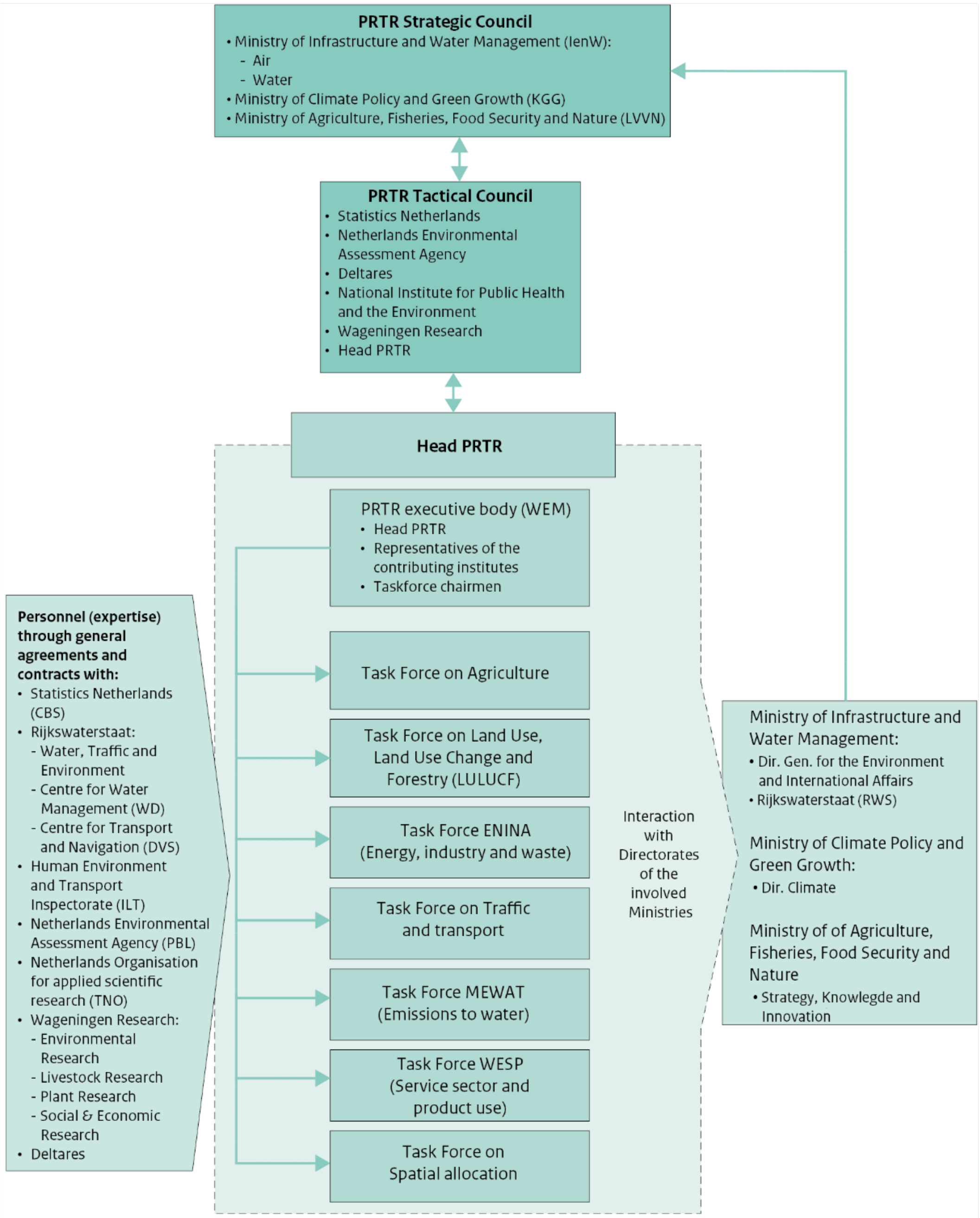


Figure ES.1 Organisational arrangements for the Dutch PRTR project

Methodology reports

Emissions data is reported in accordance with the 2006 IPCC Guidelines (IPCC, 2006) and for a significant part (where indicated), the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Methodologies are described in methodology reports. The present CRT/NID is based on these methodology reports, which are part of the National System.
Note that the methodology reports are also part of the national GHG submission. References are included in Annex 7 and are also available at http://english.rvo.nl/nie. The methodology reports, and any changes in

them, have been prepared and approved under the lead of the Chair of the respective PRTR Task Force. Moreover, the methodology reports are reviewed and approved by the National Inventory Entity (NIE).

Base year

In line with the reporting guidelines, the Netherlands uses 1990 as the base year for all gases.

Key categories

The IPCC Approach 1 method consists of ranking the list of source category/gas combinations according to their contribution to annual national total emissions and to the national total trend (for details of the Approach 1 analysis see the corresponding methodology reports).
The key categories are those whose emissions add up to 95% of the national total (including LULUCF): 40 categories for annual level assessment (emissions in 2023) and 45 categories for the trend assessment. In total the Netherlands reports 124 source categories.

The IPCC Approach 2 method for the identification of key categories requires the incorporation of the uncertainty in each of these source categories before ordering the list of shares. This has been carried out using the uncertainty estimates presented in Annex 2. Here, a total contribution of up to 90% to the overall uncertainty has been used to avoid the inclusion of too many small sources. The results of the Approach 1 and Approach 2 level and trend assessments are summarised in Annex 1. A combination of Approach 1 and 2 and level and trend assessments yields a total of 63 key categories including LULUCF.

Based on the approach 1 level assessment the five major key sources in the Netherlands are given below. Together these key five key sources account for 40% of the total emissions in 2023 (CO_2 eq).

CRT category	Name	Gas
1A1a	Public Electricity and Heat Production: gaseous	CO_2
1A3b	Road transportation: diesel oil	CO_2
1A3b	Road transportation: gasoline	CO_2
1A2	Manufacturing Industries and Construction: gaseous	CO_2
1A4b	Residential gaseous	CO_2

ES.2. Summary of trends related to national emissions and removals

Total GHG emissions (including indirect CO_2 emissions and emissions from LULUCF) in the Netherlands in 2023 were estimated at 146.4 Tg (Teragram or Megaton) CO_2 equivalents (CO_2-eq). This is approximately 35.6% below total emissions in the base year 1990 (227.5 Tg CO_2-eq).

CO_2 emissions (including indirect CO_2 emissions and emissions from LULUCF) in 2023 were 28.1% lower than in 1990. CH_4 emissions in 2023 were 49.5% below 1990 levels, mainly due to decreases in emissions from the Waste sector and the Agricultural sector. N_2O emissions decreased by 59.0% in 2023 compared to 1990, mainly due to decreases in emissions from Agriculture and from Industrial Processes and Product Use (IPPU).

Compared to the base year, the emissions of F-gases (HFCs, PFCs and SF_6) decreased by 85.3%, 98.3% and 50.6%, respectively (see Table ES.2). Total emissions of all F-gases were 88.6% lower than in 1990, partly as a result of the Netherlands' programme for reducing emissions of non-CO_2 greenhouse gases (ROB). Figure ES.1 shows a graphical representation of these trends.

Table ES.1 Summary of emissions trends per gas (Tg CO_2 equivalents, including LULUCF and indirect CO_2 emissions), 1990–2023 (differences due to rounding)

	***CO_2* incl. indirect and LULUCF**	***CH_4* incl. LULUCF**	***N_2O* incl. LULUCF**	***HFCs***	***PFCs***	***SF_6***	***Total (incl LULUCF)***
1990	167.7	36.5	16.1	4.7	2.4	0.2	227.5
1995	177.7	34.0	16.2	6.3	2.1	0.3	236.5
2000	176.5	27.9	14.4	4.0	1.7	0.2	224.6
2005	182.5	22.9	12.9	1.3	0.3	0.2	220.1
2010	186.8	22.3	7.9	2.0	0.3	0.1	219.4
2015	169.0	20.9	8.1	1.7	0.1	0.1	200.0
2020	140.0	19.5	7.5	1.0	0.1	0.1	168.3
2022	130.8	18.6	6.7	0.8	0.1	0.1	157.0
2023	120.6	18.4	6.6	0.7	0.0	0.1	146.4

Compared to 2022, overall 2023 GHG emissions decreased by 6.8%. The changes for the specific gases were as follows (please note that differences compared to table ES.2 are due to rounding):

- CO_2 emissions (including LULUCF) decreased by 7.8% (-10.2 Tg CO_2) – mainly in the categories 1A1 Energy industries (-7.9 Tg CO_2), 1A2 Manufacturing industries and construction (-1.3 Tg CO_2) and 1A4 Other Sectors (-2.1 Tg CO_2) – due to a decrease in natural gas consumption in 2023 as a result high natural gas prices between the end of 2021 and the beginning of 2023. The transport emissions of CO_2 increased by 1.1 Tg in 2023. The amount of energy from renewables and waste in the Netherlands increased from 15% in 2022 to 17% of final energy consumption in the Netherlands in 2023.
- CH_4 emissions decreased by 0.9% (-0.2 Tg CO_2-eq), mainly due to a small decrease in emissions in 3B (Manure management).
- N_2O emissions decreased by 1.8% (-0.1 Tg CO_2-eq), mainly due to a small decrease in emissions in 2B2 (Nitric acid production) and 2B4 (Caprolactam production).
- F-gas emissions decreased by 12.7% (-0.12 Tg CO_2 -eq). Emissions of all F-gases decreased (HFC emissions decreased by

11.7% or 0.09 Tg CO_2-eq, PFC emissions by 20.0% or 0.01 Tg CO_2-eq and SF_6 emissions by 16.1% or 0.02 Tg CO_2-eq). Fluctuations in F-gas emissions over the past few years are mainly due to market circumstances. The main decrease for both HFCs and PFCs in 2023 stemmed from category 2B9 (fluorochemical production).

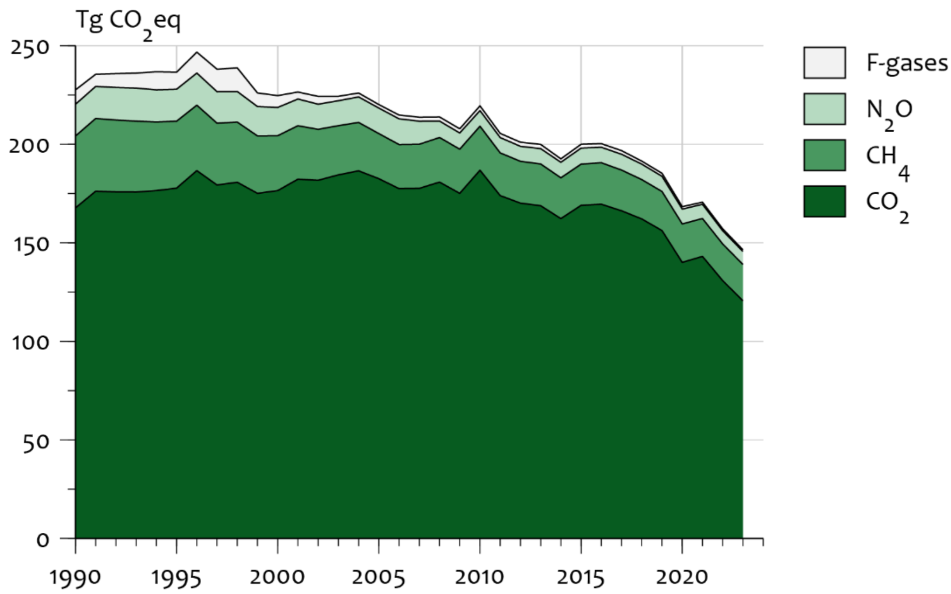


Figure ES.2 Overview of trends in GHG emissions (including LULUCF), 1990–2023

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

Table ES.2 and Figure ES.3 provide an overview of the emissions trends (in CO_2-eq) per IPCC sector. The Energy sector is by far the largest contributor to national total GHG emissions. In 2023, emissions from this sector were about 29.9% lower than in 1990. Emissions from all sectors were lower than in the base year, the largest decreases being in Waste and IPPU.

In this inventory, all major source categories show a decrease in CO_2 equivalent emissions compared to 1990. Only a few relatively minor source categories show an increase in emissions since 1990, e.g. category 1A1b Petroleum refining, total, gases (+0.33 Tg CO_2), 1A3b Road vehicles, gasoline (+1.5 Tg CO_2), 1A3d domestic navigation (+0.2 Tg CO_2), 3A1 cattle, mature dairy cattle (+0.3 Tg CO_2-eq) and 3Da2 organic N fertilizers (+0.4 Tg CO_2-eq).

Table ES.2 Summary of emissions trends per sector (Tg CO_2 equivalents, with all indirect emissions included in the IPPU sector), 1990–2023

	1. Energy	2. IPPU	3. Agriculture	4. LULUCF	5. Waste	Total (incl.) LULUCF
1990	154.5	27.0	25.3	4.4	16.3	227.5
1995	167.3	26.3	24.3	4.3	14.4	236.5
2000	164.2	24.0	20.8	4.5	11.3	224.6
2005	168.8	20.8	18.4	4.6	7.4	220.1
2010	172.3	18.8	18.3	4.6	5.4	219.4
2015	154.9	16.5	19.2	5.3	4.1	200.0
2020	126.7	16.6	16.6	3.3	3.3	168.3
2022	118.5	14.1	18.0	3.5	2.9	157.0
2023	108.3	13.5	18.0	3.8	2.8	146.4

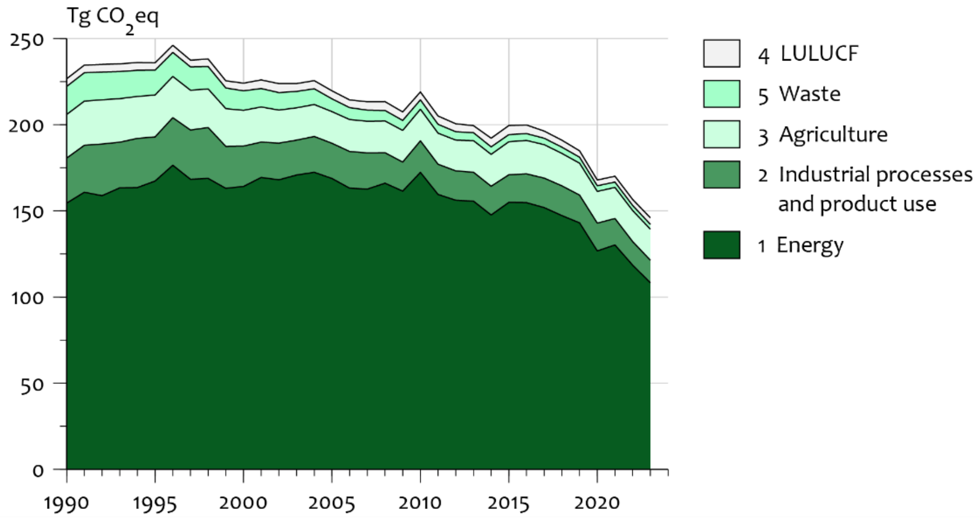


Figure ES.3 Overview of trends in GHG emissions per sector (incl. LULUCF), 1990–2023

ES.4. Other information

Emissions trends for indirect GHGs and precursor gases

Compared to 1990, CO and NMVOC emissions were reduced in 2023 by 67.2% and 60.3%, respectively. For SO_2, the reduction was 91.2%; for NO_x, the 2023 emissions were 73.1% below the 1990 level. Table ES.3 provides trend data. Further documentation on these gases can be found in the annual Informative Inventory Report (IIR, Staats et al., 2025).

Table ES.3 Emissions trends for indirect GHGs and SO_2 (in Gg)

	1990	1995	2000	2005	2010	2015	2020	2022	2023
Total NOx	682	580	491	432	346	271	209	192	184
Total CO	1,177	942	758	723	655	521	427	401	386
Total NMVOC	601	433	335	268	272	256	253	240	238
Total SO2	198	137	78	68	36	31	20	20	18

ES.5. Key category analysis

Key category analyses were conducted according to approach 1 and 2 (for details see chapter 1.4 and annex 1. The IPCC Approach 1 method (without uncertainties) identified 40 categories as key categories for annual level assessment (emissions in 2023) and 45 categories for the trend assessment out of a total of 124 source categories. A combination of Approach 1 and 2 (the last one including uncertainties), level and trend assessments amount to a total of 63 key categories including LULUCF.

ES.6. Improvements introduced

Since the NIR 2024 (Van der Net et al., 2024), some improvements to the inventory (including recalculations) have been implemented, and these are documented in this NIR 2025. The rationale behind the recalculations is documented in Chapters 3–9 and their impacts on the inventory are summarised in Chapter 10. Table ES.4 presents the results of these recalculations in the NIR 2025 compared to the figures reported in the NIR 2024.

Table ES.4 Differences between the NIR 2023 and NIR 2024 for the 1990–2022 period due to recalculations (Units: **Tg CO_2-eq;** for F-gases: **Gg CO_2-eq**)

Gas	Source	1990	2000	2010	2020	2022
CO_2 [Tg]	NIR 2025	166.8	175.9	186.3	139.6	130.3
	NIR 2024	167.5	177.8	187.0	140.3	131.6
	Difference	*-0.4%*	*-1.0%*	*-0.4%*	*-0.5%*	*-1.0%*
CH_4 [Tg CO_2-eq]	NIR 2025	36.5	27.9	22.3	19.5	18.6
	NIR 2024	36.4	27.7	22.2	19.4	18.5
	Difference	*0.3%*	*0.5%*	*0.5%*	*0.6%*	*0.4%*
N_2O [Tg CO_2-eq]	NIR 2025	16.1	14.4	7.9	7.5	6.7
	NIR 2024	16.1	14.3	7.8	7.4	6.6
	Difference	*0.1%*	*0.1%*	*1.6%*	*1.7%*	*1.4%*
PFCs [Gg CO_2-eq]	NIR 2025	2396.6	1715.2	290.5	61.8	52.4
	NIR 2024	2396.6	1715.3	290.5	61.8	52.4
	Difference	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*
HFCs [Gg CO_2-eq]	NIR 2025	4697.2	4029.3	1978.0	1026.9	779.9
	NIR 2024	4697.2	4029.3	1977.9	1043.2	1036.3
	Difference	*0.0%*	*0.0%*	*0.0%*	*-1.6%*	*-24.7%*
SF_6 [Gg CO_2-eq]	NIR 2025	213.1	235.6	108.1	128.4	125.5
	NIR 2024	213.1	234.6	108.1	128.4	125.5
	Difference	*0.0%*	*0.4%*	*0.0%*	*0.0%*	*0.0%*
Total [Tg CO_2-eq.]	NIR 2025	227.5	224.6	219.4	168.3	157.0
	NIR 2024	228.1	225.2	219.9	168.8	158.4
	Difference	*-0.3%*	*-0.2%*	*-0.2%*	*-0.3%*	*-0.9%*

1 National circumstances, institutional arrangements and cross-cutting information

1.1 Background information on greenhouse gas inventories and climate change

This report documents the Netherlands' annual submission of its greenhouse gas (GHG) emissions inventory for 2025, in line with the United Nations Framework Convention on Climate Change (UNFCCC) and the annual reporting requirements under the Paris Agreement. The report is also in line with reporting requirements under the Governance Regulation of the Energy Union (EU 2018/1999) and implementing regulations.

The report has been prepared in line with the reporting guidelines provided in Decisions by the UNFCCC Conference of the Parties (COP) and the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement (CMA).

This report is structured as follows:

- Chapter 1 documents the National System as approved by the UNFCCC review in 2007 (and reconfirmed in 2017).
- Chapter 2 summarises the emissions trends, which are further described and documented in the subsequent chapters.
- Chapters 3–8 document emissions and trends for the following sectors:
  - Energy (sector 1);
  - Industrial processes and product use (IPPU, sector 2);
  - Agriculture (sector 3);
  - Land use, land use change and forestry (LULUCF, sector 4);
  - Waste (sector 5);
  - Other (sector 6).
- Chapter 9 describes indirect CO_2 emissions.
- Chapter 10 documents recalculations and improvements since the previous report (NIR 2024).
- Annexes to provide information about key categories, uncertainty analysis and other detailed information. As from the NIR 2025, a first attempt to verify the inventory data by inverse modelling results (provided by the PARIS project) is also added as an annex to the document.

In this chapter, accompanying information to the national greenhouse gas inventory is provided, including a description of the National System, QA/QC procedures, key categories, uncertainties, and a general description of data sources.

1.1.1 Background information on climate change reporting

Climate Convention, Kyoto Protocol and Paris Agreement

The United Nations Framework Convention on Climate Change (UNFCCC) was ratified for the European part of the Netherlands in 1994 and took effect in March 1994. In 2005, the convention's Kyoto Protocol

(KP) came into force. Rules for Monitoring, Reporting and Verification (MRV), initially agreed under the Convention itself, were further extended in the KP under Articles 5, 7 and 8, and implemented successively. The National System for the Netherlands under Article 5.1 of the KP was reviewed (Article 8 of the KP) and accepted in 2007. The greenhouse gas (GHG) inventory is prepared annually under this National System. The UNFCCC review of the inventory in October 2022 confirmed that the Netherlands' inventory and inventory process continues to be in line with the requirements for National Systems.

Following the replacement of the Kyoto Protocol by the Paris Agreement, the national arrangements for the preparation of the inventory (including quality assurance and control procedures) must still be implemented and maintained, similar to the previous requirements.

This National Inventory Document (NID) 2025, accompanied by the Common Reporting Table (CRT), reports on the Netherlands' national GHG emissions. The methodologies applied for calculating the emissions are in accordance with the 2006 IPCC Guidelines, as well as the 2019 Refinement to the 2006 IPCC Guidelines, where relevant, and can be found in this report and the methodology reports.

The structure of this report complies with the format required by the UNFCCC (FCCC/SBSTA/2004/8) and the subsequent suggested outline of the national inventory document, pursuant to the modalities, procedures and guidelines for the enhanced transparency framework under the Paris Agreement (Decision 5/CMA.3, Annex V).

Geographical coverage
The reported emissions are those that derive from the legal territory of the Netherlands. This includes inland water bodies and coastal waters in a zone stretching 12 nautical miles from the coastline. It excludes the constituent countries of the Kingdom of the Netherlands: Aruba, Curaçao and Sint Maarten. It also excludes Bonaire, Saba and Sint Eustatius, which have been public bodies (*openbare lichamen*) since 10 October 2010 with their own legislation, which is not applicable to the European part of the Netherlands.
Emissions from offshore oil and gas production on the Dutch part of the continental shelf are included.

1.1.2 Background information on the GHG emissions inventory
The NID (and CRT) cover the seven direct GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3) (the last four are termed the 'F-gases'). For reasons of data confidentiality, NF_3 emissions cannot be reported separately; therefore, they are included in the PFC emissions.
The Netherlands reports total GHG emissions including indirect CO_2 emissions (originating from the use and/or evaporation of NMVOC). The following *indirect* GHG emissions are also reported: nitrogen oxides (NO_x); carbon monoxide (CO); non-methane volatile organic compounds (NMVOC); and sulphur oxides (SO_x).

This report provides explanations for the trends in GHG emissions per gas and per sector for the 1990–2023 period. Moreover, it summarises the methods and data sources used for the assessments of the uncertainty in annual emissions and in emissions trends, as well as for the Key Category Assessment following Approach 1 and 2 of the 2006 IPCC Guidelines.

This inventory report does not include detailed assessments of the extent to which changes in emissions are due to the implementation of policy measures. This information can be found in, among others, the 1st Biennial Transparency Report of the Netherlands under the Paris Agreement (RVO, 2024) and the Climate and Energy Outlook 2024 (PBL, TNO, Statistics Netherlands, RIVM 2024).

The Netherlands also reports emissions under other international agreements. All emissions estimates are adopted from the Netherlands' Pollutant Release and Transfer Register (PRTR), which is compiled by various cooperating organisations, described in Box 1. One unique database is used to ensure consistency regarding all internationally reported data.

In line with the requirements of the national arrangements for the preparation of the inventory, the methodologies for calculating GHG emissions in the Netherlands are updated on an annual basis.
Since 2015, emissions data has been calculated according to the 2006 IPCC Guidelines (IPCC, 2006) and, for a significant part (where indicated), according to the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

The methodologies applied in the NIR 2025 are documented in five methodology reports. The methodology reports are an integral part of this submission (see Annex 7) and are available on the website: http://english.rvo.nl/nie. The methodology reports are prepared and approved under the lead of the PRTR Task Force Chair. Any changes in methodologies are also reviewed by the National Inventory Entity (NIE). Changes in methodologies are described in the relevant chapters. Chapter 10 documents the recalculations and improvements made following the recommendations of the latest reviews.

The CRT spreadsheet files accompany this document as electronic annexes. The CRT contains detailed information on GHG emissions, activity data, and (implied) emission factors (EFs) by sector, source category, and GHG. The complete CRT set and this National Inventory Document (NID) comprise the National Inventory Report (NIR), which is available on http://english.rvo.nl/nie.

1.2 A description of national circumstances and institutional arrangements

1.2.1 National entity or national focal point

The Ministry of Climate Policy and Green Growth (KGG) has overall responsibility for climate change policy issues, including the preparation of the National GHG Emissions Inventory.

The National System was finalised and established by the end of 2005 and is described in greater detail in the 1st Biennial Transparency Report of the Netherlands under the Paris Agreement (RVO, 2024).

As part of this system, the Act on the Monitoring of Greenhouse Gases also took effect in December 2005. This Act required the establishment of the National System for the monitoring of GHGs and empowered the Climate Policy and Green Growth Minister of Economic Affairs and Climate Policy (EZK, now Climate Policy and Green Growth (KGG)) to appoint an authority responsible for the National System and the National GHG Emissions Inventory. In a subsequent regulation, the Minister appointed the Rijksdienst voor Ondernemend Nederland (RVO) as the NIE, the single national entity required under the Kyoto Protocol. Following the end of the second commitment period under the Kyoto Protocol and the transition to reporting under the Paris Agreement, national arrangements for the preparation of the inventory still have to be maintained, similar to the previous requirements. Additionally, under EU regulation Member States have to operate, and seek to continuously improve, a national inventory system in accordance with UNFCCC requirements on national systems. This obligation is included in the EU's Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action ('Governance Regulation') and elaborated in implementing acts.

In addition to coordinating the establishment and maintenance of a National System, RVO was tasked with the coordination of improved QA/QC activities as part of the National System, as well as the coordination of support/response to the UNFCCC review process.
EZK assigned the National Institute for Public Health and the Environment (RIVM) as the institute responsible for coordinating the compilation and maintenance of the pollutants emission register/inventory (PRTR system), which includes GHGs. The main purpose of the PRTR project is the production of an annual set of emissions data that is up-to-date, complete, transparent, comparable, consistent, and accurate. The PRTR project system is used as the basis for the GHG emissions documented in this NID and for the completion of the CRT. RIVM coordinates the annual compilation of the NIR.

1.2.2 Inventory preparation process

1.2.2.1 The Dutch PRTR project

The Dutch PRTR system has been in operation in the Netherlands since 1974. This system encompasses data collection, data processing, and registering and reporting emissions data for approximately 375 policy-relevant compounds and compound groups present in air and water. The emissions data is produced in an annual (project) cycle (RIVM, 2023).

In addition to RIVM, various external agencies contribute to the PRTR by performing calculations or submitting activity data (see Box 1).

Box 1: Pollutant Release and Transfer Register (PRTR) project

Responsibilities for coordination of the PRTR project
Major decisions on tasks and priorities are taken by the Steering Committee ER (SCER) by approving the Annual Work Plan. This committee consists of representatives of the commissioning ministries, regional governments, RIVM, Statistics Netherlands (CBS) and the Netherlands Environmental Assessment Agency (PBL).

As per September 2020, the SCER was split into a Strategic Board, consisting of representatives of the commissioning ministries (Ministries of Infrastructure and Water Management; Climate Policy and Green Growth; and Agriculture, Fisheries, Food Security and Nature), and a Tactical Board, consisting of representatives of the various external agencies and RIVM (see Figure 1.1). The Strategic Board formally approves the Annual Work Plan.

The PRTR project leader at RIVM acts as Head of the PRTR and is responsible for the PRTR process; the outcomes of that process are the responsibility of the bodies involved. The collaboration of the various bodies is ensured by means of contracts, covenants or other agreements.

Task Forces
Emissions experts from the participating organisations take part in the Task Forces that calculate national emissions from ~500 relevant emission sources. After intensive checking, national emissions figures are accepted by the PRTR project leader and the dataset is stored in the Central Database.

The ~500 relevant emissions sources are logically divided into 48 work packages. An emissions expert is responsible for one or more work packages, for data collection, and for emissions' calculation. The experts are also closely involved in developing the methodologies for calculating the emissions. Work packages are assigned to the seven Task Forces described below.

Task Force on Energy, Industry and Waste Management (ENINA)
Covers emissions to air from the Industry, Energy production, Refineries and Waste management sectors. ENINA includes emissions experts from the following organisations: RIVM, TNO, Statistics Netherlands, Rijkswaterstaat Environment (Waste Management Department).

Task Force on Transportation
Covers emissions to soil and air from the Transportation sector (aviation, shipping, rail and road transport). PBL, Rijkswaterstaat, Statistics Netherlands, RIVM, and TNO participate in this task force.

Task Force on Agriculture
Covers the calculation of emissions to soil and air from Agriculture.

Participating organisations include RIVM, PBL, Wageningen Research (WR, including Wageningen Environmental Research, Wageningen Livestock Research, Wageningen Plant Research and Wageningen Social and Economic Research), NMI (Nutriënten Management Instituut) and Statistics Netherlands.

Task Force on Water (MEWAT)
Covers the calculation of emissions from all sectors to water. MEWAT includes experts from Rijkswaterstaat, Deltares, RIVM, Statistics Netherlands and WenR.

Task Force on Consumers and Other Sources of Emissions (WESP)
Covers emissions caused by consumers, trade and services. The members are emissions experts from RIVM and TNO.

Task force on Land Use, Land Use Change and Forestry (LULUCF)
Covers the calculation of sources and sinks from Land use, land use-change and forestry. The LULUCF task force includes emission experts from the following organisations: Wageningen Research (WR, including Wageningen Environmental Research), PBL, Deltares and RIVM.

Task force on spatial allocation
This task force does not calculate emissions, but geographically distributes the emissions throughout the Netherlands. The task force includes emission experts from Wageningen Research (WR, including Wageningen Environmental Research), TNO, Statistics Netherlands, Deltares,RIVM and PBL.

These Task Forces are responsible for assessing the emissions estimates. RIVM commissioned TNO to assist in the compilation of the CRT. A complete overview of the organisational arrangements of the PRTR project are shown in Figure 1.1.

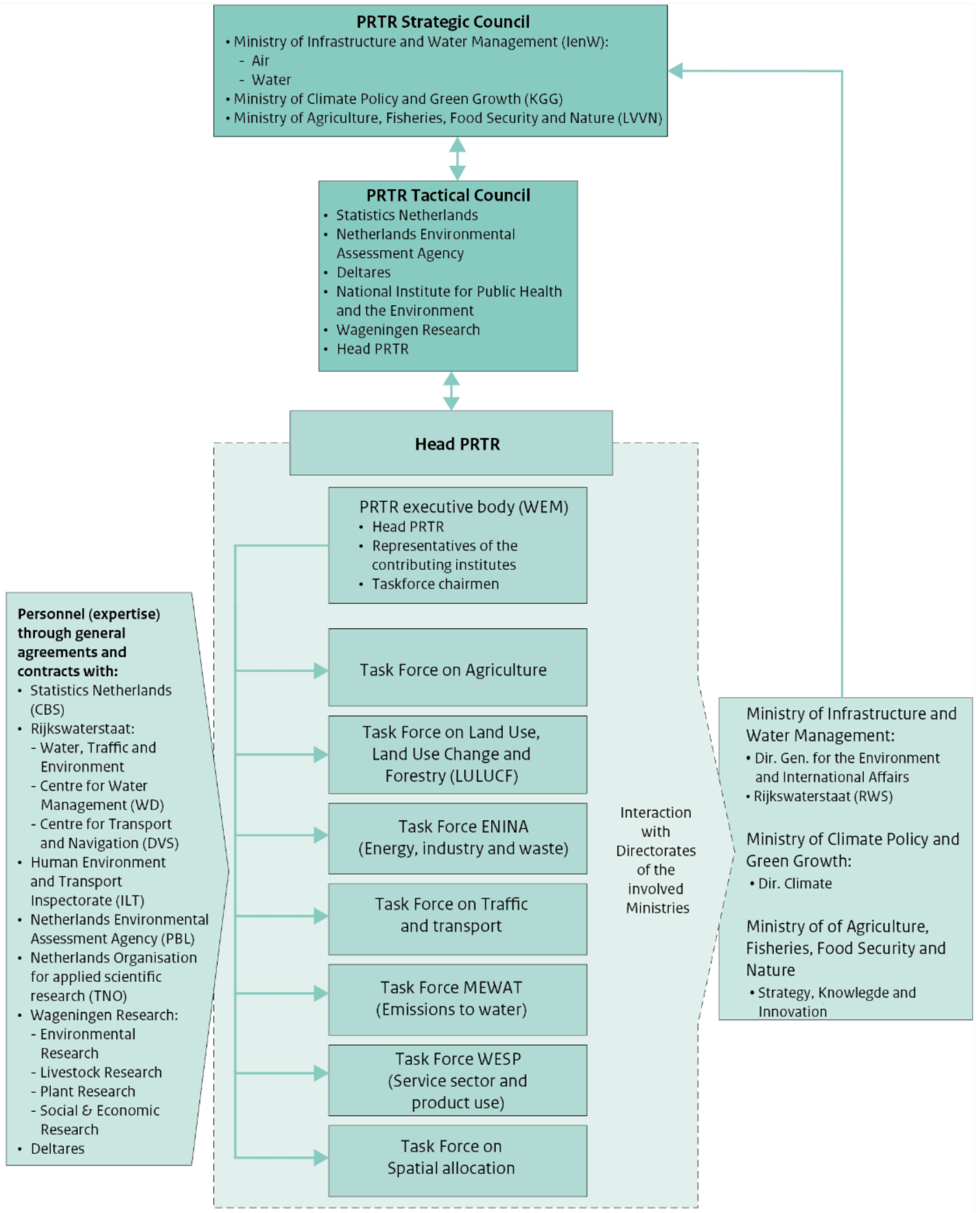


Figure 1.1 Organisational arrangements for the Dutch PRTR project

1.2.2.2 GHG inventory data collection process

The primary process for preparing the GHG emissions inventory in the Netherlands is summarised in Figure 1.2.

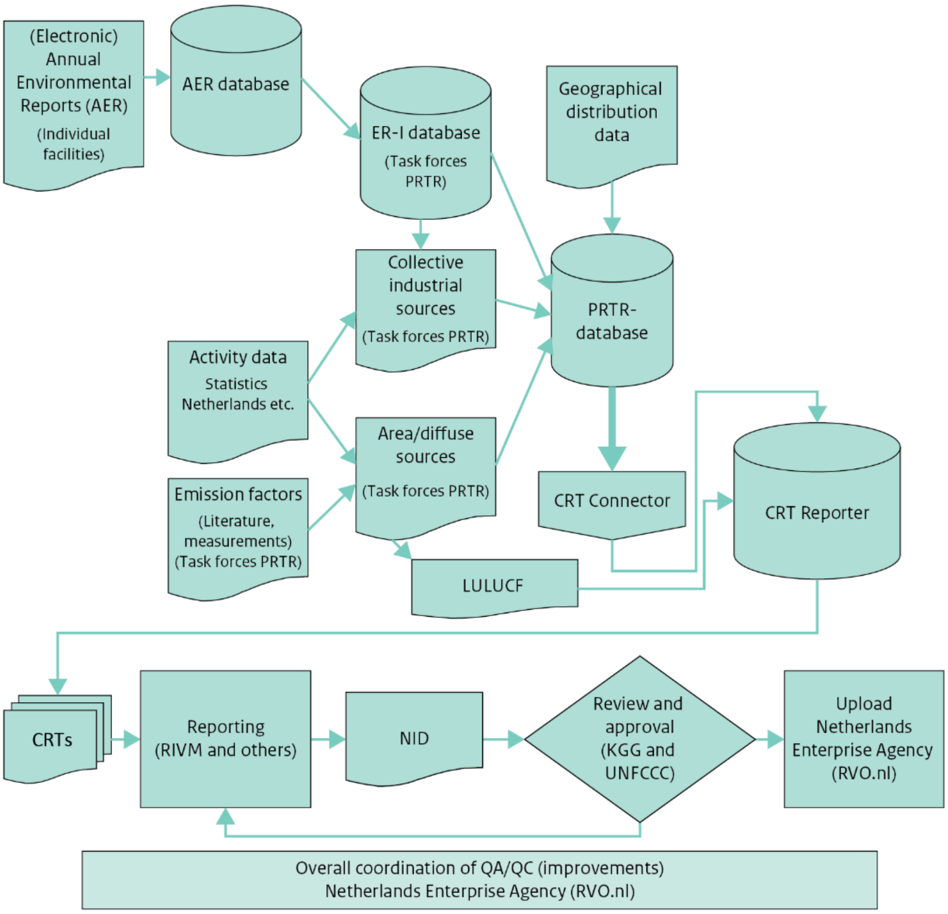


Figure 1.2 Main elements in the GHG emissions inventory process

Various data suppliers provide the basic input data for emissions estimates. The principal data sources for GHG emissions are:

Statistical data
Statistical data is provided under various (not specifically GHG-related) obligations and legal arrangements. These include national statistics from Statistics Netherlands and various other sources of data on sinks, water, and waste. The provision of relevant data for GHGs is guaranteed through covenants and an Order in Decree prepared by KGG. For GHGs, agreements with Statistics Netherlands and Rijkswaterstaat Environment with respect to waste management are in place.

Data from individual companies
Data from individual companies are provided in the form of electronic annual environmental reports (e-AERs). A large number of companies have a legal obligation to submit an e-AER that includes – in addition to other environment-related information – emissions data validated by the competent authorities (usually regional implementing agencies and occasionally local authorities) that also issue environmental permits to these companies.

Any industrial activity in the Netherlands requires an environmental permit. As part of the permit application, the operator has to submit a documented account of the emissions and the production capacity. On the basis of this data, the competent authority will set (emissions) limits in the environmental permit. The determination of the applicable (emissions) limits is based on national policies and the specific expertise of the competent authorities. This expertise is also used in the annual verification of the emissions in the environmental reports. The national inventory relies on this verification and only performs sample checks on the data. This procedure is only possible due to the country-specific situation in the Netherlands, where industry is fully aware of the need for emissions reductions that are required by legislation. This results in an open and constructive communication between plant operators and competent authorities on activity levels and emissions. For this reason, the inventory team can limit the verification of the emissions data from individual companies to a minimum.

Some companies provide data voluntarily within the framework of environmental covenants. Large companies are also obliged to participate in the European Emission Trading System (EU-ETS). They have to report their CO_2 emissions in specific annual ETS emissions reports.
When these major industry reports contain plant-specific activity data and EFs of sufficient quality and transparency, these are used to calculate CO_2 emissions estimates for specific sectors.
The AERs from individual companies also provide information that is essential to calculating the emissions of substances other than CO_2. The calculations of industrial process emissions of non-CO_2 GHGs (e.g. N_2O, HFC-23 and PFCs released as by-products) are mainly based on information from these AERs, as are emissions figures for precursor gases (CO, NO_x, NMVOC and SO_2). Only those AERs with high-quality and transparent data are used as a basis for calculating total source emissions in the Netherlands.

Many Dutch industrial (sub)sectors consist of a single company. This is the reason why the Netherlands cannot report activity data (confidential business information) in the NID or CRT at the most detailed level. Although this may hamper the review process, all confidential data can and will be made available to the EU and UNFCCC review teams on request.

Additional GHG-related data
Additional GHG-related data is provided by other institutes and consultants specifically contracted to provide information on sectors not sufficiently covered by the above-mentioned data sources. For example, RIVM has contracts and financial arrangements with various agricultural institutes and TNO.

In 2004, the Ministry of Agriculture, Nature and Food Quality (LNV) contracted a number of agricultural institutes to develop a monitoring system and methodology description for the LULUCF dataset. In accordance with a written agreement between the Ministry of Climate Policy and Green Growth (KGG) and RIVM, these activities also form part of the PRTR.

1.2.3 *Archiving of information*

The preparation of the NIR includes the documentation and archiving of statistical data for the estimates and QA/QC activities. RVO is responsible for coordinating QA/QC and responses to the EU, as well as for providing additional information requested by the UNFCCC once the NID and the CRT have been submitted. RVO is also responsible for coordinating the submission of supporting data for the UNFCCC review process. KGG formally approves the NIR prior to submission; in some cases, approval follows consultation with other ministries. See chapter 1.5 for more information about the QA/QC plan.

Data processing and storage are coordinated by RIVM. These processes consist notably of the elaboration of emissions estimates and data preparation in the PRTR database. The emissions data is stored in a central database, thus efficiently and effectively satisfying national and international criteria for emissions reporting. Using the Enhanced Transparency Framework (ETF) tooling and corresponding Common Reporting Tables (CRT), all relevant emissions and activity data is extracted from the PRTR database, thus ensuring the highest level of consistency. The data from the CRT is used in the compilation of the NIR.

1.2.4 *Processes for official consideration and approval of inventory*

RIVM is responsible for the preparation of the NIR with input from the relevant PRTR Task Forces and from RVO in its role as the NIE.
RVO is responsible for submission to the UNFCCC in its role as the NIE, following approval by KGG.

1.3 Brief general description of methodologies (including tiers used) and data sources used

1.3.1 *Methodologies*

Table 1.1 provides an overview of the methods used to estimate GHG emissions. Methodology reports documenting the methodologies, data sources, and QA/QC procedures used in the GHG emissions inventory of the Netherlands, as well as other key documents, are listed in Annex 3.

The sector-specific chapters of this report provide a brief description of the methodologies applied for estimating the emissions from each key source.

Table 1.1 CRT Summary Table 3 with methods and EFs applied

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2		CH_4		N_2O	
	Method applied	**Emission factor**	**Method applied**	**Emission factor**	**Method applied**	**Emission factor**
1. Energy	T1,T2,T3,CS,NA,NO	D,CS,PS,NA,NO	T1,T1b,T2,T3,OTH,NA,NO	D,CS,PS,OTH,NA,NO	D,T1,T2,NA,NO	D,CS,NA,NO
1.A. Fuel combustion	T1,T2,CS,NA,NO	D,CS,NA,NO	T1,T2,T3,NA,NO	D,CS,NA,NO	D,T1,T2,NA,NO	D,CS,NA,NO
1.A.1. Energy industries	T2,CS,NA	D,CS,NA	T1,T2,NA	D,CS,NA	D,T1,NA	D,NA
1.A.2. Manufacturing industries and construction	T2,NA,NO	D,CS,NA,NO	T1,T2,T3,NA,NO	D,CS,NA,NO	D,T1,T2,NA,NO	D,CS,NA,NO
1.A.3. Transport	T1,T2,NA	D,CS,NA	T1,T2,T3,NA	D,CS,NA	T1,T2,NA	D,CS,NA
1.A.4. Other sectors	T1,T2,NA	D,CS,NA	T1,T2,NA	D,CS,NA	T1,T2,NA	D,CS,NA
1.A.5. Other	T2,NA	CS,NA	T2,NA	CS,NA	T2,NA	CS,NA
1.B. Fugitive emissions from fuels	T1,T2,T3,CS,NA	D,CS,PS,NA	T1,T1b,T2,T3,OTH,NA	D,CS,PS,OTH,NA	NA	NA
1.B.1. Solid fuels	T2,NA	CS,NA	OTH,NA	OTH,NA	NA	NA
1.B.2. Oil and natural gas and other emissions from energy production	T1,T2,T3,CS,NA	D,CS,PS,NA	T1,T1b,T2,T3,NA	D,CS,PS,NA	NA	NA
1.C. CO_2 transport and storage	NA	NA				
2. Industrial processes	T1,T2,T3,CS,NA	D,CS,PS,NA	T1,CS,NA	D,CS,NA	T1,T2,CS,NA	CS,PS,NA
2.A. Mineral industry	T1,T3,CS,NA	D,PS,NA	NA	NA	NA	NA
2.B. Chemical industry	T1,T3,CS,NA	D,CS,NA	T1,CS,NA	CS,NA	T1,T2,NA	CS,PS,NA
2.C. Metal industry	T2,NA	PS,NA	NA	NA	NA	NA
2.D. Non-energy products from fuels and solvent use	T1,T3	D,CS	T1,NA	D,NA	NA	NA
2.E. Electronic Industry					NA	NA
2.F. Product uses as ODS substitutes						

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2		CH_4		N_2O	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
2.G. Other product manufacture and use	CS,NA	CS,NA	T1,CS	CS	T1,CS,NA	CS,NA
2.H. Other	T1	CS	NA	NA	NA	NA
3. Agriculture	T1,NA	D,NA	T1,T2,T3,NA	D,CS,NA	T1,T1b,T2,NA	D,CS,NA
3.A. Enteric fermentation			T1,T2,T3,NA	D,CS,NA		
3.B. Manure management			T1,T2,NA	D,CS,NA	T1,NA	CS,NA
3.C. Rice cultivation			NA	NA		
3.D. Agricultural soils			NA	NA	T1,T1b,T2,NA	D,CS,NA
3.E. Prescribed burning of savannahs			NA	NA	NA	NA
3.F. Field burning of agricultural residues			NA	NA	NA	NA
3.G. Liming	T1	D				
3.H. Urea application	T1	D				
3.I. Other carbon-containing fertilizers	NA	NA				
3.J. Other	NA	NA	NA	NA	NA	NA
4. Land use, land-use change and forestry	T1,T2,T3,CS,NA	D,CS,NA	T1,T2,CS,NA	D,CS,NA	T1,T2,CS,NA	D,CS,NA
4.A. Forest land	T1,T2,NA	D,CS,NA	T1,NA	D,CS,NA	T1,NA	D,CS,NA
4.B. Cropland	T1,T3,CS,NA	D,CS,NA	NA	NA	T2,NA	D,CS,NA
4.C. Grassland	T1,T2,T3,CS,NA	D,CS,NA	T2,CS,NA	D,CS,NA	T2,CS,NA	D,CS,NA
4.D. Wetlands	T1,T2,NA	D,CS,NA	T2,NA	D,NA	T1,NA	D,NA
4.E. Settlements	T1,T2,CS,NA	D,CS,NA	NA	NA	T2,NA	D,CS,NA
4.F. Other land	T1,T2,CS,NA	D,CS,NA	NA	NA	T2,NA	D,CS,NA
4.G. Harvested wood products	T2	D				
4.H. Other	NA	NA	NA	NA	NA	NA
5. Waste	CS,NA	CS,NA	T1,T2,CS,NA	D,CS,NA	T1,T2,CS,NA	D,CS,NA

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2		CH_4		N_2O	
	Method applied	**Emission factor**	**Method applied**	**Emission factor**	**Method applied**	**Emission factor**
5.A. Solid waste disposal			NA	NA		
5.B. Biological treatment of solid waste			T1,NA	CS,NA	T1,NA	CS,NA
5.C. Incineration and open burning of waste	CS,NA	CS,NA	CS,NA	CS,NA	CS,NA	CS,NA
5.D. Waste water treatment and discharge			T1,T2	D,CS	T2,NA	D,NA
5.E. Other	NA	NA	NA	NA	NA	NA
6. Other *(as specified in summary 1)*	NA	NA	NA	NA	NA	NA

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	HFCs		PFCs		Unspecified mix of HFCs and PFCs		SF_6		NF_3	
	Method applied	**Emission factor**	**Method applied**	**Emission factor**	**Method applied**	**Emission factor**	**Method applied**	**Emission factor**	**Method applied**	**Emission factor**
2. Industrial processes	T2,CS,NA	CS,NA	T2,NA	CS,NA	NA,NO	NA,NO	CS,NA	CS,NA	NA	NA
2.A. Mineral industry										
2.B. Chemical industry	T2,NA	CS,NA	T2,NA	CS,NA	NA,NO	NA,NO	NA	NA	NA	NA
2.C. Metal industry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.D. Non-energy products from fuels and solvent use										
2.E. Electronic Industry	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2.F. Product uses as ODS substitutes	T2,CS,NA	CS,NA	NA	NA	NA	NA	NA	NA	NA	NA
2.G. Other product manufacture and use	NA	NA	NA	NA	NA,NO	NA,NO	CS,NA	CS,NA	NA	NA
2.H. Other	NA	NA	NA	NA	NA	NA				

Abbreviations: CS = country-specific, D=default, T1 = Tier 1, T2 = Tier 2 and T3 = Tier 3

1.3.2 *Data sources*

The methodology reports provide detailed information on the activity data used for the inventory. In general, the following primary data sources supply the annual activity data used in the emissions calculations:

- Fossil fuel data: (1) Statistics Netherlands national energy statistics (Energy Balance); (2) natural gas and diesel consumption in the agricultural sector (Wageningen Economic Research (WecR); (3) (residential) biofuel data: Statistics Netherlands national renewable energy statistics (Renewable Energy).
- Transport statistics: (1) monthly statistics for traffic and transport; (2) Statistics Netherlands national renewable energy statistics (Renewable Energy).
- Industrial production statistics: (1) individual company AERs; (2) national statistics; ETS reports as a data source and for QA/QC reasons.
- Consumption/emissions of PFCs and SF_6: reported by individual firms.
- Refrigerant use data from inspection authorities: data about filling, reusing, dismantling and retrofitting stationary cooling installations, for calculating HFC emissions from stationary cooling.
- Data from EU F-gas portal, summarized by EEA
- Data from individual companies about use of metered-dose inhalators
- Anaesthetic gas: data provided by the three suppliers in the Netherlands for the period until 2019. Should not all suppliers provide their data, gap-filling is performed on the basis of market shares. For 2022, data is provided by the Dutch organisation for anesthesiology (Nederlandse Vereniging voor Anesthesiologie, NVA).
- Spray cans containing N_2O: the Dutch Association of Aerosol Producers (Nederlandse Aerosol Vereniging, NAV).
- Animal numbers and Manure production and handling: Statistics Netherlands /WecR agricultural database, data from the annual agricultural census and the I&R system of RVO.
- Fertiliser statistics and distribution: WecR agricultural statistics and the INITIATOR model from WenR.
- Forest and wood statistics:
  - stem volume, annual growth, carbon balance: data from five National Forest Inventories: HOSP (1988–1992), 5th National Forest Inventory (NFI-5, 2001–2005), 6th National Forest Inventory (NFI-6 2012–2013), 7th National Forest Inventory (NFI-7 2017-2021) and the first two years of the 8th National Forest Inventory (NFI-8 2022-2026);
  - harvest data: wood balance data from the National Forest Inventories NFI-5, NFI-6, NFI-7 and NFI-8, in combination with FAO harvest statistics;
  - FAO and Probos data on imports, exports, and production of sawnwood, wood panels and paper and paperboard from 1961 onwards.
- Land use and land use change: based on digitised and digital topographical maps of 1990 (Kramer and van Dorland, 2009), 2004 (Kramer et al., 2007), 2009 (Kramer and Clement, 2016),

2013 (Kramer and Clement, 2015), 2017 (Kramer, 2019) and 2021 (Kramer and Los, 2022).
- Soil maps: De Vries et al. (2003) and 2014 update (De Vries et al., 2014) and projected map 2040 (Erkens et al., 2021).
- Soil information system: information on soil profiles, soil organic matter, bulk density (Finke et al., 2001; Kuikman et al., 2003; De Groot et al., 2005; Lesschen et al., 2012; Knotters et al., 2022).
- RothC and Miterra models for calculating carbon stock changes in managed mineral soils under agricultural use.
- SOMERS model for calculating emissions from coastal organic soils (Erkens et al., 2022).
- Waste treatment in incineration plants, composting and digestion of organic waste, amount landfilled, and CH_4 recovery from landfills: Working Group on Waste Registration (WAR), Rijkswaterstaat Environment and Statistics Netherlands.
- Wastewater data: national statistics from Statistics Netherlands, individual company AERs.

Many recent statistics are available on the Statistics Netherlands' statistical website StatLine, and from the Statistics Netherlands /PBL/RIVM Environmental Data Compendium. It should be noted, however, that the units and definitions used for domestic purposes on these websites can differ from those used in this report (for instance: temperature-corrected CO_2 emissions versus actual emissions in this report; in other cases, emissions are presented with or without the inclusion of organic CO_2 and with or without LULUCF sinks and sources).

1.4 Brief description of key categories

The analysis of key categories is performed in accordance with the 2006 IPCC Guidelines. To facilitate identification of key categories, the contribution made by categories to emissions is classified per gas according to the IPCC potential key category list, as presented in volume 1, chapter 4, Table 4.1 of the 2006 IPCC Guidelines. An extensive overview of the results of the key category analysis (KCA) is provided in Annex 1 of this report. The key categories are also listed per sector in each of Chapters 3 to 9. Please note that the Netherlands uses a country-specific aggregation. The KCA is used for the prioritisation of possible inventory improvement actions.

Two approaches for performing the KCA have been used. In approach 1, key categories are identified using a pre-determined cumulative emission threshold. Key categories are those that, when listed in descending order of magnitude, add up to 95% of the total national inventory level. In approach 2, uncertainties are included for activity data, emission factors and total emissions. Here, key categories are those that, together, are responsible for 90% of the uncertainty at the total national inventory level. The method of error propagation is used to calculate the total uncertainty per category resulting from the uncertainties in activity data and emission factors. Apart from the level assessment, a trend assessment is performed. The level assessment looks at the contribution made by each source or sink category to the total national inventory level. The trend assessment identifies those categories that may not be large enough to be identified by means of the level assessment, but whose trend is significantly different from the trend of the overall inventory, and should therefore receive particular attention. As with the level assessment, the trend assessment is performed with and without the incorporation of uncertainty data, the latter being based on error propagation.

The IPCC Approach 1 method (without uncertainties) has 40 categories for annual level assessment (emissions in 2023) and 43 categories for the trend assessment out of a total of 124 source categories. A combination of Approach 1 and 2 (the last one including uncertainties), level and trend assessments amounts to a total of 63 key categories including LULUCF.

1.5 Brief general description of QA/QC plan and implementation

1.5.1.1 Information on the QA/QC plan

As part of its National System, the Netherlands has developed and implemented a QA/QC programme. This programme is assessed annually and updated as necessary. The key elements of the current programme (RVO, 2023) are summarised in this chapter, notably those relating to the NIR. For more detailed information on the QA/QC programme, please see Quality assurance and quality control (rvo.nl).

1.5.1.2 QA/QC procedures for the CRT/NID 2025

The system of methodology reports was developed and implemented in order to increase the inventory's transparency, including methodologies, procedures, tasks, roles and responsibilities. Transparent descriptions of all these are included in the methodology reports for each gas and sector and in process descriptions for other relevant tasks in the National System. The methodology reports are assessed annually and updated when necessary.

The generic annual data and QC process is as follows. The responsible experts (in Dutch: 'werkveldtrekkers') within the respective PRTR Task Forces fill in a standard-format database with emissions data for the time series – this year, that relates to 1990–2023 (with the exception of the LULUCF data, which is delivered via a separate submission). This standard format database is uploaded to and stored in the national emissions database. Following a first check of the data by RIVM for completeness, the (corrected) data is made available to the relevant Task Forces for consistency checks and trend analyses (comparability, accuracy).
Several weeks before the dataset was fixed, a trend verification workshop was organised by RIVM (5 December 2024). The verification process is described in more detail in section 1.2.3.3. The workshop's conclusions, including with respect to how the experts should resolve issues for improvement identified during the workshop, were documented and collected by RIVM. After collecting all these issues from the workshop, the task forces add other inventory improvement actions (e.g. from review actions). This improvements actions are then prioritized within the Task Forces and in consultation with the PRTR head it is decided what improvements points will be executed and implemented in the upcoming year by the Task Forces.

QA for the current NIR 2025 also includes the following activities:

- Take remaining issues from former UNFCCC reviews and ESD reviews into account and make the requested improvements (summarised and updated in Annex 10).
- A peer and public review on the basis of the final submission of the previous NIR, respectively in Q2 and from August through October 2024. Results of these reviews are summarised in Chapter 10. Identified issues will be addressed in upcoming NIRs.
- In order to identify and detect possible errors, the following tools are also used:
    - A list that links NL PRTR database entries to CRT entries was shared with the responsible experts. The aim is to give the experts insights into the link between the NL PRTR database and the CRT;
    - An Excel tool used to prepare tables and figures for the NIR was also made available for experts. This tool permits checking trends at a sub-category level;
    - An Excel overview including IEFs per (sub)category was extracted from the CRT. This overview permits checking dips and jumps across the time series.

The QA/QC system must operate within the available resources (both capacity and finance). Within these limitations, QA/QC activities focus on:

- *The QA/QC programme* (RVO, 2023), which has been developed and implemented as part of the national arrangements. This programme includes quality objectives, the QA/QC plan and a general schedule for the implementation of the activities. The programme is reviewed annually and updated when necessary (the full description of the QA/QC programme can also be found here: Quality assurance and quality control (rvo.nl)).
  Figure 1.1 summarises the main elements of the annual QA/QC cycle. To ensure high-quality and continuous improvement, the annual inventory process is implemented as a cyclical project, on the basis of the iterative Deming cycle of Plan–Do–Check–Act. QA/QC procedures for basic LULUCF data are different from QA/QC procedures for other sectors, and have been elaborated and documented in the description of QA/QC of the external agencies (Wanders et al., 2021).

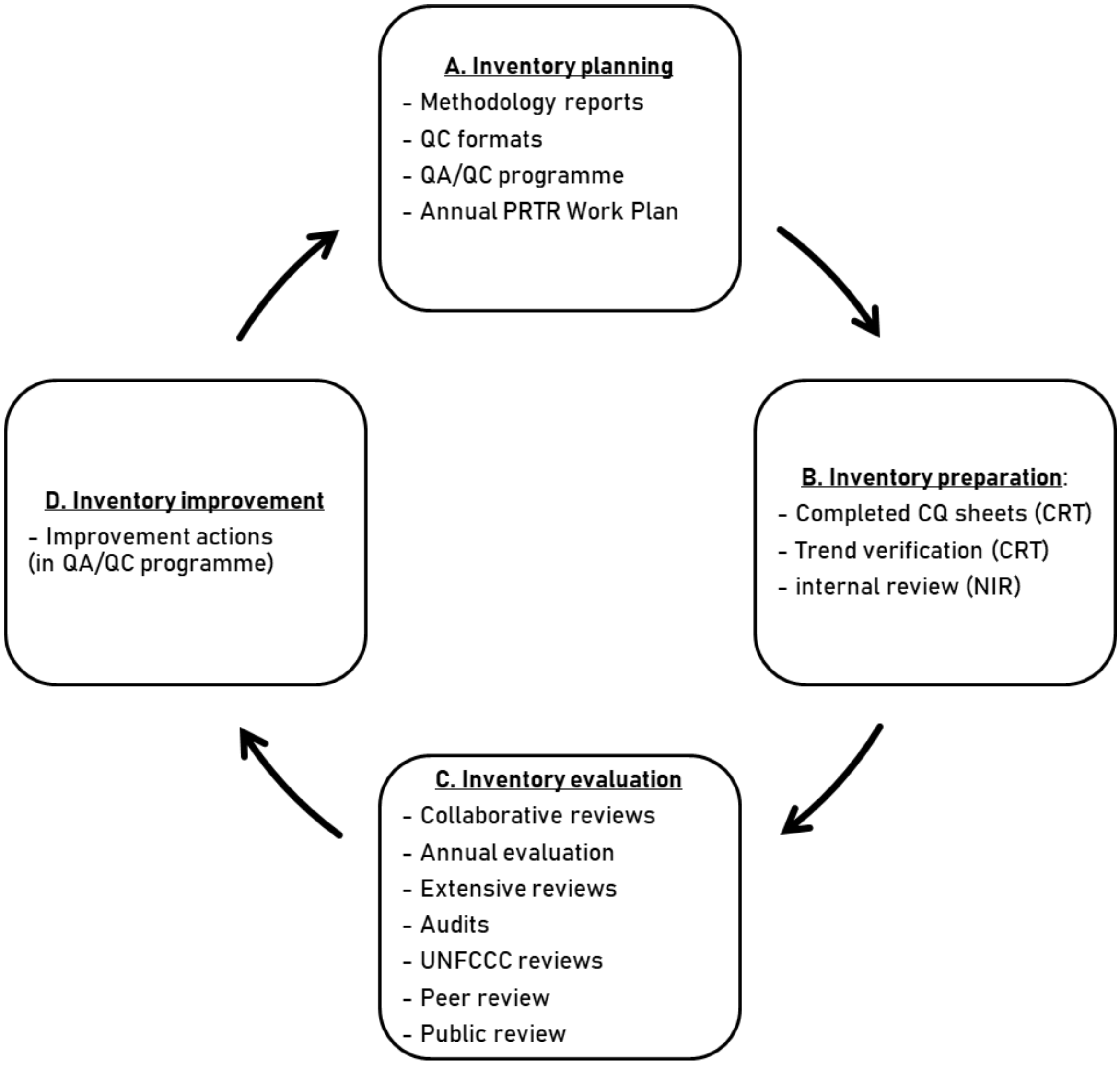


Figure 1.3 QA/QC management cycle (RVO, 2023)

- *The annual RIVM Work Plan* (RIVM, 2024). The Work Plan describes the tasks and responsibilities of the parties involved in the PRTR process, such as products to be delivered, scheduling (planning), and emissions estimation (including the methodology reports on GHGs), as well as those of the members of the Task Forces. The annual Work Plan also describes the general QC activities to be performed by the Task Forces before the annual PRTR database is fixed (see section 1.6.2).
- *European Emission Trading Scheme (EU-ETS).* Selected companies (large emitters) are part of the EU-ETS. They are obliged to report their CO_2 emissions in accordance with monitoring procedures which include strict QA/QC. The reported emissions are checked and approved by the Dutch Emissions Authority (NEa) and used in the inventory for QC and to calculate specific EFs.
- *Agreements/covenants* between RIVM and other institutes involved in the annual PRTR process. The general agreement is that, by accepting the annual Work Plan, the institutes involved commit to delivering capacity for the work/products specified in

that Work Plan. The role and responsibilities of each institute have been described (and agreed) within the framework of the PRTR Work Plan.

- *Specific procedures* established to fulfil the QA/QC requirements. General agreements on these procedures are described in the QA/QC programme as part of the National System. The following specific procedures and agreements have been described in the QA/QC plan and the annual PRTR Work Plan:
  - QC on data input and data processing as part of the annual trend analysis and consolidation of the database following approval of the institutions involved.
  - Documentation of the consistency, completeness and correctness of the CRT data (see also section 1.6.2). According to the 2006 IPCC Guidelines (Volume 1, chapter 6), the emission estimates for all source categories or sub-source categories that show a greater than 10% change in the last year compared to the previous year have to be checked. The Netherlands has chosen for a lower limiting value: 5% changes at target group level, and 0.5% at levels concerning the national total. In these cases, the work package leaders give explanations for the identified changes. The work package leaders send these explanations to the secretary of the PRTR project, who archives them centrally.
  - A peer and public review based on the final submission of the previous NIR. Results of this review are summarised in Chapter 10 and in the QA/QC sections of the specific chapters. Identified issues will be addressed in upcoming NIRs.
  - Audits: In the context of the annual Work Plan, it has been agreed that the institutions involved in the PRTR will inform RIVM about forthcoming internal audits. Furthermore, RVO is assigned the task of organising audits, if needed, of relevant processes or organisational issues within the National System.
  - Archiving and documentation: Internal procedures have been agreed (in the PRTR annual Work Plan) for general data collection and the storage of fixed datasets in the RIVM database, including the documentation/archiving of QC checks. To improve transparency, the implemented QC checklists have also been documented and archived, as part of the QA/QC plan. A shared online workspace (Teams) used during the preparation of the NIR has also facilitated checks and systematic documentation during the drafting stage, improving the traceability of comments/recommendations and implementation thereof (as well as other changes), which can also be more easily carried forward in subsequent inventory cycles.
  - Methodology reports: These have been updated and documented and are an integral part of this submission (see Annex 7).
  - RVO (as the NIE) maintains a website (www.rvo.nl/nie) and a central archive of relevant documents.
- *Annual inventory improvement*: Within the inventory project, resources are made available to keep the total inventory up to the latest standards. In an annual cycle, Task Forces are invited

to draft proposals for improving their emissions estimates. The proposals are prioritised in a consensus process and budgets are made available for the selected improvements. Proposals for improvements that contribute to a reduction in uncertainty of emissions estimates are given priority over others. All planned improvements are documented in the annual Work Plan.

- *Evaluation*: Once a year, those involved in the annual inventory tasks are invited to participate in an evaluation of the process. The results are input into the annual review of the QA/QC programme and the annual Work Plan.
- *General QC checks:* A checklist was developed and implemented to facilitate general QC checks. A number of general QC checks have been added to the annual PRTR Work Plan and are mentioned in the methodology reports. The general QC for the present inventory was largely performed at the institutes involved as an integral part of their PRTR work (Wanders et al, 2021).
- *Category-specific QC*: The comparison of emissions data with data from independent sources was one of the actions proposed in the inventory improvement programme. In the current submission, an annex is added in which the reported Dutch emissions are compared to emissions estimates derived from atmospheric observations. The data for this comparison is provided by the PARIS project.

1.5.1.3 Verification activities for the CRT/NID 2025

Two weeks prior to the trend analysis meeting, RIVM made available a snapshot of the database in a web-based application (Emission Explorer, EmEx), allowing checks by the institutes and experts involved (PRTR Task Forces). This enabled the Task Forces to check for level errors and inconsistencies in the algorithms/methods used for calculations throughout the time series. The Task Forces performed checks for all gases and sectors. The sector totals were compared to the previous year’s dataset. Where significant differences were found, the Task Forces evaluated the emissions data in greater detail. The results of these checks were used as input for discussions at the trend analysis workshop and were subsequently documented.
During the trend analysis, the GHG emissions for all years between 1990 and 2023 were checked in two ways:

1. The datasets from previous years’ submissions were compared to the current submission; regarding all emissions for which no methodological changes have been announced, emissions from 1990 to 2022 should be identical to those reported last year.
2. The data for 2023 was compared to the trend development for each gas since 1990. Checks of outliers were carried out at a more detailed level for the sub-sources of all sector background tables. Experts specifically checked:
   - annual changes in emissions of all GHGs;
   - annual changes in activity data;
   - annual changes in IEFs;
   - level values of IEFs.

Data checks were performed by sector experts and others involved in preparing the emissions database and the inventory. This resulted in a checklist of actions to be taken. This checklist was used as input for the trend analysis meeting and supplemented with the actions agreed at this meeting. This action list is shared with all work package leaders and Task Force Chairs. Table 1.2 presents the key verification actions for the CRT tables/NID 2025.

The completion of an action was reported on the checklist. On the basis of the completed checklist and the documentation of trends, Chairs of the Task Forces approved the dataset of their respective Task Force. The dataset was then fixed by the Head of the PRTR (RIVM project leader) and formally agreed to by the principal institutes: RIVM, PBL, Statistics Netherlands, Deltares and WR.

The internal versions of the CRT and NID and all documentation (emails, data sheets and checklists) used in the preparation of the NIR are stored electronically on a server at RIVM.

Lastly, as part of the overall QA/QC and verification system, the IPCC guidelines also highlight the value of verification activities that include comparisons with emission estimates derived from independent assessments. Comparisons with atmospheric observations such as through inverse modelling can be particularly useful, since these are fully independent of standard estimation drivers such as sector activity data. Significant differences between inventory and model results can point to areas deserving further investigation by the inventory compilers. In this vein, starting with the NIR2025 submission, a dedicated annex is included on comparing inventory emission estimates with estimates based on atmospheric observations, which will form an additional component of annual verification activities.

Table 1.2 Key actions for the NIR 2025

Item	Date	Who	Result	Documentation
Automated initial check on internal and external data consistency	During each upload	Data Exchange Module (DEX)	Acceptance or rejection of uploaded sector data	Result logging in the PRTR database
Inventory of methodological issues and new insights	05-07-2024	Task Forces	List of methodological issues and recalculations for the upcoming NIR	Definitief OVERZICHT Methodewijzigingen reeks 1990-2023.xlsx on Microsoft teams ER Consortium channel
Input of outstanding issues for this inventory	3-12-2024	RIVM	Input for trend analysis	Actiepunten Definitieve cijfers 1990-2023 on Microsoft teams ER Consortium channel
Trend analysis	5-12-2024	Task Forces	Updated action list	Actiepunten Definitieve cijfers 1990-2023 on Microsoft teams ER Consortium channel
Resolving the issues on the action list	12-12-2024	Task Forces RIVM/ TNO National Inventory Compiler (NIC)	Final dataset	Actiepunten Definitieve cijfers 1990-2023 on Microsoft teams ER Consortium channel
Comparison of data in CRT and E-PRTR database	Until 15-03-2025	NIC/TNO	Draft CRT sent to EU Final CRT to EU	15-01-2025 15-03-2025
Writing and checks of NIR	Until 15-3-2025	Task Forces/ NIC/TNO/NIE	Final texts	R:\.\NI National Inventory Report\NIR 2025\NIR redactie and shared Teams pages
Generation of tables for NIR from CRT tables	Until 15-3-2025	NIC/TNO	Final CRT and corresponding sector tables NID	R:\....\NIR 2025\CRT….\Tables and Figures.xlsx

1.5.1.4 Treatment of confidentiality issues

Some of the data used in the compilation of the inventory is confidential and cannot be published in print or electronic format. The Netherlands uses the code ‘C’ in the CRT for these data items. All confidential data can be made available to the official UNFCCC review process upon request.

1.6 General uncertainty assessment, including data pertaining to the overall uncertainty of inventory totals

An IPCC Approach 2 methodology for estimating uncertainty in annual emissions has been applied to all of the emission categories, in order to compare the results with the Approach 1 methodology (without uncertainties). In the approach 2 method applied here, propagation of error is used to calculate total uncertainties on the basis of data for emission factors and activities (see Annex 1).

On the national level, a Monte Carlo assessment was also performed. These results have been compared to the results of the error propagation method.

1.6.1 GHG emissions inventory

Uncertainty estimates – propagation of error

The following information sources were used for estimating the uncertainty in activity data and EFs:

- default uncertainty estimates is reported in accordance with the 2006 IPCC Guidelines (IPCC, 2006) and the 2019 Refinement to the 2006 IPCC Guidelines;
- sections on uncertainties included in the methodology reports (. see Annex 7 for references).

These data sources were supplemented with expert judgements by RIVM, PBL, WR and Statistics Netherlands emissions experts. Uncertainty estimates were prepared independently, and their views were discussed to reach consensus. Uncertainties were estimated for 1990 and 2022 data for both annual emissions and the emissions trend for the Netherlands. Uncertainties are presented here as half the 95% confidence interval. The reason for halving the 95% confidence interval is that the value then corresponds to the familiar plus or minus value when uncertainties are loosely quoted as ‘plus or minus x%’. In cases where asymmetric uncertainty ranges were assumed, the larger percentage was used in the calculation.

The results of the uncertainty calculation are summarised in Annex 2 of this report. The calculation of annual uncertainty in CO_2 equivalent emissions gives an overall uncertainty of approximately 3% in 2023, based on calculated uncertainties of 3%, 8%, 30% and 24% for CO_2 (including LULUCF), CH_4, N_2O and F-gases, respectively.

Table 1.3 presents the 1990-2023 trend uncertainties per greenhouse gas, table 1.4 the 1990-2023 trend uncertainties per CRT category. Both are based on error propagation.

Table 1.3 Trend uncertainties (95%-confidence ranges) of individual gases based on standard error propagation

Greenhouse gas	Trend compared to base year (%)	Uncertainty in trend (%)
CO_2	-28.1	1.3
CH_4	-50	4.5
N_2O	-59	4.9
F gases	-88.6	3.0
All	**-35.7**	**1.4**

Table 1.4 Trend uncertainties (95%-confidence ranges) per CRT category based on standard error propagation

Category	Trend compared to base year (%)	Uncertainty in trend (%)
Sector 1	-29.9	1.1
Sector 2	-50	6.6
Sector 3	-28.9	5.5
Sector 4	-16.3	7.8
Sector 5	-82.5	1.8

However, these figures do not include the correlation between source categories (e.g. cattle numbers for enteric fermentation and animal manure production), nor do they include a correction for non-reported sources. The correlation between source categories is included in a Monte Carlo uncertainty assessment.

Monte Carlo analysis
A Monte Carlo analysis has been implemented in the Dutch emissions inventory on the 2023 emission level data and its results are used for comparison with the error propagation results.

Where possible, correlations between activity data and emission factors have been included in the Monte Carlo analysis.
Activity data:

- The energy statistics are more accurate on an aggregated level (e.g. for Industry) than on a detailed level (e.g. for each individual industry sector). This type of correlation also occurs in several Transport subsectors, such as road transport, shipping, and aviation.
- The same data source is used to calculate different emissions. This type of correlation occurs where the identifier of the activity (e.g. animal number or inhabitants) must be equal in different source/pollutant combinations.

Emission factors:

- The uncertainty of an EF for a specific fuel from stationary combustion is assumed to be equal for all the sources using this fuel in the stationary combustion sector. This type of correlation

is also used in several Transport subsectors such as shipping and aviation.
- The EFs for the various types of cattle (cattle for meat production or dairy cattle) are assumed to be correlated. The same goes for the EFs for poultry, and for horses, mules and asses.

The results of the Approach 2 uncertainty analysis based on Monte Carlo are presented in Table 1.5 and the uncertainties based on standard error propagation is presented in Table 1.6.

Table 1.5 Level uncertainties for 2023 (95% confidence ranges) based on Monte Carlo analysis, including LULUCF

CRT category	CO_2	CH_4	N_2O	F-gases	Total (CO_2-eq)
1	2%	35%	32%		3%
2	20%	61%	43%	24%	18%
3	19%	9%	41%		13%
4	34%	79%	100%		30%
5	27%	20%	22%		17%
Total	**4%**	**9%**	**30%**	**24%**	**4%**

Table 1.6 Level uncertainties for 2023 (95% confidence ranges) based on standard error propagation including LULUCF

CRT category	CO_2	CH_4	N_2O	F-gases	Total (CO_2-eq)
1	2%	26%	32%		2%
2	20%	62%	42%	24%	18%
3	19%	9%	39%		13%
4	55%	74%	278%		50%
5		21%	27%		17%
Total	**3%**	**8%**	**30%**	**24%**	**3%**

For LULUCF, the total uncertainty calculated with Monte Carlo is significantly lower than those based on error propagation. For CO_2, N_2O and CH_4 there are skew distributions for uncertainty (e.g. -80% and +200%). In the Monte Carlo analysis, both values are used, while in the error propagation calculation, only the + value (or 200%) is used. As a result, the total uncertainty according to the error propagation method is higher than the uncertainty according to the Monte Carlo analysis.

More details on the level and trend uncertainty assessments can be found in Annex 2. In the analyses described above (and in more detail in Annex 2), only random errors were estimated, on the assumption that the methodology used for the calculations did not include any systematic errors that can occur in practice.

Base year (1990) uncertainties
Table 1.7 presents the uncertainties in the base year (Approach 2, including uncertainties using error propagation), which are based on expert judgement in 2000 (Van Amstel et al., 2000) as well as on the

methodology used in this submission (2025 methodology). Please note that these uncertainties were calculated including LULUCF.

Table 1.7 Assessment of uncertainties in 1990 emissions (without LULUCF)

Greenhouse gas	2000 methodology	2025 methodology
CO_2	3%	2%
CH_4	17%	4%
N_2O	34%	12%
HFC/SF_6 PFC	41% 100%	 4%
F-gases	100%	4%
Total	**4.4%**	**2%**

1.7 General assessment of completeness

DNV GL (2020) was commissioned by the NIE to investigate the completeness of the Netherlands Greenhouse Gas Inventory. As a result, the conclusions from the former assessment of completeness still stand. The Netherlands' GHG inventory includes almost all sources that, according to the 2006 IPCC Guidelines, should be included in the inventory. The following minor sources are not included:

- CO_2 from Asphalt roofing (2A4d), due to negligible amounts (below threshold);
- CO_2 from Road paving (2A4d), due to negligible amounts (below threshold);
- CH_4 emissions from Other livestock (alpacas) (3A1), due to negligible amounts (below threshold);
- CH_4 and N_2O emissions from the decomposition of manure from other livestock (alpacas) (3A2), due to negligible amounts (below threshold);
- CH_4 from Enteric fermentation: poultry (3A4), due to missing EFs: for this source category, no IPCC default EF is available;
- Part of CH_4 from Industrial wastewater (5D2 sludge), due to negligible amounts;
- Direct N_2O emissions from septic tanks (5D3), as they are unlikely to occur given the anaerobic circumstances in these tanks;
- Precursor emissions (carbon monoxide (CO), nitrogen oxide (NO_x), non-methane volatile organic compounds (NMVOC) and sulphur dioxide (SO_2)) from memo item 'International bunkers' (international transport), as these emissions are not included in national total emissions;
- Indirect CO_2 emissions from CO process emission, due to negligible amounts.

A number of recommendations by DNV GL relating to the 2019 refinement of the IPCC Guidelines are implemented, and other recommendations will be further explored. During the COP26, it was decided that the implementation of these guidelines will be voluntary as of the NIR 2023.
Annex 6 presents the assessment of completeness and sources, potential sources and sinks for this submission of the NID 2025 and the CRT tables.

1.8 Metrics

In this report, GHG emissions are given in gigagrams (Gg) and teragrams (Tg). 1 gigagram is equal to 1 kiloton (kt); 1 teragram (Tg) is equal to 1 megaton (Mt).
Global warming potential (GWP)-weighted emissions of the GHGs are also provided (in CO2 equivalents), using GWP values that are based on the effects of GHGs over a 100-year horizon, in accordance with UNFCCC Decision -/CP.27 'Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention' (UNFCCC, 2022) and the 5th IPCC Assessment Report (AR5). The GWP of each individual GHG is provided in Annex .

2 Trends in greenhouse gas emissions and removals

2.1 Description of emission and removal trends for aggregated GHG emissions and removals

This chapter summarises the trends in GHG emissions for the 1990–2023 period by GHG and by sector. More sectoral details are provided in Chapters 3–8.

Table 2.1 presents all GHG emissions by gas and by sector in 2023. Also, the relative shares of the sectors are provided. CO_2 is the main GHG emission in the Netherlands, followed by CH_4, N_2O and F-gases.

Table 2.1 The Netherlands' GHG emissions in CO_2 equivalents (kt) by gas and sector in 2023

Sector	**CO_2**	**CH_4**	**N_2O**	**HFCs**	**PFCs**	**SF_6**	**Unspecified mix of HFCs and PFCs**	**NF_3**	**Total**	**Share**
1. Energy	105578.95	2135.69	596.41						108311.06	74%
2. Industrial processes and product use	11344.33	415.80	471.22	688.45	41.92	105.33	NO	IE	13067.05	9%
3. Agriculture	93.21	13037.54	4850.58						17981.33	12%
4. Land use, land-use change and forestry[(1)]	3114.55	588.43	101.48						3804.46	3%
5. Waste	NA	2258.57	581.47						2840.04	2%
6. Other *(as specified in summary 1.A)*	NO	NO	NO	NO	NO	NO	NO	NO		
Indirect CO_2 [(3)]	432.73								432.73	0%
Total CO_2 eq, including indirect CO_2 and LULUCF									**146436.65**	**100%**

International bunkers	43142.56	238.62	313.53						43694.71	
Aviation	9985.20	1.99	75.42						10062.61	
Navigation	33157.36	236.63	238.11						33632.10	

The energy sector is by far the largest contributor to the inventory, followed by Agriculture, IPPU, LULUCF and Waste.

Figure 2.1 presents the contributions made by the individual sectors (including LULUCF) to the total emissions of the various GHGs.

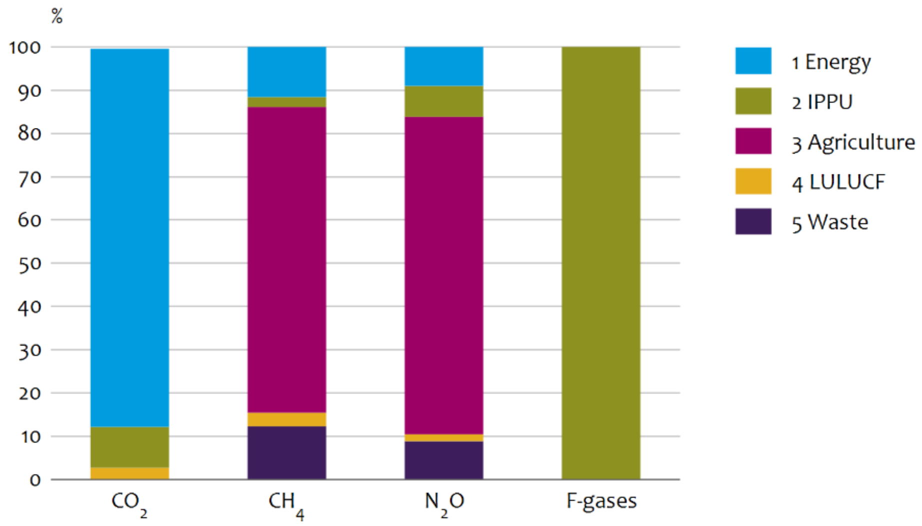


Figure 2.1 Relative contributions of the individual sectors (including LULUCF) to GHG emissions in 2023

The dominance of the Energy sector regarding CO_2 emissions is clearly visible. The agricultural sector is the main contributor of CH_4 and N_2O emissions. All F-gases originate from the IPPU sector.

Figure 2.2 shows the index of economic development (GDP) of the Netherlands since 1990, compared with the development in GHG emissions for the 1990–2023 period.

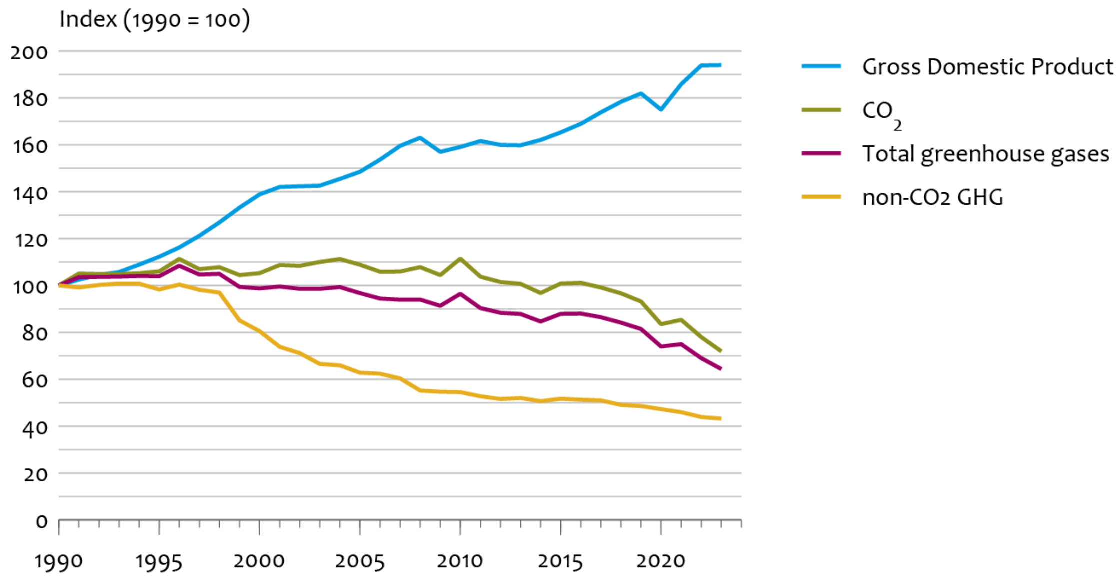


Figure 2.2 Development of greenhouse gas emissions compared with GDP (Gross Domestic Product), for the 1990–2023 period

In 2023, total GHG emissions (including indirect CO_2 emissions and including emissions from LULUCF) in the Netherlands were estimated at 146.4 Tg CO_2-eq. This is 35.6% lower than the 227.5 Tg CO_2-eq reported for the base year (1990), while the economy increased by more than 90% in the same period. The trend in total GHG emissions was largely determined by the emission reductions achieved in non-CO_2 gases (56.8% reduction in 2023 compared to 1990; over the same period, CO_2 emissions declined by 28.1%).

Renewable energy
Figure 2.3 shows the mix of renewable energy sources in the Netherlands and the trend. Renewables accounted for 308 PJ in 2023 (17% of total energy use in the Netherlands), a year-on-year increase of 11% compared to 2022[1].

[1] Energy from renewable sources rises to 17 percent | CBS (consulted 11 December 2024)

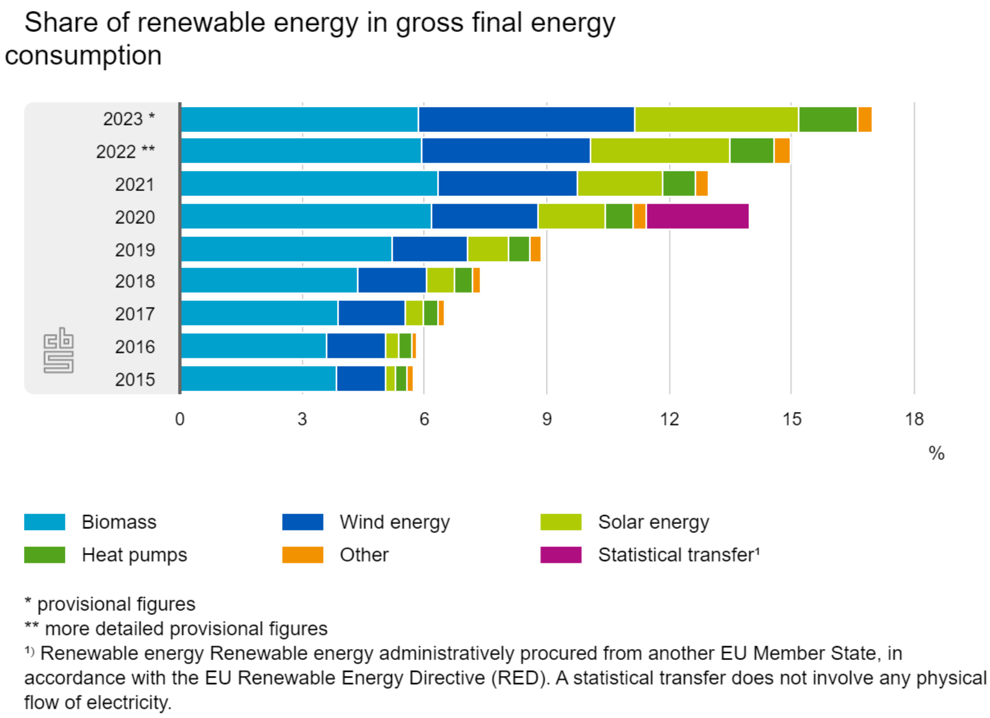


Figure 2.3 Development of renewable energy sources as a percentage of total energy demand in the Netherlands, 1990–2023 (Statistics Netherlands, 2024)

Energy efficiency

The efficiency of total final energy consumption can be expressed by the so-called technical ODEX as defined by the Odyssee-Mure project[2]. The technical ODEX measures the energy efficiency progress by sector (industry, transport, households, services) and for the economy as a whole (total of all final energy consumers). The dimension of the ODEX is final energy used divided by a measure of energy consuming activities, which means that a lower value of the ODEX represents an increase in energy efficiency. For each sector, the index is calculated as a weighted average of sub-sectoral indices of energy efficiency progress; sub-sectors being industrial branches, services sector branches, end-uses for households and transport modes.

[2] https://www.indicators.odyssee-mure.eu/odex-indicators-database-definition.pdf

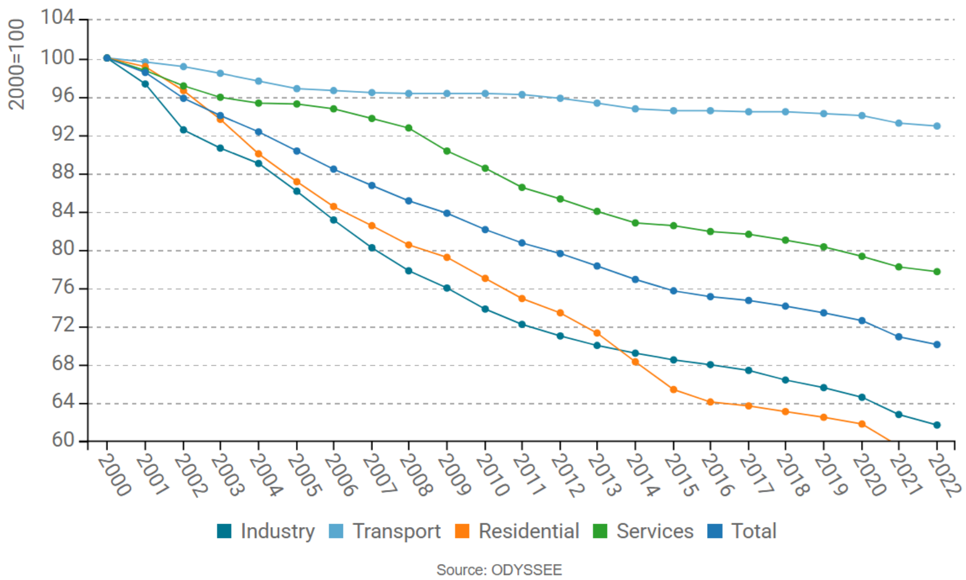


Figure 2.4 Technical ODEX for the Netherlands, 2000-2022[3]

Efficiency for total final energy consumption, as measured by the so-called technical ODEX, has improved by around 1.6% per year since 2000[4]. This can be derived from the value of 70 of the total ODEX in 2022 shown in Figure 2.4. Smaller than average annual gains have been achieved in services (1.1%/year) and especially in transport (0.3%/year), larger gains were achieved in the residential sector (2.4%/year) and in industry (2.2%/year). The highest efficiency improvement since 2019 thus occurred in the households sector, which was caused by the high energy prices towards the end of 2021 and in 2022.

2.2 Description of emission and removal trends by gas

Figure 2.5 shows the emissions trends for the various gases and aggregated national total GHGs.

[3] One negative point in this figure (-1) represents a 1% increase in efficiency for final energy consumption compared to reference year 2000.
[4] https://www.odyssee-mure.eu/publications/efficiency-trends-policies-profiles/netherlands.html

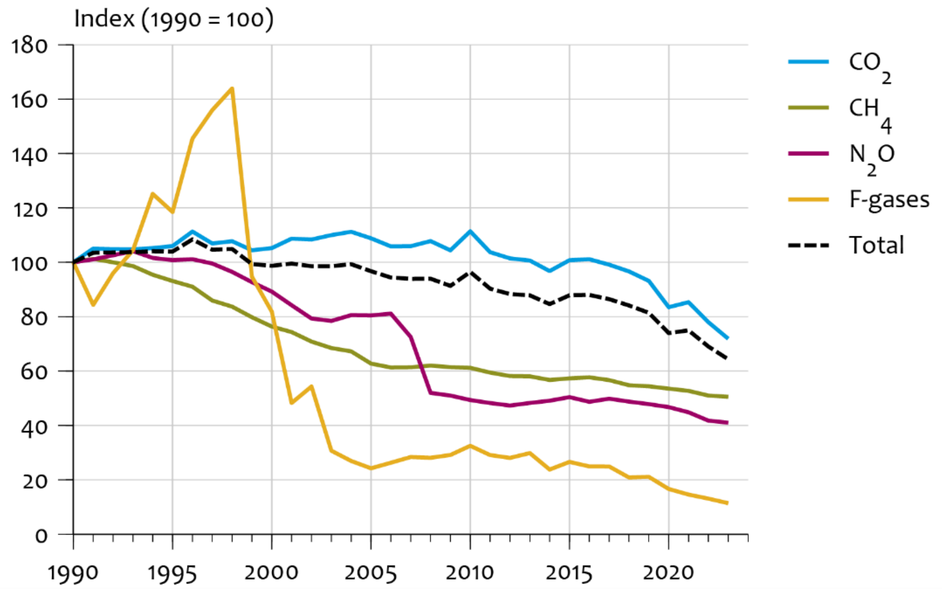


Figure 2.5 Relative emissions trends of the individual GHGs (including LULUCF) in the Netherlands, 1990-2023. The base year 1990 is set at 100

In the 1990-2023 period, emissions of total GHG (including LULUCF) decreased by 35.6%. Emissions of carbon dioxide (CO_2) decreased by 28.1%. Emissions of the non-CO_2 GHGs methane (CH_4), nitrous oxide (N_2O) and F-gases decreased by 49.5%, 59.0% and 88.6%, respectively.

2.2.1 *Carbon dioxide*

Figure 2.6 shows the CO_2 emissions trends for the individual sectors.

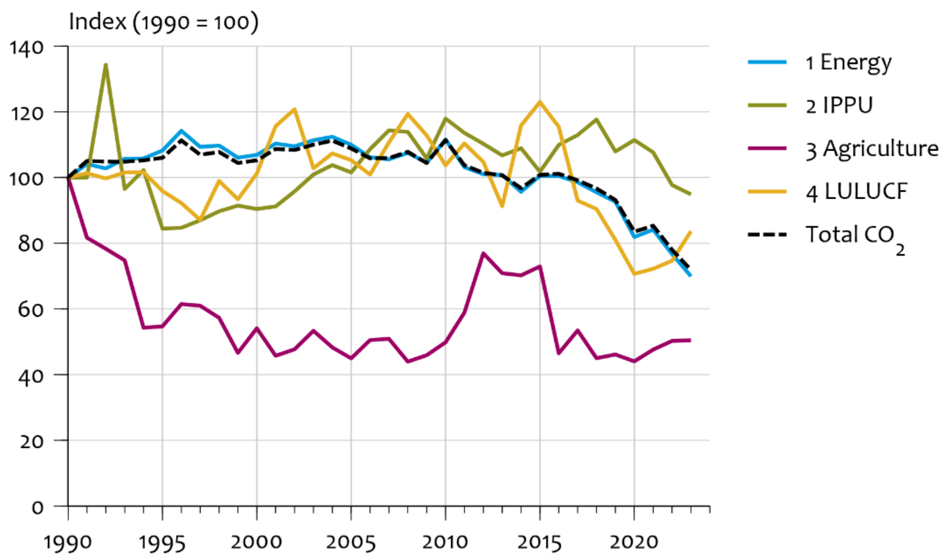


Figure 2.6 Relative emissions trends of CO_2 in the Netherlands, 1990-2023. The base year 1990 is set at 100

In the 1990–2023 period, national CO_2 emissions (including indirect CO_2 emissions from LULUCF) decreased by 28.1% (from 167.7 Tg CO_2-eq to 120.6 Tg CO_2-eq).

With regard to CO_2 emissions, the Energy sector is the primary sector in the Dutch GHG emissions inventory and is responsible for 88% of the total CO_2 emissions in the country (Figure 2.1). In the 1990-2023 period, CO_2 emissions from the Energy sector decreased by 30.0%. Note that in Figure 2.6, the CO_2 emissions trend for the Energy sector almost completely overlaps with that of total CO_2 emissions.

Within the Energy sector, an increasing trend in electric power production until 2005 corresponds to a substantial increase in CO_2 emissions from fossil fuel combustion by power plants. Also, the diesel fuel consumption from road transport increased by 60% between 1990 and 2008, resulting in increased emissions in this sector. The decreasing trend of CO_2 between 2016 and 2022 is the result of a decline in coal combustion caused by the closure of coal-fired power plants, and an increase in renewable energy. Apart from these overall trends, some substantial interannual fluctuations are visible. These peaks and dips are mostly due to weather conditions. More natural gas is used during cold winters (1996 and 2010) while less is used in warm winters (2014 and 2020). The dip in the graph in 2020 is amplified by a decrease in liquid fuel combustion for vehicle use during the COVID-19 pandemic. In 2021, CO_2 emissions show a peak as a result of a cold winter. The large decrease in CO_2 emissions in 2022 and 2023 is mainly caused by a decrease in gaseous fuel consumption due to high prices of natural gas in 2022 and increased renewable electricity production. For more details about the emissions in the subsectors Energy, see section 2.3.

Compared with the Energy sector, other sectors contribute much less to CO_2 emissions (Figure 2.1). The IPPU sector is responsible for 9.4% of the total CO_2 emissions in the Netherlands). CO_2 emissions from the Agriculture and LULUCF sectors amount to 0.1% and 2.6% of the total CO_2 emissions in 2023.

The trend of CO_2 emissions from Agriculture is mainly explained by fluctuations in the application of liming products and urea application (see Chapter 5).

2.2.2 *Methane*

Figure 2.7 shows the relative CH_4 emissions trends of all individual sectors over time.

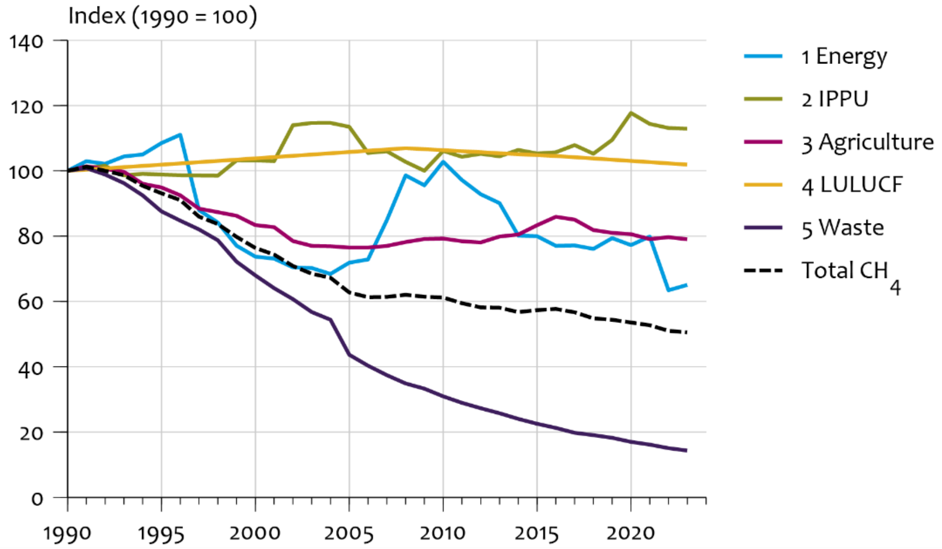


Figure 2.7 Relative emissions trends for CH_4 in the Netherlands, 1990-2023. The base year 1990 is set at 100

Between 1990 and 2023, national CH_4 emissions decreased by 49.5%, from 36.5 Tg to 18.4 Tg CO_2-eq.

The trend of total CH_4 emissions shows a relatively strong reduction between 1990 and 2005. After 2005, emissions declined further, but at a slower pace.

The Agriculture sector was the largest contributor to total methane emissions in 2023 (70.7%) (Figure 2.1). Between 1990 and 2023, CH_4 emissions from Agriculture declined by 21%.

The trend in methane emission from the Agriculture sector is mainly explained by changes in the number of mature dairy cattle and pigs (further explained in Chapter 5). The number of dairy cattle has decreased since the 1990s due to higher production rates per animal and production quotas. Between 2012 and 2016, the number of cattle increased as dairy farmers anticipated the abolition of milk production quotas. However, this resulted in exceeding the European phosphate production ceiling. The Dutch government implemented new policies in accordance with the phosphate production ceiling: the phosphate reduction scheme followed by the phosphate quota that were introduced in 2018 (MLNV, 2017). These policies resulted in a decrease in cattle (all categories) that can be kept in the Netherlands and resulted in a decrease in cattle numbers from 2017 to 2023.

CH_4 emission from the Waste sector was 12.3% of total CH_4 emissions in 2023 (Figure 2.1). In the 1990-2023 period, methane emission from the Waste sector decreased by 86%, mainly due to an 88% reduction in CH_4 from Managed waste disposal on land (5A).

The Energy sector contributed 11.6% to total CH_4 emissions in the Netherlands in 2023 (Figure 2.1). In the 1990-2023 period, CH_4 emissions from Energy declined by 35%, mainly in the category

Fugitive emissions (1B). The strong increase between 2005 and 2010 can be explained by more natural gas combustion by the increased installation of gas engines (with a relatively high emission factor compared to other engines) in the agricultural sector in that period.

2.2.3 *Nitrous oxide*

Figure 2.8 shows the N_2O emissions trends of all individual sectors over time.

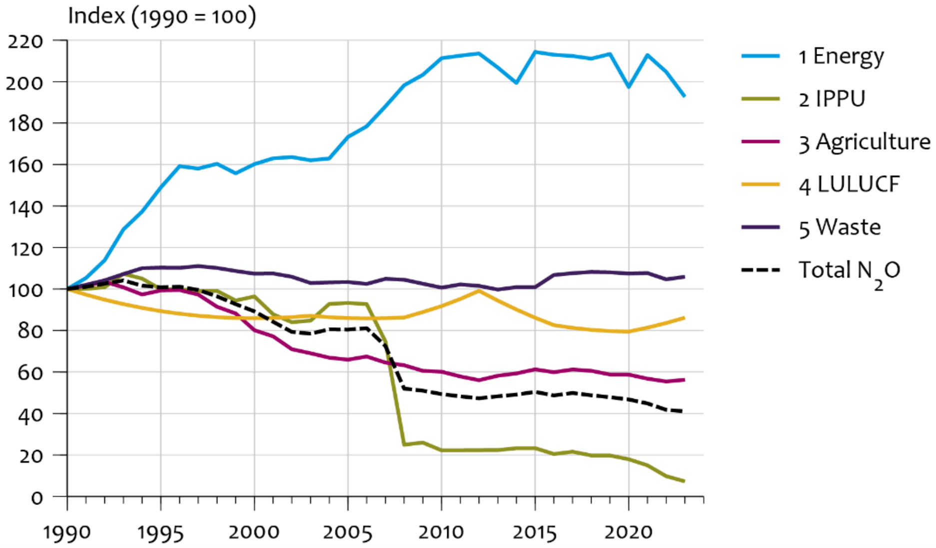


Figure 2.8 Relative emissions trends for N_2O in the Netherlands, 1990-2023. The base year 1990 is set at 100

The national total inventory of N_2O emissions decreased by 59.0%, from 16.1 Tg CO_2-eq in 1990 to 6.6 Tg CO_2-eq in 2023.

The Agriculture sector was the largest contributor to the total nitrous oxide emissions in 2023 (73.5%) (Figure 2.1). N_2O emissions from Agriculture declined by 44% between 1990 and 2023.

The decreasing trend of N_2O emission in the agricultural sector is a result of a decrease in organic and inorganic N fertiliser application, a decrease in animal numbers and a decrease in grazing in the agricultural sector from 1990 to 2012. Emissions slightly increased in 2013-2017, while 2018 and 2019 show a decrease. Emissions increased in 2020 and decreased in 2021 and 2022. Emissions increased in 2023, mainly due to higher emissions from manure application, pasture manure and losses of soil organic matter.

In 2023, the IPPU, Waste and Energy sectors contributed 7.1%, 8.8% and 9.0%, respectively, to total N_2O emissions in the Netherlands (Figure 2.1). In the 1990-2023 period, N_2O emissions from the IPPU sector decreased by 93%. N_2O emissions within the IPPU show a sharp decrease in 2008. This is a result of a applying catalytic reduction technologies in the production process of nitric acid (2B2). The installation of these technologies was a result of bringing this sector under EU-ETS regulation. Emissions from Waste and Energy increased by 6% and 93% respectively, in the 1990-2023 period. In the Energy sector, the increase in N_2O emissions mostly took place in the category Fuel combustion (1A).This is mainly the result of the introduction of catalysts in vehicles.

2.2.4 *Fluorinated gases*

Fluorinated gases are only emitted in the IPPU sector (Figure 2.1). Within the IPPU sector, there are several F-gas emissions. Figure 2.9 shows the F-gas emissions trends over the 1990-2023 period.

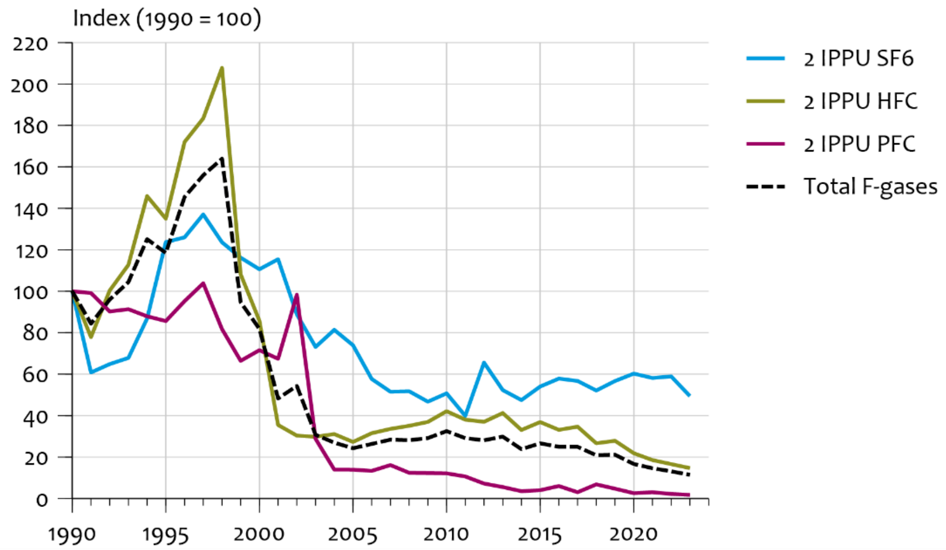


Figure 2.9 Relative emissions trends of fluorinated gases in the Netherlands, 1990-2023. The base year 1990 is set at 100

Total emissions of F-gases have decreased by 88.6%, from 7.3 Tg CO_2-eq in 1990 to 0.8 Tg CO_2-eq in 2023, partly as a result of the Netherlands' program for reducing emissions of non-CO_2 greenhouse gases (ROB).

Within the fluorinated gases, emissions of hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) decreased by 85.3%, 98.3% and 50.6% respectively, during the 1990-2023 period.

It should be noted that, because emissions of NF_3 only take place in one company, the NF_3 emissions are included in PFC emissions due to confidentiality reasons.

The increase in emissions between 1995 and 1998 is mainly due to a 35% increase in the HFC-23 emission as a result of increased production of HCFC-22. The sharp decrease in emissions in the 1998–2000 period is the result of a 69% decrease in HFC-23 emissions following the installation of a thermal converter (TC) at the plant.

Since 1990, there has been a substantial increase in HFC use as a substitute for (H)CFC use (category 2F). In 2023, this category accounts for 88.1% of national total HFC emissions (0.61 Tg CO_2-eq).

2.3 Description of emission and removal trends by sector

Table 2.2 and Figure 2.10 provide an overview of emissions trends for each CRT category in Tg CO_2 equivalents. Please note that all indirect CO_2 emissions are assigned to IPPU in these overviews.

Table 2.2 Summary of emissions trends per sector (Tg CO2 equivalents, including indirect CO_2 emissions), 1990–2023

	1. Energy	2. IPPU	3.Agriculture	4. LULUCF	5. Waste	Total (incl.) LULUCF
1990	154.5	27.0	25.3	4.4	16.3	227.5
1995	167.3	26.3	24.3	4.3	14.4	236.5
2000	164.2	24.0	20.8	4.5	11.3	224.6
2005	168.8	20.8	18.4	4.6	7.4	220.1
2010	172.3	18.8	18.3	4.6	5.4	219.4
2015	154.9	16.5	19.2	5.3	4.1	200.0
2020	126.7	16.6	16.6	3.3	3.3	168.3
2022	118.5	14.1	18.0	3.5	2.9	157.0
2023	108.3	13.5	18.0	3.8	2.8	146.4

The Energy sector is by far the largest contributor to national total GHG emissions (contributing 67.9% in the base year and 74.0% in 2023).

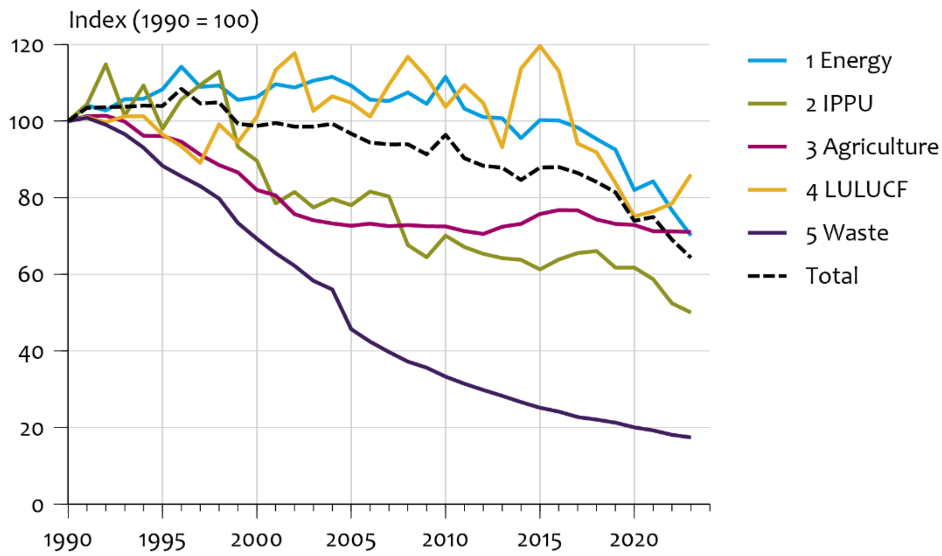


Figure 2.10 Relative GHG emissions trends (including LULUCF) of the individual sectors in the Netherlands, 1990-2023. The base year 1990 is set at 100

The emissions of the Energy sector decreased by 29.9% in the 1990–2023 period.

In 2023, total GHG emissions of all other sectors (IPPU, Agriculture, LULUCF and Waste) decreased by 50.0%, 28.9%, 13.9% and 82.6%, respectively, compared to the base year.

2.3.1 *Energy*

Figure 2.11 shows the relative trend in total GHG emissions from the Energy sector and individual subsectors.

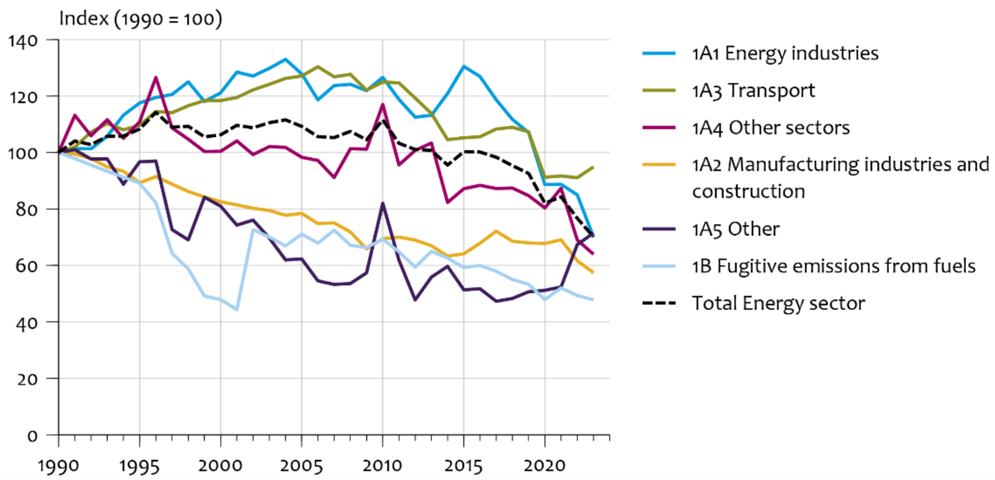


Figure 2.11 Relative emissions trends for the Energy sector and subsectors, 1990-2023. The base year 1990 is set at 100

Between 1990 and 2023, total fossil fuel combustion decreased by 18.4%, due to a 56.9% decrease in solid fuel consumption, a 27.8% decrease in gaseous fuel consumption, and a 2.7% increase in liquid fuel consumption (see Chapter 3).

The main fluctuations in GHG emissions in this sector can be explained as follows:

- Weather conditions: Natural gas is the main source of energy used in the Netherlands for space heating. The peaks in Figure 2.11 are cold winters in 1996 and 2010, while the dip in 2014 is the result of a relatively mild winter.
- COVID-19: In 2020, there was a dip in total GHG emissions, mainly due to a decrease in liquid fuel combustion for vehicle use during the COVID-19 pandemic;
- The decreasing trend between 2016 and 2020 in total GHG emissions in the Energy sector is the result of a decline in coal combustion caused by the closure of coal-fired power plants, and an increase in renewable energy.
- In 2021 the CO_2 emissions show a peak as a result of a cold winter.
- The decrease in CO_2 emissions in 2022 and 2023 is mainly caused by a decrease in gaseous fuel consumption due to high prices of natural gas between end of 2021 and beginning of 2023 and an increased renewable electricity production.

As the Energy sector is the largest contributor to national total GHG emissions, more details about the emissions trends for the individual subsectors in the Energy sector are provided in the paragraphs below.

2.3.1.1 Energy industries (1A1)

The main fluctuations in GHG emissions in this sector (1A1) can be explained as follows:

- an increase in natural gas combustion due to a change in ownership structures of CHP (Combined Heat and Power) plants which resulted in a shift of natural gas combustion from 1A2 to 1A1a in 1990-1998;
- new, large coal-fired power plants commencing operations in 2015 and 2016, resulting in a shift from natural gas to coal;
- closure of old coal-fired power plants in 2015–2019, resulting in a decrease in coal consumption from 2017 onwards;
- in some years, the import of electricity was higher (e.g. in 1999–2008, 2012–2014) than in other years;
- total CO_2 emissions from the five large refineries in the Netherlands fluctuated between 10 and 13 Tg CO_2;
- combustion of natural gas by the oil and gas production industry for heating purposes increased from 2008 until 2013. Between 2013 and 2023, the production of natural gas was reduced by 86%, which also resulted in a decrease in the amount of natural gas combusted in this sector;
- The combustion of solid fuels has increased again in 2021, as a result of the high prices of natural gas at the end of 2021, in 2022 and beginning of 2023.
- In 2023, the solid fuel consumption decreased again, as a result of increased renewable electricity production and lower natural gas prices.

2.3.1.2 Manufacturing industries and construction (1A2)

The main fluctuations in GHG emission in this sector (1A2) can be explained as follows:

- decreasing emissions between 1990 and 2000 were mainly due to a decrease in cogeneration facilities in the industrial sector (category 1A2c Chemicals);
- emissions in the category 1A2 generally follow production in the manufacturing industries. The effect of the economic crisis in 2008 is clearly visible. In 2016 and 2017, emissions increased because of growing economic activities;
- the decrease in GHG emissions in 2018 and 2019 was a result of less natural and residual gas combustion (category 1A2c Chemicals);
- the increase in gaseous and liquid fuel consumption in 2019 and 2020 is because one power plant (using natural gas and chemical waste gas) is now part of a chemical plant. The emissions of this power plant are therefore allocated to 1A1a in the period up to 2019 and to 1A2c in 2020;
- The chemical industry chiefly contributed to the decrease of 42.5% in CO_2 emissions from combustion in 1A2 over the 1990-2023 time period.

2.3.1.3 Transport (1A3)

The main fluctuations in GHG emissions in this sector (1A3) can be explained as follows:

- an increase in diesel fuel consumption between 1990 and 2006 resulted in increased emissions in category 1A3b (Road vehicles);
- since 2006, GHG emissions from transport have decreased, while from 2014 till 2020, they have slightly increased again; this is

explained by an improving economy with more transport in the 2014-2019 period;
- in 2020, a dip in GHG emissions in the transport sector is clearly visible. This is due to measures taken during the COVID-19 pandemic, resulting in much less road traffic;
- After the resumption of road traffic, GHG emissions increased by 4% in 2023 compared to 2022 but are lower than before the COVID-19 pandemic.

2.3.1.4 Other sectors (1A4)

The main fluctuations in GHG emission in this sector (1A4) can be explained as follows:
- substantial interannual fluctuations in emissions are a result of fluctuations in temperature. More natural gas is used during cold winters (e.g. 1996 and 2010) and less in mild winters (e.g. 2014 and 2020).
- In the residential category (1A4b), CO_2 emissions decreased since 1990, while the number of households has increased. This is mainly due to improved insulation and increased use of high-efficiency boilers for central heating.
- In 2022 and 2023, a large decrease of CO_2 emissions can be seen, which is caused by the high natural gas prices (resulting in less heating by households).

2.3.2 Industrial processes and product use

In 2023, IPPU (including all indirect CO_2 emissions) contributed 9.2% to national total GHG emissions (including LULUCF and indirect CO_2 emissions) compared to 11.9% in 1990. The sector is also a source of N_2O emissions, accounting for 7.1% of national total N_2O emissions in 2023.

The main fluctuations in GHG emissions as shown in Figure 2.10 can be explained as follows:
- category 2B: an increase in emissions of fluorinated gases until 1998, mainly due to increased production of HCFC-22;
- category 2B: a major decrease in emissions of fluorinated gases from 1999 onwards, due to a reduction in HFC-23 emissions from HCFC-22 production;
- category 2B: a decrease in N_2O emissions as a result of applying catalytic reduction technologies in the production of nitric acid under EU-ETS regulations.

2.3.3 Agriculture

In 2023, agriculture contributed 12.3% of the national GHG emissions compared to 11.1% in 1990. This sector is a major contributor to national total CH_4 and N_2O emissions; in 2023, agriculture accounted for 70.7% of the total CH_4 emissions and for 73.5% of the total N_2O emissions.

The main fluctuations in GHG emissions in the Agriculture sector as shown in Figure 2.10 can be explained as follows:
- category 3A: Emissions decreased slightly, mainly due to a decrease in CH_4 emissions from cattle;

- category 3D: N_2O emissions have decreased from 1990 onwards, caused by a relatively large decrease in N inputs into soil.

2.3.4 *LULUCF*

The total net emissions in the LULUCF sector decreased from 4.4 Tg CO_2-eq in 1990 to 3.8 Tg CO_2-eq in 2023. The sector accounts for 2.6% of national total CO_2 equivalent emissions in 2023.

The main fluctuations in GHG emissions from 1990 to 2023 can be explained as follows:

- CO_2 emissions from the drainage of peat soils and peaty soils were the major source to the net emission of Cropland (4B), Grassland (4C) and Settlements (4E) and decreased from 6.12 Tg CO_2 in 1990 to 5.13 Tg CO_2 in 2023.
- Drainage ditches on organic soils added 8.6 Gg CH_4 (0.24 Tg CO_2-eq) in 2023, compared to 10.2 Gg CH_4 (0.29 Tg CO_2-eq) in 1990.

Compared to 2022, emissions in the LULUCF sector increased from 3.5 to 3.8 Tg CO_2-eq, because of decreased uptake and increased decomposition of carbon in mineral soils of remaining grasslands and cropland respectively. This might be due to fact that 2023 was a wet year hindering uptake and increasing decomposition of carbon in mineral soils.

2.3.5 *Waste*

Between 1990 and 2023, emissions from the Waste sector decreased by 82.6% (from 16.3 Tg CO_2-eq in 1990 to 2.8 Tg CO_2-eq in 2023). This decrease is mainly due to an 87.5% reduction in CH_4 from landfills. The landfilling of waste with large amounts of biodegradables (such as household waste) was first discouraged and then banned in the Netherlands.

2.3.6 *Precursor gases*

The emissions of carbon monoxide (CO), nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOC), and sulphur dioxide (SO_2) are also reported in the greenhouse gas inventory as requested by the UNFCCC guidelines. Although these gases are not included in the GWP weighted GHG emission totals, they affect the overall radiative balance of the atmosphere and thus contribute to climate change. Nitrogen oxides, carbon monoxide and NMVOCs can result in an increase in tropospheric ozone concentration, increasing radiative forcing. Sulphur oxides are included because they contribute to sulphate aerosol formation, which has a cooling effect.

The calculation methodologies regarding these emissions are explained in detail in the Netherlands' Informative Inventory Report (Staats et al, 2025), in line with the EMEP guidebook. Table 2.3 provides the emission trends for carbon monoxide (CO), nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOC), and sulphur dioxide (SO_2). Figure 2.12 shows the relative emissions trends of these gases.

Table 2.3 Emission trends for NO_x, CO, NMVOC and SO_2 (in Gg)

	1990	1995	2000	2005	2010	2015	2020	2022	2023
Total NOx	682	580	491	432	346	271	209	192	184
Total CO	1,177	942	758	723	655	521	427	401	386
Total NMVOC	601	433	335	268	272	256	253	240	238
Total SO2	198	137	78	68	36	31	20	20	18

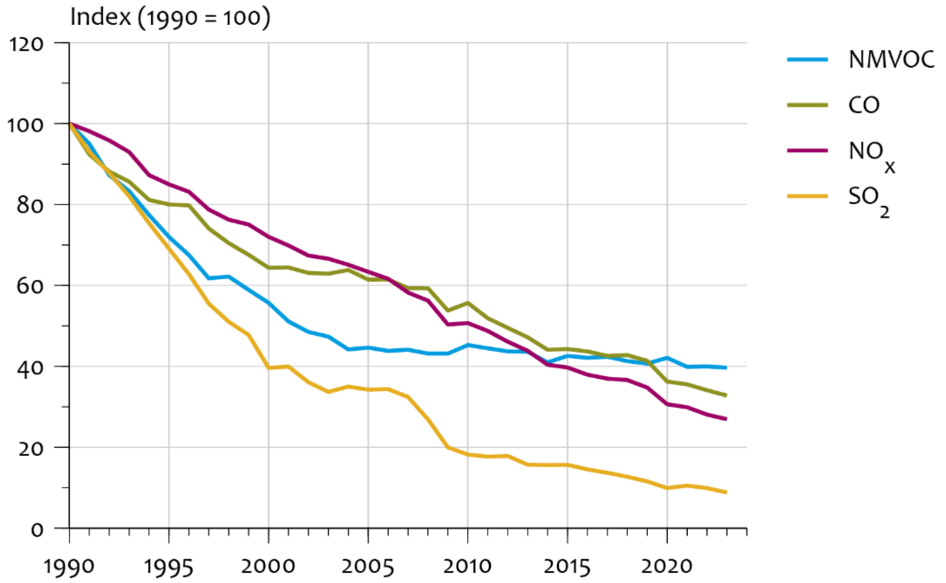


Figure 2.12 Relative emissions trends for NO_x, CO, NMVOC and SO_2 in the Netherlands, 1990-2023. The base year 1990 is set at 100

In the 1990-2023 period, emissions of CO, NO_x, NMVOC and SO_2 were reduced by 67%, 73%, 60% and 91%, respectively. With the exception of NMVOC, most of the emissions stem from fuel combustion.

3 Energy (CRT sector 1)

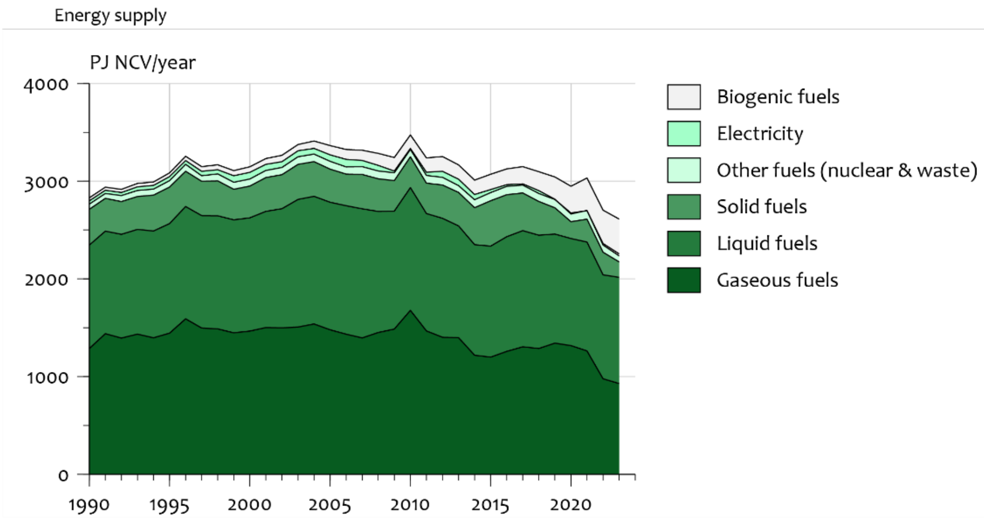
Major changes in the Energy sector compared to the National Inventory Report 2024	
Emissions:	In 2023, GHG emissions related to the Energy sector decreased by 8.6% compared to 2022. The decrease mainly occurred in the categories Energy Industries (1A1), Manufacturing industries and construction (1A2) and Other Sectors (1A4), mainly due to a decrease in natural gas combustion and increase of renewables.
New key categories:	
1A3b	Road transportation N_2O
No longer a key category:	
1A1a	Public Electricity and Heat Production: liquids CO_2
1A3b	Road transportation: gaseous CO_2
1A3e	Other CO_2
Methodologies and recalculations:	Energy statistics have been updated/improved for the years 2015-2022. The LPG data for road transportation (1A3b) has been corrected for the years 1990-2022. The emission factors CH_4 and N_2O for road transportation (1A3b) were updated for the years 1990-2022. The model for Non-road Mobile Machinery (1A2gvii, 1A4aii, 1A4bii, 1a4cii) has been updated/improved for the years 1990-2022.

3.1 Overview of the sector and background information

3.1.1 Energy supply and energy demand

The energy system in the Netherlands is largely driven by the combustion of fossil fuels (Figure 3.1). Natural gas is used most except in 2022 and 2023 when high prices of natural gas between the end of 2021 and the beginning of 2023 resulted in a reduction of the natural gas consumption in these years. The share of biogenic fuels has been increasing from 1% in 1990 to 14% in 2023. The contribution made by other fuels (waste & nuclear) is relatively small (2-3%).

Part of the supply of fossil fuels is not used for energy purposes but for feed stocks in the (petro-)chemical or fertiliser industries. Emissions from fuel combustion (as reported for the Sectoral Approach in CRT 1A) are consistent with national energy statistics (available via: https://opendata.cbs.nl/statline/#/CBS/en/dataset/83140ENG/table?dl=B37C3).



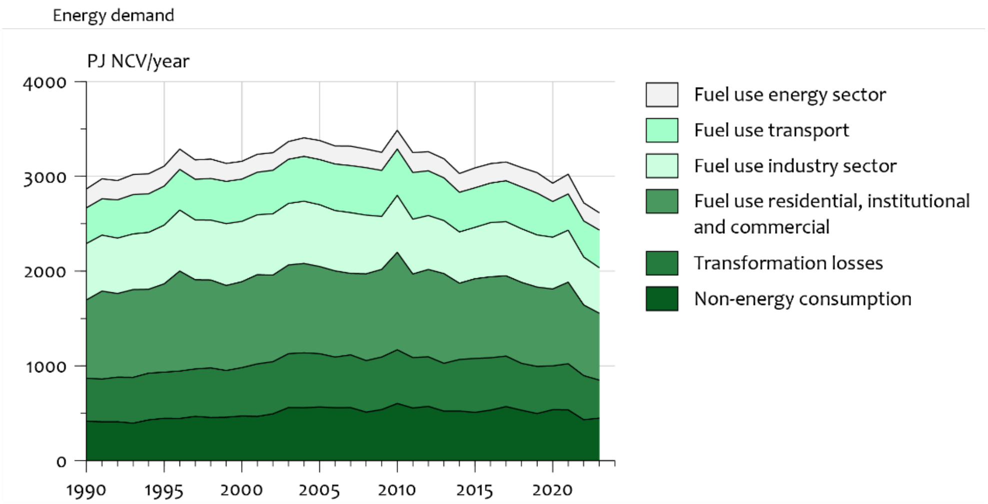


Figure 3.1 Overview of energy supply and energy demand in the Netherlands, 1990–2023, as published by Statistics Netherlands ('Electricity' refers to imported electricity only)

3.1.2 *Trends in fossil fuel use and fuel mix*

Natural gas represents a majority share (>50%) of national energy consumption in all non-transport subsectors: Energy industries, Manufacturing industries and construction and Other sectors (mainly for space heating). Oil products are primarily combusted in transport, refineries and the petrochemical industry, while the use of coal is limited to power generation and steel production.

Between 1990 and 2023, total fossil fuel combustion decreased by 18.4%, due to a 56.9% decrease in solid fuel consumption, a 27.8% decrease in gaseous fuel consumption, and a 2.7% increase in liquid fuel consumption.
Total fossil fuel consumption for combustion decreased by about 4.5% between 2022and 2023, due to a 31.7% decrease in solid fuel combustion, a 5.0% decrease in gaseous fuel combustion, and a 2.2% increase in liquid fuel combustion.
Note that solid fuel consumption showed an increase in 2015 and 2016 caused by three new coal-fired power plants. The decrease in solid fuel

consumption between 2016–2020 was due to the closure of old coal-fired power plants. The combustion of solid fuels has increased again in 2021 and 2022, as a result of the increasing prices of natural gas at the end of 2021, in 2022 and beginning of 2023. In 2023, the solid fuel consumption decreased again, as a result of increased renewable electricity production and lower natural gas prices.
Winter temperatures have a large influence on gas consumption, as natural gas is used for space heating in most buildings in the Netherlands. 1996 and 2010 both had a cold winter compared to other years, causing an increase in the use of gaseous fuel for space heating. 2014 had a mild winter compared to other years resulting in a decline in the use of gaseous fuel for space heating.

3.1.3 GHG emissions from the Energy sector

Table 3.1 shows the emissions in the main categories in the Energy sector. The Energy sector is the prime sector in the Dutch GHG emissions inventory and is responsible for 87.6% of the total CO_2 emissions in the country, resulting primarily from combustion with a relatively limited amount from fugitive emissions.

Table 3.1 Overview of emissions in the Energy sector in the base year and the last two years of the inventory (in Tg CO_2 eq.). The middle column shows the change (%) of the last year of the inventory compared to the base year. On the right side of the table, the contribution of the last year inventory's emissions of the category to the sector, to the total national emissions of the specific gas and to the total national emissions (in CO_2 eq) are provided.

Sector/category	**Gas**	**1990**	**2022**	**2023**	**2023 vs 1990**	**Contribution of the category in 2023 (%) to the**		
		Emissions in Tg CO_2 eq			**%**	**sector**	**total gas**	**total CO_2 eq**
1 Energy	CO_2	150.9	115.7	105.6	-30.0%	97.5%	87.6%	72.1%
	CH_4	3.3	2.1	2.1	-34.9%	2.0%	11.6%	1.5%
	N_2O	0.3	0.6	0.6	92.7%	0.6%	9.0%	0.4%
	all	154.5	118.5	108.3	-29.9%	100.0%		74.0%
1A Fuel combustion	CO_2	150.0	114.6	104.5	-30.3%	96.5%	86.7%	71.4%
	CH_4	1.0	1.6	1.7	68.3%	1.5%	9.0%	1.1%
	N_2O	0.3	0.6	0.6	92.7%	0.6%	9.0%	0.4%
	all	151.3	116.9	106.8	-29.4%	98.6%		72.9%
1B Fugitive emissions	CO_2	0.9	1.1	1.0	17.4%	1.0%	0.9%	0.7%
	CH_4	2.3	0.5	0.5	-78.9%	0.4%	2.6%	0.3%
	all	3.2	1.6	1.5	-52.2%	1.4%		1.0%
Total national emissions (incl. LULUCF)	CO_2	167.7	130.8	120.6	-28.1%			
	CH_4	36.5	18.6	18.4	-49.5%			
	N_2O	16.1	6.7	6.6	-59.0%			
	Total*	227.5	157.0	146.4	-35.6%			

including f-gases

The Energy sector includes:
- use of fuels in stationary and mobile applications;
- conversion of primary energy sources into more usable energy forms in refineries and power plants;
- exploration and exploitation of primary energy sources;
- distribution of fuels.

Key categories are indicated throughout the chapter on (sub)category level.

3.1.4 Overview of shares and trends in emissions

Figure 3.2 show the contributions of the subcategories and emissions trends in the Energy sector. Most of the emissions from the energy sector stem from the Energy industries sector (1A1), followed by transport (1A3) and Other sectors (1A4).

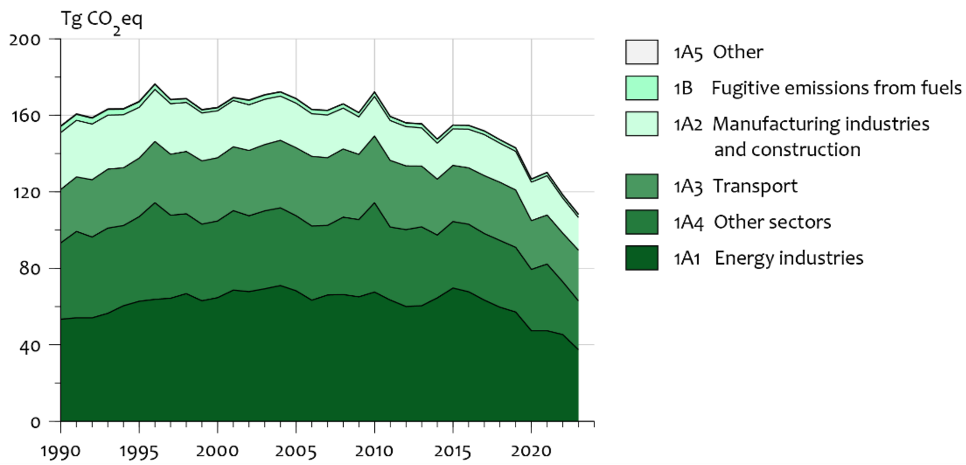


Figure 3.2 Sector 1 Energy – trend and emissions levels of total greenhouse gas emissions per source category, 1990–2023

3.2 Fuel combustion (1A)

Table 3.2 presents the source categories and trend in emissions under category 1A in the Energy sector.

Table 3.2 Overview of emissions in the Fuel combustion sector (1A) in the base year and the last two years of the inventory (in Tg CO_2 eq.). The middle column shows the change (%) of the last year of the inventory compared to the base year. On the right side of the table, the contribution of the last year inventory's emissions of the category to the sector, to the total national emissions of the specific gas and to the total national emissions (in CO_2 eq) are provided.

Sector/category	**Gas**	**1990**	**2022**	**2023**	**2023 vs 1990**	**Contribution of the category in 2023 (%) to the**		
		Emissions in Tg CO_2 eq			**%**	**sector**	**total gas**	**total CO_2 eq**
1A Fuel combustion	CO_2	150.0	114.6	104.5	-30.3%	96.5%	86.7%	71.4%
	CH_4	1.0	1.6	1.7	68.3%	1.5%	9.0%	1.1%
	N_2O	0.3	0.6	0.6	92.7%	0.6%	9.0%	0.4%
	All	151.3	116.9	106.8	-29.4%	98.6%		72.9%
1A1 Energy Industries	CO_2	53.1	45.0	37.1	-30.2%	34.3%	30.8%	25.3%
	CH_4	0.1	0.1	0.1	40.9%	0.1%	0.6%	0.1%
	N_2O	0.1	0.3	0.2	55.1%	0.2%	3.1%	0.1%
	All	53.4	45.3	37.4	-29.9%	34.5%		25.6%
1A2 Manufacturing industries and construction	CO_2	29.7	18.2	17.0	-42.7%	15.7%	14.1%	11.6%
	CH_4	0.1	0.1	0.1	-6.6%	0.1%	0.3%	0.0%
	N_2O	0.0	0.0	0.0	20.4%	0.0%	0.6%	0.0%
	All	29.8	18.3	17.1	-42.6%	15.8%		11.7%
1A3. Transport	CO_2	27.7	25.1	26.2	-5.4%	24.1%	21.7%	17.9%
	CH_4	0.2	0.1	0.1	-66.4%	0.1%	0.4%	0.0%
	N_2O	0.1	0.3	0.3	214.2%	0.3%	4.5%	0.2%
	All	27.9	25.4	26.5	-5.1%	24.5%		18.1%
1A4. Other sectors	CO_2	39.2	26.1	24.1	-38.6%	22.2%	20.0%	16.4%
	CH_4	0.6	1.4	1.4	121.6%	1.3%	7.7%	1.0%
	N_2O	0.0	0.1	0.1	10.7%	0.0%	0.8%	0.0%
	All	39.9	27.5	25.5	-36.0%	23.6%		17.4%
1A5 Other	CO_2	0.3	0.2	0.2	-28.6%	0.2%	0.2%	0.2%
	CH_4	0.0	0.0	0.0	-36.8%	0.0%	0.0%	0.0%
	N_2O	0.0	0.0	0.0	-36.0%	0.0%	0.0%	0.0%
	All	0.3	0.2	0.2	-28.7%	0.2%		0.2%

3.2.1 Comparison of the sectoral approach with the reference approach

Emissions from fuel combustion are estimated by multiplying fuel quantities combusted through specific energy processes by fuel-specific emission factors (EFs) and, in the case of non-CO_2 GHGs, source category-dependent EFs. This Sectoral Approach (SA) is based on actual fuel demand statistics. The IPCC Guidelines also require – as a quality control activity – the estimation of CO_2 emissions from fuel combustion on the basis of a national carbon balance derived from fuel supply statistics. This is the Reference Approach (RA). This section gives a detailed comparison of the SA with the RA.

Energy supply balance

Table 3.3 presents the energy supply balance of fossil fuels for the Netherlands in 1990 and 2023 at a relatively high aggregation level. The Netherlands used to produce large amounts of natural gas, both onshore (Groningen gas) and offshore. A large share of the gas produced was exported. Due to earthquakes in Groningen caused by natural gas extraction, the production has been reduced since 2014. More natural gas has been imported. Natural gas represents a major share of the national energy supply.

Table 3.3 Energy supply balance for the Netherlands (PJ NCV/year) as reported in CRT table 1.A(b)

Year	Role	Indicator name	Solid fuels	Liquid fuels	Gaseous fuels
1990	Supply	Primary production	0	170	2283
		Total imports	390	3811	85
		Stock change	2	13	0
		Total exports	-25	-2422	-1081
		Bunkers	0	-530	0
	Consumption	Gross inland consumption	-367	-1043	-1286
		whereof: Final non-energy consumption	0	-324	-95
2023	Supply	Primary production	0	17	355
		Total imports	176	5974	1210
		Stock change	-4	79	-29
		Total exports	-14	-4462	-598
		Bunkers	0	-565	0
	Consumption	Gross inland consumption	-158	-1043	-937
		whereof: Final non-energy consumption	0	-380	-67

Comparison of CO_2 emissions

The IPCC Reference Approach (RA) uses apparent consumption data (gross inland consumption) per fuel type to estimate CO_2 emissions from fossil fuel use. This approach is used as a means of verifying the sectoral total CO_2 emissions from fuel combustion (IPCC, 2006). The RA uses Eurostat energy statistics (production, imports, exports, stock changes and bunkers) to determine apparent fuel consumption, which is then combined with carbon EFs to calculate carbon content of the fuels. Non-combusted carbon used as feedstock, as a reductant, or for other non-energy purposes is then deducted.

The Eurostat energy statistics for the Netherlands are based on the national energy statistics as provided by Statistics Netherlands, but the level of aggregation is sometimes different. The fuels from the Eurostat energy statistics are allocated to the fuels in the RA, as presented in Table 3.4. National default, partly country-specific, CO_2 EFs are adopted from Zijlema (2025) (see Annex 5).

Table 3.4 Relation between fuel types in RA and in Eurostat energy statistics

Fuel types in the Reference Approach			**Fuel types in the Eurostat energy statistics**
Liquid fossil	Primary fuels	Crude oil	Crude oil
		Natural gas liquids	Natural gas liquids
	Secondary fuels	Gasoline	Additives and oxygenates (excluding biofuel portion) Gasoline-type jet fuel Motor gasoline (excluding biofuel portion) Aviation gasoline
		Jet kerosene	Kerosine-type jet fuel (excluding biofuel portion)
		Other kerosene	Other kerosene
		Gas/diesel oil	Gas oil and diesel oil (excluding biofuel portion)
		Residual fuel oil	Fuel oil
		Liquefied petroleum gases (LPG)	Liquified petroleum gases
		Naphtha	Naphtha
		Bitumen	Bitumen
		Lubricants	Lubricants
		Petroleum coke	Petroleum coke
		Other oil	Paraffin waxes Other oil products n.e.c Refinery gas White spirit and special boiling point industrial spirit
Solid fossil	Primary fuels	Anthracite	Anthracite
		Coking coal	Coking coal
		Other bituminous coal	Other bituminous coal
		Lignite	Lignite
	Secondary fuels	BKB and patent fuel	Brown coal briquettes Patent fuel
		Coke oven/gas coke	Coke oven coke Gas coke

Fuel types in the Reference Approach			Fuel types in the Eurostat energy statistics
		Coal tar	Coal tar
Gaseous fossil		Natural gas (dry)	Natural gas
Waste (non-biomass fraction)		Other	Non-renewable municipal waste Industrial waste (non-renewable)
Peat			NO [1)]
Biomass total		Solid biomass	Primary solid biofuels Charcoal
		Liquid biomass	Pure biogasoline Blended biogasoline Pure biodiesels Blended biodiesels Pure bio jet kerosene Blended bio jet kerosene Other liquid biofuels
		Gas biomass	Biogases
		Other non-fossil fuels (biogenic waste)	Renewable municipal waste

Notes:
1. NO = Not occurring; Peat is not used in the Netherlands.

Table 3.5 presents the results of the RA calculations for the 1990-2023 period, compared with the official national total emissions reported as fuel combustion (SA, source category 1A). The annual difference calculated from the direct comparison ranges between -0.8% and 8.2%.

Table 3.5 Comparison of CO_2 emissions: RA versus SA (in Tg)

	1990	1995	2000	2005	2010	2015	2020	2022	2023
Reference Approach									
Liquid fuels	49.2	52.4	52.7	54.9	53.1	47.5	42.5	45.7	46.8
Solid fuels	33.4	34.2	30.1	31.4	29.4	43.6	15.9	21.5	14.6
Gaseous fuels	67.7	76.3	77.5	78.6	87.5	62.1	68.7	51.6	49.0
Other fuels	0.6	0.9	1.5	2.2	2.5	2.8	2.7	2.9	2.7
Total RA	150.9	163.8	161.8	167.1	172.6	156.0	129.8	121.7	113.1
	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2022**	**2023**
Sectoral Approach									
Liquid fuels	45.9	50.3	52.1	51.8	46.6	41.4	36.0	37.9	38.4
Solid fuels	33.6	34.2	29.9	31.7	29.9	42.9	16.2	21.5	14.6
Gaseous fuels	69.9	77.4	77.3	79.2	88.2	63.4	67.7	52.5	49.0
Other fuels	0.6	0.8	1.6	2.1	2.5	2.9	2.8	2.7	2.6
Total SA	150.0	162.7	160.9	164.7	167.2	150.6	122.6	114.6	104.5
	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2022**	**2023**
Difference (%)									
Liquid fuels	7.2%	4.1%	1.2%	6.1%	14.0%	14.7%	17.9%	20.5%	21.8%
Solid fuels	-0.4%	-0.1%	0.7%	-1.1%	-1.8%	1.6%	-1.5%	-0.2%	0.2%
Gaseous fuels	-3.2%	-1.4%	0.2%	-0.7%	-0.7%	-2.0%	1.5%	-1.7%	0.1%
Other fuels	1.3%	5.6%	-5.7%	4.5%	0.6%	-2.7%	-2.6%	6.6%	4.6%
Total	0.6%	0.6%	0.6%	1.4%	3.2%	3.6%	5.8%	6.2%	8.2%

Differences between the RA and the SA are due to four factors:

- In response to review recommendation (E.2 2022) and in line with the IPCC 2006 Guidelines (vol. 3, chapter 1, box 1.1 and vol. 3, chapter 3.9.4.2), the emissions from combustion of chemical waste gas in the chemistry sector have been reallocated from 1A2c to 2B10. However, these emissions actually result from the combustion of fuels, and are also included in the energy statistics as fuel combustion. The chemical waste gas is produced during the production process by fuels that are included as 'transformation input' in the energy statistics. Therefore, the CO_2 emissions from chemical waste gas should be included in the comparison between the Reference Approach and Sectoral

Approach. Chemical waste gas combustion is responsible for 3.5 – 9.7 Mton CO_2, which is now included in CRT 2B.
- The energy statistics contain production data for additives. This data cannot be included in the RA tables and is therefore excluded from the RA (while combustion of these fuels is included in the SA). As a result, the CO_2 emissions from liquid fuels in the RA are slightly underestimated. Production is additives is responsible for 0.3-1.2 Mton CO_2.
- There is a 'statistical difference' in the energy statistics, responsible for approximately 0-2% of the RA total.
- In the SA, company-specific EFs are used, while country-specific EFs are used in the RA.

If the CO_2 emissions in the Reference Approach and Sectoral Approach are corrected for the production of additives and the combustion of waste gases reported in CRT category 2, then the differences between the Reference Approach and Sectoral Approach is between –5.7% and +2.5%. For the years 2000-2023, the difference is between –1.4% and +2.5%. See table 3.6.

Table 3.6 Comparison of CO_2 emissions: RA versus SA after correction for production of additives in the Reference Approach and correction for combustion of chemical waste gas in CRT category 2 in the Sectoral Approach (in Tg).

	1990	1995	2000	2005	2010	2015	2020	2022	2023
	Reference Approach, corrected for production of additives								
Total RA	150.9	163.8	161.8	167.1	172.6	156.0	129.8	121.7	113.1
Correction RA - production of additives	0.3	0.6	0.7	0.7	0.6	0.7	0.6	0.7	0.8
Corrected RA	151.2	164.3	162.5	167.7	173.1	156.7	130.4	122.4	113.9

	1990	1995	2000	2005	2010	2015	2020	2022	2023
	Sectoral Approach, corrected for combustion of chemical waste gas reported in CRT category 2								
Total SA	150.0	162.7	160.9	164.7	167.2	150.6	122.6	114.6	104.5
Correction SA - combusted waste gas reported in CRT2	5.7	3.5	3.9	5.3	7.7	6.5	7.6	6.9	6.9
Corrected SA	155.7	166.2	164.8	170.1	174.9	157.1	130.2	121.6	111.5

	1990	1995	2000	2005	2010	2015	2020	2022	2023
	Difference between corrected Reference Approach and corrected Sectoral Approach (%)								
Difference corrected RA/SA	-2.9%	-1.1%	-1.4%	-1.4%	-1.0%	-0.3%	0.1%	0.7%	2.1%

3.2.2 International bunker fuels (1D)

3.2.2.1 Category description

Figure 3.3. shows that jet kerosene consumption (used in international aviation) more than doubled between 1990 and 1999 and continued to increase slowly between 2000 and 2019 (except for the 2009-2012 period, when the economic crisis resulted in a decrease in fuel deliveries). In 2020 and 2021, the jet kerosene consumption decreased as a result of measures taken during the COVID-19 pandemic. After that, consumption increased again to 140 PJ in 2023. No deliveries of aviation gasoline for international aviation are reported in the Energy Balance. However, sales of biokerosene have been reported as of 2022.

Fuel deliveries for international navigation (residual fuel oil, gas/diesel oil, LNG and biodiesel) increased by 57% between 1990 and 2007, but then decreased by 39% to 448 PJ in 2023. In the 2008–2012 period, this decrease can mainly be attributed to the economic crisis. Fuel deliveries have, however, continued to decrease in recent years, even though the economy and transport volumes have grown. The continued decrease can be attributed partially to more fuel-efficient shipping (resulting, for instance, from lower sailing speed, as shown by Marin, 2019) and partially to the decreased share of Dutch ports in the Northwest European bunker market.
Deliveries of diesel oil for international maritime navigation almost doubled between 2014 and 2015. Ships switched to using diesel oil instead of fuel oil. This can be attributed to more stringent regulation in 2015 on sulphur oxide emissions from ships in the Emission Control Areas (ECAs) of the North Sea. Diesel oil contains less sulphur dioxide than the cheaper fuel oil.
In 2023 diesel deliveries declined from 81 PJ in 2022 to 63 PJ (-21%). The supply of LNG increased from 3.2 to 8.6 PJ. This development is due to international agreements (EU, International Maritime Organization) to emit less CO_2. Ships are becoming more energy efficient and are using more often cleaner fuels.

Deliveries of lubricants for international navigation increased from 3.8 PJ in 1990 to 7.1 PJ in 2001, followed by a decrease to 3.2 PJ in 2009 (economic crisis), before they increased again to 4.7 PJ in 2023.

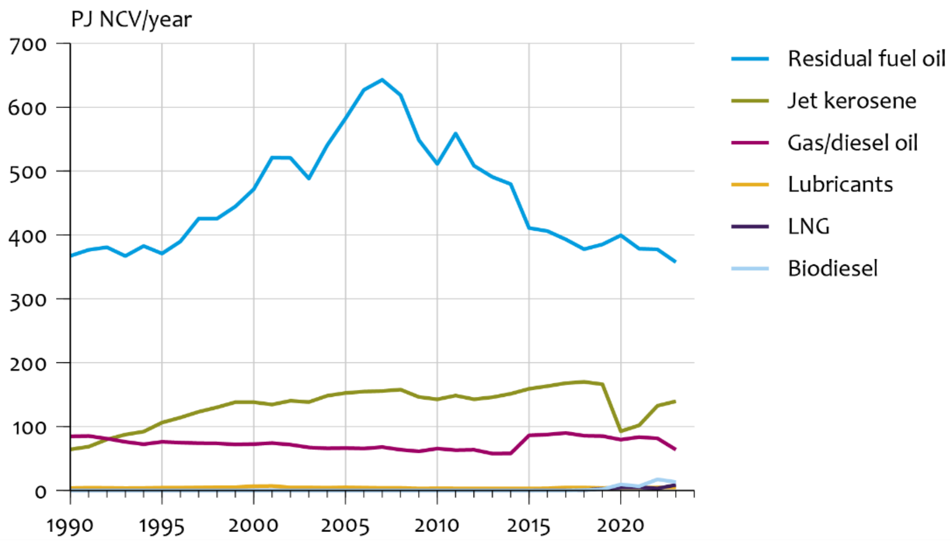


Figure 3.3 Marine and aviation bunker fuels, 1990–2023, as reported in CRT table 1.D (from Statistics Netherlands)

3.2.2.2 Methodological issues

As described in Witt et al. (2025), CO_2 emissions from bunker fuels are calculated using a Tier 1 and 2 approach. Default IPCC heating values and CO_2 EFs are used for heavy fuel oil, jet kerosene, and lubricants, whereas country-specific heating values and CO_2 EFs are used for diesel oil derived from the Netherlands' list of fuels (Zijlema, 2025). CH_4 and N_2O emissions resulting from the use of bunker fuels are calculated by means of a Tier 1 approach, using default IPCC EFs for both substances (IPCC Guidelines, Volume 2, Chapter 3, tables 3.5.3 and 3.6.5).

3.2.2.3 Uncertainty assessment and time-series consistency

Uncertainty assessment

Uncertainty estimates for the activity data and EFs used for calculating international bunker fuel emissions are presented in Table 2.5 of the tables annex to Witt et al. (2025), which also shows the sources used to estimate uncertainties.

Time-series consistency

Emissions from international bunker fuels are calculated from the energy statistics combined with default and country-specific EFs as mentioned in 3.2.2.2. Energy statistics are prepared by Statistics Netherlands, using the same methodology for the complete time series. In 2015 and 2016, the energy statistics from 1990 onwards were revised, using the same methodology for all years. These revised energy statistics have been used from the 2017 submission onwards. The activity data is consistent for the complete time series.

3.2.2.4 Category-specific QA/QC and verification

The quantity of bunker fuels sold will depend on developments in aviation and shipping with foreign destinations and on fuel prices.
The number of flights, most of them international, to and from Dutch airports increased gradually between 1990 and 2019 to 566 thousand flights in 2019. Due to international travel restrictions as a result of the corona pandemic, the number of flights has been halved in 2020. From

2021, the number of commercial flights increased again to 506 thousand flights in 2023 (Statistics Netherlands). This development corresponds to the amount of fuel sold jet kerosine.
In international navigation a comparison with the volume of goods and people transported is less clear also due to the different types of fuel and the fact that ships have become more energy efficient. In 2023, the transported cargo weight of cross-border freight transport was with 713 million tons 7% lower than in 2022, and this also applies to the amount of fuel sold (Statistics Netherlands).

3.2.2.5 Category-specific recalculations
The energy statistics have been updated for a few fuels/years:
- LNG (international navigation): The fuel sales of LNG has been updated for 2013 - 2022, resulting in a small increase in LNG consumption, the most in 2022 by 6% (0.2 PJ). Jet kerosene (international aviation): The fuel sales has been updated for 2022, because 0.7% (0.9 PJ)_of the kerosene was biokerosene, which was counted as fossil kerosene, now resulting in a decrease of fossil kerosene. Only the fossil part counts.

This updated activity data is used to calculate the emissions of CO_2, CH_4 and N_2O.

3.2.2.6 Category-specific planned improvements
There are no planned improvements.

3.2.3 Feed stocks and non-energy use of fuels
Table 3.3 shows that a large share of the gross national consumption of petroleum products was due to non-energy applications. These fuels were mainly used as feedstock in the petrochemical industry (naphtha), and the carbon is stored in many products (bitumen, lubricants, et cetera). A fraction of the gross national consumption of natural gas (mainly in ammonia production) and coal (Electronics industry, Food processing) was also used in non-energy applications, and hence this gas/coal was not directly oxidised. In many cases, these products are finally oxidised in waste incinerators or during use (e.g. lubricants in two-stroke engines). In the RA, these product flows are excluded from the calculation of CO_2 emissions.

3.2.4 Energy industries (1A1)
3.2.4.1 Category description
Table 3.7 provides an overview of the emissions in the Energy industries sector (1A1) as well as for the key categories. Figure 3.4 presents the development of total GHG emissions by sub-category of the energy industries, in the years 1990-2023.

Table 3.7 Overview of emissions in the energy industries sector (1A1) in the base year and the last two years of the inventory (in Tg CO_2 eq.). The middle column shows the change (%) of the last year of the inventory compared to the base year. On the right side of the table, the contribution of the last year inventory's emissions of the category to the sector, to the total national emissions of the specific gas and to the total national emissions (in CO_2 eq) are provided.

Sector/category	Gas	1990	2022	2023	2023 vs 1990	Contribution of the category in 2023 (%) to the		
		Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
1A1 Energy Industries	CO_2	53.1	45.0	37.1	-30.2%	34.3%	30.8%	25.3%
	CH_4	0.1	0.1	0.1	40.9%	0.1%	0.6%	0.1%
	N_2O	0.1	0.3	0.2	55.1%	0.2%	3.1%	0.1%
	All	53.4	45.3	37.4	-29.9%	34.5%		25.6%
1A1a Public Electricity and Heat Production, total	CO_2	40.0	33.2	26.2	-34.5%	24.2%	21.7%	17.9%
1A1a liquids	CO_2	0.2	0.5	0.3	29.8%	0.3%	0.3%	0.2%
1A1a solids	CO_2	25.9	16.5	10.6	-58.9%	9.8%	8.8%	7.3%
1A1a gas	CO_2	13.3	13.5	12.7	-4.5%	11.7%	10.6%	8.7%
1A1a other fuels	CO2	0.6	2.7	2.5	323.6%	2.4%	2.1%	1.7%
1A1b. Petroleum refining, total	CO_2	11.0	9.4	9.3	-15.6%	8.6%	7.7%	6.3%
1A1b liquids	CO_2	10.0	8.3	7.9	-20.6%	7.3%	6.6%	5.4%
1a1b gases	CO_2	1.0	1.2	1.4	31.9%	1.3%	1.1%	0.9%
1A1c Manufacture of Solid Fuels and Other Energy Industries, total	CO_2	2.1	2.4	1.6	-23.7%	1.5%	1.3%	1.1%
1A1c solids & liquid	CO_2	0.9	1.3	0.7	-28.3%	0.6%	0.6%	0.5%
liquids	CO_2	0.0	NO	NO		0.0%	0.0%	0.0%
solids	CO_2	0.9	1.3	0.7	-27.5%	0.6%	0.6%	0.5%
1A1c gases	CO_2	1.2	1.1	0.9	-20.2%	0.9%	0.8%	0.6%

In line with the IPCC Guidelines (see volume 1, Table 4.1 in IPCC, 2006), aggregated emissions by fuel type and category are used for the categorisation of key categories in 1A1 (the same approach is used for 1A2, 1A3 and 1A4). On that basis, category 1A1 comprises the following key categories:

1A1 Energy Industries: all fuels N_2O
1A1a Public Electricity and Heat Production: solids CO_2
1A1a Public Electricity and Heat Production: gaseous CO_2
1A1a Public Electricity and Heat Production: other fuels: waste incineration CO_2
1A1b Petroleum Refining: liquids CO_2
1A1b Petroleum Refining: gaseous CO_2
1A1c Manufacture of Solid Fuels: solids CO_2
1A1c Manufacture of Solid Fuels: gaseous CO_2

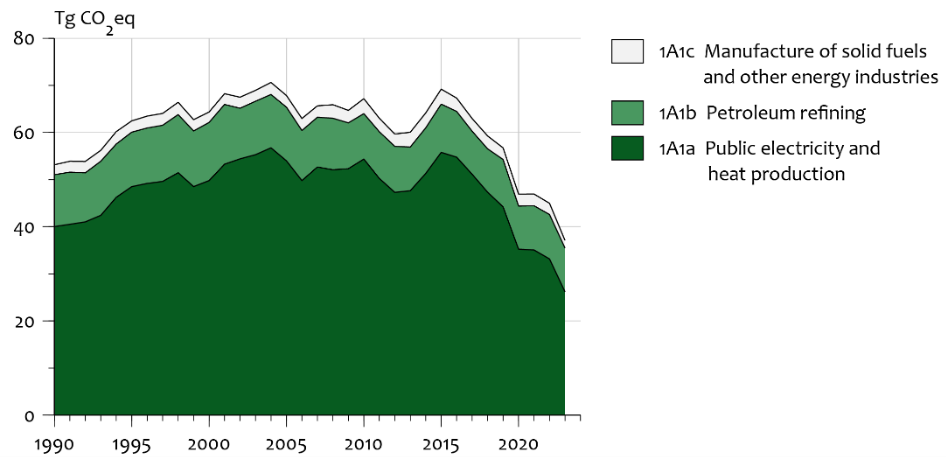


Figure 3.4 1A1 Energy industries – trend in total GHG emission by sub-category, 1990–2023

Public electricity and heat production (1A1a)

The Dutch electricity sector mainly consist of gas and coal-fired power stations and gas-fired cogeneration plants (combined heat and power, CHP). Many of the gas-fired cogeneration plants are operated as joint ventures with industries. The increasing trend in electric power production until 2005 corresponds to a substantial increase in CO_2 emissions from fossil fuel combustion by power plants (see Figure 3.4). The decreasing trend of CO_2 from 2016 onwards is the result of a decline in coal combustion caused by the closure of coal-fired power plants (2016-2020), and an increase in renewable energy (with the main increase from 2020 onwards).

Renewable energy was in 1990 only responsible for a small share of the electricity production in the Netherlands, but this increased to 47% of the total electricity production in 2023 (as reported by Statistics Netherlands in: https://opendata.cbs.nl/#/CBS/en/dataset/80030eng/table?dl=76A65). The main renewable energy sources for electricity production are wind, biomass and solar.
The public electricity and heat production source sub-category also includes all emissions from large-scale waste incineration facilities. Since all these incineration facilities produce heat and/or electricity, the emissions from waste incineration are allocated in 1A1a and the waste incinerated in these installations is allocated under other fuels (fossil part of waste) and biomass (biogenic part of waste).
In addition, a large proportion of blast furnace gas and a significant part of coke oven gas produced by the single iron and steel plant in the Netherlands is combusted in the public electricity sector (see Figure 3.5; BF/OX/CO/FO refers to blast furnace gas, oxygen furnace gas, coke oven gas, and phosphor oven gas).

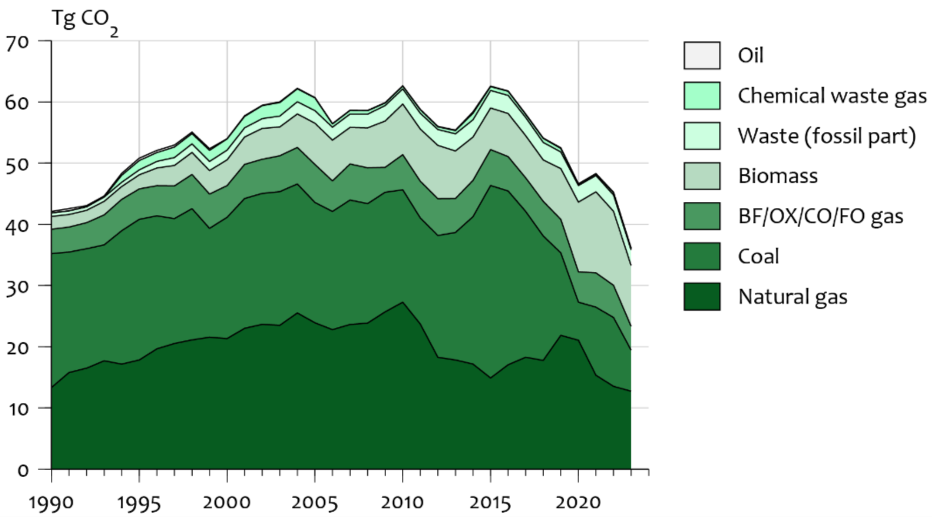


Figure 3.5 Trend in CO_2 emissions from fossil and biogenic fuel use in power plants, 1990–2023

Waste oils (waste oil, waste lubricant, waste solvent, etcetera) are collected by certified waste management companies. Until 2002, waste oils were used in the preparation of bunker fuels. Since then, this use has been prohibited for environmental reasons, and waste oils are now either exported to Germany or recycled. The recycling part of waste oils (feedstock for chemical plants, clean-up and or distillation) results in small fractions of non-useable wastes. In the past, these were incinerated in a special combustion facility in the Netherlands (at that time, they were reported under 1.A.1.a, as plant-recovered waste heat). Since the closure of this plant, which reported its emissions and activity data directly to the inventory, the residues have been exported for ecological processing, and the resulting foreign emissions are no longer included in the Dutch inventory.

Most of the biogas combustion recovered at landfill sites occurs in combined heat and power (CHP) plants operated by utilities; therefore, these emissions are also allocated to 1A1a.

CO_2 emissions from the waste incineration of fossil carbon increased from 1990 until 2017. Since then, these emissions have declined. From 1990 onwards, an increasing amount of waste has been combusted rather than deposited in landfills, the result of environmental policy aimed at reducing waste disposal in landfills as well as at the import of waste (see Chapter 7). The increase in the CO_2 EF for other fuels between 2004 and 2010 was due to the increase in the share of plastics (with a high carbon content) in combustible waste.
The decrease in the implied emission factor (IEF) for CO_2 from biomass in the 1990-2000 period is due to the increase in the share of pure biomass co-combusted with coal-firing, which has a lower EF than the organic carbon in waste combustion with energy recovery.

Between 1990 and 1998, a change in the ownership structures of plants (joint ventures) caused a shift of cogeneration plants from category 1A2

(Manufacturing industries and construction) to 1A1a (Public electricity and heat production). This shift largely explains the increase in natural gas combustion in 1A1a between 1990 and 1998. A similar shift occurred for a few large chemical waste gas-fired steam boilers. The corresponding CO_2 emissions allocated to the Energy sector increased from virtually zero in 1990 to 8.5 Tg in 1998 and to 9.1 Tg in 2005. The strong increase in liquid fuel use in 1994 and 1995 was due to the use of chemical waste gas (which is included in liquid fuels) in joint venture electricity and heat production facilities. This also explains the somewhat lower IEF for CO_2 from liquids since 1995, because the EF for chemical waste gas is lower than the EF for other liquid fuels.

Figure 3.5 shows a fluctuation in CO_2 emissions in 1A1a due to market circumstances. Other influencing factors have been:

- an increase in natural gas combustion due to a change in ownership structures of plants which resulted in a shift of natural gas combustion from 1A2 to 1A1a in 1990–1998;
- new, large coal-fired power plants commencing operations in 2015 and 2016 resulted in a shift from natural gas to coal;
- closure of old coal-fired power plants in 2015–2019 has resulted in a decrease in coal consumption from 2017 onwards;
- high natural gas prices in 2022 resulted in a decrease in natural gas consumption and an increase in coal consumption;
- In some years, the import of electricity was higher (e.g. 1999–2008, 2012–2014) than in others.

Petroleum refining (1A1b)
There are five large refineries in the Netherlands; they export a large part of their products to the European market. Consequently, the Dutch petrochemical industry is relatively large.
1A1b is the second largest emission source sub-category in category 1A1. The combustion emissions from this sub-category should be viewed in relation to the fugitive emissions reported under category 1B2. From 1990 to 2023, total CO_2 emissions from the refineries (as reported in 1A1b and 1B2a-iv) fluctuated yearly between 10 and 13 Tg CO_2.

Since 1998, one refinery has operated a Shell Gasification and Hydrogen Production (SGHP) unit, supplying all the hydrogen for a large-scale hydrocracker. The chemical processes involved in the production of hydrogen also generate CO_2 (CO_2 removal and a two-stage CO shift reaction). Refinery data specifying these fugitive CO_2 emissions is available and has been used since 2002. It is reported in the category 1B2. Combustion emissions reported in this category are calculated by subtracting the carbon for this non-combustion process from the total fuel use in this category.

The use of plant-specific EFs for refinery gas from 2002 onwards has also caused a change in the IEF for CO_2 emissions from total liquid fuel compared to the years prior to 2002. The EF for refinery gas is adjusted to ensure exact correspondence between the total CO_2 emissions calculated and the total CO_2 emissions officially reported by the refineries.
The interannual variation in the IEFs for CO_2, CH_4 and N_2O emissions from liquid fuels is explained by the high and variable proportion

(between 40% and 90%) of refinery gas in total liquid fuel. Refinery gas has a low default EF compared to most other oil products and has shown variable EFs for the years from 2002 onwards.

Manufacture of solid fuels and other energy industries (1A1c)
Source sub-category 1A1c comprises:

- 1A1ci: Fuel combustion (of solid fuels) for on-site coke production by the iron and steel plant Tata Steel and fuel combustion from an independent coke production facility (Sluiskil, which ceased operations in 1999).
- 1A1cii: Combustion of 'own' fuel (natural gas) by the oil and gas production industry for heating purposes: the difference between the amounts of fuel produced and sold, minus the amounts of associated gas that are flared, vented, or lost by leakage.

Fuel combustion emissions from coke production (1A1ci) by the iron and steel plant are based on a mass balance. See section 3.2.5.1 for more information on emissions from the iron and steel sector, including emissions from coke production.

CO_2 emissions from 1A1cii increased from 2008 till 2013. The increase is mainly due to the operation of less productive sites for oil and gas production compared to those operated in the past. This explains the steady increase over time in this category with respect to gas consumption. Between 2013 and 2023, the production of natural gas declined by 86%, which also resulted in a decrease in the amount of natural gas combusted in this sector. The interannual variability in the EFs for CO_2 and CH_4 emissions from gas combustion (non-standard natural gas) is mainly due to differences in gas composition and the variable losses in the compressor stations of the gas transmission network, reported in the Annual Environmental Reports (AERs) of the gas transport company.
Liquid fuels are generally not used in 1A1c; only a small amount of liquid fuels was used until 2013. From 2014 onwards, no liquid fuel use has been registered in the energy statistics for this sub-sector.

3.2.4.2 Methodological issues

This section provides a description of the methodology to calculate emissions from stationary combustion in the energy industries. This section is split into two parts: First, a description of the stationary combustion of all sectors except waste incineration, followed by a description on the methodology for waste incineration.
Details of methodologies, data sources, and country-specific source allocation issues are provided in section 2.1 (stationary combustion excluding waste incineration) and section 2.3.2.1 (waste incineration) of the ENINA methodology report (Honig et al., 2025).

Methodology for all sectors except waste incineration
The emissions from this source category are calculated in two steps: First, emissions are calculated by multiplying fuel consumption by country-specific EFs. Second, reported emissions of a select number of companies are used to refine the emissions calculation. The following section provides a description of these two steps as well as a

comparison of the country-specific EFs and the IEFs (including an explanation of the differences).

Emissions calculation step 1
The first step of the emissions calculation consists of a multiplication of fuel consumption by country-specific EFs.
Activity data is derived from the aggregated statistical data from national energy statistics published annually by Statistics Netherlands (see https://opendata.cbs.nl/statline/#/CBS/en/dataset/83140ENG/table?dl=B37C3). The aggregated statistical data is based on confidential data from individual companies.
Emission factors are either IPCC default or country-specific EFs (Tier 1 and Tier 2 method for CO_2, Tier 2 method for CH_4, and Tier 1 method for N_2O). For CO_2, IPCC default EFs are used (see Annex 5) with the exception of CO_2 from natural gas, coal, cokes, waste, waste gases, gas/diesel oil, gasoline, LPG, liquid biomass, and gaseous biomass, for which country-specific EFs are used. When necessary, emissions data from individual companies is also used; for example, when companies report a different EF for derived gases (see the following section, Emissions calculation step 2). The CH_4 EFs are adopted from Scheffer (1997), except for the use of natural gas in gas engines and for waste. See section 2.1 of the ENINA methodology report (Honig et al., 2025) for more details on the CH_4 EF for gas engines. For N_2O, IPCC default EFs are used, except for waste and for solid fuels from the combined iron and steel plant.
A complete overview of the EFs is presented in section 2.1.3.3 of the ENINA methodology report (Honig et al., 2025).

Emissions calculation step 2
In the second step, the reported emissions of selected companies are used to refine the emissions calculation. Emissions data from individual companies (as reported in the AER and/or ETS reports) is used if companies report a different CO_2 EF for derived gases or other bituminous coal. The reported emissions data is validated by the competent authority. If this data is not accepted by the competent authority, the CO_2 emissions data is not used for the emissions inventory; country-specific EFs are used instead. This has occurred only occasionally, and the emissions are recalculated when the validated data from these companies becomes available.
For each relevant company, data from the AERs and the ETS is compared (QC check) and the data that provides greater detail for the relevant fuels and installations is used. The reported CO_2 emissions of a company are combined with energy use as recorded in energy statistics for that specific company, to derive a company-specific EF. For each selected company, a different company-specific EF is derived and used to calculate the emissions.
The following company-specific EFs have been calculated:

- Natural gas: Since 2003, company-specific EFs have been derived for the combustion of ‘raw’ natural gas (i.e. unprocessed natural gas). For the years prior to 2003, EFs from the Netherlands’ list of fuels (Zijlema, 2025) are used.
- Refinery gas: Since 2002, company-specific EFs have been derived for all companies and are used in the emissions inventory. For the years prior to 2002, EFs from the Netherlands’ list of fuels (Zijlema, 2025) are used.

- Chemical waste gas: Since 1995, company-specific EFs have been derived for a selection of companies (largest companies). For the remaining companies, the default EF is used. If data from any of the selected companies was missing, a company-specific EF for the missing company was used (derived in 1995). For the 1990–1994 period, a country-specific EF based on an average EF for four (large) companies has been used.
- Coke oven gas: Since 2007, company-specific EFs have been derived for most companies. As coke oven gas is produced only at the single iron and steel company in the Netherlands, it is assumed that all coke oven gas has the same content, and the derived EF is used for all companies that use coke oven gas. For years prior to 2007, EFs from the Netherlands' list of fuels (Zijlema, 2025) are used.
- Phosphorus gas: Since 2006, company-specific EFs have been derived for the single company and are used in the emissions inventory. For years prior to 2006, EFs from the Netherlands' list of fuels (Zijlema, 2025) are used. This fuel was only used until 2012, when the single company using this fuel has ceased operation.
- Coal: Since 2006, company-specific EFs have been derived for most companies (for the power plants that report a reliable company-specific EF), and the default EFs are used for the remaining companies. For years prior to 2006, EFs from the Netherlands list of fuels (Zijlema, 2025) are used.
- Coke oven/gas coke (cokes): Since 2006, a company-specific EF has been derived for one company. For the other companies, a country-specific EF is used. For the years prior to 2006, a country-specific EF is used for all companies.

Methodology for waste incineration
Detailed information on activity data and EFs (waste incineration in WIPs) can be found in section 2.3.2.1 in Honig et al. (2025).

The activity data for the amount of waste incinerated derives mainly from the annual survey performed by the Working Group on Waste Registration (WAR) at all 14 waste incinerators in the Netherlands. Data can be found in a background document (Rijkswaterstaat, 2024). The waste incineration plants process a small portion of hazardous waste (100-150 kiloton). Examples are certain organic liquids from the chemical industry, cleaning cloths contaminated with oil and/or solvents and oil filters. Other hazardous waste is incinerated abroad (mainly in north-western Europe) in rotary kilns. Hospital waste is almost always incinerated in a special facility, see Appendix C-5 of the aforementioned report. This installation processes approximately 10 kiloton of hospital waste.
Fossil-based and biogenic CO_2, CH_4 and N_2O emissions from waste incineration are country-specific (Tier 2) and are calculated from the total amount of waste incinerated by waste stream. For some waste streams, the composition is updated annually, on the basis of analyses of household residual waste. Table 3.8 presents the total amounts of waste incinerated in terms of mass, energy, the fraction of biomass in energy, and the corresponding amounts of fossil and biogenic carbon in the total waste incinerated. The variations in annual emissions arise from the variations in the composition of the various waste streams. The

decrease in the amount of incinerated waste in 2023 is due to the fact that one waste incinerator was shut down for a longer period of time as a result of an incident.

Table 3.8 Composition of incinerated waste

	1990	2000	2005	2010	2015	2020	2022	2023
Total waste incinerated (Gg)	2,780	4,896	5,503	6,459	7,564	7,572	7,392	6,841
Total waste incinerated (TJ)	22,746	51,904	55,058	63,818	75,299	71,742	69,762	65,665
Energy content (MJ/kg)	8.2	10.6	10.0	9.9	10.0	9.5	9.4	9.6
Fraction biomass (energy %)	58.2	50.4	47.8	53.1	54.2	53.5	53.7	53.1
Amount of fossil carbon (Gg)	164	433	561	675	780	739	727	695
Amount of biogenic carbon (Gg)	544	938	909	1,172	1,381	1,343	1,316	1,220

Fossil-based CO_2 is calculated on the basis of the fossil-based carbon content of the incinerated waste. The fossil-based carbon content is calculated on the basis of the carbon content of the various components in the various waste streams. As stated above, for some waste streams the composition is updated annually.

The capture of carbon in a product is taken into account in the CO_2 emissions of WIPs. In earlier years, the amount of carbon capture was insignificant and in 2023, this amount is still low; less than 1 kton of CO_2 (fossil and biogenic) was captured and used in the production of bicarbonate.

Several Dutch WIPs capture CO_2. There is no clear guidance from IPCC on how to account for usage of captured CO_2 from this specific category in the inventory. The Netherlands deals with this in two lines of potential application of the carbon captured:

- *use as growth medium in agriculture*. As most of the CO_2 will ultimately be emitted to the atmosphere, this amount is not subtracted from the produced CO_2;
- *use as raw material in the production of bicarbonate*. The captured amount is subtracted from the produced CO_2.

The data on the amount and type of usage comes from the annual survey of WIPs (Rijkswaterstaat, 2024). Detailed information can be found in Honig et al. (2024).

On the basis of measurement data (Spoelstra, 1993), an EF of 20 g/ton waste is applied to N_2O from incineration with selective catalytic reduction (SCR). For incineration with selective non-catalytic reduction (SNCR), an EF of 100 g/ton is applied. The percentage of SCR has increased significantly since 1990.
A survey of EFs for CH_4 used in other countries and an analysis of emissions from waste incinerators in the Netherlands made it clear that

the CH_4 concentration in the flue gases from waste incinerators is below the background CH_4 concentration in ambient air. Therefore, the Netherlands uses an EF of 0 g/GJ and reports no methane. That an EF of 0 g/GJ is possible is stated in the 2006 IPCC Guidelines (Vol. 5, sections 5.2.2.3 and 5.4.2. Emissions are reported in the CRT file with the code ‘NO’ (as the CRT cannot handle zero values)).

A more detailed description of the method and the EFs used can be found in Honig et al. (2024). A comparison between the country-specific EFs and the IPCC defaults can also be found in this report. Table 3.9 presents the emissions from the waste incineration plants. The emissions trend is directly related to the trend for the amount of waste processed.

Table 3.9 Emissions due to incinerated waste

(in Gg)	1990	2000	2005	2010	2015	2020	2022	2023
Total CO_2 emission	2,596	5,025	5,392	6,770	7,924	7,634	7,494	7,022
CO_2 captured and stored in a product	-	-	-	-	-	1	-	-
Fossil CO_2 emissions	601	1,586	2,058	2,473	2,861	2,709	2,667	2,548
Biogenic CO_2 emissions	1,995	3,439	3,334	4,296	5,063	4,925	4,827	4,474
N_2O emissions	0	0.1	0.1	0.1	0.2	0.4	0.4	0.4
Total fossil GHG emissions (Gg CO_2-eq)	620	1,647	2,129	2,562	2,975	2,821	2,776	2,649

Comparison of emission factors

For 2023, approximately 98% of fossil CO_2 emissions were calculated using either country-specific or company-specific EFs. The remaining 2% of CO_2 emissions (from petroleum cokes, other oil, lignite and bitumen) were calculated using default IPCC EFs.

Table 3.10 provides an overview of the implied emission factors (IEFs) used for the most important fuels (up to 95% of fuel use) in the category Energy industries (1A1). Since part of the emissions data in this sector originates from individual companies, some of the values (in Table 3.10) deviate from the standard emission factors. For reasons of confidentiality, detailed data on fuel consumption and EFs per CRT category and fuel is not presented in the NIR, but it is available to reviewers on request.

Table 3.10 Overview of IEFs used for the most important fuels (up to 95% of fuel use) for the year 2023 in the category Energy industries (1A1)

Fuel	Amount of fuel used in 2023 (TJ NCV)	IEFs (g/GJ)		
		CO_2 (x1000)	N_2O	CH_4
Natural gas	264,796	56.8	0.26	7.45
Other Bituminous Coal	142,208	93.4	0.84	0.44
Waste gas	102,569	66.5	0.10	3.60
Solid biomass	47,758	109.6	4.00	30.00
Waste, biomass	34,900	128.2	6.34	0.00
Waste, fossil	30,766	82.8	5.17	0.00
Blast furnace gas	16,199	239.9	0.10	0.35

Explanation of the implied EFs

Natural gas

The CO_2, CH_4 and N_2O EFs for natural gas deviate from the standard EFs (56.3 kg CO_2/GJ, 5.7 g CH_4/GJ and 0.1 g N_2O/GJ) because this category includes emissions from the combustion of crude natural gas.

Other bituminous coal

CO_2 emissions from coal are based on emissions data from the ETS, and the IEF is different from the country-specific EF. The N_2O emissions are calculated on the basis of default IPCC emission factors (for 1A1a) and a company-specific emission factor for the combined iron/steel plant (for 1A1c). The IEF for N_2O in Table 3.9 is a weighted average.

Waste gas (refinery gas)

CO_2 emissions from refinery gas occur in refineries and in the Energy sector. The CO_2 emissions are partly based on emissions data from the ETS, and therefore the IEF is different from the country-specific EF.

Waste

The EF for N_2O emissions from waste incineration (both the fossil and biomass fraction) is either with selective non-catalytic reduction (SNCR) or with selective catalytic reduction (SCR) (100 g/ton and 20 g/ton, respectively). The EF thus depends on how the incinerator is operated. The EF for CH_4 from waste incineration is 0 g/GJ, the result of a study on emissions from waste incineration (section 2.3.2.1.2 of Honig et al. (2025); DHV, (2010); and NL Agency, (2010)). This is in accordance with the 2006 IPCC Guidelines V5, sections 5.2.2.3 and 5.4.2. The emissions are therefore reported in the CRT file with the notation key NO as the CRT cannot handle zero values. The EF for CO_2 is dependent on the carbon content of the waste, which is determined annually (section 7.4 and Honig et al., 2025).

Blast furnace gas

CO_2 emissions from blast furnace gas are based on emissions data from the ETS, and the IEF is different from the country-specific EF.

Trends in the IEF
Trends in the IEF for most sectors can be explained by the composition of fuels used in that sector. The largest fluctuations can be explained as follows:

- 1A1a solid CO_2: The CO_2 IEF for solid fuels in 1A1a ranges between 103.1 and 131.3 kg/GJ. The main fuels used are other bituminous coal (with an EF of 92.7 kg/GJ) and blast furnace gas (with a default EF of 247.4 kg/GJ). A larger share of blast furnace gas results in a higher IEF. The steep increase in IEF between 2019 and 2020 is caused by the reduction (by more than 50%) in consumption of other bituminous coal, while the consumption of blast furnace gas only changed slightly.
- 1A1c gaseous CO_2: The CO_2 IEF for gaseous fuels in 1A1c ranges between 42.6 and 70.4 kg/GJ. The main fuels used in the production of oil and natural gas are crude 'wet' natural gas (directly extracted from the wells) and regular natural gas. The EF for wet natural gas is variable and tends to be slightly higher than the EF for regular natural gas. The variation in the EF for wet natural gas causes the variation in the IEF for gaseous fuels in 1A1c.
- 1A1c solid CO_2: The CO_2 IEF for solid fuels in 1A1a ranges between 51.4 and 115.3 kg/GJ. Emissions are based on a mass balance of Tata Steel. The fuels in the mass balance are other bituminous coal (with an EF of 92.7 kg/GJ), coke oven / gas coke (with a default EF of 106.8 kg/GJ), blast furnace gas (with a default EF of 247.4 kg/GJ) and coke oven gas (with a default EF of 42.8 kg/GJ).

3.2.4.3 Uncertainty assessment and time-series consistency

Uncertainty assessment
The uncertainty in CO_2 emissions from this category is estimated at 6% (see section 1.7/Annex 2 for details). The accuracy of data on fuel consumption in power generation and oil refineries is generally considered to be high, with an estimated uncertainty of approximately 1-5%. The high accuracy in most of this activity data is due to the limited number of utilities and refineries, their large fuel consumption, and the fact that the data recorded in national energy statistics is verified as part of the European ETS.

The consumption of gaseous fuels in the 1A1c sub-category is mainly in the oil and gas production industry, where the split into 'own use' and 'venting/flaring' has proven difficult to establish, resulting in a high uncertainty of 15%. For other fuels, a 3% uncertainty is used, which relates to the amount of fossil waste incinerated and, therefore, to the uncertainties in the total amount of waste and the fossil and biomass fractions.

For natural gas, the uncertainty in the CO_2 EF is estimated at 0.25% on the basis of the fuel quality analysis reported by Heslinga and Van Harmelen (2006) and in the methodology reports. This value is used in the uncertainty assessment in Annex 2 and the key category assessment in Annex 1.

For hard coal (bituminous coal), an analysis was made of coal used in power generation (Van Harmelen and Koch, 2002), which is accurate to within approximately 0.5% for the year 2000 (based on 1,270 samples taken in 2000). In 1990 and 1998, however, the EF varied by ±0.9 kg CO_2/GJ (see Table 4.1 in Van Harmelen and Koch, 2002); consequently, if the default EF is applied to other years, the uncertainty is greater: approximately 1%.
Analysis of the default CO_2 EFs for coke oven gas and blast furnace gas reveals uncertainties of approximately 10% and 15%, respectively (data reported by the steel plant). Since the share of BF/OX gas in total solid fuel emissions from power generation is approximately 15–20%, the overall uncertainty in the CO_2 EF for solids in power generation is estimated to be approximately 3%. The CO_2 EFs for chemical waste gas are more uncertain than those for other fuels used by utilities. So, for liquid fuels in these sectors, a higher uncertainty of 20–25% is assumed in view of the variable composition of the derived gases used in both sectors.

For natural gas in oil and gas production (1A1c), an uncertainty of 5% is assumed, which relates to the variable composition of offshore gas. For the CO_2 EFs for other fuels (fossil waste), an uncertainty of 7% is assumed, reflecting the limited accuracy in the waste composition and, therefore, the carbon fraction per waste stream.

The uncertainty in the EFs for emissions of CH_4 and N_2O from stationary combustion is estimated at 31% and 38%, respectively, an aggregate of the various sub-categories.

For waste incineration, the uncertainty in the fossil CO_2 and N_2O emissions for 2023 is estimated at 7% and 99% respectively. The main factors influencing the uncertainties are the total amount being incinerated and the fractions of various waste components used for calculating the amounts of fossil and biogenic carbon in the waste (from their fossil and biogenic carbon fraction), and the corresponding amounts of fossil and biogenic carbon in the total waste incinerated. The uncertainty for CO_2 in the amounts of incinerated fossil waste and the uncertainty in the corresponding EF are estimated at 4% and 6%, respectively. The uncertainty for N_2O in the amounts of incinerated fossil waste and the uncertainty in the corresponding EF are estimated at 0.3% and 99%, respectively. For a more detailed analysis of these uncertainties, see Rijkswaterstaat (2014).

Time-series consistency
Emissions from stationary energy combustion are calculated from the energy statistics combined with country-specific EFs (at the beginning of the time series), or a combination of company-specific and country-specific EFs (at the end of the time series).

Time series consistency is ensured for EFs and activity data for most sectors as follows:

- The country-specific EFs are based on company-specific data. Multi-year company-specific data from the most relevant companies has been used to calculate an average country-specific EF. As the same information is used to calculate both the

country-specific EFs and the company-specific EFs, the EFs are consistent for the complete time series.
- Energy statistics are prepared by Statistics Netherlands using the same methodology for the complete time series. In 2015 and 2016, the energy statistics from 1990 onwards were revised using the same methodology for all years. These revised energy statistics have been used from the 2017 submission onwards. The activity data is consistent for the complete time series.

Time-series consistency in other sectors
For 1A1cii, the emissions data for 1990–2001 is obtained from the annual reports by the oil and gas extraction companies as drawn up by Fugro-Ecodata; data from 2002 onwards has been reported by individual companies in their AERs. Both datasets are based on data from individual companies and are therefore consistent for the complete time series.

3.2.4.4 Category-specific QA/QC and verification

The trends in fuel combustion in public electricity and heat production (1A1a) are compared to trends in domestic electricity consumption (production plus net imports). Large annual changes were identified and explained (e.g. changes in fuel consumption by joint ventures). For oil refineries (1A1b), a carbon balance calculation was made to check completeness. The trend in total CO_2 reported as fuel combustion by refineries was also compared to trends in activity indicators, such as total crude throughput. The IEF trend tables were then checked for changes, and interannual variations were explained in this NIR. Changes in the IEF were mainly due to changes in the type of fuel used. Furthermore, the IEFs of individual fuels were also compared to the default emission factors, and deviations from the standard EFs are explained in the NIR.
CO_2 emissions reported by companies (both in their AERs and within the ETS) were validated by the competent authority and compared.
More details on the validation of energy data can be found in section 2.1 of the ENINA methodology report (Honig et al., 2025).

3.2.4.5 Category-specific recalculations

The energy statistics have improved for 2015-2022, the main improvements being seen in the update of solid biomass, and an improvement in the processing of data for stored liquid natural gas. Also a small shift between fossil natural gas and biogenic natural gas has been implemented, resulting in a reduction of natural gas and an increase in biogenic natural gas compared to the previous submission. Additionally, energy statistics of lignite have been reallocated from a remaining industry category (1A2gviii) to specific sectors in 1A1a and 1A2b from 2015 onwards.

Other large recalculations include an update of waste gas emissions in 1A1b in 2021 and an update of emissions from the combined coke and iron and steel plant in 1A1c in 2015-2022.

These resulted in the following changes in emissions (in Gg for fossil and biogenic emissions together):

1A1a	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
CO_2 (incl biomass)	+16.2	+15.1	+14.5	+14.7	+7.0	+16.1	+9.2	+106.8
CH_4	+0.001	+0.001	+0.001	+0.001	+0.000	+0.001	+0.000	+0.025
N_2O	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.000	+0.004

Main recalculations in 1A1a include an update of solid biomass statistics (+91.2 Gg CO_2 in 2022), a shift between fossil and biogenic natural gas (0.004 Gg CO_2 in 2015, 0.01 Gg CO_2 in 2020 and 8.7 Gg CO_2 in 2022, this is not visible in the above table) and the reallocation of lignite emissions from 1A2gviii to a.o. 1A1a (+16.7 Gg CO_2 in 2015, +16.2 Gg CO_2 in 2020 and +25.6 Gg CO_2 in 2022). Also emissions from CH_4 and N_2O have been recalculated with the updated energy statistics.

1A1b	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
CO_2 (incl biomass)	-0.366	-0.176	-0.159	-0.557	+38.1	+13.4	-75.5	+0.069
CH_4	-0.000	-0.000	-0.001	+0.001	+0.000	+0.001	+0.000	+0.000
N_2O	-0.000	-0.000	-0.000	+0.000	+0.000	+0.000	+0.000	+0.000

Main recalculations in 1A1b include a correction of CO_2 from chemical waste gas in 1 plant in 2021 (-75.2 Gg CO_2 in 2021), and corrections in the energy statistics for several fuels. Also emissions from CH_4 and N_2O have been recalculated with the updated energy statistics.

1A1c	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
CO_2 (incl biomass)	+4.731	+0.010	-0.318	-26.89	-0.719	-0.865	-0.926	+8.155
CH_4	+0.000	+0.000	-0.000	-0.000	+0.000	+0.000	-0.000	+0.011
N_2O	+0.000	+0.000	-0.000	-0.000	+0.000	+0.000	-0.000	+0.000

Main recalculation in 1A1c include a correction of emissions from the combined iron and steel & cokes plant in the Netherlands. Also emissions from CH_4 and N_2O have been recalculated with the updated energy statistics.

3.2.4.6 Category-specific planned improvements
There are no planned improvements.

3.2.5 Manufacturing industries and construction (1A2)
3.2.5.1 Category description
Table 3.11 provides an overview of sub-source categories and emissions in the Manufacturing industries and construction sector (1A2).

Key categories

1A2	Manufacturing Industries and Construction: liquids	CO2
1A2	Manufacturing Industries and Construction: solids	CO2
1A2	Manufacturing Industries and Construction: gaseous	CO2

Table 3.11 Overview of emissions in the Manufacturing industries and construction sector (1A2) in the base year and the last two years of the inventory (in Tg CO2 eq.). The middle column shows the change (%) of the last year of the inventory compared to the base year. On the right side of the table, the contribution of the last year inventory's emissions of the category to the sector, to the total national emissions of the specific gas and to the total national emissions (in CO2 eq) are provided.

Sector/category	**Gas**	**1990**	**2022**	**2023**	**2023 vs 1990**	**Contribution of the category in 2023 (%) to the**		
		Emissions in Tg CO_2 eq			**%**	**sector**	**total gas**	**total CO_2 eq**
1A2 Manufacturing industries and construction	CO_2	29.7	18.2	17.0	-42.7%	15.7%	14.1%	11.6%
	CH_4	0.1	0.1	0.1	-6.6%	0.1%	0.3%	0.0%
	N_2O	0.0	0.0	0.0	20.4%	0.0%	0.6%	0.0%
	All	29.8	18.3	17.1	-42.6%	15.8%		11.7%
1A2 liquids	*CO_2*	4.0	1.8	1.8	-55.3%	1.6%	1.5%	1.2%
1A2 solids	*CO_2*	6.6	3.7	3.3	-50.7%	3.0%	2.7%	2.2%
1A2 gases	*CO_2*	19.0	12.7	11.9	-37.3%	11.0%	9.9%	8.1%
1A2a. Iron and steel	CO_2	5.6	4.1	3.6	-35.6%	3.3%	3.0%	2.5%
1A2b. Non-Ferrous Metals	CO_2	0.2	0.1	0.1	-52.6%	0.1%	0.1%	0.1%
1A2c. Chemicals	CO_2	11.6	6.0	5.8	-49.9%	5.4%	4.8%	4.0%
1A2d. Pulp, Paper and Print	CO_2	1.7	0.9	0.6	-61.3%	0.6%	0.5%	0.4%
1A2e. Food Processing, Beverages and Tobacco	CO_2	4.0	3.3	3.2	-20.9%	2.9%	2.6%	2.2%
1A2f. Non metalic minerals	CO_2	2.3	1.2	1.0	-56.2%	0.9%	0.8%	0.7%
1A2g. Other	CO_2	4.3	2.7	2.7	-38.3%	2.4%	2.2%	1.8%

Natural gas is mostly used in the chemical, food and drinks, and related industries (1A2c and 1A2e); solid fuels (i.e. coal and coke-derived fuels, such as blast furnace/oxygen furnace gas) are mostly used in the iron and steel industry (1A2a); and liquid fuels are mostly used in the chemicals industry (1A2c) and in other industries (1A2g) (see Table 3.11).
Within category 1A2 (Manufacturing industries and construction), sub-category 1A2c (Chemicals) is the largest fuel user (see Table 3.11). Other large fuel-using industries are included in 1A2a (Iron and steel), 1A2e (Food processing, beverages and tobacco), and 1A2g (Other).
In response to review recommendation (E.2, 2022) and in line with the IPCC 2006 Guidelines (vol. 3, chapter 1, box 1.1 and vol. 3, chapter 3.9.4.2), the combustion emissions of waste gases have been reallocated to CRT2 (in cases where the waste gases are combusted at the plant where they are produced) in the 2024 NIR. Therefore, part of the combustion emissions has been reallocated from 1A2c to 2B from the 2024 NIR onwards.

The shares of CH_4 and N_2O emissions from industrial combustion are relatively small, and these are not key sources.

In the 1990–2023 period, CO_2 emissions from combustion in 1A2 decreased by 42.7% (see Table 3.12 and Figure 3.6); the chemical industry chiefly contributed to this decrease.

Table 3.12 Fuel use in 1A2 Manufacturing industries and construction in selected years (PJ NCV/year)

Gaseous fuels

Fuel type/ Sub-category	Amount of fuel used (PJ NCV/year)								
	1990	1995	2000	2005	2010	2015	2020	2022	2023
1A2a. Iron and steel	11.7	13.0	13.7	12.5	12.0	11.1	11.0	9.2	8.0
1A2b. Non-ferrous metals	3.8	4.3	4.2	4.0	3.6	2.3	2.7	2.6	1.8
1A2c. Chemicals	170.7	138.9	115.8	103.6	96.4	93.9	124.8	103.4	101.6
1A2d. Pulp, paper and print	29.2	24.4	27.4	29.7	21.0	18.6	15.6	15.1	11.5
1A2e. Food processing, beverages and tobacco	63.7	68.4	73.7	67.1	57.0	58.2	0.0	57.9	55.7
1A2f. Non-metallic minerals	26.1	23.8	26.5	23.5	22.6	20.4	19.1	18.4	16.4
1A2g. Other	30.1	34.8	36.2	32.6	31.4	24.2	80.6	17.7	17.0

Liquid fuels

Fuel type/ Sub-category	Amount of fuel used (PJ NCV/year)								
	1990	1995	2000	2005	2010	2015	2020	2022	2023
1A2a. Iron and steel	0.3	0.3	0.1	0.1	0.1	NO	0.1	0.1	0.1
1A2b. Non-ferrous metals	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A2c. Chemicals	10.7	10.3	7.7	2.9	2.6	0.6	1.4	1.7	1.1
1A2d. Pulp, paper and print	0.0	0.0	NO	NO	NO	NO	NO	NO	NO
1A2e. Food processing, beverages and tobacco	2.2	0.6	0.2	0.2	NO	NO	0.0	0.0	0.0
1A2f. Non-metallic minerals	5.6	4.2	1.9	0.8	0.7	0.2	0.0	0.0	0.0
1A2g. Other	34.6	33.4	34.9	32.8	28.7	25.2	24.4	23.2	23.4

Solid fuels

Fuel type/ Sub-category	Amount of fuel used (PJ NCV/year)								
	1990	1995	2000	2005	2010	2015	2020	2022	2023
1A2a. Iron and steel	73.4	80.6	68.5	81.0	70.5	80.7	71.1	72.0	57.4
1A2b. Non-ferrous metals	0.0	NO	NO	NO	NO	0.0	0.0	NO	NO
1A2c. Chemicals	12.8	0.2	0.1	1.7	1.2	NO	NO	NO	NO
1A2d. Pulp, paper and print	0.1	NO	NO	NO	NO	NO	NO	NO	NO
1A2e. Food processing, beverages and tobacco	2.4	1.2	1.1	0.6	1.0	0.9	0.7	0.4	0.4

Fuel type/ Sub-category	Amount of fuel used (PJ NCV/year)								
	1990	1995	2000	2005	2010	2015	2020	2022	2023
1A2f. Non-metallic minerals	3.3	2.1	2.3	1.5	1.5	1.4	1.0	1.0	0.7
1A2g. Other	0.4	0.2	0.3	0.5	1.6	0.5	0.3	0.0	NO

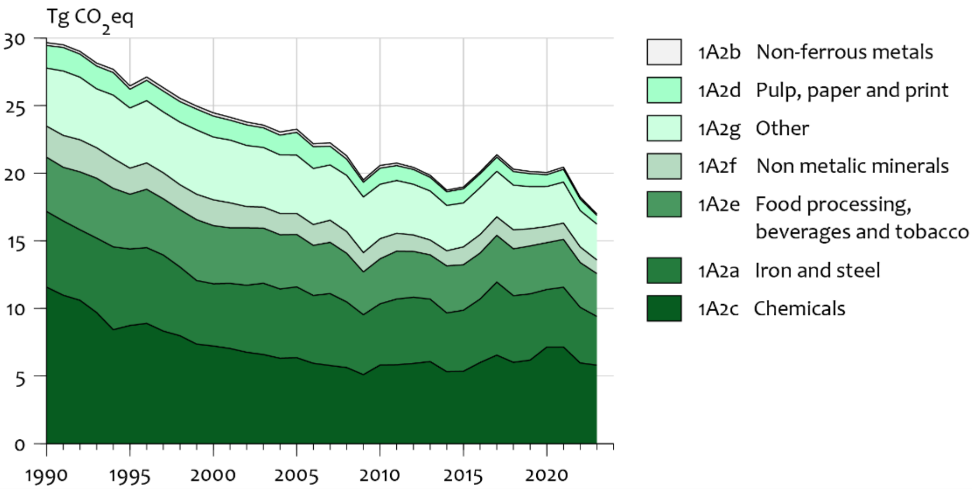


Figure 3.6 1A2 Manufacturing industries and construction – trend and emissions levels of source categories, 1990–2023.

Iron and steel (1A2a)
This sub-category refers mainly to the integrated steel plant (Tata Steel, previously known as Corus and/or Hoogovens), which produces 5,000-7,000 kton of crude steel per annum. Figure 3.7 shows the production process of the Tata Steel integrated steel plant. The reduction in steel production and CO2 emission in 2023 is caused by maintenance at the Tata steel plant in 2023. In addition to the integrated crude steel plant, the sector comprises a (small) secondary steel-making plant which mostly uses scrap metal in an electric arc furnace to produce wire, and a number of iron foundries.
The method used for calculating CO_2 emissions from Tata Steel is based on a carbon mass balance, so CO_2 emissions are not measured directly. The method allocates a quantity of C to relevant incoming and outgoing process streams (Table 3.13). As a result, CO_2 emissions can be determined at plant level only; allocation of emissions to the various sub-processes is not possible. The final difference between input and output, net C, is converted into a net CO_2 emission at plant level. For reasons of confidentiality, Table 3.13 does not include the quantities of the inputs and outputs. The figures can, however, be made available for review purposes.

Table 3.13 Input/output table for the Tata Steel integrated steel plant

Input	**Output**
Excipients	Produced steel
Steel scrap and raw iron	Carbonaceous products
Oil	Cokes
Pellets	BTX
Additives (limestone/dolomite)	TPA (tar, pitch and asphalt)
Iron ore	Mixed process gases: power plants
Injection coal	
Natural gas	
Coking coal	

Figure 3.7 shows the relation between the input streams from Table 3.13 (highlighted yellow) and the processes, together with the resulting emissions and the CRT categories in which the emissions were reported. Please note that the sub-flows of the gases (emissions) cannot be disaggregated in this approach; only the final flows are relevant and reported.

During the production of iron and steel, coke and coal are used as reducing agents in the blast and oxygen furnaces, resulting in blast furnace gas and oxygen furnace gas as by-products, which are used as fuel for energy purposes (see also Figure 3.7).
The Energy Balance of Statistics Netherlands distinguishes between energy figures from the Cokes Plant and the summed fuel use of the rest of processes in the integrated steel plant. Therefore, only combustion emissions from the Coke Plant and the rest of the integrated crude steel plant can be estimated. These combustion emissions (including flaring emissions) are included in 1A1ci (Manufacture of solid fuels) and 1A2a (Energy iron and steel).
Tata Steel also exports a large part of its carbon to the Energy sector in the form of mixed production gas. These emissions are included in 1A1a (Public electricity and heat production).
The relevant net process emissions are reported under sub-categories 1B1b (Solid fuel transformation), 2C1 (Iron and steel production), and 2A4d (Other process uses of carbonates).

Interannual variations in CO_2 combustion emissions from the crude steel plant can be mainly explained by the varying amounts of solid fuels used in this sector.

Combining all CO_2 emissions from the sector, total emissions closely follow the interannual variation in crude steel production (see Figure 3.8). Even though production of crude steel has increased over time, total CO_2 emissions from crude steel production have not increased. This indicates a substantial energy efficiency improvement in the sector.

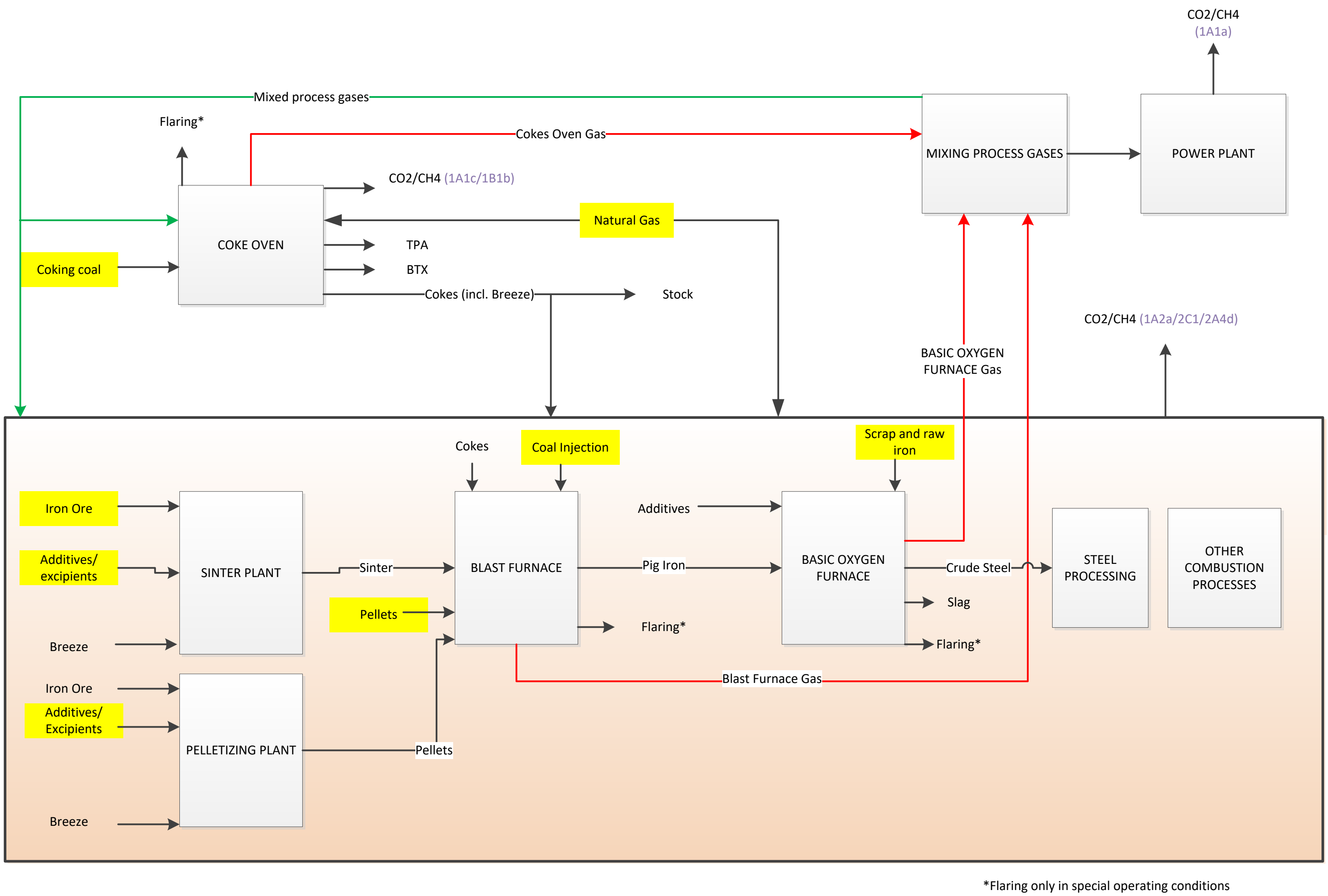


Figure 3.7 Production process of the Tata Steel integrated steel plant

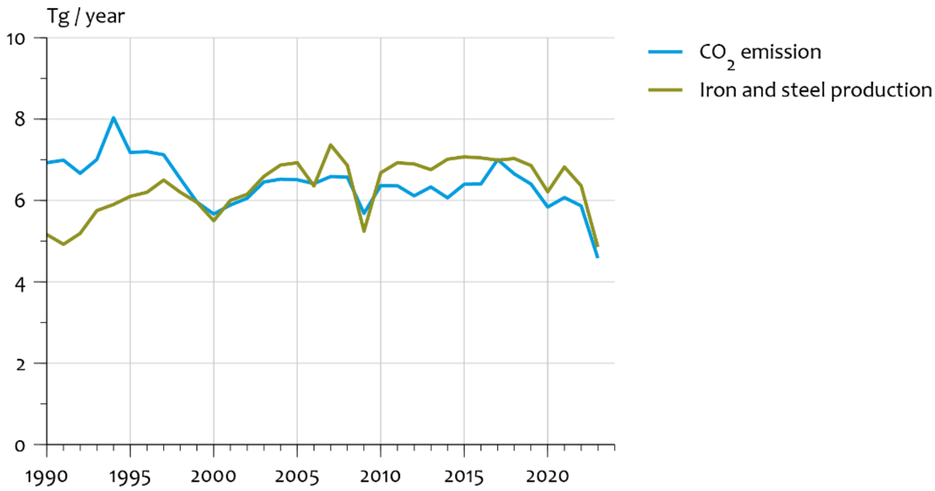


Figure 3.8 CO_2 emissions (Gg) and crude steel production (in kton) category 1A2a, 1990–2023

Non-ferrous metals (1A2b)
This sub-category consists mainly of two aluminium smelters (of which the last one ceased production in 2022) and several smaller non-ferro companies. CO_2 emissions from anode consumption in the aluminium industry are included in 2C (Metal production). This small source category contributes only about 0.1-0.2 Tg CO_2-eq to the national total GHG Emissions Inventory, predominantly from the combustion of natural gas. Energy consumption in the aluminium industry is largely based on electricity, the emissions of which are included in 1A1a (Public electricity and heat production).

The amounts of liquid and solid fuels vary considerably between years, but both the amounts and the related emissions are almost negligible. The interannual variation of the IEFs for liquid fuels is largely a result of changes in the mix of underlying fuels (e.g. the share of LPG, which has a relatively low EF) and partly due to the small amounts used.

Chemicals (1A2c)
CO_2 emissions from this sub-category have decreased since 1990, mainly due to a large decrease in the consumption of natural gas during the same period. This is largely due to a decrease in cogeneration facilities in this industrial sector.
In response to review recommendation (E.2, 2022) and in line with the IPCC 2006 Guidelines (vol. 3, chapter 1, box 1.1 and vol. 3, chapter 3.9.4.2), the emissions from the combustion of chemical waste gas (in liquids) and phosphor oven gas (in solids) have been reallocated from 1A2c to 2B10 from the 2024 NIR onwards (for waste gases which are combusted within the same source category). The IPCC 2006 Guidelines (vol. 3, chapter 1, box 1.1) state that "Combustion emissions from fuels obtained directly or indirectly from the feedstock for an IPPU process will normally be allocated to the part of the source category in which the process occurs (these source categories are normally 2B and 2C). However, if the derived fuels are transferred for combustion in another source category, the emissions should be reported in the appropriate part of Energy Sector source categories (normally 1A1 or 1A2)".

Therefore, all combustion emissions from chemical waste gas which are produced and combusted within the chemical sector have been reallocated from 1A2c to 2B10 from the 2024 NIR onwards.

Pulp, paper and print (1A2d)
In line with the decreased consumption of natural gas, CO_2 emissions have decreased since 1990. A substantial fraction of natural gas has been used for cogeneration. The relatively low CO_2 emissions since 1995 can be explained by the reallocation of emissions to the Energy sector due to the formation of joint ventures.

The amounts of liquid and solid fuel combustion vary considerably between years, but the amounts and related emissions are almost negligible. The interannual variation in the IEFs for liquid fuels is due to variable shares of derived gases (chemical waste gas) and LPG in total liquid fuel combustion.

Food processing, beverages and tobacco (1A2e)
CO_2 emissions from this sub-category increased in the 1990-1998 period, decreased in the 1998-2010 period, and has been rather stable from 2010 onwards. The decrease between 1998 and 2010 was due to the reallocation (since 2003) of joint ventures at cogeneration plants whose emissions were formerly allocated to 1A2e but are now reported under Public electricity and heat production (1A1a).

The amounts of liquid and solid fuels vary considerably between years, but the amounts and related emissions are relatively small. The interannual variation in the IEFs for liquid fuels is due to variable shares of LPG in total liquid fuel combustion.

Non-metallic minerals (1A2f)
CO_2 emissions from this sub-category decreased in the 1990-2023 period as a result of the decreasing consumption of natural gas.

The amounts of liquid and solid fuels vary considerably between years, but the amounts and related emissions are relatively small. The interannual variation in the IEFs for liquid fuels is due to variable shares of LPG in total liquid fuel combustion which has a lower CO_2 EF.

Other (1A2g)
This sub-category comprises all other industry branches, including production of textiles, wood and wood products, and electronic equipment. It also includes GHG emissions from non-road mobile machinery (NRMM) used in industry and construction, which are described in section 3.2.7. Most of the CO_2 emissions from this sub-category stem from gas, liquid fuels, and biomass combustion.

3.2.5.2 Methodological issues

Details of methodologies, data sources and country-specific source allocation issues are provided in section 2.1 of the ENINA methodology report (Honig et al., 2025) and chapter 9 of the transport methodology report (Witt et al., 2025). The emissions calculation for stationary combustion in category 1A2 follows the same steps as the calculation for Energy industries (1A1), see section 3.2.4.2. The only difference is that

for the iron and steel plant Tata (reported in 1A2a), an EF of 0.27 g N_2O/GJ (based on reported emissions from Tata Steel) and an EF of 0.44 g CH_4/GJ (standard EF for other bituminous coal) are used to calculate emissions from the iron and steel plant Tata in 1A2a.
The methodology for the calculation of NRMM emissions is described in section 3.2.7.2.

For 2023, approximately 99% of the fossil CO_2 emissions were calculated using country-specific or company-specific EFs. The remaining 1% of CO_2 emissions was calculated by means of default IPCC EFs. These remaining emissions are mainly the result of the combustion of other oil, lignite, and petroleum cokes.

An overview of the IEFs used for the principal fuels (up to 95% of the fuel use) in the Manufacturing industries and construction category (1A2) is provided in Table 3.14. As some emissions data in this sector originates from individual companies, the IEFs sometimes deviate from the standard emission factors. For reasons of confidentiality, detailed data on fuel consumption and EFs per CRT category and fuel is not presented in the NIR, but is available to reviewers on request.

Table 3.14 Overview of IEFs used for the most important fuels (up to 95% of fuel use) for the year 2022 in the Manufacturing industries and construction category (1A2)

Fuel	**Amount of fuel used in 2023 (TJ NCV)**	**Implied emission factors (g/GJ)**		
		CO_2 (x1000)	**N_2O**	**CH_4**
Natural gas	211,974	56.3	0.10	6.99
Coke Oven / Gas Coke	39,196	106.9	0.29	1.30
Other Bituminous Coal	28,606	93.1	0.28	0.44
Gas / Diesel oil	22,865	72.5	1.83	1.13
Solid biomass	15,072	109.6	4.00	37.39

Explanations for the IEFs
Natural gas
The standard CH_4 EF for natural gas is 5.7 g/GJ. Only for gas-powered CHP plants is a higher EF used (see section 2.1 of Honig et al. (2025)), which explains the higher IEF for CRT 1A2.

Coke oven / Gas coke and other bituminous coal
For solid fuels, an EF of 0.27 g N_2O/GJ (based on reported emissions from Tata Steel) and an EF of 0.44 g CH_4/GJ (standard EF for other bituminous coal) are used to calculate emissions from the iron and steel plant. The standard EFs are used for solid fuel combustion in other sectors. Reported CO_2 emissions from other bituminous coal and coke oven/gas coke are based on emissions data from the ETS. Therefore, the CO_2 IEFs are different from the standard country-specific EF.

Gas / Diesel oil
Gas/Diesel oil is used in stationary and mobile combustion for which various EFs for CH_4 and N_2O are used.

Solid biomass
The CH_4 emission factor differs per sector, ranging between 30 and 300 g/GJ.

In the iron and steel industry, a substantial proportion of total CO_2 emissions is reported as process emissions in CRT 2C1, based on net losses calculated from the carbon balance of the process (coke and coal inputs in the blast furnaces and the blast furnace gas produced). Since the fraction of BF/OX gas captured and used for energy varies over time, the trend in the emissions of CO_2 accounted for by this source category should be viewed in association with the reported process emissions (see Figure 3.7). The emissions calculations for the iron and steel industry are based on a mass balance.

The fuel consumption data in 1A2g (Other) is not based on large surveys and therefore is the least accurate in this part of sub-category 1A2.

The methodology for the calculation of NRMM emissions is described in section 3.2.7.2.

3.2.5.3 Uncertainty assessment and time-series consistency

Uncertainty assessment
The uncertainty in CO_2 emissions of this category is estimated to be about 9% (see Annex 2 for details). The uncertainty of fuel consumption data in the manufacturing industries is about 2% with the exception of that for derived gases included in solids and liquids (Olivier et al., 2009). The uncertainty of fuel consumption data takes into account the uncertainty in the subtraction of the amounts of gas and solids for non-energy/feedstock uses, including the uncertainty in the conversion from physical units to Joules, and the assumed full coverage of capturing blast furnace gas in total solid consumption and full coverage of chemical waste gas in liquid fuel consumption.

For natural gas, the uncertainty in the CO_2 EF is estimated to be 0.25% on the basis of the fuel quality analysis reported by Heslinga and Van Harmelen (2006) and further discussed in Olivier et al. (2009). The 2% uncertainty estimate in the CO_2 EF for liquids is based on an uncertainty of 2% in the EF for diesel. An uncertainty of 24% is assigned to solids, which reflects the uncertainty in the carbon content of blast furnace gas/oxygen furnace gas. BF/OX gas accounts for the majority of solid fuel use in this category.

Time-series consistency
Emissions from stationary energy combustion are calculated from the energy statistics combined with country-specific EFs (at the beginning of the time series) or a combination of company-specific and country-specific EFs (at the end of the time series). Time series consistency is ensured for EFs and activity data for most sectors as follows:

- The country-specific EFs are based on company-specific data. Multi-year company-specific data from the most relevant companies has been used to calculate an average country-specific EF. As the same information is used to calculate both the country-specific EF and the company-specific EFs, the EFs are consistent for the complete time series.

- Energy statistics are prepared by Statistics Netherlands, using the same methodology for the complete time series. In 2015 and 2016, the energy statistics from 1990 onwards were revised, using the same methodology for all years. These revised energy statistics have been used from the 2017 submission onwards. The activity data is consistent for the complete time series.

3.2.5.4 Category-specific QA/QC and verification

The trends in CO_2 emissions from fuel combustion in the iron and steel industry, non-ferrous industry, food processing, pulp and paper and other industries are compared to trends in the associated activity data: crude steel and aluminium production, indices of food production, pulp and paper production, and cement and brick production. Large annual changes are identified and explained (e.g. changed allocation of fuel consumption due to joint ventures). Moreover, for the iron and steel industry, the trend in total CO_2 emissions reported as fuel combustion-related emissions (included in 1A2a) and industrial process emissions (included in 2C1) is compared to the trend in the activity data (crude steel production). A similar comparison is made for the total trend in CO_2 emissions from the chemical industry (sum of 1A2c and 2B) and trends split per main fuel type or specific process (chemical waste gas combustion and process emissions from ammonia production). IEF trend tables are checked for large changes and large interannual variations at different levels, which are explained in the NIR. Changes in the IEF are mainly due to changes in the type of fuel used. Furthermore, the IEFs of individual fuels are also compared to the default emission factors, and deviations from the standard EFs are explained in the NIR.

CO_2 emissions reported by companies (both in AERs and as part of the ETS) are validated by the competent authority and then compared (see also section 3.2.4.4). More details on the validation of the energy data can be found in Honig et al. (2025), section 2.1.

QA/QC and verification of NRMM data and emissions are described in section 3.2.7.4.

3.2.5.5 Category-specific recalculations

Stationary combustion

The energy statistics for 2015-2022 have been improved, the main improvements being seen in the update of solid biomass, an improvement in the processing of data for stored liquid natural gas, and an update of natural gas statistics in the wood and wood products industry. This is visible in all 1A2 categories. Additionally, energy statistics of lignite have been reallocated from a remaining industry category (1A2gviii) to specific sectors in 1A1a and 1A2b from 2015 onwards.

These improvements resulted in the following changes in emissions (in Gg for fossil and biogenic emissions together):

1A2a.Iron and steel

	2015	2016	2017	2018	2019	2020	2021	2022
CO_2 (incl biomass)	2.163	0.676	-0.215	10.712	-0.451	-0.412	-1.408	4.075
CH_4	0.000	0.000	-0.000	0.000	-0.000	0.000	-0.000	0.000
N_2O	0.000	0.000	-0.000	0.000	-0.000	0.000	-0.000	0.000

1A2b.Non-ferrous metals

	2015	2016	2017	2018	2019	2020	2021	2022
CO_2 (incl biomass)	-21.080	-19.307	9.388	8.891	0.610	29.133	10.052	9.529
CH_4	-0.002	-0.002	0.001	0.001	-0.000	0.003	0.001	0.001
N_2O	-0.000	-0.000	0.000	0.000	-0.000	0.000	0.000	0.000

1A2c.Chemicals

	2015	2016	2017	2018	2019	2020	2021	2022
CO_2 (incl biomass)	7.647	4.348	-1.442	-5.494	0.154	-0.820	-0.862	-49.162
CH_4	0.001	0.000	-0.000	-0.001	0.000	-0.000	-0.000	-0.001
N_2O	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.001

1A2d.Pulp,paper and print

	2015	2016	2017	2018	2019	2020	2021	2022
CO_2 (incl biomass)	-0.333	1.348	1.997	13.383	13.297	12.799	-0.000	0.261
CH_4	-0.000	0.000	0.000	0.001	0.001	0.001	-0.000	0.000
N_2O	-0.000	0.000	0.000	0.000	0.000	0.000	-0.000	0.000

1A2e.Food processing, beverages and tobacco

	2015	2016	2017	2018	2019	2020	2021	2022
CO_2 (incl biomass)	21.519	21.830	18.547	32.593	24.334	19.715	14.961	13.745
CH_4	0.004	0.004	0.002	0.003	0.002	0.003	0.001	0.001
N_2O	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000

1A2f.Non-metallic minerals

	2015	2016	2017	2018	2019	2020	2021	2022
CO_2 (incl biomass)	-0.200	0.473	0.060	-23.220	4.255	4.027	0.421	1.062
CH_4	-0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000
N_2O	0.000	0.000	0.000	-0.000	0.000	0.000	0.000	0.000

1A2gi.Other: Manufacturing of machinery

	2015	2016	2017	2018	2019	2020	2021	2022
CO_2	0.557	0.829	-8.946	-6.906	-8.201	2.090	2.169	-0.765
CH_4	0.000	0.000	-0.001	-0.001	-0.001	0.000	0.000	-0.000
N_2O	0.000	0.000	-0.000	-0.000	-0.000	0.000	0.000	-0.000

1A2gii.Other: Manufacturing of transport equipment

	2015	2016	2017	2018	2019	2020	2021	2022
CO_2 (incl biomass)	-0.000	0.000	0.000	-0.000	0.287	0.000	-0.066	-2.799
CH_4	-0.000	0.000	0.000	-0.000	0.000	0.000	-0.000	-0.000
N_2O	-0.000	0.000	0.000	-0.000	0.000	0.000	-0.000	-0.000

1A2giii.Other: Mining (excluding fuels) and quarrying

	2015	2016	2017	2018	2019	2020	2021	2022
CO_2 (incl biomass)	-0.000	0.000	0.025	-4.364	-0.457	4.973	5.732	2.014
CH_4	-0.000	0.000	0.000	-0.000	-0.000	0.001	0.001	0.000
N_2O	-0.000	0.000	0.000	-0.000	-0.000	0.000	0.000	0.000

1A2giv.Other: Wood and wood products

	2015	2016	2017	2018	2019	2020	2021	2022
CO_2	-0.000	0.000	30.586	31.306	31.140	27.015	27.533	23.047
CH_4	-0.000	-0.000	0.003	0.003	0.003	0.003	0.003	0.002
N_2O	-0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

1A2gv.Other:Construction

	2015	2016	2017	2018	2019	2020	2021	**2022**
CO_2 (incl biomass)	-0.000	0.000	0.000	0.000	-0.000	-0.000	0.000	-4.865
CH_4	-0.000	-0.000	0.000	0.004	-0.000	-0.000	-0.000	-0.003
N_2O	-0.000	0.000	-0.000	-0.000	-0.000	0.000	0.000	-0.000

1A2gvi.Other:Textile and leather

	2015	2016	2017	2018	2019	2020	2021	**2022**
CO_2 (incl biomass)	11.482	12.042	0.000	-0.513	0.000	0.000	-0.000	-0.515
CH_4	0.001	0.001	0.000	-0.000	0.000	0.000	-0.000	-0.000
N_2O	0.000	0.000	0.000	-0.000	-0.000	0.000	0.000	-0.000

1A2gviii.Other:Other

	2015	2016	2017	2018	2019	2020	2021	**2022**
CO_2 (incl biomass)	-16.949	-18.146	-23.014	-15.032	-7.180	-14.348	-8.834	-59.622
CH_4	-0.001	-0.001	-0.001	-0.001	-0.000	-0.000	-0.000	-0.010
N_2O	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.002

Mobile combustion
Recalculations relating to NRMM are described in section 3.2.7.5.

3.2.5.6 Category-specific planned improvements
No category-specific improvements for stationary combustion have been planned. Planned improvements to the NRMM modelling are described in section 3.2.7.6.

3.2.6 Transport (1A3)
3.2.6.1 Category description
Table 3.15 provides an overview of sources and emissions in this category in the Netherlands. CO_2 is by far the most important GHG within the transport sector.

Table 3.15 Overview of emissions in the Transport sector (1A3) in the base year and the last two years of the inventory (in Tg CO_2 eq.). The middle column shows the change (%) of the last year of the inventory compared to the base year. On the right side of the table, the contribution of the last year inventory's emissions of the category to the sector, to the total national emissions of the specific gas and to the total national emissions (in CO_2 eq) are provided.

Sector/category	Gas	1990	2022	2023	2023 vs 1990	Contribution of the category in 2023 (%) to the		
		Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
1A3. Transport	CO_2	27.7	25.1	26.2	-5.4%	24.1%	21.7%	17.9%
	CH_4	0.2	0.1	0.1	-66.4%	0.1%	0.4%	0.0%
	N_2O	0.1	0.3	0.3	214.2%	0.3%	4.5%	0.2%
	All	27.9	25.4	26.5	-5.1%	24.5%		18.1%
1A3a. Civil aviation	CO_2	0.1	0.0	0.0	-65.5%	0.0%	0.0%	0.0%
1A3b. Road vehicles	CO_2	26.4	24.1	25.1	-5.1%	23.1%	20.8%	17.1%
	CH_4	0.2	0.1	0.1	-70.1%	0.1%	0.3%	0.0%
	N_2O	0.1	0.3	0.3	227.9%	0.3%	4.4%	0.2%
1a3b gasoline	CO_2	10.7	10.9	12.2	14.2%	11.2%	10.1%	8.3%
1a3b diesel oil	CO_2	13.0	12.7	12.4	-4.8%	11.4%	10.3%	8.5%
1a3b LPG	CO_2	2.7	0.3	0.3	-87.9%	0.3%	0.3%	0.2%
1a3b Natural gas	CO_2	0.0	0.2	0.1		0.1%	0.1%	0.1%
1A3c. Railways	CO_2	0.1	0.1	0.1	-25.5%	0.1%	0.1%	0.0%
1A3d. Domestic Navigation	CO_2	0.7	0.9	0.9	26.0%	0.8%	0.8%	0.6%
1A3e Other Transportation	CO_2	0.3	0.1	0.1	-78.6%	0.1%	0.1%	0.0%

This sector comprises the following key categories:

1A3b	Road transportation: gasoline	CO_2
1A3b	Road transportation: diesel oil	CO_2
1A3b	Road transportation: LPG	CO_2
1A3b	Road transportation	N_2O
1A3d	Domestic navigation	CO_2

Emissions from mobile sources that are described elsewhere in the report:

- Emissions from fuels delivered to international aviation and navigation (aviation and marine bunkers) are reported separately in the inventory (see section 3.2.2).
- Emissions from military aviation and shipping are included in 1A5 (see section 3.2.8).
- Energy consumption for pipeline transport is not recorded separately in the national energy statistics, but CO_2 and N_2O combustion emissions for gas transport are included in 1A3e. CO_2 process emissions and the CH_4 emissions of gas transport are reported in 1B2b (Gas transmission and storage), while CO_2 and CH_4 emissions from oil pipelines are included in 1B2a (Oil transport) as described in section 3.3.2.
- CO_2 emissions from lubricant use in two-stroke engines in mopeds and motorcycles have been included into 1A3biv, in accordance with the 2006 IPCC Guidelines.
- Emissions from NRMM (non-road mobile machineries; see section 3.2.7) are reported under various sub-categories, in line with the agreed CRT format:
    - Industrial and construction machinery: 1A2g;

    - Commercial and institutional machinery: 1A4a;
    - Residential machinery: 1A4b;
    - Agricultural machinery: 1A4c.
- Emissions from Fisheries (1A4ciii) are reported in section 3.2.7.

Overview of shares and trends in energy use and emissions
In 2023, transport was responsible for 18.1% of GHG emissions in the Netherlands. GHG emissions from transport increased by 30% between 1990 and 2006, from 27.9 to 36.4 Tg CO_2-eq. This increase was mainly due to an increase in diesel fuel consumption and resulting CO_2 emissions from road transport. From 2006 to 2022, GHG emissions from transport have decreased by 30% to 25.4 Tg CO_2-eq. In 2023 the GHG emissions increased by 4% to 26.5 Tg CO_2-eq.
Total energy use and resulting GHG emissions from transport are summarised in Figure 3.9 and Figure 3.10, respectively. As these figures show, road transport accounts for the majority of energy use and GHG emissions in this category throughout the time series.

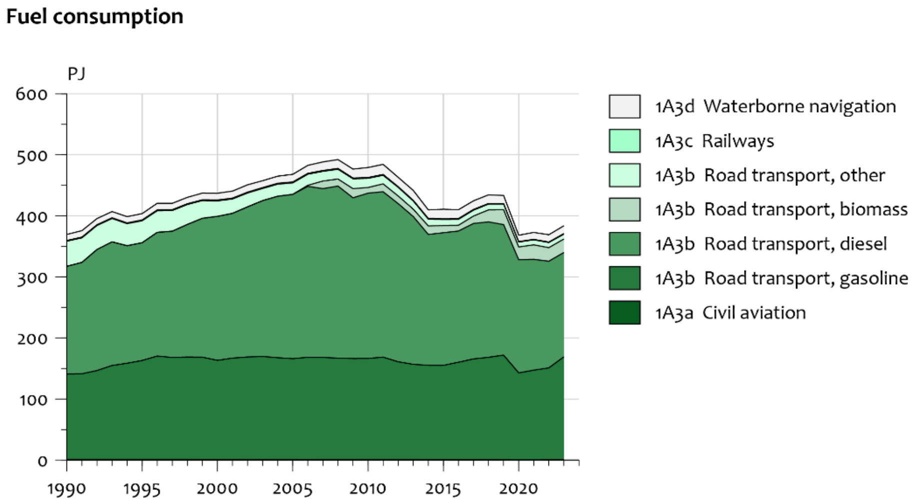


Figure 3.9 1A3 Transport – energy use of source categories in PJ, 1990–2023

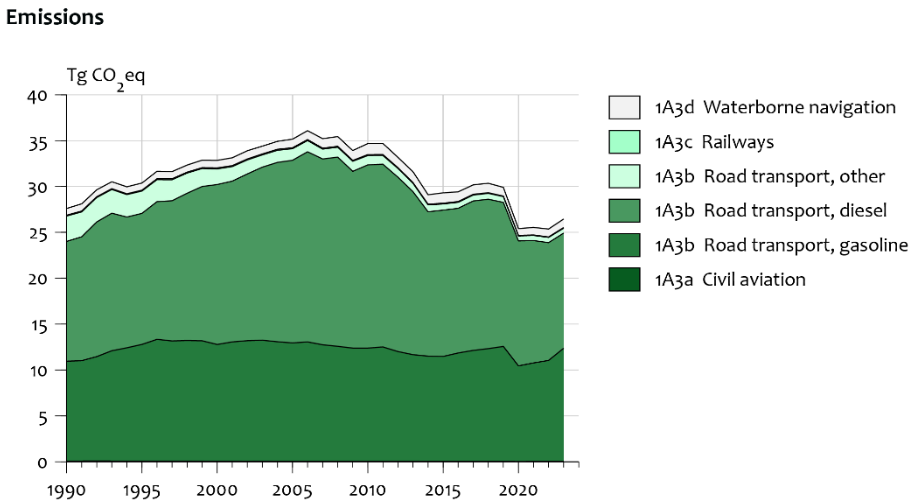


Figure 3.10 1A3 Transport – emissions levels of source categories, 1990–2023

Figure 3.10 shows that GHG emissions from transport steadily increased between 1990 and 2006. The increase is more or less in line with the increase in road transport volumes, although energy efficiency has increased (see Road transport). Between 2006 and 2008, emissions stabilised due to an increase in the use of biofuels in road transport. CO_2 emissions from biofuels are reported separately in the inventory and are not part of the national emissions totals (and are therefore not included in Figure 3.10). In 2009, GHG emissions from transport decreased slightly primarily due to the economic crisis and the resulting decrease in freight transport volumes. In 2010 and 2011, emissions increased slightly due to a decrease in the use of biofuels in 2010, and an increase in road transport volumes in 2011. Between 2011 and 2014, CO_2 emissions decreased by 16%. This can largely be attributed to an increase in cross-border refuelling resulting from an increasing difference in fuel prices between the Netherlands and Belgium/Germany (Geilenkirchen et al., 2017). Due to an improving economy with more transport in the 2014-2019 period, CO_2 emissions increased by 3%. In 2020 and 2021, there was much less road traffic due to the COVID-19 pandemic and the guidelines regarding social distancing. As a result, the emissions decreased significantly compared to 2019.
After the resumption of road traffic, GHG emissions increased by 4% in 2023 compared to 2022 but are lower than before the pandemic.

Civil aviation (1A3a)
Given the small size of the Netherlands, there is hardly any domestic aviation. The share of domestic civil aviation (i.e. aviation with departure and arrival in the Netherlands, including emissions from overland flights which depart from and arrive at the same airport) in GHG emissions in the Netherlands was less than 0.1% throughout the entire time series. The use of jet kerosene for domestic aviation decreased from 1.0 PJ in 1990 to 0.3 PJ in 2023, and the use of aviation gasoline decreased from 0.2 PJ in 1990 to 0.06 PJ in 2023. GHG emissions from civil aviation decreased accordingly.

Road transport (1A3b)
The share of road transport (1A3b) in national GHG emissions increased from 11.7% in 1990 to 17.4% in 2023. Between 1990 and 2006, total GHG emissions from road transport increased from 26.7 to 35.0 Tg CO_2-eq, mainly due to an increase in transport volume. From 2006 to 2014 GHG emissions decreased to 28.0 CO_2-eq before increasing slightly to 28.9 Tg CO_2-eq in 2019. In 2020-2022, total GHG emissions decreased to 24.4 Tg CO_2-eq in 2022 due to the COVID-19 restrictions. Additionally, a daytime speed reduction to 100 km/h was imposed on motorways from March 2020, resulting in a reduction of fuel consumption by road transport on motorways. After the resumption of road transport GHG emissions increased by 4% to 25.4 Tg CO_2-eq in 2023.

Between 1990 and 2008, diesel fuel consumption increased by 60% (+105 PJ). This increase was caused by both a large increase in freight transport volumes and a growing number of diesel passenger cars and light-duty trucks in the Dutch car fleet.

Between 2008 and 2019, diesel fuel consumption decreased by 24% to 214 PJ. This decrease can be attributed to three factors: the improved fuel efficiency of the diesel passenger car fleet; a very modest growth of diesel road transport volumes; and an increase in cross-border fuelling. The fuel efficiency of the passenger car fleet in the Netherlands has improved in recent years as a result of increasingly stringent EU CO_2 emissions standards for new passenger cars and fiscal incentives for the purchase of fuel-efficient cars. In recent years, as more fuel-efficient cars have entered the car fleet, average fuel efficiency has improved (although it should be noted that improvements in fuel efficiency in the real world were much smaller than those indicated by type approval values). Moreover, road transport volumes were more or less stable between 2008 and 2014, mainly due to the economic crisis. In recent years until 2022, however, the economic upturn has resulted in an increase in transport volumes. In 2023, Dutch trucks transported 7 percent less million tons of goods than in 2022, this is the lowest volume since 2015. This decrease is mainly because fewer goods were transported within the Dutch borders (-8%). Finally, an increase in excise duties for diesel fuel in the Netherlands in 2014 resulted in an increase in cross-border refuelling, especially for freight transport (Geilenkirchen et al., 2017).

Gasoline consumption increased from 140 to 169 PJ between 1990 and 1996 and subsequently fluctuated between 163 and 169 PJ until 2011. Subsequently, gasoline sales for road transport decreased to 155 PJ in 2014 but increased again to 171 PJ in 2019. The decrease between 2011 and 2014 can be attributed to a combination of improved fuel efficiency of the passenger car fleet, stabilisation of road transport volumes, and an increase in cross-border refuelling. The subsequent increase can be chiefly attributed to economic growth resulting in increased traffic volumes. Restrictions for social interaction during the coronavirus pandemic (such as the work-from-home policy) caused sales of both gasoline and diesel to decrease by 14-15% in 2021 compared to 2019.

Road transport increased again in 2023, but remained below the level of 2019. Gasoline sales increased by 12% to 169 PJ in 2023, but diesel sales to road transport continued to decline by 2% to 171 PJ due to a decrease in freight transport. An increasingly cleaner fleet reduces emissions per traffic kilometre. Due to the high fuel prices in 2022 as a result of the war in Ukraine, cross-border refuelling has played a greater role than in previous years. The pump price of diesel in the Netherlands in 2022 was generally slightly higher than the price in Germany (Dutch Ministry of Finance, 2023). The price of gasoline was also higher than in surrounding countries. In 2023, fuel prices have fallen but are still high. Because emissions are calculated on the basis of the amount of fuel sold, increased cross-border refuelling results in apparently lower emissions.

LPG consumption for road transport decreased steadily throughout the time series: from 41 PJ in 1990 to 5 PJ in 2023, mainly due to the decreasing number of LPG-powered passenger cars in the car fleet. As a result, the share of LPG in energy use by road transport decreased significantly between 1990 and 2023, from 11% to 1%. The use of natural gas in road transport has increased in recent years and amounted to 2.5 PJ in 2023. Within the Transport sector, natural gas is mainly used for public transport buses, although the number of CNG-powered passenger cars and light-duty trucks has also increased in recent years.

Biofuels have been used in road transport since 2003. The use of biofuels increased from 0.1 PJ in 2003 to 24 PJ in 2021. In 2022 and 2023, this was slightly lower at 22 PJ, which accounts for 6% of total energy use for road transport in both years. This is a result of a legal obligation to use renewable energy for transport. For the most part, this obligation is met by the increasing use of biofuels, and also through electrification of road vehicles.

The share of CO_2 emissions is 99% of total GHG emissions from road transport. The share of N_2O in total GHG emissions from road transport (in CO_2-eq) is small (1.15% in 2023). N_2O emissions from road transport increased from 0.3 Gg in 1990 to 0.9 Gg in 1997, then stabilized a few years, then increased to 1.3 Ggin 2011, but has fluctuated between 1.0 and 1.2 Gg since then. The development of N_2O emissions in addition to the development in transport volumes, can be explained by a combination of two factors:

- N_2O emissions per vehicle–kilometre of subsequent generations of three-way catalyst (TWC) equipped gasoline cars have decreased (Kuiper and Hensema, 2012). Nitrous oxide (N_2O) is mainly released by an incomplete reduction of nitrogen oxides to nitrogen in TWC. The emission has remained almost constant in recent years. On the one hand, the number of cars with a catalytic converter is increasing, on the other hand, cars with the latest generation of catalytic converters produce considerably less N_2O. (A TWC or non-selective catalytic reduction (NSCR) oxidizes CO and hydrocarbons to CO_2 and water and reduces NOx to nitrogen gas. The flue gases are passed over the catalyst without the addition of reagents).
- Recent generations of heavy-duty diesel trucks equipped with selective catalytic reduction (SCR) catalysts to reduce NO_x emissions emit more N_2O per vehicle–kilometre than older trucks (Kuiper and Hensema, 2012). (SCR is a chemical process used to remove nitrogen oxides (NOx) from the flue gases produced by a combustion process by injecting ammonia or a mixture of urea and demineralized water, known as Diesel Exhaust Fluid (DEF), into the exhaust gases.) In recent years, this has resulted in an increase in N_2O emissions from heavy-duty vehicles, which offsets the decrease in N_2O emissions from gasoline-powered passenger cars.

The share of CH_4 in GHG emissions from road transport (in CO_2-eq) is also small (0.23% in 2023). CH_4 emissions from road transport decreased by 70% between 1990 and 2023. This was due to a reduction in VOC emissions, resulting from the implementation and subsequent tightening of EU emissions legislation for new vehicles. CH_4 emissions are estimated as a fraction of total VOC emissions. As almost the entire gasoline car fleet is currently equipped with catalysts and carbon canisters, the decrease in VOC emissions, and therefore CH_4 emissions, has stagnated since 2009.

Railways (1A3c)
Railways (1A3c) are a minor source of GHG emissions, accounting for 0.3% of total GHG emissions from Transport in the Netherlands in 2023. Diesel fuel consumption by railways has fluctuated between 0.7 and 1.5 PJ throughout the time series, even though transport volumes have grown. This decoupling between transport volumes and diesel fuel consumption has been caused by the increasing electrification of rail (freight) transport. In 2023, diesel fuel consumption by railways amounted to 0.9 PJ. Most rail transport in the Netherlands is electric, with total electricity use for rail transport amounting to over 6 PJ annually in recent years. GHG emissions resulting from electricity generation for railways are not reported under 1A3c but are included in 1A1a.

Waterborne navigation (1A3d)
(Domestic) waterborne navigation is a small source of GHG emissions in the Netherlands. Waterborne navigation in the Netherlands is mostly internationally orientated, i.e. ships either depart or arrive abroad. As emissions from international navigation are reported under Bunkers (1D, section 3.2.2), the share of (domestic) waterborne navigation in total GHG emissions from the transport sector is small, ranging between 2% and 4% throughout the time series (3.4% in 2023).

Domestic waterborne navigation includes emissions from passenger and freight transport within the Netherlands, including offshore operations and recreational craft. Fuel consumption for domestic waterborne navigation increased from 10 PJ in 1990 to 17 PJ in 2011, but then decreased to 10 PJ in 2020 before increasing again to 13 PJ in 2023. These fluctuations can partially be explained by changes in offshore operations.

In line with the fuel consumption trend, GHG emissions from domestic waterborne navigation increased from 0.7 Tg CO_2-eq in 1990 to 1.2 Tg in 2011 and then decreased to 0.7 Tg in 2020. In 2023, they amounted to 0.9 Tg.

Other transportation (1A3e)
Other transportation consists of pipeline transport with CO_2 and N_2O emissions occurring at natural gas compressor stations. This is a minor source, which accounted for 1.2% of total Transport sector GHG emissions in 1990 and only 0.3% in 2023.

3.2.6.2 Methodological issues
This section gives a description of the methodologies and data sources used to calculate GHG emissions from transport in the Netherlands. Table 3.16 summarises the methods and types of EFs used for transport. More details on methodological issues can be found in Witt et al. (2025).

Table 3.16 Overview of methodologies for the Transport sector (1A3)

CRT code	Source category description	Method	EF
1A3a	Civil aviation	T1	CS, D
1A3b	Road transport	T2, T3	CS, D
1A3c	Railways	T1, T2	CS, D
1A3d	Waterborne navigation	T1, T2	CS, D
1A3e	Pipeline transport	T2	CS, D

CS: Country-specific, D: Default

Civil aviation (1A3a)
GHG emissions from domestic civil aviation in the Netherlands are estimated using a Tier 1 methodology. Fuel deliveries for domestic and international aviation are derived from the Energy Balance. This includes deliveries of jet kerosene and aviation gasoline. The heating values and CO_2 EFs for aviation gasoline and kerosene are derived from Zijlema (2023). Country-specific values are used for aviation gasoline, whereas for jet kerosene default values from the 2006 IPCC Guidelines are used. Default EFs are also used for N_2O. For CH_4, the EF is based on the VOC-profiles in the CLEO-model as described below. Since domestic civil aviation is not a key source in the inventory, the use of a Tier 1 methodology is deemed sufficient.

Emissions of precursor gases (NO_x, CO, NMVOC and SO_2), reported in the CRT under Domestic aviation, are calculated as the sum of domestic LTO emissions, which are calculated by means of the CLEO model (Dellaert & Hulskotte, 2017) and are used for the NL PRTR, and domestic cruise emissions as provided by Eurocontrol to member countries. As the data provided by Eurocontrol does not include flights that did not submit a flight plan, scaling factors have been used to estimate the missing emissions.

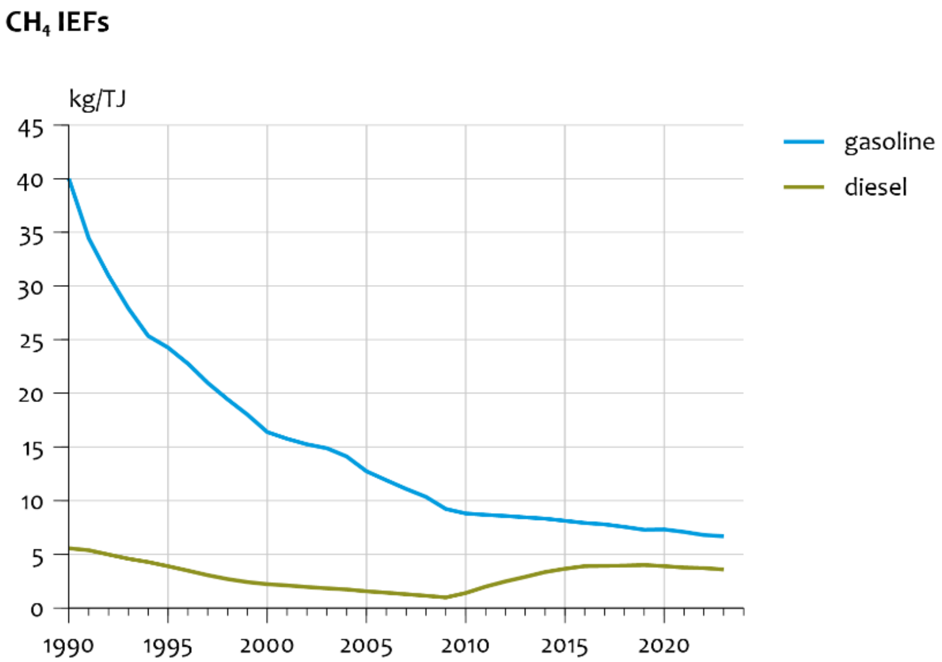
Road transport (1A3b)
The activity data for calculating GHG emissions from road transport is derived from the Energy Balance. This includes fuel sales of gasoline, diesel, liquefied petroleum gas (LPG), natural gas (CNG and LNG) and biofuels. Table 2.1 in the (seperate Excel) annex to Witt et al. (2025) provides an overview of the methodology used to distribute the Energy Balance data across the various CRT categories.

CO_2 emissions from road transport are calculated using a Tier 2 methodology. Country-specific heating values and CO_2 EFs are used. These were derived from measurement programmes, the most recent being performed in 2016 and 2017 with a follow-up for gasoline in 2017-2019, and have been brought up to date by Statistics Netherlands. A detailed description of the methodology currently used for calculating GHG emissions for road transport is provided in chapter 2 of Witt et al. (2025). The EFs used are provided in the tables annex to Witt et al. (2025) in Table 2.2B (for CH_4 and N_2O EFs) and Tables 2.2A and 2.7 (CO_2 EFs).

The implied N_2O and CH_4 emission factors for road transport have been changed due to new EFs for Euro 5 and Euro 6 petrol passenger cars based on measurements as a result of the European New Car

Assessment Program (NCAP), new CH_4 EFs for Euro 5 mopeds (through new insights for EFs VOC) and also by changes in the vehicle fleet. (TNO, 2024).

Figure 3.11 shows the implied N_2O and CH_4 EFs for road transport. The CH_4 EFs have decreased steadily for all fuel types throughout the time series due to EU emissions legislation for hydrocarbon (HC). Since 2009, diesel vehicles have been equipped with a selective catalytic reduction (SCR), which can lead to incomplete combustion and increased methane emissions. That is why Euro 5 and 6 diesel vehicles have a higher CH_4 emission factor. The N_2O EFs for gasoline increased between 1990 and 1995 due to the increasing number of catalyst-equipped passenger cars in the car fleet, but have since decreased steadily, as described in section 3.2.6.1. The N_2O IEF for diesel has increased in recent years, mainly due to the increasing number of heavy-duty trucks and buses equipped with an SCR catalyst.



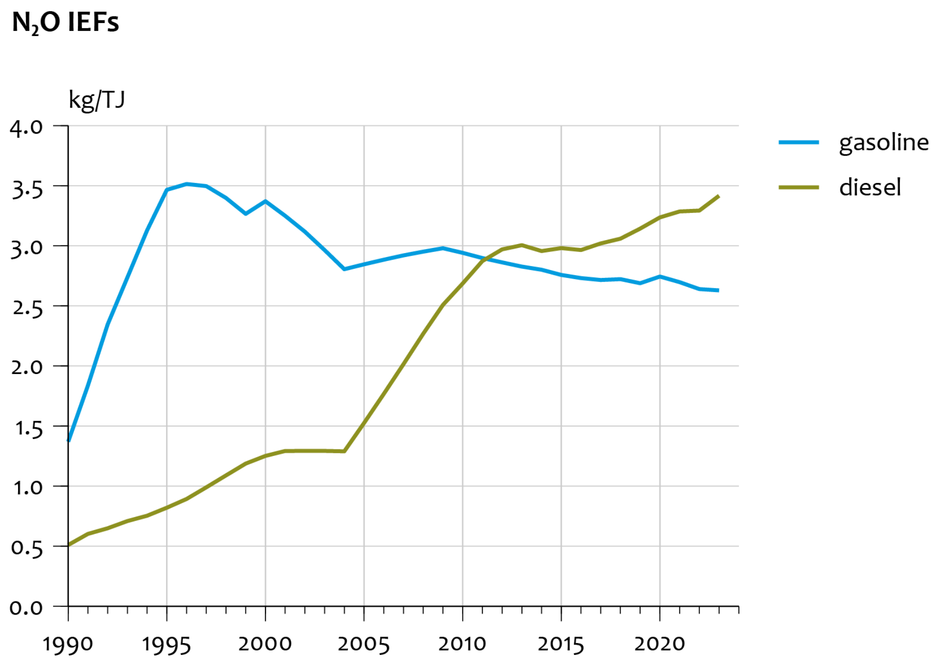


Figure 3.11 IEFs per fuel type for CH_4 (upper graph) and N_2O (lower graph) emissions by road transport, 1990–2023

Railways (1A3c)
Fuel deliveries to railways are derived from the Energy Balance. Since 2020, Statistics Netherlands has obtained diesel data from ProRail, which, in turn, receives the data from the railway operators. ProRail is responsible for the railway network of the Netherlands and is part of Vivens, a cooperative of rail carriers that purchase diesel for the entire rail sector in the Netherlands. Previously, Statistics Netherlands obtained this data from Vivens.
CO_2 emissions from railways are calculated by means of a Tier 2 methodology, using the same country-specific CO_2 EFs as those used for road transport (Swertz et al., 2018). Due to a lack of country-specific EFs, CH_4 and N_2O emissions for railways are estimated using a Tier 1 methodology, using EFs that have been derived from the 2023 EEA Emission Inventory Guidebook.

Waterborne navigation (1A3d)
Diesel fuel consumption for domestic inland navigation is derived from the Energy Balance. In order to calculate GHG emissions from gasoline consumption by recreational craft, fuel consumption is estimated annually using an updated bottom-up approach derived from Hulskotte (in press in 2024). These estimated gasoline sales to recreational craft are separately reported in the energy statistics from 2015 onwards. For the years 1990-2014, the gasoline sales to recreational craft are not reported separately in the energy statistics, but are included under Road transport. For the period 1990-2014, gasoline sales data for road transport derived from the Energy Balance is corrected accordingly (as shown in Table 2.1 of the tables annex to Witt et al., 2025).

The fuel consumption from the Energy Balance is allocated to international bunkers and inland navigation. Each fuel supplier has to report its total fuel sales to Statistics Netherlands, and subsequently fills in a survey. In this survey, the fuel supplier indicates to which type(s) of shipping (inland navigation, fisheries, international shipping, etcetera) its fuels have been delivered. Within inland navigation, the distinction between domestic inland navigation (included in 1A3d) and international inland navigation (included in 1D International bunker fuels) is uncertain. Based on the survey and expert judgement by Statistics Netherlands, the fuel sales of each fuel supplier for inland navigation are attributed to either national or international navigation. This methodology is used consistently throughout the time series.

A Tier 2 methodology is used to calculate CO_2 emissions from domestic waterborne navigation using country-specific CO_2 EFs, while a Tier 1 method is used for CH_4 and N_2O emissions. A description of the country-specific EFs for CO_2 and the EFs used for CH_4 and N_2O, as well as the underlying methodology, is provided in Witt et al. (2025); the EFs are included in Table 2.2 of the tables annex.

Other transportation (1A3e)
The methodology used for calculating emissions from other transportation (Pipeline transport gaseous fuels) is described in section 3.3.

Fossil carbon in biofuels
Part of the carbon in certain types of biofuels has a fossil origin, and as such should be reported as fossil fuel. The following methodology is used:

- Derive the total amount of biogasoline and biodiesel used for transport in the Netherlands from the Energy Balance, as reported annually by Statistics Netherlands.
- Determine the share of various types of biogasoline and biodiesel used in the Dutch market, as reported annually by the Dutch Emissions Authority (NEa, 2024).
- Apply the fossil fraction of the carbon content for biodiesel (Sempos, 2018) and biogasoline (Annex III of the EU Renewable Energy Directive, 2018/2001/EC).

Table 3.17 Share (in %, rounded) of various types of biofuels in total biofuel consumption for transport in the Netherlands (NEa, 2024)

	Biofuel type	**Fossil part of CC**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Bio Gas-oline	bio-ethanol	0	92	91	96	100	100	99	99	77	83	90	92	92	100
	bio-ETBE	63	0	1	2	0	0	1	1	11	0	2	0	0	0
	bio-MTBE	78	7	7	0	0	0	0	0	0	0	0	0	0	0
	bio-methanol	0	1	1	2	0	0	0	0	0	1	0	0	0	0
	bionafta	0	0	0	0	0	0	0	0	11	16	8	8	8	0
	total		100	100	100	100	100	100	100	100	100	100	100	100	100
Bio diesel	FAME	5.4	100	98	99	96	98	98	99	97	79	87	78	72	65
	HVO	0	0	2	1	4	2	2	1	3	21	13	21	28	35
	FAEE	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total		100	100	100	100	100	100	100	100	100	100	100	100	100

Table 3.17 presents the input for steps 2 and 3, i.e. the shares of various types of biofuels in total biogasoline and biodiesel use for transport in the 2011–2023 period, as reported by NEa (2024), and the fossil part of the carbon content per fuel type.

3.2.6.3 Uncertainty assessment and time-series consistency

Uncertainty assessment

Uncertainty estimates for the activity data and IEFs used for calculating transport emissions are presented in Table 2.5 of the tables annex to Witt et al. (2025), which also shows the sources used to estimate uncertainties. Table 3.18 summarises the uncertainties for activity data and EFs per source category, fuel type and gas. The estimations of uncertainties in activity data are all derived from Statistics Netherlands.

The uncertainty estimates for N_2O and CH_4 for civil aviation, railways, and waterborne navigation are IPCC defaults. The uncertainties in EFs for road transport and CO_2 EFs for other source categories are based on expert judgements collected during workshops. Information on uncertainties is updated annually in accordance with methodological improvements and recalculations, following consultation with experts.

Table 3.18 Uncertainties for activity data and emission factors, category 1A3

CRT	Source category	Fuel type	Gas	Activity data	EFs
1A3a	Civil aviation	Avgas	CO_2	+- 10%	+- 4%
		Avgas	N_2O	+- 10%	+- 98%
		Avgas	CH_4	+- 10%	+- 101%
		Kerosene	CO_2	+- 10%	+- 4%
		Kerosene	N_2O	+- 10%	-70% - +150%
		Kerosene	CH_4	+- 10%	+- 53%
1A3b	Road transportation	Gasoline	CO_2	+- 2%	+- 2%
		Gasoline	N_2O	+- 2%	+- 50%
		Gasoline	CH_4	+- 2%	+- 50%
		Diesel	CO_2	+- 2%	+- 2%
		Diesel	N_2O	+- 2%	+- 50%
		Diesel	CH_4	+- 2%	+- 50%
		LPG	CO_2	+- 5%	+- 2%
		LPG	N_2O	+- 5%	+- 50%
		LPG	CH_4	+- 5%	+- 50%
		CNG_LNG	CO_2	+- 5%	+- 0%
		CNG_LNG	N_2O	+- 5%	+- 50%
		CNG_LNG	CH_4	+- 5%	+- 50%
1A3c	Railways	Diesel	CO_2	+- 1%	+- 2%
		Diesel	N_2O	+- 1%	+- 100%
		Diesel	CH_4	+- 1%	+- 100%
1A3d	Water-borne navigation	all	CO_2	+- 5%	+- 2%
		all	N_2O	+- 5%	-40% - +140%
		all	CH_4	+- 5%	+- 50%

Time-series consistency
Emissions from transport sectors are calculated from the energy statistics combined with country-specific EFs. Time series consistency is ensured for EFs and activity data for most sectors as follows:

- A description of the country-specific EFs for CO_2 and the EFs used for CH_4 and N_2O, as well as the underlying methodology, is provided in Witt et al. (2025); the EFs are included in Table 2.2 of the tables annex.
- Energy statistics are prepared by Statistics Netherlands, using the same methodology for the complete time series. In 2015 and 2016, the energy statistics from 1990 onwards were revised, using the same methodology for all years. These revised energy statistics have been used from the 2017 submission onwards. The activity data is consistent for the complete time series.

3.2.6.4 Category-specific QA/QC and verification
GHG emissions from transport are based on fuel sold. To check the quality of the emissions totals, activity data for road transport (i.e. energy use per fuel type) is also calculated using a bottom-up approach based on vehicle-kilometres travelled and specific fuel consumption per vehicle-kilometre for various vehicle types. A comparison between the fuel sales data and the bottom-up calculation of fuel consumption gives an indication of the validity of the (trends in the) fuel sales data. Figure 3.12 shows the time series for both fuel sold and fuel used for gasoline (including bioethanol) and diesel (including biodiesel) in road transport.

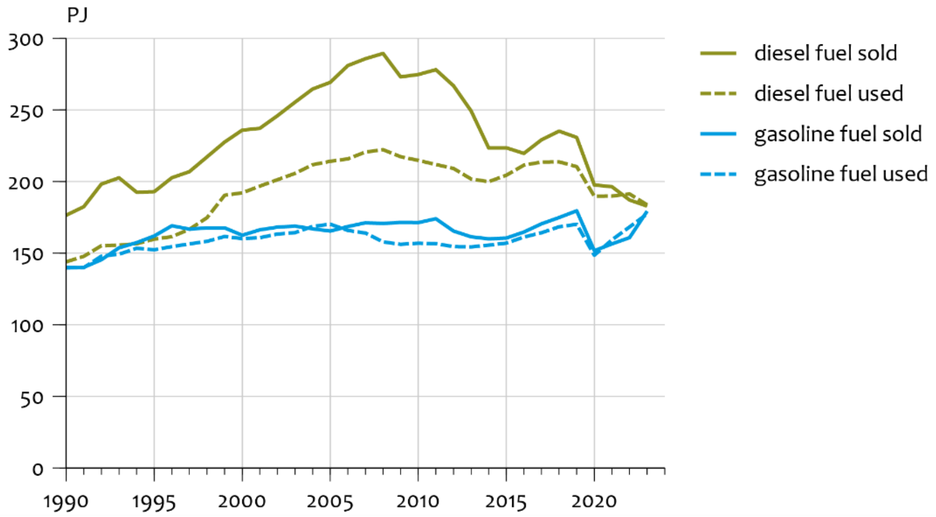


Figure 3.12 Fuel sold and fuel used for road transport in the Netherlands, 1990-2023

Between 1990 and 2023, the time series for fuel sold and fuel consumed show a strong correspondence for LPG and natural gas and, as Figure 3.12 shows, somewhat less so for gasoline. However, the time series for diesel deviate: even though the trend is mostly comparable, diesel sales on Dutch territory were substantially higher than diesel consumption. The differences ranged between 12% and 31%. In recent years the difference between fuel used and fuel sold has almost disappeared.

The difference between diesel used and diesel sold in the 1990–2020 period can partly be explained by the use of diesel in long-haul distribution trucks which can travel several thousand kilometres on a full tank. Diesel fuel sold to long-haul trucks in the Netherlands is mostly consumed abroad and is therefore not included in the diesel consumption on Dutch territory. Although this omission is partially offset by the consumption by trucks that travel in the Netherlands but do not refuel here, it is expected that the impact of Dutch long-haul trucks refuelling in the Netherlands is dominant, given the small size of the country.

In order to validate the activity data for railways and waterborne navigation, as derived from the Energy Balance, the trends in fuel sales data for both source categories are compared with trends in transport volumes. Trends in energy use for waterborne navigation closely correspond with trends in transport volumes, although this does not necessarily hold for trends in domestic inland navigation. This would suggest that the growth in transport volumes mostly relates to international transport.

For railways, the correspondence between diesel deliveries and freight transport volumes is weak. This can be explained by the electrification of rail freight transport, with the exception for shunting activity which remain mainly on diesel. Figures compiled by Rail Cargo (2007, 2013) make clear that in 2007, only 10% of all locomotives used in the Netherlands were electric, whereas by 2012, the proportion of electric locomotives had increased to over 40%, due to the electrification of most freight rail lines. For this reason, there has been a decoupling of transport volumes and diesel deliveries in recent years in the time series. Consequently, the decline in diesel consumption for railways, as derived from the Energy Balance, is deemed plausible.

3.2.6.5 Category-specific recalculations

New data was derived from the Energy Balance, and the GHG emissions changed accordingly. This applies to all types of fuels. In addition to this regular update, other changes are described in the paragraphs below.

The LPG sales data has improved over the entire time series. Previously, it was incorrectly assumed that the category LPG for road traffic included also non-road mobile machinery (NRMM) and the data was therefore erroneously subtracted from the LPG sales to road traffic. LPG for NRMM is included separately in the energy statistics. Consequently, the amount of LPG for road traffic increases, as it is not corrected for NRMM anymore.

The diesel sales data to road transportation has been updated in the energy statistics, resulting in a decrease, especially in 2021 and 2022 (-0.9% being -1.7 PJ for both years). This is due to a reallocation of diesel in the energy statistics. There is an increase in diesel for NRMM (in particular 1A4cii in 2022 and 1A2gvii in 2021) which has led to a decrease in diesel for road transportation (heavy duty trucks).

The emission factors CH_4 and N_2O for road traffic were updated. Until last submission, the emission factors had not been adjusted to the bottom-up data (IEFs) in recent years.

As mentioned before, the data for road transportation has been updated. This resulted in the following changes in emissions (in Gg):

1A3b Road transportation, total fuel

1A3b	1990	2000	2005	2010	2015	2020	2022
CO_2	158.52	146.76	122.28	113.90	49.92	25.26	-48.46
CH_4	-0.25	-0.27	-0.46	-0.78	0.04	0.02	-0.10
N_2O	0.00	0.00	0.11	0.36	0.30	0.36	0.37

1A3b Road transportation, gasoline

1A3b	1990	2000	2005	2010	2015	2020	2022
CO_2	-3.51	-3.22	-2.20	-0.99	-6.72	3.07	7.18
CH_4	-0.28	-0.32	-0.50	-0.95	-0.70	-0.63	-0.68
N_2O	0.00	0.00	0.04	0.20	0.26	0.28	0.29

1A3b Road transportation, diesel oil

1A3b	1990	2000	2005	2010	2015	2020	2022
CO_2	0.00	0.00	0.00	0,00	-21.28	-38.32	-116.54
CH_4	0.02	0.05	0.03	0.15	0.68	0.63	0.56
N_2O	0.00	0.00	0.07	0.15	0.03	0.05	0.06

1A3b Road transportation, LPG

1A3b	1990	2000	2005	2010	2015	2020	2022
CO_2	162.02	149.98	124.48	114.89	76.65	60.56	56.28
CH_4	0.00	0.00	0.01	0.05	0.06	0.01	0.02
N_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1A3b Road transportation, gaseous fuels

1A3b	1990	2000	2005	2010	2015	2020	2022
CO_2	0.00	0.00	0.00	0.00	1.26	-0.01	4.89
CH_4	0.00	0.00	0.00	0.00	0.00	0.00	0.01
N_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1A3b Road transportation, other fossil fuels

1A3b	1990	2000	2005	2010	2015	2020	2022
CO_2	0.00	0.00	0.00	0.00	0.01	-0.04	-0.27

1A3b Road transportation, other fossil fuels

CH_4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00

1A3b Road transportation, biomass

1A3b	1990	2000	2005	2010	2015	2020	2022
CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH_4	0.00	0.00	0.00	-0.03	-0.01	0.00	-0.01
N_2O	0.00	0.00	0.00	0.01	0.01	0.02	0.02

3.2.6.6 Category-specific planned improvements

No category-specific improvements have been planned.

3.2.7 Other sectors (1A4)

3.2.7.1 Category description

Table 3.19 and Figure 3.13 present the subcategories and emissions trends in sector 1A4.

Table 3.19 Overview of emissions in the Other sectors (1A4) in the base year and the last two years of the inventory

Sector/category	**Gas**	**1990**	**2022**	**2023**	**2023 vs 1990**	**Contribution of the category in 2023 (%) to the**		
		Emissions in Tg CO_2 eq			**%**	**sector**	**total gas**	**total CO_2 eq**
1A4. Other sectors	CO_2	39.2	26.1	24.1	-38.6%	22.2%	20.0%	16.4%
	CH_4	0.6	1.4	1.4	121.6%	1.3%	7.7%	1.0%
	N_2O	0.0	0.1	0.1	10.7%	0.0%	0.8%	0.0%
	All	39.9	27.5	25.5	-36.0%	23.6%		17.4%
1A4a. Commercial/Institutional	CO_2	8.6	5.8	5.4	-37.1%	5.0%	4.5%	3.7%
	CH_4	0.1	0.0	0.1	14.1%	0.1%	0.3%	0.0%
1A4a Natural gas	CO_2	7.8	5.3	4.9	-36.2%	4.6%	4.1%	3.4%
1A4b. Residential	CO_2	20.8	13.5	11.4	-45.3%	10.5%	9.4%	7.8%
	CH4	0.5	0.3	0.3	-40.5%	0.3%	1.6%	0.2%
1A4b Natural gas	CO_2	19.9	13.3	11.2	-43.7%	10.3%	9.3%	7.7%
1A4c. Agriculture/Forestry/Fisheries	CO_2	9.9	6.8	7.3	-25.9%	6.8%	6.1%	5.0%
	CH_4	0.1	1.0	1.1	1195.7%	1.0%	5.7%	0.7%
1A4c liquids	CO_2	0.2	0.1	0.1	-64.2%	0.1%	0.1%	0.1%
1A4c Natural gas	CO_2	7.3	5.1	5.6	-23.5%	5.2%	4.7%	3.8%

Sector 1A4 comprises following key categories:

1A4	Liquids excl. 1A4c	CO_2
1A4a	Commercial/Institutional: gaseous	CO_2
1A4b	Residential gaseous	CO_2
1A4b	Residential: all fuels	CH_4

1A4c	Agriculture/Forestry/Fisheries: liquids	CO_2
1A4c	Agriculture/Forestry/Fisheries: gaseous	CO_2
1A4c	Agriculture/Forestry/Fisheries: all fuels	CH_4

Sub-category 1A4a (Commercial and institutional services) comprises commercial and public services, such as banks, schools and hospitals, and services related to trade (including retail) and communications; it also includes emissions from the production of drinking water and miscellaneous combustion emissions from waste handling activities and from wastewater treatment plants (WWTPs) as well as emissions from non-road mobile machinery (NRMM) used in the trade sector.

Sub-category 1A4b (Residential) relates to fuel consumption by households for space heating, water heating, and cooking. Space heating uses about three-quarters of the Netherlands' total consumption of natural gas in the residential sector. The residential sub-category also includes emissions from NRMM used by households.

Sub-category 1A4c (Agriculture, forestry and fisheries) comprises stationary combustion emissions from agriculture, horticulture, greenhouse horticulture, cattle breeding, and forestry. It also includes emissions from agricultural NRMM (1A4cii) and from fishing (1a4ciii).

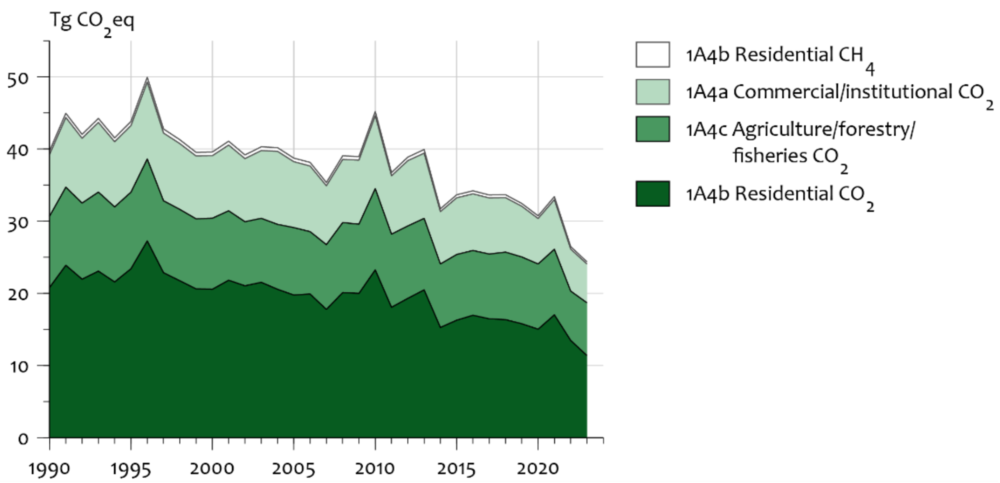


Figure 3.13 1A4 Other sectors – emissions levels of source categories, 1990–2023

Commercial and institutional services (1A4a)
CO_2 emissions in the Commercial and institutional services (1A4a) sub-category have decreased since 1990. The interannual variations in emissions are mainly caused by temperature: more natural gas is used during cold winters (e.g. 1996 and 2010), less in warm winters (e.g. 2014).

Energy use by NRMM used in trade decreased from 8.3 PJ in 1990 to 4.4 PJ in 2023, with CO_2 emissions decreasing accordingly. Energy use consists mostly of diesel fuel, although some gasoline is used, and in last decade, the use of biofuels has increased.

Residential (1A4b)
When corrected for the interannual variation in temperature, the trend in total CO_2 emissions (i.e. in gas consumption) is steady, with interannual variations of less than 5%. Only for the year 2022 and 2023, a larger decrease can be seen, which is caused by the high natural gas prices (resulting in less heating by households).
The annual variations are much larger for liquid and solid fuels because of the smaller figures. Emissions from biomass consumption relate almost entirely to wood combustion.

In the residential category, CO_2 emissions have decreased since 1990 even though the number of households has increased. This is mainly due to the improved insulation of dwellings and the increased use of high-efficiency boilers for central heating.

Energy consumption by NRMM used in the residential sector decreased from 1.5 PJ in 1990 to 0.9 PJ in 2023, with CO_2 emissions decreasing accordingly. Energy use consists only of gasoline, and from 2006 biofuels have also been applied.

Agriculture, forestry and fisheries (1A4c)
Most of the energy in this source sub-category is used for space heating and water heating, although some is used for cooling. The major fuel used is natural gas; hardly any solid fuels are used. NRMM used in agriculture mostly uses diesel oil, although some biofuel and gasoline is used. Fishing uses diesel oil and until 2020 combined with some residual fuel oil.

Total CO_2 emissions in the Agriculture, forestry and fisheries sub-category have decreased since 1990, mainly due to a decrease in gas consumption for stationary combustion as a result of various energy conservation measures. For example, in greenhouse horticulture the surface area of heated greenhouses has increased but their energy consumption has been reduced.

Part of the CO_2 emissions from the agricultural sector consists of emissions from cogeneration facilities which can also provide electricity to the national grid.

In addition, since the autumn of 2005, CO_2 emissions from two plants have been used for crop fertilisation in greenhouse horticulture. Total annual amounts are approximately 0.4 Tg CO_2. Because this CO_2 is delivered by two plants for crop fertilisation, less natural gas is combusted by the sector for producing CO_2 for crop fertilisation.

The CH_4 emissions in the Agriculture, forestry and fisheries sub-category have increased since 1990, due to the shift from natural gas combustion in boilers to the natural gas combustion in gas engines. The increase in CH_4 emissions is the result of the higher CH_4 emission factor for gas engines.

GHG emissions from agricultural NRMM (1A4cii) have been relatively constant throughout the time series, ranging between 1.0 and 1.3 Tg CO_2-eq.

CO_2 emissions from fisheries have significantly decreased, from 1.3 Tg in 2000 to 0.3 Tg in 2023. This is due to the decline in the number of fishing vessels in the Netherlands since 1990, along with a decrease in their engine power.

3.2.7.2 Methodological issues

Details of methodologies, data sources and country-specific source allocation issues are provided in:
- Honig et al. (2025), section 2.1: Stationary combustion;
- Visschedijk et al. (2025), chapters 21 and 25: Residential wood combustion and charcoal use;
- Witt et al. (2025, chapter 9: Non-road mobile machinery.

This section provides a brief description of the methodology applied to stationary combustion (1A4ai, 1A4bi and 1A4ci) and mobile combustion (1A2gvii, 1A4aii, 1A4bii, 1A4cii and 1A4ciii).

Stationary combustion

The emissions from this source category are estimated by multiplying fuel use statistics by IPCC default and country-specific EFs (Tier 1 and Tier 2 method for CO_2 and CH_4 and Tier 1 method for N_2O).

Activity data

The activity data used in this sector is mainly derived from energy statistics supplied by Statistics Netherlands. For the following emission sources, other activity data is used:
- The activity data for charcoal consumption in barbecues is based on energy statistics from Statistics Netherlands for 1 year. To create a complete time series, the activity data is following the trend for annual meat consumption.
- The activity data for residential wood combustion is based on (six-yearly) surveys by Statistics Netherlands; the results of these surveys are used to prepare a complete time series. See Visschedijk et al. (2025) for more details on these wood combustion statistics.
- The activity data for landfill gas is available from landfill site operators (in m^3). As the activity data is available in m^3 instead of GJ, the data is not included in the CRT. The amount of landfill gas for energy purposes is available in NID table 7.6.

Emission factors

The following EFs are used for stationary combustion: for CO_2, IPCC default EFs are used (see Annex 5) for all fuels except natural gas, gas/diesel oil, LPG, and gaseous biofuels for which country-specific EFs are used. The Netherlands’ list of fuels (Zijlema, 2025) specifies whether the EFs are country-specific or IPCC default values. For CH_4, country-specific EFs are used for all fuels except solid biomass and charcoal. For natural gas in gas engines, a higher EF is used than for boilers (see Honig et al., 2025). The CH_4 country-specific EF for residential gas combustion includes start-up losses, a factor mostly neglected by other countries. For N_2O, IPCC default EFs are used.

The IEF for CH_4 emissions from natural gas combustion in the residential sector (1A4bi) is the aggregate of the standard EF for gas combustion of 5.7 g/GJ plus the 35 g/GJ of total residential gas combustion that represents start-up losses. These occur mostly in cooking devices, but also in central heating and hot-water production devices. This results in an EF of 40.7 g/GJ. CH_4 emissions from start-up losses are six times higher than the CH_4 combustion emissions.

The IEF for CH_4 emissions from natural gas combustion in the agricultural sector (1A4ci) is an average of the EF gas engines and other stationary combustion. The increased use of internal combustion engines in CHP plants operating on natural gas has increased the IEF for methane in this category, as these engines are characterised by high methane emissions.

Mobile combustion

- Emissions from fisheries (1A4ciii) are calculated on the basis of IPCC Tier 2 methodologies. Fuel use data is combined with country-specific EFs for CO_2. CH_4 and N_2O emissions from fisheries are derived using a Tier 1 methodology. The EFs are presented in Table 2.2B of the tables annex to Witt et al. (2025).
- Fuel consumption by NRMM is derived from the Energy Balance, which in turn uses the output of the EMMA model (Dellaert et al., 2023). CO_2 emissions from NRMM are estimated using a Tier 2 methodology (for the EF). Country-specific heating values and CO_2 EFs are used, as for road transport.
- CH_4 and N_2O emissions from NRMM are estimated using a Tier 3 methodology, using country-specific EFs. CH_4 EFs are presented in table 9.6 of the tables annex to Witt et al. (2025).

Table 3.20 Overview of methods used for the calculation of emissions for NRMM and fisheries

CRT code	Source category description	Method	EF
1A2gvii	Industry and construction	T2, T3	CS
1A4aii	Commercial/institutional	T2, T3	CS
1A4bii	Residential	T2, T3	CS
1A4cii	Agriculture/Forestry	T2, T3	CS
1A4ciii	National Fishing	T1, T2	CS, D

CS: Country-specific, D: Default

General

For 2023, more than 99% of the CO_2 emissions in 1A4 were calculated using country-specific EFs (mainly natural gas). The remaining (less than) 1% of CO_2 emissions were calculated by means of default IPCC EFs. These consist mainly of emissions from other kerosene.

An overview of the IEFs used for the most important fuels (up to 95% of the fuel use) in *Other sectors (1A4)* is provided in Table 3.21.

Table 3.21 Overview of IEFs used for the most important fuels (up to 95% of fuel use) for the year 2023 in Other sectors (1A4)

Fuel	Amount of fuel used in 2023 (TJ NCV)	IEFs (g/GJ)		
		CO_2 (x 1000)	N_2O	CH_4
Natural gas	386,578	56.3	0.1	117.7
Gas / Diesel oil	26,169	72.5	1.9	2.2
Solid biomass	23,192	113.7	4.1	179.4

Explanations of the IEFs
- Natural gas: The standard CH_4 EF for natural gas is 5.7 g/GJ. Only for gas engines is a higher EF used (due to gas slip), which explains the higher EF for this sector.
- Gas/diesel oil: Gas/Diesel oil is used in stationary and mobile combustion for which different EFs for CH_4 and N_2O are used.
- Solid biomass: The implied CO_2 EF for solid biomass consists of a combination of wood combustion with an EF of 112 kg/GJ and solid biomass combustion with an EF of 109.6 kg/GJ. The implied CH_4 EF for solid biomass consists of a combination of residential wood combustion (with an EF of 140 g/GJ) and wood combustion in the services and agricultural sector (with an EF of 300 g/GJ).

Trends in the IEFs for most sectors can be explained by the composition of fuels used in that sector. The largest fluctuations are visible in the CH_4 EF for gaseous fuels. This is caused by the difference in CH_4 EF used for natural gas combusted in gas engines (ranging between 250 and 450 g/GJ) and the CH_4 EF used for natural gas combusted in other plants (5.7 g/GJ). Figure 3.14 shows the trend in natural gas combusted in gas engines and in other plants. The increase between 2005 and 2010 can be explained by the increased installation of gas engines in the agricultural sector in that period.

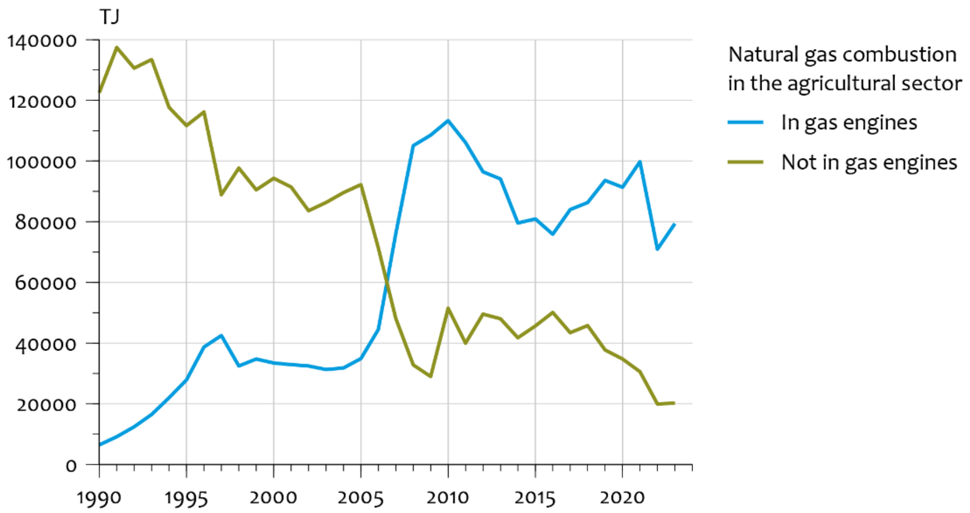


Figure 3.14 Trend in natural gas consumption in gas engines (with a relatively high emission factor) and other engines (with a relatively low emission factor) in the agricultural sector, 1990–2023

3.2.7.3 Uncertainty assessment and time-series consistency

Uncertainty assessment

The uncertainty in total CO_2 emissions from this source category is approximately 5%, with uncertainty concerning the composite parts of approximately 5% for the Residential category, 10% for the Agriculture category, and 10% for the Services category (see Annex 2 for more details).

The uncertainty in the gas consumption data is similarly estimated at 5% for the Residential category, 10% for Agriculture, and 11% for the Services category. An uncertainty of 34% is assumed for liquid fuel use in the Services and Residential category. Since the uncertainty in small values in national statistics is generally greater than in larger values, as indicated by the high interannual variability of the data, the uncertainty in solid fuel consumption is estimated to be even higher, i.e. 36%.

For natural gas, the uncertainty in the CO_2 EF is estimated at 0.25% on the basis of the fuel quality analysis reported by Heslinga and Van Harmelen (2006) and discussed in Olivier et al. (2009). To the CO_2 EFs for liquids and solids, uncertainties of 2% and 10% respectively have been assigned. The uncertainty in the CH_4 and N_2O EFs is estimated to be much higher (50-100%).

As most of the fuel consumption in this source category is used for space heating, consumption has varied considerably per year due to variations in winter temperatures. For trend analysis, a method is used to correct the CO_2 emissions from gas combustion (the main fuel for heating purposes) for the varying winter temperatures. This involves the use of the number of 'heating degree days' under normal climate conditions, which is determined by the long-term trend, as explained in Visser (2005).

The uncertainty in activity data for NRMM is estimated to be 10-30% for all fuels as reported in Table 2.5 of the tables annex to Witt et al. (2025). The uncertainty in the EFs is estimated to be 2% for CO_2 (all fuels): 50%/+300% for N_2O and -40%/+250% for CH_4. The CO_2 estimate was assumed to be equal to the estimate for road transport fuels, which in turn was based on expert judgement. The estimates for CH_4 and N_2O were derived from the 2006 IPCC Guidelines.

Time-series consistency

Emissions from stationary energy combustion are calculated from the energy statistics combined with country-specific EFs (at the beginning of the time series) or from a combination of company-specific and country-specific EFs (at the end of the time series). Time series consistency is ensured for EFs and activity data: The country-specific EFs are based on company-specific data. Company-specific data from the most relevant companies in a number of years has been used to calculate an average country-specific EF. As the same information is used to calculate both the country-specific EF and the company-specific EFs, the EFs are consistent for the complete time series.
Energy statistics are consistent for the complete time series, as these are derived from the same data source (Statistics Netherlands).

3.2.7.4 Category-specific QA/QC and verification

Trends in CO_2 emissions from the three sub-categories were compared to trends in related activity data: number of households, number of people employed in the services sector, and the total surface area of heated greenhouses. Large annual changes were identified and explanations were sought (e.g. interannual changes in CO_2 emissions, by calculating temperature-corrected trends to identify the anthropogenic emissions trends). The trend tables for the IEFs were then used to identify large changes and large interannual variations at the category level, for which explanations were sought and included in the NIR. Changes in the IEF are mainly due to changes in the type of fuel used. Furthermore, the IEFs of individual fuels are also compared to the default emission factors, and deviations from the standard EFs are explained in the NIR. More details on the validation of the energy data can be found in section 2.1 of Honig et al. (2025).

NRMM data and model

Significant effort was invested in recent years into checking and verification of NRMM modelling and outcomes.

As of 1 January 2022, all vehicles, including mobile machinery, that access the public road with a speed above 6 km/h must be registered in a national database and obtain a licence plate, similar to the existing registration of passenger cars and other road transport vehicles. This public database, maintained by the RDW (Dienst Wegverkeer, an administrative body of the Dutch government), can be queried and makes available a relatively complete overview of the Dutch NRMM fleet, which was notably lacking before. As the registry contains information on machine type, fuel type, and date of entry, this allows a further comparison with and validation of the modelled machine fleet, resulting in continuous updates to the model, especially to the estimated machine sales for some machinery types (see section 3.2.7.5.).

The modelled diesel usage for NRMM has been compared to a time series of ‘red diesel’ sales in the Netherlands between 1990 and 2012, compiled by Statistics Netherlands. Over this period, a separate excise duty rate for diesel sales to NRMM existed, providing a reference value for comparison with the model outcome. After implementing the model improvements discussed in section 3.2.7.5., the modelled diesel usage correlates slightly better with the available diesel sales statistics. For the 2009-2011 period, following the economic crisis, the model appears to underestimate the effect of the crisis and overestimates the diesel usage by 15-20%, compared to the sales statistics, indicating that further model improvements may be needed.

3.2.7.5 Category-specific recalculations

Stationary combustion

The energy statistics have been improved for the period 2015-2022, including updates for natural gas and biogenic natural gas. Furthermore, LPG statistics have been updated in 1A4ai (1990-2022), resulting in an increase in CO_2 emissions in 1A4ai of 80.04 Gg in 1990-2014, 105.34 Gg in 2015 and 124.38 Gg in 2022.

The changes in energy statistics (including the other small changes) resulted in the following changes in emissions (in Gg for fossil and biogenic emissions together):

1A4ai	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
CO_2 (incl biomass)	105.471	109.497	106.930	109.589	107.971	110.207	138.906	106.662
CH_4	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002
N_2O	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

1A4bi	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
CO_2 (incl biomass)	0.107	-0.014	0.054	-0.014	-0.025	-0.017	0.035	0.013
CH_4	0.000	-0.000	0.000	-0.000	-0.000	-0.000	0.000	0.000
N_2O	0.000	-0.000	0.000	-0.000	-0.000	-0.000	0.000	-0.000

1A4ci	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
CO_2 (incl biomass)	0.002	-0.000	0.001	-0.000	-0.001	-0.106	-2.788	-53.299
CH_4	0.000	-0.000	-0.000	-0.000	-0.000	-0.179	-0.000	-0.044
N_2O	0.000	-0.000	0.000	-0.000	-0.000	-0.000	-0.000	-0.001

Non-road Mobile Machinery
Several updates have been implemented into the model and the input data:

1. For several machine types, previous rough estimates of the historical machine sales have been improved by analysing the size and composition (incl. construction year) of the current fleet for these machines, as registered in the RDW database on NRMM (see section 3.2.7.4.). This is a continuous effort with additional machine types being updated every year.
2. A new diesel consumption total for agriculture has been provided by Wageningen Economic Research for the year 2022, resulting in a substantial increase in 1.4 PJ of diesel in sector 1A4cii and also resulting in a reallocation of diesel in the energy statistics, resulting in a decrease of diesel for heavy-duty trucks (1A3biii).
3. A correction in the economic output of the construction sector in 2021 resulted in an increase of 1.3 PJ of diesel consumption for NRMM in manufacturing industries and construction sector (1A2gvii). This has also led to a reallocation of diesel in the energy statistics and a decrease of diesel for heavy duty trucks (1A3biii).

The changes that are described result in a small increase of gasoline consumption and related emissions over the full time series. Also, there was a small decrease in the diesel consumption over the period 1990 – 2015, and an increase for the years 2021 and 2022.

The energy statistics were updated to report gasoline and LPG sales to NRMM separately in the years from 2015 onwards by using the data from the NRMM model as described before. Since the data from the NRMM model were already assumed, this does not lead to changes in emissions from NRMM. For the years 1990-2014, the gasoline and LPG sales to NRMM are not reported separately in the energy statistics and the NRMM model data are used. Gasoline for NRMM is in the energy statisticsincluded in the road traffic category in these years. For sales to NRMM, therefore the model data are still used for that period and gasoline sales to road vehicles in 1990-2014 are adjusted accordingly. This is not the case for LPG, where the allocation of LPG in the energy statistics still have to be adjusted.

Diesel sales to NRMM are recorded as such in the energy statistics. For diesel sales to NRMM in Agriculture (1A4c.ii) and Construction industry (1A2g.vii) the data from the energy statistics are used, which are the same as in the NRMM model. For NRMM in Industry (also part of 1A2g.vii), the data from the NRMM model is used. The difference between this and the diesel sales data in the energy statistics for NRMM in Industry (1A2g.vii) is attributed to diesel sales to NRMM in Commercial/Institutional (1A4a.ii) in order to be in accordance with the Energy Balance for the total sales of diesel to NRMM.

For a small fraction of diesel sales in the energy statistics, the allocation to mobile or stationary use is unreliable. From now on, all sales in the energy statistics that are marked as mobile use are included here. A detailed description of the methodology currently used for calculating GHG emissions for NRMM is provided in chapter 2 of Witt et al. (2025).

As mentioned before, the activity data on NRMM has been updated. This resulted in the following changes in CO_2 emissions (in Gg):

CO_2	1990	2000	2005	2010	2015	2020	2022
Total	-3,47	-8.99	-2.90	-1.93	44.57	62.54	141.56
1A2gvii	-105.05	-152.54	-86.51	-34.80	-0.16	26.17	17.29
1A4aii	99.31	141.14	81.23	30.74	36.35	21.77	20.82
1A4bii	0.00	0.00	0.00	0.00	0.03	0.18	0.26
1A4cii	2.26	2.42	2.38	2.12	8.35	14.43	103.20

3.2.7.6 Category-specific planned improvements

No category-specific improvements for stationary combustion have been planned.

As a major new source of information on the NRMM fleet has become available in 2022 (see section 3.2.7.4), additional analysis of the new RDW registry is likely to result in further updates and model improvements in the NRMM calculation.

3.2.8 Other (1A5)

3.2.8.1 Category description

Source category 1A5 (Other) consists of emissions from military aviation and navigation (in 1A5b); see Table 3.22. This sector has no key categories.

Table 3.22 Overview of emissions in the sector Other (1A5) in the base year and the last two years of the inventory (in Tg CO2 eq.). The middle column shows the change (%) of the last year of the inventory compared to the base year. On the right side of the table, the contribution of the last year inventory's emissions of the category to the sector, to the total national emissions of the specific gas and to the total national emissions (in CO2 eq) are provided.

Sector/category	Gas	1990	2022	2023	2023 vs 1990	Contribution of the category in 2023 (%) to the		
		Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
1A5 Other	CO_2	0.3	0.2	0.2	-28.6%	0.2%	0.2%	0.2%
	CH_4	0.0	0.0	0.0	-36.8%	0.0%	0.0%	0.0%
	N_2O	0.0	0.0	0.0	-36.0%	0.0%	0.0%	0.0%
	All	0.3	0.2	0.2	-28.7%	0.2%	0.2%	0.2%

3.2.8.2 Methodological issues

A country-specific top-down (Tier 2) method is used for calculating the emissions from fuel combustion from military aviation and navigation. Activity data for both aviation and navigation is derived from the National Energy Statistics and comprises all fuel delivered for military aviation and navigation purposes within the Netherlands, including fuel deliveries to militaries of other countries; the EFs are presented in Table 3.23. The CO_2 EFs were derived from the Ministry of Defence, whereas the EFs for N_2O and CH_4 were derived from Hulskotte (2004).

Table 3.23 Emission factors used for military marine and aviation activities.

Category		CO_2	CH_4	N_2O
Military ships	EF (g/GJ)	75.250	2.64	1.87
Military aviation	EF (g/GJ)	72.900	10.00	5.80
Total	Emissions in 2023 (Gg)	224	0.02	0.01

Source: Hulskotte (2004)

3.2.8.3 Uncertainty assessment and time-series consistency

Uncertainty assessment

The uncertainty in total CO_2 emissions from this source category is approximately 6%. Uncertainties for CH_4 and N_2O emissions from this category are substantially higher: 83% for CH_4 and 123% for N_2O.

Time-series consistency

Emissions from energy combustion are calculated from the energy statistics combined with country-specific EFs. This method and the source of activity data and emission factor is the same for the complete time series.

3.2.8.4 Category-specific QA/QC and verification
The source category is covered by the general QA/QC procedures discussed in Chapter 1.

3.2.8.5 Category-specific recalculations
Activity data has been updated for military ships and aviation in 2015-2022. This resulted in changes of less than 0.001% (varying between –0.00014 Gg in 2020 and +0.00082 Gg in 2015).

3.2.8.6 Category-specific planned improvements
No category-specific improvements have been planned.

3.3 Fugitive emissions from fuels; oil and natural gas and other emissions from energy production (1B)

This source category includes fuel-related emissions from non-combustion activities in the energy production and transformation industries and comprises two categories:

- 1B1 Solid fuels (coke manufacture);
- 1B2 Oil and gas (production, gas processing, hydrogen plant, refineries, transmission, distribution).

The following categories are key categories:

1B2	Fugitive emissions from oil and gas operations	CO_2
1B2c	Venting and flaring	CH_4

Table 3.24 shows that total GHG emissions in 1B decreased from 3.2 Tg CO_2-eq to 1.5 Tg CO_2-eq between 1990 and 2023.

Table 3.24 Overview of emissions in the Fugitive emissions from fuels sector (1B) in the base year and the last two years of the inventory (in Tg CO_2 eq.). The middle column shows the change (%) of the last year of the inventory compared to the base year. On the right side of the table, the contribution of the last year inventory's emissions of the category to the sector, to the total national emissions of the specific gas and to the total national emissions (in CO_2 eq) are provided.

Sector/category	Gas	1990	2022	2023	2023 vs 1990	Contribution of the category in 2023 (%) to the		
		Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
1B Fugitive emissions from fuels	CO_2	0.9	1.1	1.0	17.4%	1.0%	0.9%	0.7%
	CH_4	2.3	0.5	0.5	-78.9%	0.4%	2.6%	0.3%
	All	3.2	1.6	1.5	-52.2%	1.4%		1.0%
1B1. Solid fuels transformation	CO_2	0.1	0.1	0.1	-40.3%	0.1%	0.1%	0.0%
	CH_4	0.0	0.0	0.0	-59.8%	0.0%	0.0%	0.0%
1B2. Oil and Natural Gas and Other Emissions from Energy Productions	CO_2	0.8	1.0	1.0	25.6%	0.9%	0.8%	0.7%
	CH_4	2.3	0.5	0.5	-79.0%	0.4%	2.6%	0.3%

3.3.1 Solid fuels (1B1)

3.3.1.1 Category description

Both CO_2 and CH_4 emissions in this source category are only a small part of the national totals. Fugitive emissions from this category relate to coke manufacture and charcoal production.

- Coke manufacture: The Netherlands currently has only one coke production facility at the Tata Steel iron and steel plant. A second independent coke producer in Sluiskil discontinued its activities in 1999.
- Charcoal production: In the past, another emission source in this category was the production of charcoal. The decrease in CH_4 emissions throughout the time series is explained by changes in charcoal production. Until 2009, the Netherlands had one large charcoal production location that served most of the Netherlands, and it also had a large market share in neighbouring countries. Production at this location stopped in 2010.

3.3.1.2 Methodological issues

Charcoal production

The following EFs have been used: 1990–1997: 0.03 kg CH_4/kg charcoal (IPCC 2006 Guidelines) and 1998–2010: 0.0000111 kg CH_4/kg charcoal (Reumermann and Frederiks, 2002). This sharp decrease in EF was applied because the operator changed from a traditional production system to the Twin Retort system (with reduced emissions). More background information can be found in section 2.2.3.1 of the annex 'Methodology for the Calculation of Emissions to Air from the Sectors Energy, Industry and Waste' by Honig et al. (2024).

Coke production

To calculate emissions of CH_4 from coke production, the standard IPCC value of 0.1 g CH_4 /ton of coke produced is used.

CO_2 emissions related to transformation losses from coke ovens form only a relatively small part of the total emissions from the iron and steel industry in the Netherlands. Emission totals for the iron and steel industry can be found in section 3.2.5. The figures for emissions from transformation losses were originally based on national energy statistics of coal inputs and of coke and coke oven gas produced, from which a carbon balance of the losses was calculated. Any non-captured gas was by definition included in the net carbon loss calculation used for the process emissions. Because of uncertainty in the large input and output volumes of the coke oven, the amount of fugitive emissions calculated by means of the mass balance method was unrealistically high. Therefore, the method has been changed and the CO_2 EF for fugitives is determined on the basis of the conservative assumption that about 1% of coke oven input is lost in the form of fugitive emissions.

For category 1B1, the production of coke oven coke registered by Statistics Netherlands is reported in the CRT. Detailed information on activity data and EFs can be found in the annex titled 'Methodology for the Calculation of Emissions to Air from the Sectors Energy, Industry and Waste' by Honig et al. (2025).

3.3.1.3 Uncertainty assessment and time series consistency

Uncertainty assessment

The uncertainty in annual CO_2 emissions from coke production (included in 1B1b) is estimated to be about 15%. This uncertainty relates to the conservative assumption of the carbon losses in the conversion from coking coal to coke and coke oven gas. The uncertainty in annual CH_4 emissions from coke production and charcoal production is estimated to be about 10%.

Time-series consistency

The methodology used to estimate emissions from solid fuel transformation is consistent throughout the time series.

3.3.1.4 Category-specific QA/QC and verification

These source categories are covered by the general QA/QC procedures discussed in Chapter 1.

3.3.1.5 Category-specific recalculations

No recalculations have been performed.

3.3.1.6 Category-specific planned improvements

No improvements have been planned.

3.3.2 Oil and natural gas (1B2)

3.3.2.1 Category description

Emissions from oil and natural gas comprise:

- emissions from oil and gas exploration, production, processing, flaring and venting (CO_2, CH_4, N_2O);
- emissions from oil and gas transmission (CO_2, CH_4, N_2O);
- emissions from gas distribution networks (pipelines for local transport) (CO_2, CH_4);
- emissions from oil refining (CH_4);
- emissions from hydrogen plants (CO_2).

Note that:

- Combustion emissions from oil and gas exploration and production are reported under 1A1c.
- Fugitive emissions from gas and oil exploration and production are included in fugitive emissions from combined venting and flaring (1B2c).
- CO_2 and N_2O combustion emissions from gas transmission are included in 1A3ei (Pipeline transport gaseous fuels). CO_2 process emissions and CH_4 emissions from gas transmission can be found in 1B2biv (Gas transmission and storage).
- CO_2 and CH_4 emissions from oil pipelines are included in 1B2aiii (Oil transport). This is consistent with the 2006 IPCC Guidelines.
- Fugitive CO_2 emissions from refineries are included in the combustion emissions reported in category 1A1b, as the fugitive emissions cannot be separated from the total emissions reported under 1A1b. Fugitive CH_4 emissions from refining can be found in 1B2aiv.
- Process emissions of CO_2 from a hydrogen plant of a refinery (about 0.9 Tg CO_2 per year) were reported in 1B2aiv. As refinery data specifying these fugitive CO_2 emissions has been available

from 2002 onwards (environmental reports (AER) from the plant), these emissions have been re-allocated from 1A1b to 1B2aiv.

- Due to the Dutch emission regulation for VOCs all possible sources included in 1B2av Distribution of oil products are equipped with abatement measures to capture fugitive emissions. There are no emission factors of CH_4 and CO_2 for this category in the IPCC guidelines and therefore these emissions are considered 'not applicable' (NA) and activity data is considered 'not estimated' (NE).
- There are no relevant emissions expected in the Netherlands in categories 1B2avi Other, 1B2bvi Other, and 1B2d Other, which all have the notation key 'not occurring' (NO).

Gas production and gas transmission vary according to demand: in cold winters, more gas is produced. The gas distribution main lines network was gradually expanding as new housing estates were being built, but is now stabilised at around $125*10^3$ km. PVC and PE are mostly used as materials for this expansion, replacing cast iron pipelines (see Honig et al., 2025 chapter 2.4).
The IEF for gas distribution has gradually decreased as the proportion of cast iron pipelines decreased due to their gradual replacement and the expansion of the network. Their present share of the total is less than 2%; in 1990, it was 10%. See the Methodological issues of Gas distribution in section 3.3.2.2.

Since the 1990's, CO_2 and CH_4 emissions from oil and gas production, particularly from flaring and venting, have been significantly reduced. This is due to the implementation of environmental measures to reduce venting and flaring, such as using formerly 'wasted' gas for energy production purposes.

3.3.2.2 Methodological issues

Oil and gas exploration, production, processing, flaring, and venting
Country-specific methods comparable to the IPCC Tier 3 method are used to estimate emissions of fugitive CH_4 and CO_2 from Oil and gas exploration, production and processing, and from venting and flaring (1B2). Each operator uses its own detailed installation data to calculate emissions and reports those emissions and fuel uses in aggregated form in its electronic AER (e-AER). Activity data is obtained from national energy statistics as a proxy and reported in the CRT tables. The data in the statistics can be adjusted retrospectively (changes in definitions/ allocation) and these changes will show up in the CRT tables.

Gas distribution
Since 2004, the gas distribution sector has annually recorded the number of leaks found per material of the pipelines, with detailed information on pipeline length per material. A roughly five-yearly survey of leakages per length, material, and pressure range is conducted, covering the entire length of the grid. Total CH_4 emissions in m^3 are obtained from the Methane Emission from Gas Distribution (*Methaanemissie door Gasdistributie*) annual reports, commissioned by Netbeheer Nederland (Association of Energy Network Operators in the Netherlands) and compiled by KIWA (KiWA, 2023). In the KIWA annual

reports, the CH_4 emissions in m^3 are calculated using a bottom-up method that complies with the Tier 3 methodology described in the 2006 IPCC Guidelines, chapter 4. The IPCC Tier 3 method for calculating CH_4 emissions from gas distribution due to leakages (1B2bv) is based on country-specific EFs calculated from leakage measurements for the main lines emissions . Based on in total 65 leakage measurements, the pipeline material mix in 2013, and the results of the leakage survey, three EFs were calculated: 323 m^3 CH_4 per km of pipeline for grey cast iron, 51 m^3 CH_4 per km of pipeline for other materials with a pressure of <=200 mbar, and 75 m^3 CH_4 per km of pipeline for other materials with a pressure of >200 mbar.
From the NIR 2025 submission on the emissions of 1.B.2.b.v. Gas distribution are improved as a result of monitoring and improvement actions from the six Dutch gas distribution companies in the Oil and Gas Methane Partnership (OGMP). The method of estimating the methane emissions of the main lines is used by the separate companies and ongoing investigations resulted in additional emission estimates of emissions from methane (e.g. systematic review of leaks of service pipelines, 3rd party damage of main pipelines and 3rd party damage of service pipelines). To create new time series the overlap splicing technique from the IPCC Guidelines was used. This technique can be found in Guidebook chapter 5 Times series consistency, section 5.3.3.1. Overlap data were made available for the period 2018-2023 and recalculation took place for the years 1990-2017 Details of methodologies, data sources and country-specific source allocation issues are provided in section 2.4 of the ENINA methodology report (Honig et al., 2025).

Oil and gas transmission
Emissions of CO_2 and CH_4 due to the transmission of natural gas (1B2biv) are obtained from the VG&M ('*safety, health and environment*') part of the NV Nederlandse Gasunie annual reports. The emissions of CO_2 presented in the annual reports are considered to be combustion emissions and are therefore reported under IPCC category 1A3ei (gaseous). Additionally, to give a complete overview of emissions, the amount of fugitive CO_2 emissions from gas transmission is calculated using the Tier 1 method with the new default IPCC EF of 8.8 E-7 Gg/106 m^3 of marketable Gas, adopted from the 2006 IPCC Guidelines, Chapter 4, Table 4.2.4. This figure has been applied to CRT category 1B2biv for the whole time series.

For the NIR 2016, emissions of methane from gas transmission were evaluated and improved. As a result of the implementation of Gasunie's LDAR (Leak Detection and Repair) programme, new emissions data for CH_4 became available. Leakages at larger locations, such as the thirteen compressor stations, were all fully measured. In addition, fugitive emissions of methane from each of those locations were added to the emissions in the year after the facilities came into operation. The adjustments of the CH_4 emissions for the smaller locations were based on measurements of a sample from those locations and added for the whole time series. These improvements have been implemented in all submissions from the NIR 2016 onwards.

The emissions of CO_2 and CH_4 from the transport of crude oil are calculated on the basis of the default TIER 1 IPCC emission factors (IPCC 2006, Table 4.2.4), which are converted from kg/m3 to kg/Gg for the situation in the Netherlands. For the activity data, the volume of crude oil transported through the Netherlands to Germany and Belgium, as reported annually by Statistics Netherlands, are used.

Oil refining and hydrogen plant
Fugitive emissions of CH_4 from refineries in category 1B2aiv are based on a 4% share in total VOC emissions reported in the refinery AERs (Spakman et al., 2003) and in recent years have been directly reported in these AERs. These show significant annual fluctuations in CH_4 emissions, as the allocation of the emissions to either combustion or process has not been uniform over time; for more information, see Honig et al. (2024). Also, process emissions of CO_2 from the only hydrogen factory of a refinery in the Netherlands are reported in category 1B2aiv. As Dutch companies are not obliged to report activity data, the AERs only include emissions.

The energy input of refineries from national energy statistics is taken as a proxy for activity data for this category and is reported in the CRT tables. The data in the statistics can be adjusted retrospectively (changes in definitions/allocation), and these adjustments will show up in the latest version of the CRT tables.

Detailed information on activity data and EFs of Oil and natural gas (1B2) can be found in chapter 2.4 of the annex titled 'Methodology for the Calculation of Emissions to Air from the Sectors Energy, Industry and Waste'; Honig et al. (2025).

3.3.2.3 Uncertainty assessment and time-series consistency

Uncertainty assessment
The uncertainty for flaring is based on expert judgement, estimated to be 50% for the activity data, 5% for the CO_2 emission factor and 50% for the CH_4 emission factor. The uncertainty for venting is estimated to be 50% for the activity data and 20% for the CO_2 and CH_4 emission factors.
For flaring, this uncertainty takes into account the variability in the gas composition of the smaller gas fields. For venting, it accounts for the high CO_2 content of the natural gas produced at some locations.

For CH_4 from gas transport and gas distribution, the uncertainty in the emissions is estimated to be 40% and 50%, respectively. This uncertainty refers to the limited number of actual leakage measurements for various types of materials and pressures, on which the Tier 3 methodology for methane emissions from gas distribution is based.

For CH_4 from oil refining and oil transport, the uncertainty is estimated to be 100% for both sources.

Time-series consistency
A consistent methodology is used to calculate emissions throughout the time series, relying on, among others, national energy statistics.

3.3.2.4 Category-specific QA/QC and verification
The source categories are covered by the general QA/QC procedures discussed in Chapter 1.

3.3.2.5 Category-specific recalculations
As a result of the Oil and Gas Methane partnership (OGMP) new data have become available for the methane emission of Gas distribution category 1.B.2.b.v. The recalculations resulted in the following changes in emissions of (in kton, rounded to two decimal places):

1.B.2.b.v	**1990**	**2010**	**2018**	**2019**	**2020**	**2021**	**2022**
CH_4	+ 4.47	+ 4.67	+4.24	+4.30	+4.37	+4.15	+3.42

The above recalculations resulted in the change of the CH_4 emissions of all years of on average +76%.
Details are provided in section 2.4 of the ENINA methodology report (Honig et al., 2025).

3.3.2.6 Category-specific planned improvements
No improvements have been planned.

3.4 CO_2 transport and storage (1C)

Transport of combustion off-gases (containing CO_2) occurs from energy production facilities to nearby greenhouses to increase the CO_2 content of the greenhouse atmosphere (as a growth enhancer). The emissions from this activity are accounted for in the combustion emissions from the energy producers (1A1a and 1A1b).

In 2019, a methodology was developed to account for the carbon capture and usage of CO_2 (CCU) from waste incineration facilities. The methodology includes the various types of usage. In earlier years, the amount of carbon capture was insignificant and this amount is still low in 2023 less than 1 kton of CO_2 (fossil and biogenic) was captured and used in the production of bicarbonate. More information is included in section 3.2.4.2.

4 Industrial processes and product use (CRT sector 2)

Major changes in the Industrial processes and product use (IPPU) sector compared to the National Inventory Report 2024	
Emissions:	The total GHG emissions of the IPPU sector show a decrease (from 13.7 Tg CO_2-eq in 2022 to 13.0 Tg CO_2-eq in 2023). This was the result of a decrease in, amongst others, CO_2 emissions (-0.2 Tg) and N_2O emissions (-0.2 Tg CO_2-eq, mainly within category 2B (chemical industry).
Key categories:	No changes compared to the NIR 2024

4.1 Overview of the sector and background information

Emissions of GHGs in this sector include the following:
- all non-energy-related emissions from industrial activities (including construction);
- all emissions from the use of F-gases (HFCs, PFCs (incl. NF_3) and SF_6), including their use in other sectors;
- N_2O emissions originating from the use of N_2O in anaesthesia and as a propelling agent in aerosol cans (e.g. cans of cream).

Fugitive emissions of GHGs in the Energy sector (not related to fuel combustion) are included in IPCC category 1B (Fugitive emissions). Table 4.1 and Figure 4.1 present the trends in total GHG emissions from the IPPU sector.

In 2023, IPPU contributed 8.9% to total national GHG emissions (including LULUCF) in comparison to 11.5% in 1990. The sector is a major source of N_2O emissions, accounting for 7.1% of total national N_2O emissions in 2023, of which the major share (0.4 Tg CO_2-eq, or 6.3% of total N_2O emissions) came from category 2B (Chemical industry).

Table 4.1 Overview of emissions in the Industrial production and product use sector, in the base year and the last two years of the inventory (in Tg CO2 eq.). The middle column shows the change (%) of the last year of the inventory compared to the base year. On the right side of the table, the contribution of the last year inventory's emissions of the category to the sector, to the total national emissions of the specific gas and to the total national emissions (in CO2 eq) are provided.

Sector/category	**Gas**	**Key**	**1990**	**2022**	**2023**	**2023 vs 1990**	**Contribution of the category in 2023 (%) to the**		
			Emissions in Tg CO_2 eq			**%**	**sector**	**total gas**	**total CO_2 eq**
2. Total Industrial Processes	CO_2		12.0	11.7	11.3	-5.1%	86.8%	9.4%	7.7%
	CH_4		0.4	0.4	0.4	12.9%	3.2%	2.3%	0.3%
	N_2O		6.5	0.6	0.5	-92.7%	3.6%	7.1%	0.3%
	HFC		4.7	0.8	0.7	-85.3%	5.3%	100.0%	0.5%
	PFC		2.4	0.1	0.0	-98.3%	0.3%	100.0%	0.0%
	SF_6		0.2	0.1	0.1	-50.6%	0.8%	100.0%	0.1%
	All		26.1	13.7	13.1	-50.0%	100.0%		8.9%
2A. Mineral industry	CO_2		1.4	1.2	1.0	-32.2%	7.3%	0.8%	0.7%
2B. Chemical industry	CO_2		9.8	10.1	10.0	1.4%	76.3%	8.3%	6.8%
	CH_4		0.3	0.4	0.4	17.6%	2.8%	2.0%	0.2%
	N_2O		6.3	0.6	0.4	-93.4%	3.2%	6.3%	0.3%
	HFC	T	4.7	0.1	0.1	-98.3%	0.6%	11.9%	0.1%
	PFC		NO	0.01	0.01		0.0%	12.7%	0.0%
	All		21.1	11.2	10.8	-48.7%	82.9%		7.4%
2C. Metal Production	CO_2		0.5	0.0	0.0	-98.1%	0.1%	0.0%	0.0%
	PFC		2.4	NO	NO		0.0%	0.0%	0.0%
	All		2.8	0.0	0.0	-99.7%	0.1%		0.0%
2D. Non-energy products from fuels and solvent use	CO_2		0.2	0.4	0.4	103.1%	2.9%	0.3%	0.3%
	CH_4		0.0	0.0	0.0	146.1%	0.0%	0.0%	0.0%
	All		0.2	0.4	0.4	103.1%	2.9%		0.3%
2E. Integrated circuit or semiconductor	PFC	non key	0.02	0.04	0.04	60.9%	0.3%	87.3%	0.0%
2F. Product uses as substitutes for ODS	HFC		NO	0.6	0.6		4.6%	88.1%	0.4%

Sector/category	Gas	Key	1990	2022	2023	2023 vs 1990	Contribution of the category in 2023 (%) to the		
			Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
2G. Other	CO_2	non key	0.0	0.0	0.0	230.2%	0.0%	0.0%	0.0%
	CH_4	non key	0.1	0.1	0.1	-12.7%	0.4%	0.3%	0.0%
	N_2O	non key	0.2	0.1	0.1	-72.0%	0.4%	0.8%	0.0%
	SF_6		0.21	0.13	0.11	-50.6%	0.8%	100.0%	0.1%
	All		0.5	0.2	0.2	-54.9%	0.8%		0.1%
2H. Other process emissions	CO_2	non key	0.07	0.02	0.03	-63.0%	0.2%	0.0%	0.0%
Indirect CO2 emissions	CO_2	T	0.9	0.5	0.4	-52.8%	3.3%	0.4%	0.3%
National Total GHG emissions (incl. LULUCF)	CO_2		167.7	130.8	120.6				
	CH_4		36.5	18.6	18.4				
	N_2O		16.1	6.7	6.6				
	HFCs		4.7	0.8	0.7				
	PFCs		2.4	0.1	0.0				
	SF_6		0.2	0.1	0.1				
	All		227.5	157.0	146.4				

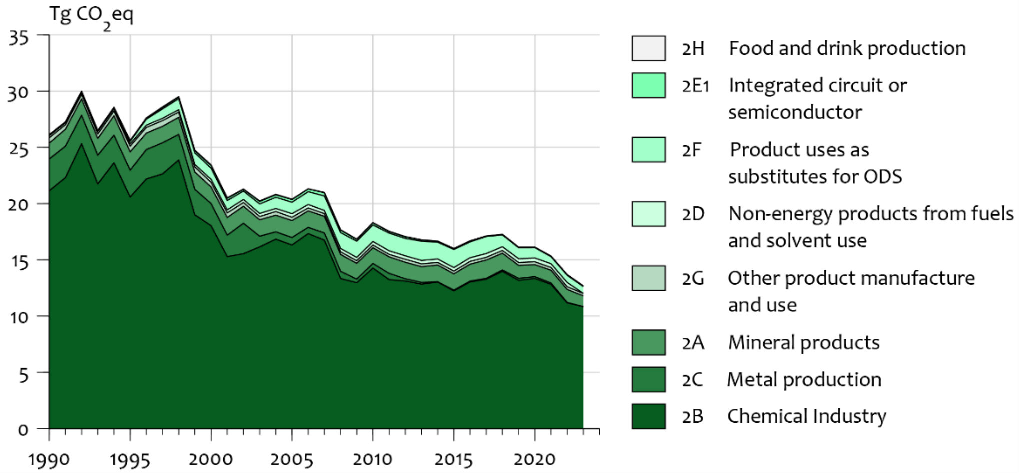


Figure 4.1 Sector 2 Industrial processes and product use – trends and emissions levels of source categories, 1990–2023

Figure 4.1 shows two major decreases in emissions in the chemical industry (2B):

- In 1999 a reduction in HFC-23 emissions from HCFC-22 production took place as a result of the installation of a thermal converter;
- In 2008 a sharp reduction in N_2O emissions took place as a result of applying catalytic reduction technologies in the production process of nitric acid. The installation of these technologies was a result of bringing this sector under EU-ETS regulation.

In the Netherlands, many industrial processes take place in one or two companies. Because of the sensitivity of data from these companies, only total emissions are reported, in accordance with the Aarhus Convention. Emissions at installation level and production data are treated as confidential unless a company has no objection to publication. All confidential information is, however, available for the inventory compilation, and the ENINA Task Force has direct access to it. ENINA can also provide this information to official review teams once they have signed a confidentiality agreement.

In response to review recommendation (E.2, 2022) and in line with the IPCC 2006 Guidelines (vol. 3, Chapter 1, box 1.1 and vol. 3, Chapter 3.9.4.2), the emissions from combustion of waste gases occurring within the same source category are allocated to CRT 2. This includes chemical waste gas and phosphor oven gas emissions from the chemical industry (reported in CRT 2B10).

The main categories (2A–H) in the IPPU sector are discussed in the following sections.

4.2 Mineral products (2A)

4.2.1 Category description

Table 4.2 presents the CO_2 emissions related to the sub-sectors in this category 2A.

Table 4.2 Overview of the sector Mineral Industry (2A), in the base year and the last two years of the inventory (in Tg CO_2 eq.). The middle column shows the change (%) of the last year of the inventory compared to the base year. On the right side of the table, the contribution of the last year inventory's emissions of the category to the sector, to the total national emissions of the specific gas and to the total national emissions (in CO_2 eq) are provided.

Sector/category	Gas	Key	1990	2022	2023	2023 vs 1990	Contribution of the category in 2023 (%) to the		
			Emissions in Tg CO2 eq			%	sector	total gas	total CO_2 eq
2A. Mineral industry	CO_2		1.4	1.2	1.0	-32.2%	7.3%	0.8%	0.7%
2A1. Cement production	CO_2	T	0.4	NO	NO		0.0%	0.0%	0.0%
2A2. Lime production	CO_2	non key	0.2	0.2	0.2	15.9%	1.4%	0.2%	0.1%
2A3. Glass production	CO_2	non key	0.1	0.1	0.1	-52.3%	0.5%	0.1%	0.0%

Sector/category	Gas	Key	1990	2022	2023	2023 vs 1990	Contribution of the category in 2023 (%) to the		
			Emissions in Tg CO2 eq			%	sector	total gas	total CO_2 eq
2A4a Ceramics	CO_2	non key	0.1	0.1	0.1	-25.5%	0.8%	0.1%	0.1%
2A4b Other uses of Soda Ash	CO_2	non key	0.1	0.1	0.1	50.1%	0.8%	0.1%	0.1%
2A4d Other	CO_2	L,T	0.5	0.6	0.5	2.5%	3.8%	0.4%	0.3%

Sector 2A comprises the following key categories:

2A1	Cement production	CO_2
2A2	Lime production	CO_2
2A4d	Other	CO_2

The following processes are included in 2A4a: production of bricks, roof tiles, floor tiles, wall tiles, vitrified clay pipes and refractory products, and other ceramic products. Process-related CO_2 emissions from ceramics originate from the calcination of carbonates in the clay.

CO_2 emissions from other process-uses of carbonates (2A4d) originate from:

- limestone use for flue gas desulphurisation (FGD);
- limestone and dolomite use in iron and steel production;
- dolomite consumption (mostly used for road construction).

4.2.2 *Methodological issues*

For all the source categories, the methodologies used to estimate emissions of CO_2 comply with the 2006 IPCC Guidelines, volume 3. More detailed descriptions of the methods and EFs used can be found in section 2.2.3.2 'Non-fossil process emissions' of the methodology report Honig et al. (2025).

2A1 (Cement clinker production)

Because of changes in raw material composition over time, it is not possible to reliably estimate CO_2 process emissions on the basis of clinker production activity data and a default EF. For that reason, the only cement producer in the Netherlands chose to base the calculation of CO_2 emissions on the carbonate content of the process input (Honig et al., 2025). Thus, process emission data was obtained from the company's AER until June 2020, when the company closed down. Since no cement production has taken place since, NO has been reported from the emission year 2021 onwards.

2A2 (Lime production)

CO_2 emissions occur in two plants in the sugar industry, where limestone is used to produce lime for sugar juice purification. The third plant was closed in 2008. Limestone use depends on the level of beet sugar production. Until 2016 this activity data was obtained from the

sugar company's annual reports. From 2017 on, one of the plants did not report this data anymore, therefore from that year on the total beet sugar production was taken from the sugar branch organization's annual yearly report. Approximately 375 kg of limestone is required for each ton of beet sugar produced (SPIN, 1992). The emissions are calculated using the IPCC default EF of 440 kg CO_2 per ton of limestone.
Lime production does not occur in the paper industry in the Netherlands.

2A3 (Glass production)
Until the 2015 submission, CO_2 emissions were based on plant-specific EFs and gross glass production; for the method, see Honig et al. (2025). From the 2015 submission onwards, the CO_2 figures have been based on the verified EU-ETS Emission Reports of the glass production companies.

2A4a (Ceramics)
The calculation of CO_2 emissions from the manufacturing process of ceramic products in the Netherlands complies with the Tier 1 method as described in the 2006 IPCC Guidelines, volume 3, Chapter 2, sect. 2.34.:
CO_2 emissions = Mc x (0.85EFls + 0.15EFd)

Where:
Mc = mass of carbonate consumed (tonnes);
0.85 = fraction of limestone;
0.15 = fraction of dolomite;
EFls = EF limestone (0.440 ton CO_2/ton limestone);
EFd = EF dolomite (0.477 ton CO_2/ton dolomite).

Based on Olivier et al (2009).
The mass of carbonate consumed (Mc) is determined as follows:

Mc = Mclay x cc

Where:
Mclay = amount of clay consumed, calculated by multiplying the national production data for bricks and roof tiles, vitrified clay pipes, and refractory products by the default loss factor of 1.1 from the 2006 Guidelines. National production data is obtained from the ceramics trade organisation.
cc = default carbonate content of clay (0.1), adopted from the 2006 Guidelines.

2A4b (Other uses of soda ash)
For 2001 and 2002, net domestic consumption of soda ash was estimated by taking the production capacity of 400 kton as a basis, then adding the import figures and deducting the export figures for the relevant year. For 1990–2000 and from 2003 onwards, these figures have been estimated by extrapolating from the 2001 and 2002 values. This extrapolation incorporates the trend in chemicals production as this is an important user of soda ash. Emissions are calculated using the standard IPCC EF of 415 kg CO_2 per ton of soda ash (Na_2CO_3) (2006 IPCC Guidelines, volume 3, Chapter 2, Table 2.1).

2A4d (Other)
This category consists of three components. CO_2 emissions are based on:

- *consumption of limestone for flue gas desulphurisation (FGD) in the coal-fired power plants:* emission data is obtained from ETS-reports;
- *limestone and dolomite use in crude steel production*: Tata Steel yearly reports this data, from which CO_2 emissions are calculated by using the IPCC emission factor (as described in Honig et al. (2025), section 2.2.3.2);
- *apparent dolomite consumption (mostly in road construction):* these emissions are calculated by means of the following formula: CO_2 emissions from dolomite use = (Total net dolomite use – Dolomite use in agriculture) * EF dolomite. Total net dolomite use is available until 2003 from Statistics Netherlands. It is assumed that the emissions by this sector have remained constant from 2004 onwards.

4.2.3 Uncertainty assessment and time-series consistency

Uncertainty assessment
The uncertainty analysis outlined in Annex 2 and presented in Table A2.3 provides the estimates of uncertainties per IPCC source category. Uncertainty estimates used in the Tier 1 analysis are based on expert judgement as no detailed information is available on the emissions reported by the facilities (cement clinker production, limestone and dolomite use, and soda ash production).

For the emission categories under 2A, uncertainties are in the range of 50-75%. This is mainly determined by the relatively high uncertainty in the emission factors, although for ceramics (2A4a) and lime production (2A2) the activity data is also relatively uncertain; 50% and 75%, respectively.

The uncertainties of the IPCC default EFs used for some processes are not assessed. However, as these are minor sources of CO_2, this absence of data has not been given any further consideration.

Time series consistency
Consistent methodologies have been applied to all source categories. The time series involves a certain amount of extrapolation with respect to the activity data for soda ash use and emissions data for glass production, thereby introducing further uncertainties in the earliest part of the time series for these sources.

4.2.4 Category-specific QA/QC and verification

The source categories are covered by the general QA/QC procedure discussed in Chapter 1.

4.2.5 Category-specific recalculations

A factor 1000 error in the 2022 CO_2 figure for 2A3 was corrected: 2022 emissions figure was reported 67 Gg too low in the previous submission.

4.2.6 Category-specific planned improvements

As asked by the TERT (I.5 in NIR 2024), for 2A4d the process emissions associated with mineral wool production will be included as per the 2006 IPCC Guidelines (vol. 3, chap. 2, p.2.27).

4.3 Chemical industry (2B)

4.3.1 Category description

The national inventory of the Netherlands includes emissions of GHGs from the following source categories reported in category 2B (Chemical industry):

- *Ammonia production (2B1): CO_2 emissions*: natural gas is used as feedstock for ammonia production. CO_2 is a by-product of the chemical separation of hydrogen from natural gas. During the process of ammonia (NH_3) production, hydrogen and nitrogen are combined and react together to form ammonia. N2O emissions from ammonia production in the Netherlands are covered by the EU-ETS.
- *Nitric acid production (2B2): N_2O emissions*: The production of nitric acid (HNO_3) generates N_2O, a by-product of the high-temperature catalytic oxidation of ammonia. Two companies are responsible for the N_2O emissions from nitric acid production in the Netherlands.
- *Caprolactam production (2B4a): N_2O emissions*: Caprolactam is produced in the Netherlands as part of the production cycle for nylon materials, and has been manufactured by one company since 1952. As a result, this emission source is responsible for all (100%) N_2O emissions by the caprolactam industry in the Netherlands. N_2O emissions from caprolactam production in the Netherlands are not covered by the EU-ETS.
- *Silicon carbide production (2B5a): CH_4 emissions*: petrol cokes are used during the production of silicon carbide. The volatile compounds in the petrol cokes form CH_4.
- *Titanium dioxide production (2B6): CO_2 emissions*: these arise from the oxidation of coke used as a reductant.
- *Soda ash production (2B7): CO_2 emissions:* these are related to the non-energy use of coke.
- *Petrochemical and carbon black production (2B8): emissions:* For each subsector below one plant is present in the Netherlands:
  - methanol: CH_4 (2B8a);
  - ethylene: CH_4 (2B8b);
  - ethylene oxide: CO_2 (2B8d);
  - acrylonitrile: CO_2/CH_4/N_2O (Included in 2B10);
  - carbon black: CH_4 (2B8f).
- *Fluorochemical production (2B9):*
  - *by-product emissions – production of HCFC-22 (2B9a1): HFC-23 emissions:* Chlorodifluoromethane (HCFC-22) is produced at one plant in the Netherlands. Tri-fluoromethane (HFC-23) is generated as a by-product during the production of chlorodifluoromethane and emitted through the plant condenser vent;
  - *by-product emissions – other – handling activities (2B9b3): emissions of HFCs:* one company repackages HFCs from large units (e.g. containers) into smaller units (e.g. cylinders) and

trades in HFCs. Many companies import small units with HFCs and sell them in the trading areas.

- *Other (2B10): CO_2 emissions*:
  - *Industrial gas production:* Hydrogen and carbon monoxide are mainly produced from the use of natural gas as a chemical feedstock. During the gas production process, CO_2 is emitted.
  - *Carbon electrode production:* For the production of carbon electrodes, (petroleum) coke is used as a feedstock. During this process, CO_2 is emitted.
  - *Activated carbon production:* the Netherlands is home to one of world's largest manufacturers of activated carbon, for which peat is used as a carbon source, and CO_2 is a by-product.
- *Other (2B10):* CO_2, CH_4 and N_2O emissions:
  - Combustion emissions of waste gases (chemical waste gas and phosphor oven gas) occurring within the same category where the waste gases are produced (i.e. the chemical sector) have been reallocated from 1A2c to 2B10 in response to review recommendation (E.2, 2022) and in line with the IPCC 2006 Guidelines (vol. 3, Chapter 1, box 1.1 and vol. 3, Chapter 3.9.4.2). The IPCC 2006 Guidelines state that "Combustion emissions from fuels obtained directly or indirectly from the feedstock for an IPPU process will normally be allocated to the part of the source category in which the process occurs. These source categories are normally 2B and 2C.)". Therefore, all combustion emissions from chemical waste gas which are produced and combusted within the chemical sector have been reallocated from 1A2c to 2B10.
    - acrylonitrile: CO_2/CH_4/N_2O

Remarks:

- Adipic acid (2B3), glyoxal (2B4b), glyoxylic acid (2B4c) and calcium carbide (2B5b) are not produced in the Netherlands. As a result, the Netherlands does not report these emissions in the CRT under 2B.
- Many processes relating to this source category take place in only one or two companies. Because of the company data confidentiality requirements, emissions from 2B5 and 2B6 are included in 2B8g.

Overview of shares and trends in emissions

Table 4.3 gives an overview of the proportions of emissions from the main category Chemical Industry (2B). Emissions from this category contributed 9.3% of the total national GHG emissions (including LULUCF) in 1990 and 7.3% in 2023.

Table 4.3 Overview of the sector Chemical industry (2B), in the base year and the last two years of the inventory (in Tg CO_2 eq.). The middle column shows the change (%) of the last year of the inventory compared to the base year. On the right side of the table, the contribution of the last year inventory's emissions of the category to the sector, to the total national emissions of the specific gas and to the total national emissions (in CO_2 eq) are provided.

Sector/category	Gas	Key	1990	2022	2023	2023 vs 1990	Contribution of the category in 2023 (%) to the		
			Emissions in Tg CO2 eq			%	sector	total gas	total CO_2 eq
2B. Chemical industry	CO_2		9.8	10.1	10.0	1.4%	76.3%	8.3%	6.8%
	CH_4		0.3	0.4	0.4	17.6%	2.8%	2.0%	0.2%
	N_2O		6.3	0.6	0.4	-93.4%	3.2%	6.3%	0.3%
	HFC	T	4.7	0.1	0.1	-98.3%	0.6%	11.9%	0.1%
	PFC		NO	0.0	0.0		0.0%	12.7%	0.0%
	All		21.1	11.2	10.8	-48.7%	82.9%		7.4%
2B1. Ammonia production	CO_2	L	2.7	1.8	2.0	-26.6%	15.1%	1.6%	1.4%
2B2. Nitric acid production	N_2O	T	5.4	0.1	0.1	-98.7%	0.5%	1.0%	0.0%
2B4. Caprolactam production	N_2O	L	0.7	0.1	0.1	-90.0%	0.5%	1.0%	0.0%
2B7. Soda ash production	CO_2	non key	0.1	NO	NO		0.0%	0.0%	0.0%
2B8. Petrochemical and carbon black production	CO_2	L,T	0.3	0.5	0.5	44.4%	3.7%	0.4%	0.3%
	CH_4		0.3	0.4	0.4	17.3%	2.7%	1.9%	0.2%
2B9. Fluorochemical production	HFC	T	4.7	0.1	0.1	-98.3%	0.6%	11.9%	0.1%
	PFC		NO	0.0	0.0		0.0%	12.7%	0.0%
2B10. Other chemical industry	CO_2	L,T	6.7	7.7	7.5	11.4%	57.4%	6.2%	5.1%

This sector comprises the following key categories:

2B	Fluorochemical production	HFC
2B1	Ammonia production	CO_2
2B4	Caprolactam production	N_2O
2B2	Nitric acid production	N_2O
2B8	Petrochemical and carbon black production	CO_2
2B8	Chemical industry: Petrochemical and carbon black production	CH_4
2B10	Other	CO_2
2B10	Other	N_2O

Figure 4.2 shows the trend in CO_2 equivalent emissions for category 2B (Chemical industry) in the 1990–2023 period.

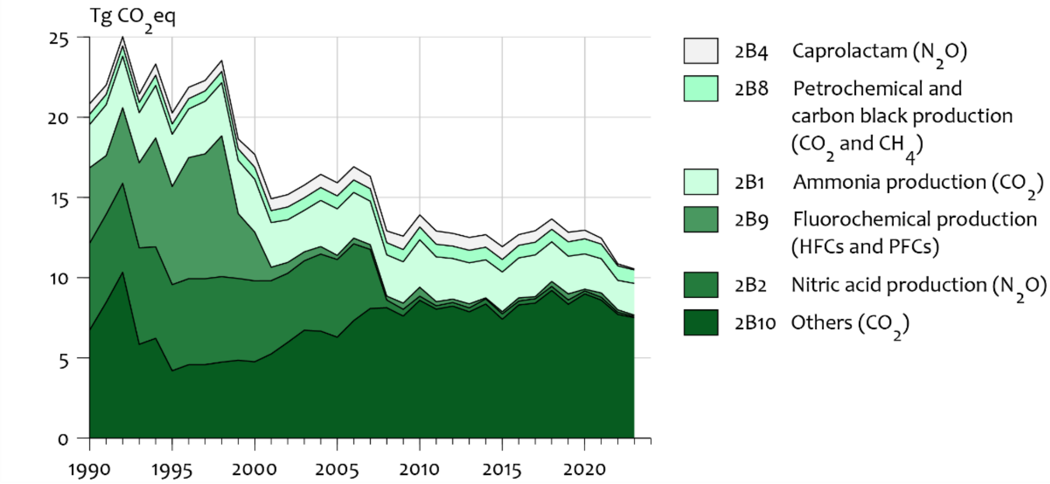


Figure 4.2 2B Chemical industry – trend and emissions levels of source categories, 1990–2023

Mainly due to a reduction in HFC-23 emissions from HCFC-22 production (by implementation of a thermal convertor in 1998), total GHG emissions from 2B (Chemical industry) decreased between 1990 and 2001. Between 2001 and 2007, total GHG emissions from 2B also remained stable. As Figure 4.2 (above) and Table 4.4 (below) show, the main decrease in N_2O emissions took place in 2008 as a result of a reduction measure relating to the production of nitric acid. From 2008 onwards, this process has been brought under EU-ETS. A major reduction was achieved by a change in the nitric acid production process. Since 2008, total GHG emissions from 2B have remained relatively stable.

Table 4.4 Trend in N_2O emissions from Chemical industry (2B) (Gg CO_2-eq)

Year	2B2 Nitric acid production	2B4a Caprolactam production	2B10 Acrylonitrile production	Total
1990	5411	658	217	6288
1991	5486	585	217	6290
1992	5539	577	221	6340
1993	6016	532	218	6767
1994	5698	697	231	6628
1995	5367	691	239	6298
1996	5353	706	246	6307
1997	5353	652	253	6260
1998	5327	688	260	6277
1999	5096	615	268	5981
2000	5042	803	275	6122
2001	4565	741	282	5591
2002	4301	770	289	5363
2003	4326	792	296	5417
2004	4802	819	304	5927
2005	4837	816	311	5967

Year	2B2 Nitric acid production	2B4a Caprolactam production	2B10 Acrylonitrile production	Total
2006	4784	824	318	5929
2007	3680	766	325	4775
2008	477	731	333	1544
2009	421	837	340	1600
2010	257	752	347	1360
2011	208	824	324	1358
2012	225	795	345	1369
2013	243	798	327	1372
2014	317	777	336	1432
2015	329	802	299	1433
2016	240	672	338	1253
2017	266	714	345	1328
2018	251	646	306	1206
2019	264	600	339	1206
2020	178	534	376	1091
2021	180	367	356	905
2022	134	124	309	570
2023	68	66	278	415

Nitric acid production (2B2)
Technical measures (optimising the platinum-based catalytic converter alloys), which were implemented at one of the nitric acid plants in 2001, resulted in an emissions reduction of 9% compared to 2000. During 2002–2006, the emissions fluctuations were caused by variations in production levels.

As mentioned above, technical measures (implemented at all nitric acid plants in the third quarter of 2007 resulted in an emission reduction of 23% compared to 2006. In 2008, the full effect of the measures was reflected in lower emissions; a reduction of 90% compared to 2006. The further reduction in 2009 was primarily caused by the economic crisis. Because of the closure of one of the plants and an improved catalytic effect in another, emissions decreased again in 2010. The reduction in 2011 was caused by an improved catalytic effect in two of the plants. After 2011, the fluctuations in N_2O emissions from the nitric acid plants were mainly caused by operating conditions (such as unplanned stops) and to a lesser extent by variations in production level.

In former NIRs (such as the 2020 NIR), all significant reduction measures for N_2O emissions from nitric acid production in 2007 and 2008 have been described, with details per plant.

Caprolactam production (2B4a) and Acrylonitrile production (2B8e)
As a result of government funding, a reduction measure was implemented in the caprolactam production plant in 2021, resulting in lower 2B4a emissions. Furthermore, the fluctuations in emissions from these sources are mainly caused by variations in production level.

Fluorochemical production (2B9)

Table 4.5 presents the trends in HFC emissions from the categories HCFC-22 production and HFCs/PFCs from handling activities during the 1990–2023 period. Emissions of HFC-23 increased by approximately 35% in the 1995–1998 period due to increased production of HCFC-22. However, in the 1998–2000 period, emissions of HFC-23 decreased by 69% following the installation of a thermal converter (TC) at the plant. The removal efficiency of the TC (kg HFC-23 processed in TC/kg HFC-23 in untreated flow/year) is the primary factor, and the production level is the secondary factor influencing the variation in emission levels between 2000 and 2008.

Due to the economic crisis, HCFC-22 production levels were much lower in the last quarter of 2008 and 2009, resulting in lower HFC-23 emissions. Following the economic recovery, the HCFC-22 production was much higher in 2010, resulting in higher HFC-23 emissions. After 2010, emission fluctuations are mainly caused by the fluctuations in the removal efficiency of the TC and to a lesser extent by the production level. The significant emission fluctuations in sub-category 2B9b3 (Handling activities) during the 1992–2022 period can be explained by the large fluctuations in handling activities, which depend on customer demand.

Table 4.5 Trends in HFC-23 by-product emissions from the production of HCFC-22 and HFC emissions from handling activities (2B9a and 2B9b) (Gg CO_2-eq)

Year	2B9a: HFC-23	2B9b3: HFCs	Total
1990	4697	0	4697
1991	3658	0	3658
1992	4687	25	4712
1993	5243	52	5295
1994	6653	131	6784
1995	6103	12	6116
1996	7299	248	7547
1997	7110	667	7777
1998	8257	517	8774
1999	3646	397	4043
2000	2566	470	3035
2001	726	112	837
2002	477	202	679
2003	440	116	556
2004	376	93	469
2005	208	44	252
2006	297	44	342
2007	257	28	285
2008	225	19	243
2009	163	126	289
2010	414	102	516

Year	2B9a: HFC-23	2B9b3: HFCs	Total
2011	176	41	217
2012	133	60	192
2013	199	35	234
2014	38	23	61
2015	99	29	127
2016	133	18	151
2017	85	25	110
2018	186	24	210
2019	229	101	329
2020	81	20	101
2021	216	29	245
2022	129	15	144
2023	59	23	82

4.3.2 Methodological issues

For all chemical industry source categories, the methodologies used to estimate GHG emissions

- 2B1 (Ammonia production): A method equivalent to IPCC Tier 3 is used to calculate CO_2 emissions from ammonia production in the Netherlands. The calculation is based on the consumption of natural gas and a country-specific EF. Data on the use of natural gas are obtained from Statistics Netherlands. Because there are only two ammonia producers in the Netherlands, the consumption of natural gas and the country-specific EF are confidential. Furthermore, according to the IPCC guidelines, CO_2 stored in urea is subtracted from the production emissions. Emissions occurring in the sectors where urea is applied (agriculture, car-SCR, melamine production), are allocated to those sectors. The CO_2 stored in urea is calculated by using production figures. As the Netherlands is a net exporter of fertilisers, the by far largest amount of the stored CO_2 is exported and emitted elsewhere by application. (CO_2 emission from melamine production is allocated to CRF category 2B8g.) The 2B1 emissions in the Netherlands are covered by the EU-ETS. For ETS, the CO_2-storage should *not* be subtracted from the production emissions.
- 2B2 (Nitric acid production): The emissions figures are based on data reported by the nitric acid manufacturing industry and are included in the emissions reports under EU-ETS and the national Pollutant Release and Transfer Register (PRTR). In the years before these were available, an IPCC Tier 2 method was used to estimate N_2O emissions.
- 2B4a (Caprolactam production): From 2015 onwards, N_2O emissions have been obtained from the company's AER. Results before 2015 were recalculated with the help of the insights provided by the updated and improved N_2O emissions measurement programme.

- 2B5 (Carbide production): The activity data (petcoke) (confidential) and the IPCC default EF are used to calculate CH_4 emissions.
- 2B6 (Titanium dioxide production): CO_2 emissions are taken from the company's AER.
- 2B7 (Soda ash production): the notation code 'NO' has been included in the CRT tables from 2010 onwards, as soda ash production has stopped. See Honig et al. (2025) for earlier years.
- 2B8 (Petrochemicals and carbon black production):
    - 2B8a: methanol, CH_4;
    - 2B8b: ethylene, CH_4;
    - 2B8f: carbon black, CH_4;
    - 2B8g: melamine production, CO_2.

      The CO_2 and CH_4 process emissions from these minor sources are calculated by multiplying the IPCC default EFs by the annual production figures from the AERs (Tier 1). The N_2O emissions from 2017 are taken from the company's AER. For the years before 2017 the emissions were recalculated with the help of the 2017 emission and production levels and the production levels that period
- 2B8d (Ethylene oxide production): CO_2 emissions are estimated on the basis of capacity data by using a default capacity utilisation rate of 86% (based on Neelis et al., 2005) and applying the default EF of 0.86 t/t ethylene oxide. From 2020 onwards, EU petrochemistry data has been used as a new source. As it is not possible to find current activity data for ethylene production in the Prodcom database from EUROSTAT, the Netherlands cannot supply activity data to verify this assumption. For reasons of confidentiality all above-mentioned sources of 2B8, 2B5 and 2B6 are included in 2B8g.
- 2B9a1 (production of HCFC-22): This source category is identified as a trend key source of HFC-23 emissions. Emission figures are obtained from the company's AER. This company determines the HFC-23 load in the untreated flow by a continuous flow meter in combination with an in-line analysis of the composition of the stream. The amount of HFC-23 destroyed in the Thermal Converter is registered.
- 2B9b3 (Handling activities: HFCs): Emission figures are obtained from the company's AER.
- 2B10 (Other), process emissions: Because no IPCC methodologies exist for these processes (and the 2019 Refinement-methodology for H_2 is not implemented yet), country-specific methods and EFs are used. These refer to:
    - The production of industrial gases: With natural gas as input (chemical feedstock), industrial gases, e.g. H_2 and CO, are produced. Emission data is available from the verified ETS emission reports.
    - Production of carbon electrodes: CO_2 emissions are estimated on the basis of fuel use (mainly petcoke and coke). A small oxidation fraction (5%) is assumed, on the basis of data reported in the AERs.

      2B108e: acrylonitrile, CO_2; CH_4; N_2O;
- Production of activated carbon: From 2013 onwards, CO_2 emissions from activated carbon production in the Netherlands

have been included in the EU-ETS. Therefore, as from the 2015 submission, the figures are based on the verified EU-ETS Emission Reports of the activated carbon producer. 2B10 (Other), waste gas combustion: The combustion of waste gas is calculated according to the methods described in section 3.2.4.2. For chemical waste gas, company-specific EFs have been derived for a selection of (the largest) companies from 1995 onwards. For the remaining companies, the default EF is used. If data from any of the selected companies was missing, a company-specific EF for the missing company was used (derived in 1995). For the 1990–1994 period, a country-specific EF that is based on an average EF for four (large) companies has been used. For phosphorus gas, company-specific EFs have been derived for the single company and have been used in the emissions inventory (since 2006). For years prior to 2006, EFs from the Netherlands' list of fuels (Zijlema, 2024) are used. This fuel was only used until 2012, when the single company using this fuel ceased operation.

Activity data for estimating CO_2 emissions is based on data for the feedstock use of fuels provided by Statistics Netherlands.

4.3.3 Uncertainty assessment and time-series consistency

Uncertainty assessment
The uncertainty analysis outlined in Annex 2 (presented in Tables A2.1 and A2.2) provides estimates of uncertainties according to IPCC source categories.

The uncertainty in annual CO_2 emissions from ammonia production is estimated to be in the range of 30%. Uncertainties for other categories are much higher. For 2B8 Petrochemical and carbon black production (both for CO_2 and CH_4) and for category 2B10 Other, uncertainties are in the range of 70%; this is determined by uncertainties in both the activity data and emission factors (both in the range of 50%, estimated by expert judgement).

As N_2O emissions from HNO_3 production in the Netherlands are included in the EU-ETS, all companies continuously measure their N_2O emissions. This has resulted in a lower annual emissions uncertainty of approximately 5%.

The uncertainty in HFC-23 emissions from HCFC-22 production is estimated to be approximately 15%. For HFC emissions from handling activities, the uncertainty is estimated to be about 20%. These figures are all based on expert judgement.

Time series consistency
Consistent methodologies are used throughout the time series for the sources in this category. A certain amount of extrapolation is involved with respect to emission data for acrylonitrile production, thereby introducing further uncertainties for the 1995–2009 period.

4.3.4 *Category-specific QA/QC and verification*

The source categories are covered by the general QA/QC procedures discussed in Chapter 1.

From 2008 onwards, N_2O emissions from HNO_3 production in the Netherlands have been included in the EU-ETS. For this purpose, the companies developed monitoring plans approved by the NEa (Dutch Emissions Authority). In 2018, the companies' emissions reports (2017 emissions) were independently verified and submitted to the NEa, where they were compared with those reported in the CRT tables for the year 2017. No differences were found between the emissions figures in the CRT tables and those in the emissions reports under EU-ETS. As described under 4.3.2, the availability of ETS reports improved the quality of the calculations. For emission year 2020, the ETS-report and AER of the largest of the two HNO_3 producers in the Netherlands were compared. The reported emissions are exactly the same. However, emission figures for the other HNO_3 producer cannot be compared because it is situated in the Chemelot industrial zone. Chemelot only reports emissions of the total estate to the ETS, not from individual companies. Therefore, no comparison could be made for this smaller producer.

Emissions from petrochemical and carbon black production are either not included in the ETS, or situated on the Chemelot estate (which only reports the total). Therefore, no emission verification to ETS reports can be made.

For the production of HCFC-22 (2B9a1), the operators' data in annual environmental reports (including confidential information) is verified on an annual basis by the competent authority.

4.3.5 *Category-specific recalculations*

No category-specific recalculations have been performed.

4.3.6 *Category-specific planned improvements*

- Applying the 2019 Refinement for hydrogen production is intended for the 2027 submission.
- Acrilonitrile production will be reported under 2B8e instead of included in 2B10 for the next submission.

4.4 Metal production (2C)

4.4.1 *Category description*

The national inventory of the Netherlands includes GHGs emissions related to two source categories belonging to 2C (Metal production):

- *Iron and steel production (2C1): CO_2 emissions:* the Netherlands has one integrated iron and steel plant (Tata Steel, previously known as Corus and/or Hoogovens). The process emissions from anode use during steel production in the electric arc furnace are also included in this category.
- *Aluminium production (2C3): CO_2 and PFC emissions:* the Netherlands had two primary aluminium smelters, of which the last one closed in 2022. Since then, no aluminium production takes place in the Netherlands, therefore NO is reported for 2C3

emissions. In the years before, emissions fluctuated because of closing and re-opening aluminium plants.

The following sources of GHG emissions do not exist in the Netherlands:

- Ferroalloys production (2C2): the small ferroalloy trading companies in the Netherlands do not produce ferroalloys.;
- magnesium production (2C4);
- lead production (2C5);
- zinc production via electro-thermic distillation or the pyrometallurgical process (2C6);
- other metal production (2C7).

Overview of shares and trends in emissions
Table 4.6 provides an overview of emissions in CRT 2C.

Table 4.6 Overview of the Metal production sector (2C), in the base year and the last two years of the inventory (in Tg CO_2 eq.). The middle column shows the change (%) of the last year of the inventory compared to the base year. On the right side of the table, the contribution of the last year inventory's emissions of the category to the sector, to the total national emissions of the specific gas and to the total national emissions (in CO_2 eq) are provided.

Sector/category	Gas	Key	1990	2022	2023	2023 vs 1990	Contribution of the category in 2023 (%) to the		
			Emissions in Tg CO2 eq			%	sector	total gas	total CO_2 eq
2C. Metal Production	CO_2		0.45	0.03	0.01	-98.1%	0.1%	0.0%	0.0%
	PFC		2.37	NO	NO		0.0%	0.0%	0.0%
	All		2.83	0.03	0.01	-99.7%	0.1%	0.0%	0.0%
2C1. Iron and steel production	CO_2	non key	0.04	0.02	0.01	-80.5%	0.1%	0.0%	0.0%
2C3. Aluminium production	CO_2	T	0.41	0.02	0.00	-100.0%	0.0%	0.0%	0.0%
	PFC	T	2.37	NO	NO		0.0%	0.0%	0.0%

This sector comprises the following key categories:

2C3	Aluminium production	CO_2
2C3	Aluminium production	PFC

From 2003 onwards, the level of the PFC emissions from aluminium production (2C3) has decreased sharply because reduction measures (side feed to point feed) were taken (see Table 4.7). From then on, emissions have depended mainly on the number of anode effects and little on production level. PFC emissions have decreased further since 2011, and stopped in 2022 as a result of the closures of Zalco and Aldel.

Table 4.7 Emissions of CF_4 and C_2F_6 from Aluminum production (2C3) (Gg CO_2-eq)

Year	PFC14 (CF4)	PFC116 (C2F6)	Total
1990	1839	535	2374
1991	1825	525	2349
1992	1659	474	2132
1993	1683	472	2154
1994	1614	453	2067
1995	1566	441	2007
1996	1745	474	2220
1997	1865	500	2365
1998	1372	446	1819
1999	1017	394	1411
2000	1066	413	1479
2001	1018	395	1414
2002	1565	642	2207
2003	349	117	466
2004	89	22	111
2005	74	18	92
2006	51	12	62
2007	82	19	102
2008	60	15	75
2009	36	9	45
2010	51	10	60
2011	71	15	86
2012	13	3	16
2013	8	2	10
2014	0	0	0
2015	5	1	6
2016	10	2	12
2017	10	2	12
2018	17	3	20
2019	20	4	25
2020	20	4	24
2021	12	2	15
2022	NO	NO	NO
2023	NO	NO	NO

4.4.2 *Methodological issues*

The methodologies used to estimate GHG emissions in all source categories of metal production comply with the 2006 IPCC Guidelines. More detailed descriptions of the methods and EFs used can be found in Honig et al. (2025: sections 2.1.3.3 and 2.2.3.2 (iron and steel production) and 2.2.3.7 (aluminium production)).

Iron and steel production (2C1)

As mentioned in section 3.2.5 (for sub-category 1A2a), the calculation for this category is based on a carbon mass balance, which is not included in the NIR for reasons of confidentiality but can be made available for review purposes. Process emissions, e.g. from the conversion of pig iron to steel, are also obtained from the carbon mass balance.

Combustion emissions are reported under 1A1c (flaring), 1A2a, 1B1b (CH_4 coke production).

Aluminium production (2C3)
Up to emission year 2017, a Tier 1a IPCC method (IPCC, 2006) was used to estimate CO_2 emissions from the anodes used in the primary production of aluminium, with aluminium production serving as activity data. From emission year 2018 onwards (2020 submission), the CO_2 figure has been obtained directly from the AERs.

Estimations of PFC emissions from primary aluminium production reported by the two facilities are based on the IPCC Tier 2 method for the 1990–2017 period. EFs are plant-specific and confidential and are based on measured data. From emission year 2018 onwards, the emission data has been obtained from ETS reports.

4.4.3 *Uncertainty assessment and time-series consistency*

Uncertainty assessment
The uncertainty analysis explained in Annex 2 provides estimates of uncertainties per IPCC source category. The uncertainty in annual CO_2 emissions is estimated at 5-6% both for iron and steel production and for aluminium production, whereas the uncertainty in PFC emissions from aluminium production is estimated to be in the range of 40%. The uncertainty in the activity data is estimated at 2% for aluminium production and 3% for iron and steel production. The uncertainty in the EFs for CO_2 (from all sources in this category) is estimated at 5%, and the EF for PFC from aluminium production at slightly over 40%.

Time series consistency
A consistent methodology has been used throughout the complete time series.

4.4.4 *Category-specific QA/QC and verification*

The source categories are covered by the general QA/QC procedures discussed in Chapter 1. For the source category 2C1, in 2018 the activity and emissions data in the AERs were compared with the EU-ETS monitoring reports. No differences were found. The confidential production data for pellet and sinter production can be made available to the review team.

4.4.5 *Category-specific recalculations*

No category-specific recalculations have been performed.

4.4.6 *Category-specific planned improvements*

As a result of the 2021 review (question I.24), performing CH_4 process emissions calculations from sinter production is planned for future submissions. with low priority because this is below the threshold of significance (it will add approximately 0.02 Gg CH_4 to the national total).

4.5 Non-energy products from fuels and solvent use (2D)

4.5.1 Category description

Table 4.8 presents an overview of the sector non-energy products from fuels and solvent use. The CO_2 emissions reported in categories 2D1 and 2D2 stem from the direct use of specific fuels for non-energy purposes, which results in partial or full oxidation during use (ODU) of the carbon contained in the products, e.g. candles. CO_2 emissions reported in category 2D3 stem from urea use in SCR in diesel vehicles.

Table 4.8 Overview of the sector non-energy products from fuel and solvent use (2D), in the base year and the last two years of the inventory (in Tg CO_2 eq.). The middle column shows the change (%) of the last year of the inventory compared to the base year. On the right side of the table, the contribution of the last year inventory's emissions of the category to the sector, to the total national emissions of the specific gas and to the total national emissions (in CO_2 eq) are provided.

Sector/category	Gas	Key	1990	2022	2023	2023 vs 1990	Contribution of the category in 2023 (%) to the		
			Emissions in Tg CO2 eq			%	sector	total gas	total CO_2 eq
2D. Non-energy products from fuels and solvent use	CO_2		0.2	0.4	0.4	103.1%	2.9%	0.3%	0.3%
	CH_4		0.0	0.0	0.0	146.1%	0.0%	0.0%	0.0%
	All		0.2	0.4	0.4	103.1%	2.9%	0.0%	0.3%
2D1. Lubricant use	CO_2	non key	0.1	0.1	0.1	8.5%	0.7%	0.1%	0.1%
2D2. Paraffin wax use	CO_2	L,T	0.1	0.2	0.3	146.1%	1.9%	0.2%	0.2%
2D3. Other non specified	CO_2	non key	NO	0.03	0.04		0.3%	0.0%	0.0%

Overview of shares and trends in emissions

The small CO_2 and CH_4 emissions from 2D1 and 2D2 remained fairly constant between 1990 and 2023. CO_2 emissions from urea use in diesel vehicles (2D3) increased from 0 to 35 kton between 2005 and 2023.

4.5.2 Methodological issues

The methodologies used to estimate GHG emissions in 2D1, 2D2 and 2D3 comply with the 2006 IPCC Guidelines, volume 3, as described in Honig et al. (2025), section 2.2.3.1.

A Tier 1 method is used to estimate emissions from lubricants and waxes using IPCC default EFs. For the use of lubricants and waxes, Oxidised During Use (ODU) factors of 20% and 100%, respectively, have been used (adopted from IPCC 2006 Guidelines). CO_2 emissions from urea-based catalysts are estimated by means of a Tier 3 methodology, using country-specific CO_2 EFs for various vehicle types. More detailed descriptions of the method and EFs used can be found in Geilenkirchen et al. (2024).

The activity data is based on fuel use data from Statistics Netherlands.

4.5.3 *Uncertainty assessment and time-series consistency*

Uncertainty assessment

The uncertainty analysis outlined in Annex 2 and presented in Tables A2.1 and A2.2 provides estimates of the uncertainties per IPCC source category.

The uncertainty in the CO_2 EF is estimated at approximately 50% in the ODU factor for lubricants. The uncertainty in the activity data (such as domestic consumption of these fuel types) is generally large as it is based on production, as well as on import and export figures. It is also estimated at 50%, resulting in an overall uncertainty of approximately 70% for category 2D1 Lubricant use.
Uncertainties in category 2D2 (Paraffin wax use) and 2D3 (Non-energy products from fuels and solvent use) are high; mostly determined by uncertainties in the activity data (100%). Overall approach 1 uncertainties for these categories are estimated at over 100%.

Time series consistency

Consistent methodologies and activity data have been used to estimate emissions throughout the time series.

4.5.4 *Category-specific QA/QC and verification*

The source categories are covered by the general QA/QC procedures discussed in Chapter 1.

4.5.5 *Category-specific recalculations*

No category-specific recalculations have been performed.

4.5.6 *Category-specific planned improvements*

No improvements have been planned.

4.6 Electronics industry (2E)

4.6.1 *Category description*

PFCs (incl. NF_3) and SF_6 are both used and emitted in Semiconductor manufacture. PFC emissions are reported in 2E1, SF_6 emissions are included in 2G2. PFC and SF_6 emissions from thin-film transistor (TFT) flat panel displays (2E2), Photovoltaics (2E3), Heat transfer fluid (2E4) manufacturing and Other sources (2E5) do not occur in the Netherlands, and are therefore not identified in the inventory.

Overview of shares and trends in emissions

The contribution made by PFC emissions from category 2E to the total national PFC emissions was 0.9% in 1990 and 87.3% in 2023. The latter figure corresponds to 0.04 Tg CO_2-eq and accounts for 0.02% of national total GHG emissions in 2023 (Table 4.9).

Table 4.9 Overview of the sector Integrated circuit or semiconductor (2E) in the base year and the last two years of the inventory (in Gg CO_2 eq.). The middle column shows the change (%) of the last year of the inventory compared to the base year. On the right side of the table, the contribution of the last year inventory's emissions of the category to the sector, to the total national emissions of the specific gas and to the total national emissions (in CO_2 eq) are provided.

Sector/category	Gas	Key	1990	2022	2023	2023 vs 1990	Contribution of the category in 2023 (%) to the		
			Emissions in Gg CO2 eq			%	sector	total gas	total CO_2 eq
2E1. Integrated circuit or semiconductor	PFC	non key	22.7	40.3	36.6	60.9%	0.3%	87.3%	0.02%

This sector comprises no key categories.

Due to an increasing production level in the semiconductor manufacturing industry, PFC emissions increased from 23 Gg CO_2-eq in the base year to 277 Gg CO_2-eq in 2007. The post-2007 decrease was mainly caused by an intensive PFC (incl. NF_3) reduction scheme (see Table 4.10).

Table 4.10 Emissions trend from the use of PFCs (incl. NF_3) in the Electronics industry (2E1) (Gg CO_2-eq)

Gas	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
PFC	23	45	236	230	186	77	28	36	40	37

4.6.2 *Methodological issues*

The methodology used to estimate PFC emissions from semiconductor manufacture complies with the 2006 IPCC Guidelines, as described in Honig et al. (2025), section 2.2.3.8.

Activity data on the use of PFCs in semiconductor manufacture was obtained from the only manufacturing company (confidential information); EFs are also confidential. Detailed information on the activity data and EFs can be found in the methodology report (Honig et al., 2025).

4.6.3 *Uncertainty assessment and time-series consistency*

Uncertainty assessment

The uncertainty analysis outlined in Annex 2 provides estimates of the uncertainties per IPCC source category. The uncertainty of PFC (incl. NF_3) emissions is estimated at about 25%. The uncertainty in the activity data for the PFC (incl. NF_3) sources is estimated at 5%; for the EFs, the uncertainty is estimated at 25%. All these figures are based on expert judgement.

Time series consistency

Consistent methodologies have been used to estimate emissions from these sources throughout the time series.

4.6.4 *Category-specific QA/QC and verification*
The source categories are covered by the general QA/QC procedures discussed in Chapter 1.

4.6.5 *Category-specific recalculations*
No category-specific recalculations have been performed.

4.6.6 *Category-specific planned improvements*
No improvements have been planned.

4.7 Product use as substitutes for ODS (2F)

4.7.1 *Category description*
The national inventory comprises the following sub-categories within this category:

- stationary refrigeration (2F1): HFC emissions;
- mobile air-conditioning (2F1): HFC emissions;
- foam-blowing agents (2F2): HFC emissions (included in 2F6);
- fire protection (2F3): HFC emissions (included in 2F6);
- aerosols (2F4): HFC emissions (included in 2F6);
- solvents (2F5): HFC emissions (included in 2F6);
- other applications (2F6): HFC emissions from 2F2, 2F3, 2F4 and 2F5 are allocated to 2F6.

In the Netherlands, many processes relating to the use of HFCs take place in only one or two companies. For data sensitivity reasons, only the sum of the HFC emissions of 2F2–2F5 is reported (included in 2F6).

There are no emissions from 2F1b (Domestic refrigeration) in the Netherlands because no HFCs are used for domestic refrigeration. In the 1990s, CFCs were replaced by propane.

Overview of shares and trends in emissions
Due to increased HFC consumption as a substitute for (H)CFC use, the contribution made by HFC emissions from category 2F to national total HFC emissions was 0% in 1990 and 88.1% in 2023. This corresponds with 0.61 Tg CO_2-eq and accounts for 0.4% of national total GHG emissions in 2023 (see Table 4.11).

Table 4.11 Overview of the sector Product use as substitutes for ODS (2F) in the base year and the last two years of the inventory (in Tg CO_2 eq.). The middle column shows the change (%) of the last year of the inventory compared to the base year. On the right side of the table, the contribution of the last year inventory's emissions of the category to the sector, to the total national emissions of the specific gas and to the total national emissions (in CO_2 eq) are provided.

Sector/category	Gas	Key	1990	2022	2023	2023 vs 1990	Contribution of the category in 2023 (%) to the		
			Emissions in Tg CO2 eq			%	sector	total gas	total CO_2 eq
2F. Product uses as substitutes for ODS	HFC		NO	0.64	0.61		4.6%	88.1%	0.4%
2F1. Stationary refrigeration and Mobile air-conditioning	HFC	L,T	NO	0.48	0.46		3.5%	66.9%	0.3%
2F6. Other	HFC	T	0.0	0.16	0.15		1.1%	21.3%	0.1%

This sector comprises two key categories:

2F1	Refrigeration and mobile air-conditioning	HFC
2F6	Other	HFC

From the 2019 submission onwards, the calculation method (via a stock model) for Stationary refrigeration (2F1) has been replaced (see Honig et al., 2025). The new method has used the Refrigerants Registration System to estimate emissions from 2013 onwards. This system is the result of a European mandatory requirement, whereby building owners are required to register refrigerants.

Emissions for 2F1 have been calculated up to 2021. This is the most recent year for which emissions data is available due to delayed reporting. Due to the phasing-out of refrigerants with a high GWP, emissions decreased from 1.028 Tg in 2015 to 0.196 Tg in 2021 (see Table 4.12). In 2017, emissions increased slightly, but decreased rapidly in 2018. This is the result of the phasing-out of some more high-GWP refrigerants. Emission data for 2022 and 2023 was kept equal to 2021.

With the new method, emission figures are available for:

- 4 sectors: Commercial, Industrial, Stationary air cons and Transport refrigeration;
- 4 emission sources: leakage, filling, dismantling and refrigerant management;
- 5 HFCs: HFC-125, HFC-134a, HFC-143a, HFC-23 and HFC-32. Refrigerants are blends of these HFCs. The registration system contains about 20 refrigerants (see Honig et al. (2025), section 2.2.3.9.2, 'Composition of refrigerants), and each of those refrigerants is a blend of the 5 mentioned HFCs. For example: R452A contains 59% HFC-125 and 11% HFC-32. R134A consists of only 100% HFC-134a.

It appears that leakage emissions are the major emissions source from stationary refrigeration. Emissions from refrigerant management, filling, and dismantling are almost negligible.

Table 4.12 Emissions trends per sub-category from the use of HFCs as substitutes for ODS (Gg CO_2-eq)

Year	2F1 Stationary refrigeration HFCs	2F1 Mobile air-conditioning: HFC134a	2F6 Other applications: HFCs	HFCs Total
1990	NO	NO	NO	NO
1991	NO	NO	NO	NO
1992	NO	NO	NO	NO
1993	NO	NO	NO	NO
1994	9	2	57	68
1995	36	8	183	227
1996	84	16	432	532
1997	129	28	680	837
1998	160	49	774	983
1999	188	76	773	1037
2000	256	111	627	994
2001	329	149	351	828
2002	396	186	165	746
2003	469	222	153	843
2004	537	256	199	992
2005	602	286	141	1029
2006	666	312	160	1138
2007	737	333	222	1293
2008	810	352	242	1404
2009	868	368	210	1446
2010	899	372	191	1462
2011	920	377	273	1570
2012	952	382	213	1546
2013	1138	384	181	1703
2014	934	385	172	1492
2015	1029	386	166	1606
2016	815	386	188	1405
2017	918	378	189	1518
2018	521	343	177	1042
2019	495	324	160	978
2020	481	308	136	926
2021	196	303	128	627
2022	196	282	158	636
2023	196	264	146	607

4.7.2 *Methodological issues*

The methodology used to estimate emissions in category 2F comply with the 2006 IPCC Guidelines, volume 3, IPCC Tier 2 methods and are described in Honig et al. (2025), sections 2.2.3.9–2.2.3.11.

The activity data used to estimate emissions of F-gases is derived from the following sources:

- Stationary refrigeration (2F1): until emission year 2012, HFCs consumption data was obtained from the annual reports by PricewaterhouseCoopers (PWC). From 2013 onwards, the Refrigerants Registration System has been used to estimate emissions.
- For mobile air-conditioning (2F1), the number of cars (by year of construction) and the number of scrapped cars (by year of construction) were obtained from Statistics Netherlands. The amounts of recycled and destroyed refrigerants were obtained from ARN, a waste-processing facility (personal communication).
- Other applications (2F6): HFC emissions from 2F2, 2F3, 2F4 and 2F5: Until the 2016 submission, consumption data on HFCs was obtained from annual reports by PricewaterhouseCoopers. From 2015 onwards, no consumption data on HFCs has been made available. Therefore, until the 2021 submission, emissions from these sources were kept equal to the 2014 emissions. From the 2022 submission onwards, a temporary estimation method has been developed and introduced. Trends from Belgium and Germany have been used to scale the 2014 emissions onwards. This is described in Honig et al. (2025). From this submission on, a new calculation method was developed. For foam blowing, data is used from the European F-gas portal on the production, import, export and destruction of fluorinated greenhouse gases at the EU level, as summarized yearly in dedicated reports by the EEA. For aerosols, detailed data about use of metered dose inhalers is available

Stationary air conditioning (2F1)

From the 2019 submission onwards, figures have been used from the Refrigerants Registration System, which includes information about leakage and the filling of (new) installations and dismantling.
Data collection within the Refrigerants Registration System takes place as follows:

- Data at plant level (amounts of leakages, filling of (new) installations and dismantling) is registered continuously by mechanics at the installation companies.
- The figures are checked by the inspection authorities every other year.
- Following approval, the figures are aggregated and delivered to the NL-PRTR.
- The NL-PRTR calculates the emissions.

Because of the complexity of the system, there is a time-lag for making data available. This means that in this submission, final figures are provided up to and including 2021. The 2022 and 2023 figures are kept equal to the last year for which figures are available (2021).
In the 2026 submission, the 2022 figures from the current submission will be replaced by the final figures for 2022.

As a result of (EU) review comments, IPCC extrapolation methods (Trend Extrapolation or Surrogate Data) were investigated to prevent over- or underestimation in the last two years. However, the Trend

Extrapolation is not recommended if the trend is fluctuating. This applies here because the mix of high and lower GWP refrigerants has been random throughout the years and no trend can be detected. Moreover, the Surrogate Data technique is inappropriate because no data can be found that has any correlation with the random-like use of refrigerants with different GWPs. So to conclude, an extrapolation cannot be performed and therefore, the emissions from the last two years are kept at the same level. However, over the past few years, a decreasing trend seems to appear. If this continues over the next years, a Trend Extrapolation method will be considered again.

EFs used to estimate emissions of F-gases in this category are based on the following:

- Stationary refrigeration: Until the 2016 submission, annual leak rates from surveys (Baedts et al., 2001) were used. Since the figures from the Refrigerants Registration System are used, implied emission factors can be derived.
- Mobile air-conditioning: Annual leak rates from surveys (Baedts et al., 2001) and other literature (Minnesota Pollution Control Agency, 2009; YU & CLODIC, 2008).

Other applications (2F6)

A new calculation method was developed for foam-blowing agents and aerosols. For fire protection and solvents (with low emission), the implemented temporary method based on scaling Germany and Belgium is still used.

- *Foam-blowing agents*: the European Environment Agency (EEA) publishes yearly reports with summaries of the EU F gas portal. The EU-figures for foam blowing agents were scaled to the Netherlands by using the number of inhabitants as a proxy.
- *Aerosols*: emissions were calculated by combining detailed data that was obtained about the number of used metered dose inhalers in the Netherlands with its content.

It appeared that the application of the new method resulted in 2F6 emissions levels comparable to the previous method, so it may be concluded that that estimation was adequate. More detailed descriptions of the methods and EFs used can be found in the methodology report (Honig et al., 2025), as indicated in section 4.1.

4.7.3 Uncertainty assessment and time-series consistency

Uncertainty assessment

The uncertainty analysis outlined in Annex 2 provides estimates of uncertainties per IPCC source category. On the basis of expert judgement, the uncertainty in HFC emissions from HFC consumption is estimated at approximately 40-50%, mostly determined by uncertainties in activity data.

Time series consistency

Consistent methodologies have been used to estimate emissions from Mobile air-conditioning (2F1) and Other applications (2F6).

For Stationary refrigeration (2F1), two methods were used to estimate emissions, as described above. The stock model method was used for the 1990–2012 period, and the Refrigerants Registration System method has been used from 2013 onwards.

For the stock model method, activity data was derived from the sales figures of individual HFCs to the total cooling sector in the Netherlands. These were available annually via a trade flow study until the 2016 submission (reporting year 2014) after which this study stopped.
After this a new method was developed, as applied from the 2019 submission onwards (emission years 2013 and further). Figures from the Refrigerants Registration System that contains data from 2013 onwards are used as the input for this method. In this system, data about leakages, filling of new installations, dismantling, etcetera is collected from the commercial, industrial, and transport refrigeration and stationary air-conditioning sectors. Data on leakages, filling of (new) installations, dismantling, etcetera is not calculated but obtained directly from the system.

This new method provides more accurate data than the stock model method. All equipment with a content >3 kg is covered by the Refrigerants Registration System. This is the best source available in the Netherlands. In addition, the emissions calculated by means of the new method are lower than those from the old stock model method, probably due to the assumption that usage figures were the same as the sales figures, and to the fact that a fixed leakage percentage of 5.8% was used; in the new method the average leakage rate for 2013–2017 was approximately 4%.

In the 2021 submission, the Overlap splicing technique from the IPCC Guidelines was used to create a consistent time series, thereby recalculating the 1990-2012 series. The formula used is described in Guidebook Chapter 5 (Time series consistency), section 5.3.3.1. The overlap period used is 2013-2015.

As described in section 4.7.2, no trend extrapolation for 2022 and 2023 has been applied; emissions have been kept equal to the 2021 emissions.

4.7.4 *Category-specific QA/QC and verification*

The source categories are covered by the general QA/QC procedures discussed in Chapter 1. From the implementation of the new method, the refrigerant use data has been available at a high level of reliability.

4.7.5 *Category-specific recalculations*

- As described in section 4.7.2, there is a time-lag for making data available. In this submission, the 2021 figure of 2F1 (HFCs from stationary refrigeration) was replaced by the new calculated value. The 2022 and 2023 emissions are kept equal to the 2021 emission. This results in a decrease of 285 Gg CO_2-eq (-59%).
- A new calculation method for 2F6 emissions was implemented (see section 4.7.2) for the emission years 2015-2023. This results in the following changes in HFC134a- emissions in 2.F.6:

	2015	2020	2021	2022
Kton CO_2-eq	+39	+68	+68	+88

- Due to an error, emission figures for 2F1 mobile air condition were corrected for the years 2018-2020 (see table 4.12). This results in a decrease of around 20 Gg (1%) for those years.

4.7.6 Category-specific planned improvements

For the next submission, it will be examined whether it is possible to split up emissions to 2F2-5 instead of including these in 2F6.

4.8 Other product manufacture and use (2G)

4.8.1 Category description

This source category comprises emissions related to Other product manufacture and use (2G) in:

- Electrical equipment (2G1): SF_6 emissions (included in 2G2).
- Other (2G2): SF_6 emissions from sound-proof windows, electron microscopes, and the electronics industry.
- N_2O from product uses (2G3): N_2O emissions from the use of anaesthesia and aerosol cans.
- Other industrial processes (2G4):
    - Fireworks: CO_2, CH_4 and N_2O emissions.
    - Degassing of drinking water: CH_4 emissions.

Table 4.13 presents 2G emissions in the base year, as well as in the last two years of the inventory.

Table 4.13 *Overview of the sector Other product manufacture and use (2G) in the base year and the last two years of the inventory (in Gg CO_2-eq). The middle column shows the change (%) of the last year of the inventory compared to the base year. On the right side of the table, the contribution of the last year inventory's emissions of the category to the sector, to the total national emissions of the specific gas and to the total national emissions (in CO_2 eq) are provided.*

Sector/category	**Gas**	**Key**	**1990**	**2022**	**2023**	**2023 vs 1990**	**Contribution of the category in 2023 (%) to the**		
			Emissions in Gg CO_2 eq			**%**	**sector**	**total gas**	**total CO_2 eq**
2G. Other	CO_2	non key	0.2	0.4	0.6	230.2%	0.0%	0.0%	0.0%
	CH_4	non key	58	51	50	-12.7%	0.4%	0.3%	0.0%
	N_2O	non key	200	66	56	-72.0%	0.4%	0.8%	0.0%
	SF_6		213	125	105	-50.6%	0.8%	100.0%	0.1%
	All		471	243	212	-54.9%	0.8%	0.0%	0.1%
2G2. SF6 and PFCs from other product use	SF_6	non key	213	125	105	-50.6%	0.8%	100.0%	0.1%
2G3. N2O from product uses	N_2O		197	61	48	-75.4%	0.4%	0.7%	0.0%
2G4. Other	CO_2		0.2	0.4	0.6	230.2%	0.00%	0.00%	0.00%
	CH_4		58	51	50	-12.7%	0.4%	0.3%	0.0%
	N_2O		3	5	8	165.6%	0.06%	0.11%	0.01%

This sector comprises no key categories.

In the Netherlands, many processes relating to the use of SF_6 take place in only one or two companies. Because of the sensitivity of data from these companies, only the sum of the SF_6 emissions in 2G1 and 2G2 is reported (both included in 2G2).

Overview of shares and trends in emissions
Table 4.14 presents the trend in emissions from the use of SF_6 during the 1990–2023 period.

Table 4.14 Emissions from the use of SF_6, 1990–2023 (Gg CO_2-eq)

Gas	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
SF_6	213.1	263.5	234.6	157.5	108.1	115.1	128.4	123.9	125.5	105.3

The decrease in SF_6 emissions since 2000 was mainly caused by:
- the closure of the only manufacturer of high-voltage installations at the end of 2002;
- the use of leak detection equipment in Electrical equipment (2G1).

N_2O emissions from 2G3 decreased by 75.4% in the 1990–2023 period. N_2O emissions from anaesthesia decreased due to better dosing in hospitals and other medical institutions.
Domestic sales of cream in aerosol cans increased sharply between 1990 and 2023. For this reason, emissions of N_2O from food aerosol cans also increased sharply.

The low CO_2 and CH_4 emissions remained fairly constant between 1990 and 2023. CO_2, CH_4 and N_2O emissions from fireworks showed a peak in 2000 because of the millennium celebrations.

4.8.2 *Methodological issues*

The source category Electrical equipment (2G1) comprises SF_6 emissions by users of high-voltage circuit breakers and by the only international test laboratory for power switches. Figures for emissions from circuit breakers were obtained from the annual inventory by the company, DNV. The methodologies used in earlier years are described in Honig et al. (2025), see sections 2.2.3.12 and 2.2.3.13.
The country-specific methods used for the sources of semiconductor manufacture, sound-proof windows, and electron microscopes are in line with IPCC Tier 2 methods.

Figures for the use of SF_6 in semiconductor manufacture, and electron microscopes were obtained from individual companies (confidential information). Emissions from disposed sound-proof windows are modelled.

EFs used to estimate the emissions of SF_6 in this category are based on the following:
- semiconductor manufacture: confidential information from the only company;

- sound-proof windows: the EF used for production is 33% (IPCC default); the EF (leak rate) used during the lifetime of the windows is 2% per year (IPCC default);
- electron microscopes: confidential information from one company.

Country-specific methodologies are used for the N_2O sources in 2G3. A full description of the methodology is provided by Visschedijk et al. (2024). The methodologies used to estimate the emissions from 2G3 are:

- *Anaesthesia:* The major hospital supplier of N_2O for anaesthetic use reports the consumption data for anaesthetic gas in the Netherlands annually. The EF used for N_2O in anaesthesia is 1 kg/kg gas used. It is assumed that the sales of N_2O for anaesthesia is equal to the consumption;
- *Aerosol cans:* The national aerosol organisation (NAV) reports data on the annual sales of N_2O-containing spray cans. The EF for N_2O from aerosol cans is estimated to be 7.6 g/can (on the basis of data provided by one producer) and is assumed to be constant over time.

The methodologies used to estimate emissions of 2G4 are:

- fireworks: Country-specific methods and EFs are used to estimate emissions of CO_2, CH_4 and N_2O.
- degassing of drinking water: A country-specific methodology and EF are used to estimate CH_4 emissions, this being the main source of CH_4 emissions in this category.

The activity data used in 2G4 is derived from the following sources:

- fireworks: data on annual sales from the trade organisation;
- production of drinking water: volume and fuel use from Statistics Netherlands;
- cigarettes and cigars: volume from excise duty statistics and the trade organisation.

The EFs used in 2G4 are based on the following:

- Fireworks: CO_2: 43.25 kg/t; CH_4: 0.825 kg/t; N_2O: 1.935 kg/t (Visschedijk et al., 2024).
- Production of drinking water: 2.47 tons $CH_4/10^6$ m^3 (Visschedijk et al., 2024).
- Smoking cigarettes and cigars: CO_2: 294 kg/t; CH_4: 1.625 kg/t; N_2O: 0.065 kg/t (Visschedijk et al., 2024).

4.8.3 *Uncertainty assessment and time-series consistency*

Uncertainty assessment

The uncertainty analysis outlined in Annex 2 provides estimates of the uncertainties by IPCC source category. The uncertainty in SF_6 emissions from 2G2 (SF_6 use) is estimated to be 34% (IPCC Tier 3a method). For the activity data and the EFs, the uncertainty is estimated at approximately 30% and 15%, respectively.

Uncertainties for the other source categories under 2G range from 15% (N_2O emissions from Other product manufacture and use) to over 50% (CO_2 and CH_4).

Time series consistency
Consistent methodologies have been applied to all source categories. The quality of the N_2O activity data needed was not uniform for the complete time series, requiring some extrapolation from the data. This is not expected to significantly compromise the accuracy of the estimates, which is still expected to be sufficient.

4.8.4 Category-specific QA/QC and verification
The source categories are covered by the general QA/QC procedures discussed in Chapter 1.

4.8.5 Category-specific recalculations
N_2O emissions in 2.G.3.a N_2O use for medical applications were updated for 2020-2022, because updated activity data became available for 2022. For the years 2020-2022, emissions were obtained by interpolating between 2019 and 2022.

4.8.6 Category-specific planned improvements
The producer of electron microscopes reports zero emission, it will be checked for the next submission if this still is correct. Also, the emissions from particle accelerators will be investigated.'

4.9 Other (2H)

4.9.1 Category description
This category comprises CO_2 emissions from Food and drink production (2H2). In the Netherlands, this concerns the calcination process in the sugar industry, as described in section 4.2.2 under lime production (2A2). CO_2 process emissions in this source category do not only occur from lime production, but are also related to the non-energy use of fuels: coke and anthracite. Carbon is oxidised during these processes, resulting in CO_2 emissions. CO_2 process emissions in the paper industry (2H1) do not occur in the Netherlands.

Overview of shares and trends in emissions
Emissions in 2023 decreased by 63.0% compared to the emissions in 1990 (see Table 4.15).

Table 4.15 Overview of the sector Other process emissions (2H) in the base year and the last two years of the inventory (in Tg CO_2 eq.). The middle column shows the change (%) of the last year of the inventory compared to the base year. On the right side of the table, the contribution of the last year inventory's emissions of the category to the sector, to the total national emissions of the specific gas and to the total national emissions (in CO_2 eq) are provided.

Sector/category	Gas	Key	1990	2022	2023	2023 vs 1990	Contribution of the category in 2023 (%) to the		
			Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
2H. Other process emissions	CO_2	non key	0.07	0.02	0.03	-63.0%	0.2%	0.0%	0.0%

This sector comprises no key categories.

4.9.2 *Methodological issues*

The methodology used to estimate the GHG emissions complies with the 2006 IPCC Guidelines, volume 3, as described in Honig et al. (2025), section 2.2.3.1.

CO_2 emissions are calculated on the basis of the non-energy use of fuels by the food and drink industry recorded by Statistics Netherlands in national energy statistics on coke consumption, multiplied by an EF. The EF is based on the national default carbon content of the fuels (see Annex 5), assuming that the carbon is fully oxidised to CO_2.

4.9.3 *Uncertainty assessment and time-series consistency*

Uncertainty assessment

The uncertainty analysis outlined in Annex 2 provides estimates of the uncertainties per IPCC source category. The uncertainty in the emissions of this category is estimated to be around 5% (2% and 5% uncertainty in activity data and EF, respectively).

Time series consistency

Consistent methodologies and activity data are used throughout the time series for this source.

4.9.4 *Category-specific QA/QC and verification*

The source categories are covered by the general QA/QC procedures discussed in Chapter 1.

4.9.5 *Category-specific recalculations*

No category-specific recalculations have been performed.

4.9.6 *Category-specific planned improvements*

No improvements have been planned.

5 Agriculture (CRT sector 3)

Major changes in the Agriculture sector compared to the National Inventory Report 2024

Emissions:	No major changes in total emissions from the Agriculture sector (2022 and 20323 both c. 18.0 Tg CO_2-eq.)
Key categories:	No changes in key categories compared to the NIR 2024
Methodologies and recalculations:	• The transport certificates of manure and the amount of treated manure have been re-examined for the years 2010-2022. This affects N_2O and CH_4 emissions from manure management (3B). • Methane emissions from poultry manure have been recalculated as the Biochemical Methane Potential has been corrected (3B4). • Methane emissions from dairy cattle manure have increased as the volatile solids excretion has been updated for the years 2017-2020 (3B1). • The NH_3 emissions from manure management have been recalculated, thus affecting the indirect N_2O emissions (3B5). • The N_2O emissions related to losses/gains in soil organic matter content have been recalculated based on new insights from the LULUCF sector(3Da5). • The N_2O emissions related to crop residues have been recalculated for the years 2006-2022 (3Da4). The area of grassland renewal has been updated.

	• Final usage rates of inorganic fertilisers, compost, liming, and urea and the grassland renewal rate of 2022 differ from the preliminary rates. This affects the N_2O emissions from Agricultural soils (3D), Liming (3G), Urea application (3H) an crop residues (3Da4).

5.1 Overview of the sector and background information

Emissions of GHGs from Agriculture include all anthropogenic GHG emissions from the agricultural sector, except for:

- Emissions from fuel combustion. These emissions are included in 1A2g Manufacturing industries and construction – Other and 1A4c Other sectors – Agriculture/Forestry/Fisheries, and
- CO_2 emissions through land use in agriculture (CRT sector 4 Land Use, Land Use Change and Forestry; see Chapter 6).

Table 5.1 provides an overview of the contribution made by the Agriculture sector subdivided in the relevant subcategories to the total greenhouse gas emissions in the Netherlands. Emissions are given for 1990, 2022 and 2023. Table 5.1 also provides the relative difference between 2023 and 1990, and presents the contribution the various sources and gases make to the total emissions of the Agriculture sector, to the national emissions per greenhouse gas and to the national emissions in terms of CO_2 equivalent.
Emissions of GHGs in this sector include the following:

- 3A Enteric fermentation (CH_4);
- 3B Manure management (CH_4 and N_2O);
- 3D Crop production and agricultural soils (N_2O);
- 3G Liming (CO_2);
- 3H Urea application (CO_2).

The IPCC categories Rice cultivation (3C), Prescribed burning of savannahs (3E), Field burning of agricultural residues (3F), Other carbon-containing fertilisers (3I) and Other (3J) do not occur in the Netherlands. Throughout the 1990-2023 period, Field burning of agricultural residues was prohibited in the Netherlands (article 10.2 of the Environmental Management Act, or ‘*Wet Milieubeheer’* in Dutch).

This chapter discusses the national emissions from agriculture and their trends. All emissions are calculated using the NEMA model (Netherlands Emission Model Agriculture). A detailed description of the NEMA model and the exact methods used to calculate the emissions can be found in Van der Zee et al. (2025). The activity data used to calculate the emissions are summarised in Van Bruggen et al. (2025). The activity data that could not be included in the CRT is added to Van Bruggen et al. (2025). The calculation method of the volatile substances excreted is described in Bannink et al. (2018). The calculation method of the nitrogen excretion is described in Van Bruggen et al. (2010).

In 2023, agriculture contributed 12.3% of the national GHG emissions in comparison to 11.1% in 1990. This sector is a major contributor to national total CH_4 and N_2O emissions; in 2023, agriculture accounted for 70.7% of total CH_4 emissions and for 73.5% of total N_2O emissions (Table 5.1).

Table 5.1 Overview of emissions in the Agriculture sector, in the base year 1990 and the last two years of the inventory (in Tg CO_2 eq.). The middle column shows the change (%) of the last year of the inventory compared to the base year. On the right side of the table, the contribution of the last year inventory's emissions of the category to the sector, to the total national emissions of the specific gas and to the total national emissions (in CO_2 eq) are provided.

Sector/category	Gas	Key	1990	2022	2023	2023 vs 1990	Contribution of the category in 2023 (%) to the		
			Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
3. Agriculture	CO_2		0.2	0.1	0.1	-49.5%	0.5%	0.1%	0.1%
	CH_4		16.5	13.1	13.0	-21.0%	72.5%	70.7%	8.9%
	N_2O		8.6	4.8	4.9	-43.7%	27.0%	73.5%	3.3%
	All		25.3	18.0	18.0	-28.9%	100.0%		12.3%
3A. Enteric fermentation	CH_4		10.3	9.2	9.2	-10.7%	51.4%	50.1%	6.3%
3B. Manure management	CH_4		6.2	4.0	3.8	-38.3%	21.1%	20.6%	2.6%
	N_2O		0.8	0.7	0.6	-23.1%	3.6%	9.8%	0.4%
	All		7.0	4.6	4.4	-36.4%	24.7%		3.0%
3D. Agriculture soils	N_2O		7.8	4.1	4.2	-46.0%	23.4%	63.7%	2.9%
3G. Liming	CO_2	non key	0.2	0.03	0.03	-86.3%	0.1%	0.0%	0.0%
3H. Urea application	CO_2	non key	0.00	0.06	0.07	4393.4%	0.4%	0.1%	0.0%
National Total GHG emissions (incl. LULUCF)	CO_2		167.7	130.8	120.6	-28.1%			
	CH_4		36.5	18.6	18.4	-49.5%			
	N_2O		16.1	6.7	6.6	-59.0%			
	Total		227.5	157.0	146.4	-35.6%			

5.1.1 *Overview of shares and trends in emissions*

Figure 5.1 shows the trend in total GHG emissions from the sector Agriculture. Please note that the contributions of 3G Liming and 3H Urea application are so small that they are barely visible in the figure.

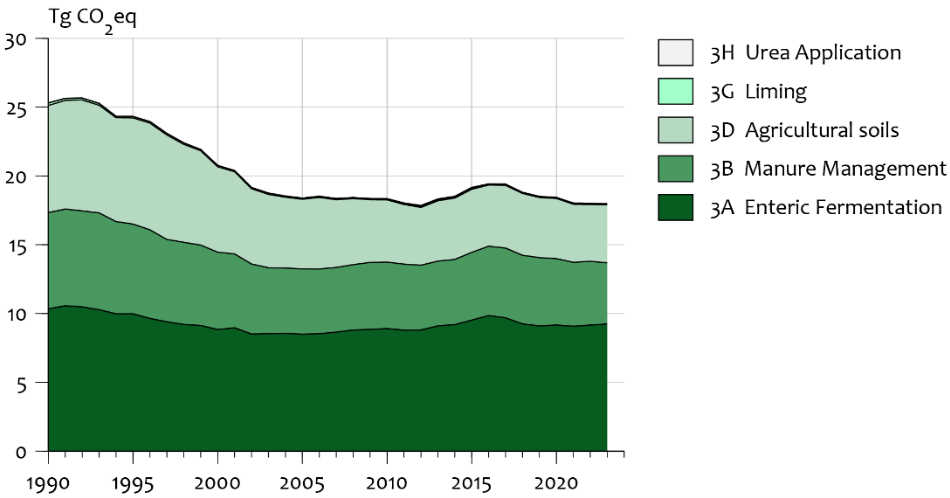


Figure 5.1 Sector 3 Agriculture – trend and emission levels of source categories, 1990–2023. Please note that the contributions of 3G Liming and 3H Urea application are so small that they are barely visible in the figure.

Trend in methane emissions

In broad terms, the CH_4 emissions from agriculture showed a decline from 1990 to 2006, after which the emissions increased again, peaking in 2016. After 2016, the emissions decreased except for the year 2022. The trends in methane emissions are mainly explained by changes in the number of mature dairy cattle and pigs. The time series of CH_4 emissions are available in section 9.3 of Van Bruggen et al. (2025).

Trend in nitrous oxide emissions

From 1990 to 2012, the Netherlands saw a decline in N_2O emissions due to a decrease in organic and inorganic N fertiliser application, a decrease in animal numbers, and a decrease in grazing. Emissions increased in 2013-2017, while 2018 to 2020 show a decrease. After a decrease in 2021 and 2022, emissions increased in 2023, mainly due to higher emissions from manure application, pasture manure and losses of soil organic matter. The time series of N_2O emissions are available in section 9.2 of Van Bruggen et al. (2025).

Trend in carbon dioxide emissions

The CO_2 emissions from agriculture reported here are limited to the emissions resulting from liming (3G) and urea application (3H). Overall, the CO_2 emissions decreased from 1990 until 2008 due to a decrease in the application of liming products in the Netherlands, with yearly fluctuations. After 2008, CO_2 emissions increased as more urea was applied as an artificial fertiliser. CO_2 emissions peaked in 2012 after which they plateaued until 2016, when a strong decrease could be observed. In 2017, there was an increase in CO_2 emissions followed by a decrease in 2018. Between 2018 and 2020, CO_2 emissions remained stable with relatively small fluctuations between years. The CO_2 emission increased in 2021, 2022 and 2023, due to increased liming and urea application. The time series of CO_2 emissions from agriculture are available in section 9.6 of Van Bruggen et al. (2025). In 2023 CO_2 emissions comprised 0.5% of the greenhouse gas emissions from agriculture in terms of CO_2eq.

5.1.2 *Overview of trends in activity data*

Animal numbers are the primary activity data used in the emissions calculations for manure management (3B) and agricultural soils (3D). Most animal numbers come from the annual agricultural census performed by Statistics Netherlands. Animal categories that are (no longer) surveyed in the agricultural census or where the agricultural census was deemed uncertain, are covered by the Identification and Registration system (I&R) of Netherlands Enterprise Agency (RVO). Table 5.2 presents an overview of the various animal categories. The entire time series of the animal numbers in the Netherlands can be found in Annex 2 of Van Bruggen et al. (2025). More information on the determination of the animal numbers can be found in section 2 of Van der Zee et al. (2025).

Table 5.2 Animal numbers in 1990–2023 (x 1,000)

Animal category	1990	1995	2000	2005	2010	2015	2020	2022	2023
Cattle	4,926	4,654	4,069	3,797	3,975	4,134	3,719	3,766	3,755
Mature dairy cattle	1,878	1,708	1,504	1,433	1,479	1,622	1,593	1,571	1,563
Other mature cattle	120	146	163	151	115	80	58	53	54
Growing cattle	2,929	2,800	2,402	2,213	2,381	2,432	2,068	2,143	2,138
Sheep	1,702	1,674	1,305	1,361	1,130	946	954	907	888
Ewes	790	771	680	647	558	523	562	549	554
Young stock and males	913	903	625	714	571	423	365	336	314
Swine	13,915	14,397	13,118	11,312	12,255	12,603	11,860	11,235	10,854
Swine (>25 kg)	8,724	8,801	8,015	6,749	7,131	7,005	6,447	6,115	5,880
Young stock (<25 kg)	5,191	5,596	5,102	4,563	5,124	5,598	5,414	5,120	4,973
Goats	61	76	179	292	353	470	633	645	647
Mature female goats	37	43	98	172	222	292	441	456	458
Young stock and males	23	33	80	120	131	178	192	189	189
Horses	370	400	417	433	441	417	410	417	419
Mules and asses	1	1	1	1	1	1	1	1	1
Poultry	91,680	88,243	102,579	91,726	99,880	104,760	96,431	89,453	87,258
Other livestock									
Rabbits	786	488	392	360	299	381	335	300	265
Does	105	64	52	48	39	48	38	35	30
Young stock	681	424	340	312	260	333	297	266	235
Furbearing animals	554	463	589	697	962	1,023	435	0	0

Between 1990 and 2023, the total number of cattle decreased by 24%. This is due to higher production rates per animal and production quotas.

Between 2012 and 2016, the number of cattle increased as dairy farmers anticipated the abolition of milk production quotas. However, this resulted in exceeding the European phosphate production ceiling. The Dutch government implemented new policies in accordance with the phosphate production ceiling: the phosphate reduction scheme followed by the phosphate quota introduced in 2018 (MLNV, 2017). These policies resulted in a decrease in cattle (all categories) that can be kept in the Netherlands and resulted in a decrease in cattle numbers from 2017 to 2023. Average milk yield of dairy cows increased from 6003 kg milk cow^{-1} $year^{-1}$ to 9095 kg milk cow^{-1} $year^{-1}$. Emissions from buffalo are included in the emissions from cattle for two reasons. Firstly, a very small number of buffalo are kept in the Netherlands (less than 5000 in 2023). The small number of buffalo (compared to the number of cattle) cannot have a significant effect on the calculated emissions. Secondly, before 2016, farmers were not asked about keeping buffalo. Farmers thus registered them as cattle in the agricultural census. From 2016 onwards, farmers have to state how many buffalo they keep, and to state the purpose of the buffalo (beef or dairy). In the calculations the buffalo are then treated accordingly as dairy cattle, growing cattle or other mature cattle. Therefore we have included the buffalo with the cattle as this results in the most consistent timeseries. Previously, buffalo were reported as NO (Not Occuring), this has been amended in the current CRT.

The total number of sheep (ewes, rams and lambs) decreased by 48% between 1990 and 2023.

The total number of swine decreased by 22% between 1990 and 2023. Increased production rates per animal resulted in a decrease in swine numbers until 2004, after which animal numbers increased. The increase levelled off after 2011 and was stable until 2015. Between 2016 and 2023, a slow decrease was observed. The number of young stock of swine (piglets up to 25 kg) has been stable between 1990 and 2022, showing that the productivity of the sows has increased.

There was an overall decrease in numbers of poultry by 5% between 1990 and 2023. An increase in the number of poultry was observed between 1990 and 2002. As a direct result of the avian flu outbreak in 2003, poultry numbers decreased by almost 30%. In 2004, poultry numbers increased again. In 2010, the number of poultry was equal to the 2002 number. From 2011 onwards, poultry numbers have stabilised, with small annual fluctuations. 2021 and 2022 were marked by large outbreaks of avian influenza.

The total number of goats increased by 964% between 1990 and 2023. This increase is due to an increased demand for goat milk and goat cheese. This increase halted in 2010, when goats were culled due to the outbreak of Q fever, but resumed in 2011.

The total number of horses increased by 13% between 1990 and 2023.

The total number of mules and asses increased by 24% between 1990 and 2023. On the basis of expert judgement, the number of mules and asses between 1990 and 2009 was set at 1000 animals. Since 2010, animal numbers have become available from the agricultural census.

The number of rabbits decreased by 66% between 1990 and 2023 due to a decrease in demand for rabbit meat.

No fur-bearing animal is held in the Netherlands. The production of fur from foxes ceased in 2008 following a ban. The production of fur from minks ceased in 2021. The number of fur-bearing animals increased by 46% between 1990 and 2019. However, due to the 2020 coronavirus pandemic, all mink farms ceased operations as the production of fur from minks was banned. This resulted in a 20% decrease in mink between 1990 and 2020. From 2021 onwards, no mink has been held in the Netherlands.

Emissions from alpacas in the Netherlands have not been included in the inventory as there is no detailed information on their numbers. Alpacas are mostly kept as pets or as a tourist attraction. Animal numbers are expected to be in the same range as mules and asses, i.e. no more than a couple of thousand animals. The threshold for a mandatory inclusion of a new source is 0.05% of national total GHG emissions or 500 kt CO_2-eq, whichever is lower. In the case of the Netherlands, this is the threshold of 0.05%, namely 73 kt CO_2-eq[5]. According to the Tier 1 default values, the combined emission per alpaca is ~325.7 kg CO_2-eq (3A and 3B). To reach the threshold of 73 kt CO_2-eq, more than 224,000 alpacas would need to be present in the Netherlands. This is highly unlikely as the highest estimate we found for alpacas in the Netherlands is 4,000 animals.

The calculations of CH_4 emissions from sheep, goats and pigs are based on different activity data than the calculations of N_2O emissions (see sections 5.2 and 5.3). CH_4 emissions from sheep, goats and pigs are based on the average number of animals present multiplied by the default IPCC emission factors. N_2O emissions are based on the N excretion. The N excretion has been estimated by the Working group on Uniformity of calculations of Manure and mineral data (WUM). The WUM does not provide N excretions for all animal categories individually. The N excretion of the rams and lambs is included in the N excretion of the ewes. The N excretion of the male goats and goat kids is included in the N excretion of female goats. The N excretion of piglets is included in

[5] Total emission from the Netherlands in 2022 is 146 Tg CO2-eq. The threshold (0.05%) is thus 73 kt CO_2-eq.

The Tier 1 emission factors from the 2006 IPCC guidebook are:
-> CH_4 from enteric fermentation: 8 kg CH_4 per head per year.
-> CH_4 from manure management: 0.955 kg CH_4 per head.
This emission can be calculated by combining the VS excretion, the emission factor of the storage system and body weight. The VS excretion is 11.5 kg VS (1000 kg animal mass)$^{-1}$ day^{-1}, combined with the high-productivity solid storage emission factor in a cool climate of 3.5 g CH_4 kg VS^{-1} and a bodyweight of 65 kg: 11.5/1000*65*3.5/1000*365 = 0.955 kg CH_4 per head.
-> N_2O from manure management: 0.282857 kg N_2O.
This emission can be calculated by combining the nitrogen excretion rate, animal weight and the emission factor from the guidebook. The default nitrogen excretion rate for western Europe is: 0.38 kg N (1000 kg animal mass per day)$^{-1}$ Nex = 0.38 * 65/1000 * 365 = 9.0 kg N, emission factor of 2%
N_2O emission manure management: 9.0 * 0.02 * (44/28) = 0.282857 kg N_2O per head.

Therefore, the total CO_2 equivalent per alpaca is: ((8 + 0.955) * 28) + (0.282857 * 265) = ~325.7 kg CO_2 equivalent.

the N excretion of the sows. Hence, for the calculation of N_2O emissions, the male and young sheep and goats and the piglets are omitted.

The amount of applied manure and fertilisers are important activity data for the calculation of emissions from agricultural soils (3D), Liming (3G) and Urea application (3H). For agricultural soils, the application method is also important, as methods developed to reduce the NH_3 emissions have higher N_2O emissions. Between 1990 and 2023, the application of animal manure in kg N decreased by 26%. The reduction is caused by the introduction of more stringent manure application limits. Manure applied to soils during pasturing decreased by 70% due to a reduction of the number of cattle as well as to a decrease in pasturing. The application of inorganic N fertilisers decreased by 48% due to more stringent application limits as well as a more efficient usage of animal manure, resulting in a reduced demand for inorganic N fertilisers. Compost application increased by 274% between 1990 and 2023. Sewage sludge application decreased by 94% between 1990 and 2023.

Detailed information on data sources can be found in Chapter 2 of Van der Zee et al. (2025).

5.2 Enteric fermentation (3A)

5.2.1 Category description

Methane emissions are a by-product of enteric fermentation, the digestive process by which organic matter (mainly carbohydrates) is degraded and utilised by micro-organisms under anaerobic conditions. Both ruminant animals (e.g. cattle, sheep and goats) and non-ruminant animals (e.g. swine, horses, mules and asses) produce CH_4, but ruminants produce considerably more per unit of feed intake. Enteric fermentation from poultry is not estimated due to the negligible amount of CH_4 production in this animal category. The 2019 refinement of the IPCC Guidelines does not provide a default EF for enteric CH_4 emissions from poultry.

The CH_4 emissions from enteric fermentation have decreased from 10.3 Tg CO_2-eq in 1990 to 9.2 Tg CO_2-eq in 2023 (-10.7% compared to 1990, see Table 5.3). The overall decrease is almost entirely due to the decrease in CH_4 emissions from cattle. Cattle accounted for the majority (90%) of CH_4 emissions from enteric fermentation in 2023. Swine contributed 5% and the animal categories sheep, goats, horses and mules and asses accounted for the remaining 5%. The reduction of CH_4 emissions from cattle is caused by a decrease in animal numbers, partly undone by an increase in EF for mature dairy cattle (higher production/animal; Table 5.4) (3A1a) and white veal calves (dietary changes to also include roughages in the diet) (3A1c).

The source category enteric fermentation includes emissions from:

- Mature dairy cattle (3A1a);
- Other mature cattle (3A1b);
- Growing cattle (3A1c);
- Sheep (3A2);
- Swine (3A3);
- Goats (3A4);

- Horses (3A4);
- Mules and asses (3A4).

Table 5.3 Overview of the sector Enteric fermentation (3A) in the base year and the last two years of the inventory (in Tg CO_2 eq.). The middle column shows the change (%) of the last year of the inventory compared to the base year. On the right side of the table, the contribution of the last year inventory's emissions of the category to the sector, to the total national emissions of the specific gas and to the total national emissions (in CO_2 eq) are provided.

Sector/category	Gas	Key	1990	2022	2023	2023 vs 1990	Contribution of the category in 2023 (%) to the		
			Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
3A. Enteric fermentation	CH_4		10.3	9.2	9.2	-10.7%	51.4%	50.1%	6.3%
3A1. Cattle	CH_4		9.2	8.2	8.3	-9.7%	46.1%	44.9%	5.7%
Mature dairy cattle	CH_4	L,T	5.8	6.0	6.1	5.4%	34.0%	33.2%	4.2%
Other mature cattle	CH_4	non key	0.2	0.1	0.1	-50.0%	0.7%	0.6%	0.1%
Growing cattle	CH_4	L	3.1	2.0	2.1	-34.7%	11.4%	11.1%	1.4%
3A2. Sheep	CH_4	L	0.4	0.2	0.2	-47.8%	1.1%	1.1%	0.1%
3A3. Swine	CH_4	L	0.6	0.5	0.5	-22.6%	2.5%	2.5%	0.3%
3A4. Other livestock	CH_4	L	0.2	0.3	0.3	54.8%	1.7%	1.6%	0.2%

This sector comprises the following key categories:

3A1	Mature dairy cattle	CH_4
3A1	Young cattle	CH_4
3A3	Swine	CH_4
3A2,3A4	Other	CH_4

5.2.2 Methodological issues

For all the sub-source categories, the methodologies used to estimate emissions follow the 2006 IPCC Guidelines. Detailed information on calculation methods and EFs can be found in Chapter 3 of Van der Zee et al. (2025). An overview of the activity data can be found in Statistics Netherlands (2019 through 2024); Van Bruggen et al. (2025).

Cattle (3A1)

A Tier 3 method is used to calculate emissions from mature dairy cattle. For the EF calculation for mature dairy cattle, the Netherlands is split into two regions because of differences in diets: North-West and South-East. Cattle in the North-West (NW) mainly have a grass diet, while those in the South-East (SE) have a larger fraction of maize in their diet. Data used between 1990 and 2012 is published in Annex 3 of Van Bruggen et al. (2014). An annual update of cattle diets is published by Statistics Netherlands, (2019 through 2024). Table 5.4 presents the IEFs (implied emission factor) for the various cattle categories reported, including the subdivision into the NW and SE regions for mature dairy cattle. A Tier 2 method is used to calculate emissions from other mature cattle and growing cattle. The IEF for growing cattle is a weighted average calculated from all cattle sub-categories except dairy cows and suckling cows and female fatteners > 2 years (Annex 27 of Van Bruggen et al., 2025).

Table 5.4 Implied emissions factors for methane emissions from enteric fermentation specified according to CRT animal category (kg CH_4/animal/year)

Animal category	1990	1995	2000	2005	2010	2015	2020	2022	2023
Mature dairy cattle	110.4	114.4	120.0	124.6	127.7	128.7	136.5	136.9	139.8
Of which NW region	111.0	115.4	121.7	126.0	129.6	130.9	136.6	136.7	139.9
Of which SE region	109.9	113.5	118.4	123.2	126.3	127.1	136.4	137.1	139.7
Other mature cattle	70.3	71.3	72.1	76.7	78.1	79.1	77.9	77.6	77.1
Growing cattle	38.3	38.6	35.4	34.4	35.0	36.4	33.5	34.1	34.3

For both mature dairy cattle and other mature cattle, EFs increased primarily because of an increase in total feed intake per animal in the 1990–2023 period. For mature dairy cattle, a change in the feed nutrient composition partly counteracted this effect. Moreover, the average weight of mature dairy cattle and the average milk production have increased over time, resulting in a higher gross energy intake of mature dairy cattle in 2023 compared to 1990, with a decrease in animal numbers (Statistics Netherlands, 2023). The IEFs of 2023 are higher than 2022 because the feed intake was higher.

For growing cattle, the decrease in EFs between 1990 and 2023 can be explained by a decrease in the average total feed intake due to an increased share of veal calves in the population of growing cattle. This is counteracted, however, by an increase in EF for white veal calves, as they are fed increasing amounts of roughage to comply with animal welfare considerations. The number of white veal calves and rosé veal calves can be found in Annex 2 of Van Bruggen et al. (2025). The EF for veal calves can be found in Annex 27 of Van Bruggen et al. (2025).

Sub-source categories with a Tier 1 method
According to the IPCC Guidelines, no Tier 2 method is required if the share of a sub-source category is less than 25% of the total emission from a key source category. This is the case for the following sub-source categories:

Sheep (3A2)
The animal category sheep has a 2.2% share in the total CH_4 emissions from enteric fermentation. Therefore, the IPCC 2006 default (Tier 1) EF of 8 kg CH_4/animal has been used. Changes in emissions from sheep are explained entirely by changes in livestock numbers.

Swine (3A3)
The animal category swine has a 4.9% share in the total CH_4 emissions from enteric fermentation. Therefore, the IPCC 2006 default (Tier 1) EF of 1.5 kg CH_4/animal has been used. Changes in emissions from swine are explained entirely by changes in livestock numbers.

Other livestock (3A4)
The sub-source category 'Other livestock' comprises goats, horses, and mules and asses. These animal categories have a combined share in total CH_4 emissions from enteric fermentation of 3.3%. Therefore, the IPCC 2006 default (Tier 1) EFs are used for goats, horses and mules and asses (5, 18 and 10 kg CH_4/animal, respectively). Changes in emissions from these animal categories are explained entirely by changes in livestock numbers.

5.2.3 Uncertainty assessment and time-series consistency

Uncertainty assessment
The uncertainty analysis explained in Annex 2 provides estimates of uncertainty according to IPCC source categories. The uncertainty of CH_4 emissions from enteric fermentation ranges between 10% and 42%, mostly determined by the uncertainties in the emission factors (e.g. the uncertainty in the EF for 3A3 Swine is estimated at 40%, whereas for 3A1a Mature dairy cattle, the uncertainty is estimated at 15%). Uncertainties for the activity data are estimated between 1% (for 3A1, Young cattle) and 17% (3A2, 3A4 Other).

Time-series consistency
A consistent methodology is used throughout the time series; see section 5.2.2. Emissions are calculated as the product of livestock numbers and EFs. Livestock numbers are collected in an annual census and the I&R and are published by Statistics Netherlands and RVO, respectively. Consistent methods are used to compile the census to ensure continuity of the collected data. Time series corrections have been implemented to ensure consistency following the switch from the annual census to the I&R. EFs are either constant (default IPCC) or calculated/modelled from feed intake data collected through an annual survey by Statistics Netherlands, (2019 through 2023).

5.2.4 Category-specific QA/QC and verification

This source category is covered by the general QA/QC procedures discussed in Chapter 1.

5.2.5 Category-specific recalculations

There have been no category-specific recalculations.

5.2.6 Category-specific planned improvements

No improvements have been planned.

5.3 Manure management (3B)

5.3.1 Category description

Overview of shares and trends in emissions
Both CH_4 and N_2O are emitted during the handling and storage of manure from all animal categories. These emissions are related to the quantity and composition of the manure, and to the various types of manure management systems used.

In the Netherlands, CH_4 emissions from manure management contribute 2.6% to national total GHG emissions and 21.1% to the GHG emissions of the Agriculture sector (Table 5.5). CH_4 emissions from manure management are particularly related to cattle and swine manure (Figure 5.2). Cattle and swine manure management contributed 11.8% and 8.7%, respectively, to the total GHG emissions of the Agriculture sector in 2023. CH_4 emissions from manure management of poultry are a minor key source and have decreased drastically over time (-85.1% from 1990 to 2023).

In 2023, N_2O emissions from manure management contributed 0.4% to national total GHG emissions and 3.6% to the Agriculture sector. Nitrous oxide emissions from manure management from cattle contributed 1.6% to the Agriculture sector total (Table 5.5. and Figure 5.3).

The source category Manure management includes emissions from:
- Mature dairy cattle (3B1a);
- Other mature cattle (3B1b);
- Growing cattle (3B1c);
- Sheep (3B2);
- Swine (3B3);
- Goats (3B4);
- Horses (3B4);
- Mules and asses (3B4);
- Poultry (3B4);
- Rabbits (3B4);
- Fur-bearing animals (3B4);
- Indirect emissions (3B5).

Table 5.5 Overview of the sector manure management (3B) in the base year and the last two years of the inventory (in Tg CO_2 eq.). The middle column shows the change (%) of the last year of the inventory compared to the base year. On the right side of the table, the contribution of the last year inventory's emissions of the category to the sector, to the total national emissions of the specific gas and to the total national emissions (in CO_2 eq) are provided.

Sector/category	Gas	Key	1990	2022	2023	2023 vs 1990	Contribution of the category in 2023 (%) to the		
			Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
3B. Manure management	CH_4		6.2	4.0	3.8	-38.3%	21.1%	20.6%	2.6%
	N_2O		0.8	0.7	0.6	-23.1%	3.6%	9.8%	0.4%
	All		7.0	4.6	4.4	-36.4%	24.7%		3.0%
3B1. Cattle (total)	CH_4		1.8	2.2	2.1	17.9%	11.8%	11.5%	1.4%
3B2. Sheep	CH_4	non key	0.0	0.0	0.0	-47.8%	0.0%	0.0%	0.0%
3B3. Swine	CH_4	L,T	3.8	1.7	1.6	-58.4%	8.7%	8.5%	1.1%
3B4. Poultry	CH_4	T	0.5	0.1	0.1	-85.1%	0.5%	0.4%	0.1%
3B4. Other livestock	CH_4	non key	0.0	0.0	0.0	-25.9%	0.1%	0.1%	0.0%
3B1. Cattle (total)	N_2O		0.3	0.3	0.3	-6.6%	1.6%	4.3%	0.2%
3B2. Sheep	N_2O	non key	0.0	0.0	0.0	-78.4%	0.0%	0.0%	0.0%
3B3. Swine	N_2O	non key	0.1	0.1	0.1	-40.9%	0.4%	1.1%	0.1%
3B4. Poultry	N_2O	non key	0.0	0.0	0.0	-16.4%	0.1%	0.3%	0.0%
3B4. Other livestock	N_2O	non key	0.0	0.1	0.1	135.4%	0.4%	1.0%	0.0%
3B5. Indirect emissions	N_2O	L,T	0.3	0.2	0.2	-43.4%	1.1%	3.0%	0.1%

This sector comprises following key categories:

3B1	Mature dairy cattle	CH_4
3B1	Growing cattle	CH_4
3B3	Swine	CH_4
3B4	Poultry	CH_4
3B5	Indirect emissions	N_2O

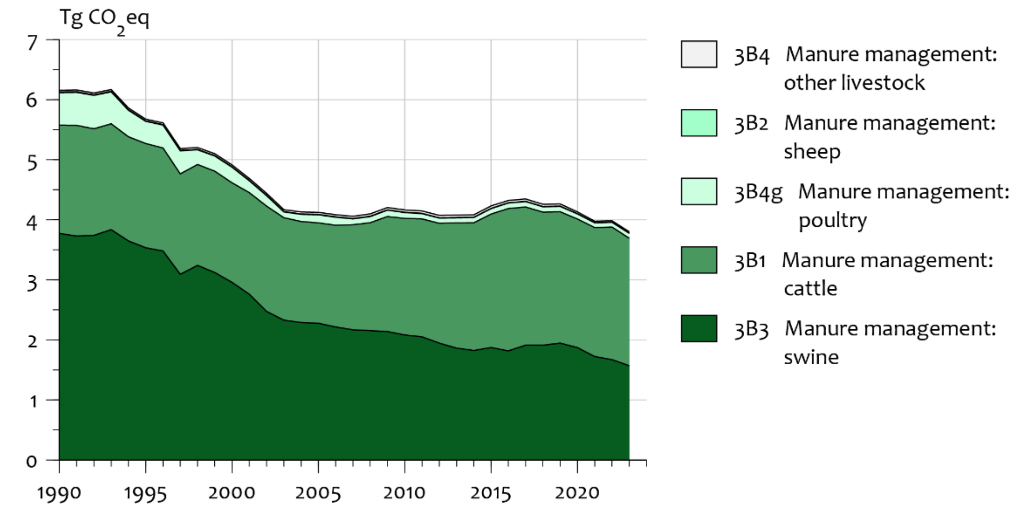


Figure 5.2 Category 3B Manure management – trend and emissions levels of source categories for CH_4, 1990–2023

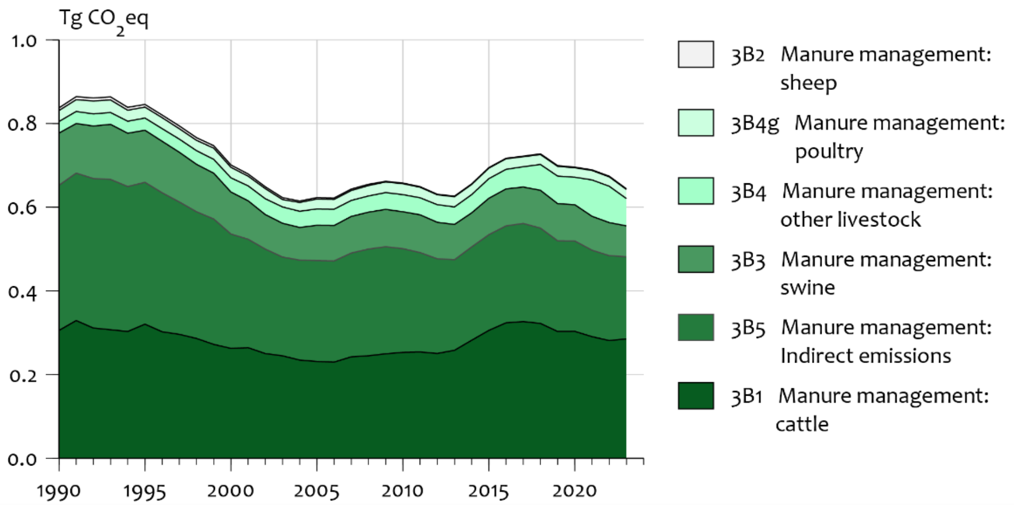


Figure 5.3 Category 3B Manure management – trend and emissions levels of source categories for N_2O, 1990–2023

Four different manure management systems are used in the Netherlands and included in the calculations:

- Liquid manure management systems;
- Solid manure management systems;
- Manure treatment;
- Manure excreted during grazing on pasture.

Animal numbers were distributed across the various manure management systems using information from the Agricultural census. In accordance with the IPCC 2006 Guidelines, N_2O emissions from manure excreted during grazing are not considered in source category 3B Manure management, but in source category 3D Agricultural soils (see section 5.4). The methods for calculating N excretion for the various livestock categories are described in Statistics Netherlands (2010).

CH_4 from manure management
Between 1990 and 2023, emissions of CH_4 from manure management decreased by 38.3% (Figure 5.2). Emissions from cattle increased by 17.9%, while swine and poultry emissions decreased by 58.4% and 85.1%, respectively (Table 5.5). With an increasing percentage of cattle kept indoors, a larger proportion of the manure is excreted inside animal housing facilities. This results in higher emissions (Annex 4 of Van Bruggen et al. (2025)). For growing cattle, emissions decreased due to lower livestock numbers; this outweighs the increase in EF (Annex 2 and Annex 29 of Van Bruggen et al. (2025)). An increase in emissions was seen between 2013 and 2017. This is due to an increase in cattle number combined with higher feed intake, resulting in a higher volatile solids (VS) excretion (Annex 2 and Annex 28 of Van Bruggen et al. (2025)). In anticipation of the end of the milk quota (2015), farmers increased their herd size. However, due to new policies, farmers subsequently had to decrease their herd size in order to comply with the phosphate quota Van der Zee et al. (2025).

For poultry, the large decrease in emissions is associated with the change from battery cage systems with liquid manure, to floor housing systems or aviary systems with solid manure (Annex 8 of Van Bruggen et al., (2025)). This lowered the CH_4 emissions as the solid manure systems have a lower EF. Moreover, the increase of manure treatment had an effect by shortening the manure’s storage time (Annex 14 of Van Bruggen et al., (2025)).

The decreasing trend in CH_4 emissions from swine is directly related to the decrease in VS excretions by swine (Annex 28 of Van Bruggen et al. (2025))This decreased due to changes in the feed composition (Zom and Groenestein, 2015). The decrease in CH_4 emissions was somewhat counteracted by an increase in livestock numbers in the first part of the time series (up to 1997). For the years 2017-2019, an increase in emissions can be seen as the VS excretion increased. In 2020-2023, VS excretion decreased again (Annex 28 of van Bruggen et al., (2025)).

N_2O from manure management
Nitrous oxide emissions are calculated using an N-flow model Van der Zee et al. (2025). Figure 5.4 is a schematic representation of N flows and the resulting emissions from agriculture. The amount of N in the manure is used throughout the model and corrected for the N emissions that have already taken place. For example, with N excretion in animal housing, losses in the form of NH_3, NO_x, N_2 and N_2O are all relative to the amount of N excreted. Only at the end of the calculation is the combined loss subtracted to yield the remaining N available for application.

The direct N_2O emissions from cattle decreased by 6.6% between 1990 and 2023. Sheep, swine and poultry emissions decreased by 78.4%, 40.9% and 16.4%, respectively (Table 5.5). Decreasing livestock numbers and N excretions per animal influenced this trend. Between 1990 and 2023, emissions from other livestock increased by 135.4% (Table 5.5); this increase was mainly caused by the increase in the number of goats. Between 1990 and 2013, the N excretion decreased due to an optimisation of animal production, resulting in higher production rates with lower dietary crude protein for all animal categories. From 2014 onwards, the amount of dietary crude protein has stabilised. In 2017, the N excretion for cattle increased again, which can be explained by a decrease in fed maize and an increase of fed grass; grass has a higher N content than maize. Apart from the increased share of grass in the feed, nutrient requirements increased through a higher average milk production and body weight per cow (Statistics Netherlands, 2024). In 2023, the N excretion of cattle increased as the roughages contained more nitrogen (Statistics Netherlands, 2022).

The Netherlands' manure and fertiliser policy, aimed at reducing N leaching and run-off, regulates the amount of manure production and its application by the introduction of measures such as restrictions on the numbers of swine and poultry per farm (so called 'manure production rights') and maximum application limits for manure and inorganic N fertiliser, all part of the Dutch 'Manure and Fertilisers Act' in accordance with the Nitrates Directive. This has also resulted in a decrease in manure management emissions over the past two decades.

Indirect N_2O emissions following atmospheric deposition of NH_3, and NO_x emitted during the handling of animal manure decreased by 43.4% from 1990 to 2023 (Table 5.5). This decrease is explained by reduction measures for NH_3 and NO_x emissions from animal housing systems and manure storages for the period.

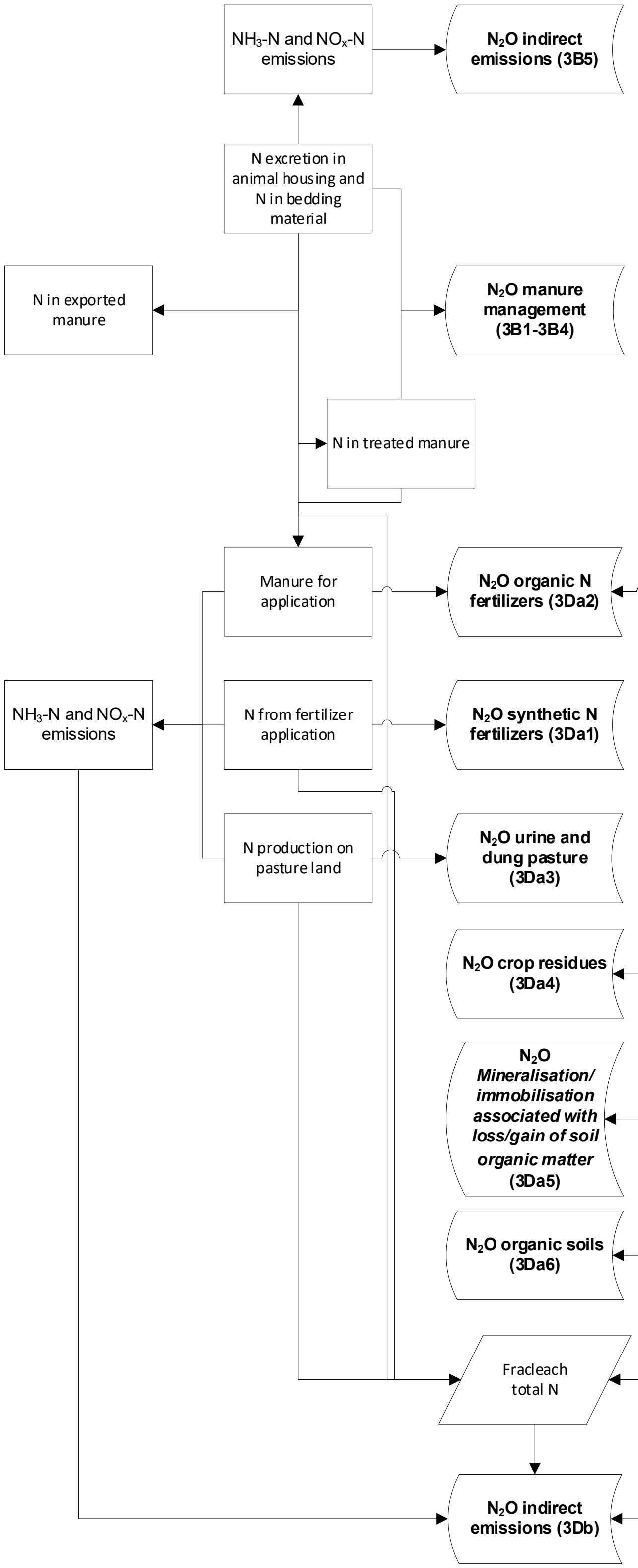


Figure 5.4 Schematic representation of N flows in agriculture and the allocation of emissions to source categories

5.3.2 *Methodological issues*

For all sub-source categories, the methodologies used to estimate emissions follow the 2006 IPCC Guidelines. Detailed information on calculation methods and EFs can be found in Chapters 4 and 7 of Van der Zee et al. (2025). An overview of the activity data can be found in Statistics Netherlands (2019 through 2023); Van Bruggen et al. (2024) and Van Bruggen et al. (2025). More information on animal housing systems used in the Netherlandscan be found at https://www.infomil.nl/onderwerpen/landbouw/stalsystemen/stalbeschrijvingen/ (in Dutch only).

Emissions from manure treatment are calculated using a Tier 2 method. Five manure treatment systems can be found in the Netherlands: Manure separation, the production of mineral concentrates, manure digestion, manure pelleting and incineration. A description of the EFs for the various types of manure treatment used in the Netherlands can be found in Melse and Groenestein, (2016). Emissions from manure digestion are reported under 5B. Biological treatment of solid waste emissions from the incineration of manure are reported under 1A1a other fuels.

CH_4 from manure management

Methane emissions from manure management are calculated using Tier 1 and Tier 2 methods. For horses, goats, mules and asses, sheep, rabbits and fur animals, a Tier 1 method is used. For cattle, swine, and poultry, a country-specific Tier 2 approach is used to calculate CH_4 EFs for manure management annually as they constitute key sources. The EFs are calculated for liquid and solid manure management systems within the key animal categories cattle, swine, and poultry and, where applicable, for the manure produced on pasture during grazing. These calculations are based on country-specific data on:

- Manure characteristics: volatile solids excretion (VS, in kg VS/animal/year) and maximum CH_4 producing potential (B0, in m^3 CH_4/kg VS);
- Manure management system conditions (storage temperature and period) for liquid manure systems, which determine the Methane Conversion Factor (MCF).

In the Netherlands, liquid animal manure is stored in pits underneath the slatted floors of animal housing facilities. This manure is regularly pumped into outside storage facilities or applied on the land. Given this practice, country-specific MCF values have been calculated for liquid manure since the manure management systems are different from the circumstances on which the default is based, as demonstrated in Groenestein et al. (2016). For solid manure management systems and manure produced on pasture while grazing, IPCC default values are used. The time that animals spend on pasture is calculated annually by the Working group on Uniformity of calculations of Manure and mineral data (Statistics Netherlands, 2011-2024). A time series with the emission factors for liquid manure, solid manure and manure in pasture can be found in Annex 29 of Van Bruggen et al. (2025). If the manure is treated, it is assumed that the storage time is short as it is beneficial for the farmer to treat the manure as soon as possible. In practice, it is possible that manure is stored for a longer period before treatment.

However, to account for this, complex calculations have to be made for all N species, with a high chance of overestimating the emissions. Methane emissions from manure treatment are based on the amount of manure in kg VS treated; emission factors are based on Melse and Groenestein (2016).

Table 5.6 presents the IEFs for manure management per animal category. These are expressed in kg CH_4 per animal per year and are calculated by dividing total emissions by livestock numbers in each category.

Table 5.6 CH_4 implied emission factors (kg/animal/year) for manure management specified by animal category, 1990–2023

Animal category	1990	1995	2000	2005	2010	2015	2020	2022	2023
Cattle									
Mature dairy cattle	23.07	24.10	27.97	31.07	34.87	36.72	37.59	38.88	37.51
Other mature cattle	7.42	7.53	7.50	7.84	8.04	8.01	6.80	6.74	5.83
Growing cattle	6.87	7.04	6.62	6.30	7.05	7.88	7.83	8.13	7.89
Sheep*	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Goats*	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Horses	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56
Mules and asses	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76
Swine*	9.68	8.77	8.05	7.19	6.07	5.31	5.64	5.31	5.21
Swine excl. piglets	15.44	14.33	13.18	12.03	10.38	9.50	10.31	11.13	10.95
Fattening pigs	12.87	11.81	10.76	9.70	8.40	7.53	8.31	7.89	7.70
Breeding swine	26.09	25.08	23.60	22.47	20.18	19.27	20.48	19.29	19.32
Poultry	0.21	0.15	0.09	0.05	0.03	0.03	0.03	0.03	0.03
Rabbits	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Fur-bearing animals	0.68	0.68	0.68	0.68	0.68	0.68	0.68	NO	NO

* The IEF is calculated for total animal numbers, including young stock. Manure production by young stock is accounted for in manure production by the mother animal.

Cattle (3B1)

The IEF for the manure management of mature dairy cattle increased between 1990 and 2023 as higher feed intake resulted in an increased VS production per cow. The shift in the proportion of the two main manure management systems used in dairy farming (liquid manure in the animal house and manure production on pasture) also contributed to the increased IEF as cows spend less time grazing: between 1990 and 2023, the share of manure produced in liquid manure management systems increased in comparison with the amount of manure produced on pasture (Statistics Netherlands, 2024).

Swine (3B3)
Between 1990 and 2023, the IEF for swine manure management (based on total swine numbers, including piglets) decreased due to a lower VS excretion per animal. The decrease in VS excretion per animal counteracts the increase in animal numbers in earlier years of the time series. The VS excretion decreased because the feed composition changed over the years, increasing the overall digestibility. The IEF also decreased as the productivity of the sows increased between 1990-2023, thus distributing the emissions across more animals.

Poultry (3B4)
For poultry, the substantial decrease in CH_4 emissions is explained by a shift in the proportion of the two poultry manure management systems (solid and liquid manure) between 1990 and 2013, when the liquid manure system was fully replaced by the solid manure system (Van der Hoek and Van Schijndel, 2006).

Sheep, goats, horses, mules and asses (3B2 and 3B4)
Sheep, goats, horses, and mules and asses only produce solid manure, which has a low EF. Therefore, the IEFs are also small. These represent the IPCC Tier 1 defaults.

Rabbits and fur-bearing animals
The IPCC Tier 1 default emission factors have been used for rabbits (solid manure) and for fur-bearing animals (liquid manure)(minks and foxes). Keeping fur-bearing animals in the Netherlands was banned in 2021.

Comparison with IPCC default EF for CH_4
The methods applied by the Netherlands for CH_4 calculations are in accordance with the 2006 IPCC Guidelines. Detailed descriptions of the methods are provided in Van der Zee et al. (2025). More detailed data on manure management, based on statistical information on manure management systems, is documented in Van der Hoek and Van Schijndel (2006) for the 1990–2006 period and in Statistics Netherlands, (2024) for the period from 2006 onwards.

N_2O from manure management
Direct emissions of N_2O from manure management are calculated using the Tier 1 method. As manure management does not constitute a key category for N_2O emissions, no higher Tier is required. Indirect N_2O emissions from manure management are calculated using a Tier 2 method. Emissions of NH_3 and NO_x are calculated using Tier 2 and Tier 3 methods. The default EF for indirect N_2O emissions from manure management has been used. An increase in IEF between 2010 and 2022 is the result of increased N excretion combined with a decrease in animal numbers (Table 5.7). This is caused by increased feed intake as a result of a higher average weight of mature dairy cattle (Statistics Netherlands, 2019; Van Bruggen et al., 2019) and a higher average milk production. As a result of new insights into the feed intake of horses and ponies, the N excretion increased in 2018 (Bikker et al., 2019).

Table 5.7 N_2O implied emission factors for manure management per animal category, 1990–2023 (mln kg/year and kg N_2O/kg manure-N)

Animal category	*1990*	*1995*	*2000*	*2005*	*2010*	*2015*	*2020*	*2022*	*2023*
Cattle									
Mature dairy cattle	0.34	0.36	0.32	0.34	0.34	0.35	0.40	0.38	0.38
Other mature cattle	0.19	0.22	0.20	0.18	0.17	0.18	0.22	0.19	0.16
Growing cattle	0.14	0.15	0.13	0.11	0.11	0.12	0.12	0.11	0.11
Sheep*	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01
Goats*	0.19	0.19	0.17	0.16	0.17	0.18	0.22	0.21	0.21
Horses	0.21	0.21	0.21	0.21	0.19	0.19	0.26	0.25	0.25
Mules and asses	NO	NO	NO	NO	0.10	0.10	0.13	0.13	0.13
Swine*	0.03	0.03	0.03	0.03	0.02	0.02	0.01	0.01	0.01
Poultry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rabbits*	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Fur-bearing animals	0.01	0.01	0.01	0.01	0.01	0.01	0.01	NO	NO

* The IEF is calculated on total animal numbers, including young stock. Manure production by young stock is accounted for in manure production by the mother animal.

For indirect emissions from manure management, the atmospheric N deposition is calculated as described in section 7.4.1 of Van der Zee et al. (2025). The IPCC Guidelines also calculate leaching and run-off from manure storage. In the Netherlands, all slurry manure is stored underneath animal houses or in fully closed external storage tanks (this is an obligation ensuing from the EU Nitrates Directive). Solid manure must be stored on concrete plates with run-off directed into a slurry pit or separate tank.

Comparison with IPCC default EF for N_2O
For the relevant manure management systems and animal categories, the total N content of the manure is calculated by multiplying N excretion (kg/year/head) by livestock numbers. Activity data is collected in compliance with a Tier 2 method. The N_2O EFs used for liquid and solid manure management systems are IPCC defaults. The used method complies with the 2006 IPCC Guidelines.

5.3.3 Uncertainty assessment and time-series consistency

Uncertainty assessment
The uncertainty analysis detailed in Annex 2 provides estimates of uncertainty according to IPCC source categories. The uncertainty for CH_4 from manure management ranges between 18% and c. 40% and is mostly determined by the estimated uncertainties in the EF (18% for 3B1 Growing cattle; 38% for 3A4 Other). Uncertainties in activity data range between 1% and c. 39%.

The uncertainty in the annual N_2O emissions from manure management is much higher; it is estimated at 64–100%, and it is attributable to the uncertainties in the EFs. A complete overview of the uncertainties can be found in section 4.4 and annex 10 of Van der Zee et al. (2025).

Time-series consistency

A consistent methodology is used throughout the time series; see section 5.3.2. Emissions are calculated from animal population data and EFs. The animal population data is collected both through the Identification and Registration system and in an annual census published by Statistics Netherlands. Consistent methods are used in compiling the census to ensure continuity in the collected data. EFs are either constant (default IPCC) or calculated/modelled from feed intake data collected through an annual survey by Statistics Netherlands (2019 through 2024).

5.3.4 *Category-specific QA/QC*

This source category is covered by the general QA/QC procedures discussed in Chapter 1.

5.3.5 *Category-specific recalculations*

Four category-specific recalculations have been performed. The transport certificates and the amount of treated manure have been re-examined and updated for the years 2010-2022. Multiple manure treatment facilities were found to have started earlier in the year than previously assumed. This results in lower storage emissions but higher emissions from treatment. The N-content of the treated or exported manure has been updated based on the mandatory transport certificates instead of default values. Previously the transport certificates were deemed to be too inaccurate, but a new analysis comparing average values from the transport certificates with the calculated values shows that the transport certificates are reliable (further details can be found in Van Bruggen et al. 2025). The total effects of the recalculation on 3B differ per year, varying between -0.57% in 2019 to +0.34% in 2017 (N_2O). The effects on methane are similar. No recalculation was performed for the years 1990-2009 as the transport certificates were not issued then, and the amount of manure transported is based on other sources (Van Bruggen et al. 2025).

The indirect N_2O emissions from manure management (3B5) have been recalculated as the emissions of NH_3 and NO_x are affected by the previous recalculation. More information on the calculation of these indirect emissions can be found in sections 12.9 and 12.10 of Van der Zee et al. (2025).

The methane emissions from poultry manure have been recalculated for the entire timeseries. The Biochemical Methane Potential (BMP) was previously set at 0.34 m^3/kg VS for all poultry types. However, the IPCC guidelines give a BMP of 0.39 m^3/kg VS for laying hens and 0.36 m^3/kg VS for all other poultry types. Since no explanation could be found for the difference between the used BMP and the BMP from the guidelines it was decided to follow the more conservative estimate from the guidelines. CH_4 emissions from 3B4 increased by around 10%.

VS excretion of dairy cattle was updated for the years 2017-2020. VS excretion has been differentiated between the two regions: North West and South East. VS excretion increased by between 0.17% and 0.35%. The ensuing methane emissions from manure management similarly increased (3B1) (Van Bruggen et al. 2025). VS excretion for the years 2021 and 2022 was already differentiated for the two regions.

5.3.6 *Category-specific planned improvements*

There are no planned improvements.

5.4 Agricultural soils (3D)

5.4.1 *Category description*

In 2023, agricultural soils were responsible for 23.4% of total GHG emissions in the Agriculture sector. Total N_2O emissions from agricultural soils decreased by 46.0% between 1990 and 2023 (Table 5.8). In 2023, N_2O emissions from grazing increased by 3% compared to 2022. Emissions from organic N fertilisers increased by 2.5% in 2023 due to a larger fraction of the manure going to arable land instead of grassland compared to 2022. Emissions from inorganic N fertilisers increased by 2.4% in 2023 compared to 2022. In 2023, emissions from crop residues decreased by 0.6% compared to 2022.

Table 5.8 Overview of the sector agricultural soils (3D) in the base year and the last two years of the inventory (in Tg CO_2 eq.). The middle column shows the change (%) of the last year of the inventory compared to the base year. On the right side of the table, the contribution of the last year inventory's emissions of the category to the sector, to the total national emissions of the specific gas and to the total national emissions (in CO_2 eq) are provided.

Sector/category	Gas	Key	1990	2022	2023	2023 vs 1990	Contribution of the category in 2023 (%) to the		
			Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
3D. Agriculture soils	N_2O		7.8	4.1	4.2	-46.0%	23.4%	63.7%	2.9%
3Da. Direct N_2O emissions from agricultural soils	N_2O	L,T	6.3	3.6	3.7	-41.6%	20.6%	56.1%	2.5%
3Da1. Inorganic ferilizers	N_2O		1.8	0.9	0.9	-46.9%	5.2%	14.2%	0.6%
3Da2. Organic N fertilizers	N_2O		0.7	1.1	1.1	57.4%	6.0%	16.5%	0.7%
3Da3. Urine and dung from grazing animals	N_2O		2.7	0.7	0.8	-71.6%	4.3%	11.6%	0.5%
3Da4. Crop residues	N_2O		0.4	0.3	0.3	-29.2%	1.7%	4.5%	0.2%
3Da5. Mineralization/ immobilization associated with loss/gain of soil organic matter	N_2O		0.05	0.02	0.04	-18.1%	0.2%	0.6%	0.0%
3Da6. Cultivation of organic soils	N_2O		0.7	0.6	0.6	-21.1%	3.2%	8.8%	0.4%
3Db. Indirect N_2O Emissions from managed soils	N_2O	L,T	1.4	0.5	0.5	-65.0%	2.8%	7.6%	0.3%

This sector comprises the following key categories:

3Da	Direct emissions from agricultural soils	N_2O
3Db	Indirect emissions from managed soils	N_2O

The decrease in total N_2O emissions from 1990 onwards has been caused by a relatively large decrease in N inputs into soil (from inorganic fertiliser and organic N fertiliser applications and from production of animal manure on pasture during grazing; Figure 5.5). This was partly counteracted by a shift from applying manure on top of the soil (surface spreading) towards incorporating it into the soil, initiated by the Dutch ammonia policy. Incorporating manure into the soil reduces emissions of ammonia but increases direct emissions of N_2O, counteracted in part by lower indirect N_2O emission following the atmospheric deposition of NH_3 and NO_x.

Methane emissions from agricultural soils are regarded as natural, non-anthropogenic emissions and are therefore not estimated.

The source category Agricultural soils includes emissions from:
- Inorganic fertilisers (3Da1);
- Organic N fertilisers (mainly animal manure, 3Da2);
- Urine and dung from grazing animals (3Da3);
- Crop residues (3Da4);
- Mineralisation/immobilisation associated with losses/gains of soil organic matter (3Da5)
- Cultivation of organic soils (3Da6);
- Indirect N_2O emissions from managed soils (3Db).

Figure 5.5 shows the trend in total agricultural soils emissions.

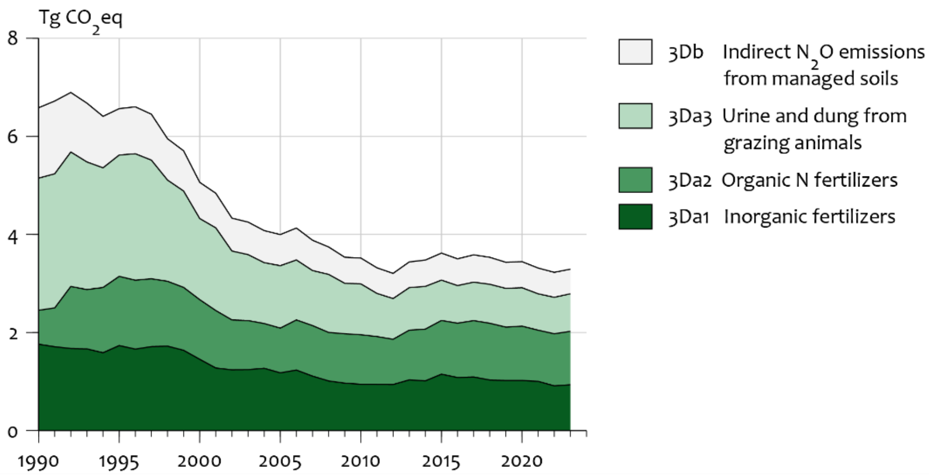


Figure 5.5 Category 3D Agricultural soils – trend and emission levels of source categories, 1990–2023

Between 70% and 80% of the N excreted in animal housing is available for application to soils. The remainder is lost during storage or exported. The export of manure increased in the last decade, but stagnated in recent years. The method to calculate manure export is explained in section 2.2.5 of Van der Zee et al. (2025). Approximately 10% to 16%

of the N excreted in housing is emitted as NH_3 or NO_x oxide during storage. In addition, part of the N stored in manure is lost as N_2 and N_2O.

The total N supply to the soil was considered to calculate leaching and run-off. This supply consists of N from manure production in animal housing and on pasture (including treated manure, corrected for manure export), as well as the application of inorganic N fertiliser, sewage sludge and compost. In accordance with the IPCC 2006 Guidelines, the calculation includes atmospheric N deposition because the N deposited to soil is also subject to leaching and run-off. Total N supply to the soil decreased by 39% between 1990 and 2023. This can be explained by the Netherlands' manure and fertiliser policy aimed at reducing N leaching and run-off. This policy regulates the amount of manure production and its application to soils by introducing measures, such as restrictions on the numbers of swine and poultry per farm (so-called 'manure production rights') and maximum application limits for manure and inorganic N fertiliser, all part of the Dutch 'Manure and Fertilisers Act' in accordance with the Nitrates Directive. Because the leaching fraction has also decreased over time, the amount of N leached or run off has been reduced by 47% since 1990.
Between 1990 and 2023, the emissions of crop residues decreased by 29.2% (Table 5.8). The same decreasing trend can be seen in the amount of crop residues left on the field. This is mainly due to a decrease in grassland renewal. The rate of grassland renewal decreased as a result of policy changes that encouraged permanent grassland (RVO, 2021). The methodology to calculate N_2O emissions from crop residues is provided in section 12.7 of Van der Zee et al. (2025). Activity data can be found in Annex 21 of Van Bruggen et al. (2025).

5.4.2 *Methodological issues*

Direct and indirect N_2O emissions from agricultural soils are estimated using country-specific activity data on N input to soil and NH_3 volatilisation during grazing, manure management, and manure application. Most of this data is estimated at Tier 2 or Tier 3 level. The present methodologies follow the 2006 IPCC Guidelines. A description of the methodologies used and the data sources is presented in Chapter 12 of Van der Zee et al. (2025). More information can be found in the background document by Van der Hoek et al. (2007). The activity data and characteristics for crops are presented in Van Bruggen et al. (2025).

Direct N_2O emissions (3Da)
An IPCC Tier 2 methodology is used to estimate direct N_2O emissions from agricultural soils.

The EF of inorganic N fertiliser application for direct N_2O emissions between 1990 and 1999 is based on a weighted mean of various inorganic N fertiliser types applied to both mineral and organic soils. The EFs for animal manure applied to or produced on pastureland during grazing between 1990 and 1999 are also based on weighted means of the EF for mineral and organic soils.

For the years from 2000 to 2023, separate EFs have been quantified for organic soils and mineral soils. A distinction has also been made between arable land and grassland. This results in three different EFs each for inorganic fertiliser application, surface spreading of manure, and manure incorporation into soil. The EFs of grassland and arable land on organic soils are the same, as the carbon content (and thus the potential for N_2O emissions) in these soils is hardly affected by the type of agriculture practiced. For the years 2000–2023, two separate EFs have also been quantified for organic and mineral soils used for grazing. The emission factors are based on field measurements which also took the effects of lowered groundwater levels into account (Velthof et al. 1996). An overview of the EFs used is presented in Table 5.9, with default IPCC EFs included for comparison.

Table 5.9 Emission factors for direct N_2O emissions from agricultural soils (kg N_2O-N per kg N supplied, except Mineralisation/immobilisation associated with losses/gains of soil organic matter, which is expressed in kg N_2O-N per kg CO_2)

Source	Default IPCC	EF used	Reference
Inorganic N fertiliser	**0.01**	**0.013**	**1**
Mineral soils grassland		0.008	1
Organic soils grassland		0.030	1
Mineral soils arable land		0.007	1
Organic soils arable land		0.030	1
Animal manure application	**0.01**		
Surface spreading average		**0.004**	**1**
Mineral soils grassland		0.001	1
Organic soils grassland		0.005	1
Mineral soils arable land		0.006	1
Organic soils arable land		0.005	1
Incorporation into soil average		**0.009**	**1**
Mineral soils grassland		0.003	1
Organic soils grassland		0.010	1
Mineral soils arable land		0.013	1
Organic soils arable land		0.010	1
Sewage sludge	**0.01**		
Surface spreading		0.004	1
Incorporation into soil		0.009	1
Compost	**0.01**	**0.004**	**2**
Animal manure during grazing (cattle/swine/poultry)	**0.02**	**0.033**	**1**
Mineral soils		0.025	1
Organic soils		0.060	1
Animal manure during grazing (sheep/other animals)	**0.01**	**0.033**	**1**
Mineral soils		0.025	1
Organic soils		0.060	1
Crop residues	**0.01**	**0.01**	**3**
Grassland renewal		**5.5***	**5**

Source	Default IPCC	EF used	Reference
Mineralisation/immobilisation associated with losses/gains of soil organic matter	**0.01**		
Cultivation of organic soils		**0.02**	**3, 4**

*kg N_2O-N per ha grassland renewed
References: 1 = Velthof et al. (2010a), Velthof and Mosquera (2011), Van Schijndel and Van der Sluis (2011); 2 = equal to that of surface-applied manure (Velthof and Mosquera, 2011); 3 = Van der Hoek *et al.* (2007); 4 = Kuikman *et al.* (2005); 5 = Velthof et al. 2010b.

Emissions from animal manure application are estimated for two manure application methods: surface spreading (which has a lower EF) and incorporation into soil (which has a higher EF). The higher value for incorporation is explained by two mechanisms. Incorporation of animal manure into the soil produces less NH_3; therefore, more reactive N enters the soil available for N_2O emission. Furthermore, the manure is more concentrated (i.e. hot spots/anaerobic) than with surface spreading, generally creating improved conditions for N_2O production during nitrification and denitrification processes.
The different EFs for mineral soils and organic soils and mineral soil - arable land and mineral soil – grassland are caused by the difference in organic matter content. The organic matter content of the soil influences the N_2O emission. Organic soils have a higher organic matter content than mineral soils and mineral soils - grassland have a higher organic matter content than mineral soils – arable land. The difference in organic matter content between organic soil – grassland and organic soil – arable is negligible (Velthof and Rietra, 2018).

The IEF of direct N_2O emissions from the application of animal manure on agricultural soils increased by 113% in the 1990–2023 period (Table 5.10). This was caused by an ammonia policy-driven shift from the surface spreading of manure to the incorporation of manure into the soil.

Table 5.10 N_2O implied emission factor (kg N_2O-N per kg N supplied) from animal manure applied (excl. manure on pasture) to agricultural soils, 1990–2023

	'90	**'95**	**'00**	**'05**	**'10**	**'15**	**'20**	**'22**	**'23**
Nitrogen input from manure applied to soils	0.004	0.008	0.009	0.007	0.008	0.008	0.008	0.008	0.009

The net decrease in direct N_2O emissions (3Da) can be explained by the decrease in the direct N input to the soil by manure and inorganic N fertiliser application, partly countered by an increase in IEF because of the manure incorporation into the soil.

No experimental data on compost emissions is available. On the basis of expert judgement, the emission factor for compost was set equal to that of surface-applied manure, because compost is also applied to the surface. The IPCC guidelines contain one emission factor for all N additions to the soil. The emission factor used is within the uncertainty range provided by the IPCC (0.003-0.03). The EF used for urine and dung deposited by grazing animals is based on Velthof et al. (1996) who conducted a field study on N_2O emissions resulting from grazing in the Netherlands, during the study the effect of a lowered ground water level was taken into account. Annex 9 of Van der Zee et al. (2025) describes how the results of this paper were used to calculate the emission factors used in the inventory of the Netherlands. As arable farming on organic soils is a relatively small compared to arable farming on mineral soils in the Netherlands, the EF for crop residues is based on mineral soils only. The EF of grassland renewal is based on the average of grassland renewal with and without ploughing up the land (Velthof et al. 2010b).

Emissions from mineralisation/immobilisation associated with losses/gains of soil organic matter are calculated using the Tier 1 method. The losses of soil organic matter are calculated by the LULUCF sector and discussed in Chapter 6. A constant C/N ratio of 10 is used throughout the time series. More information can be found in section 12.9 of Van der Zee et al. (2025).

Indirect N_2O emissions (3Db)
An IPCC Tier 2 method is used to estimate indirect N_2O emissions from atmospheric deposition. Country-specific data on NH_3 and NO_x emissions (estimated at Tier 3 level using NEMA) is multiplied by the IPCC default N_2O EF. The emissions can be found in Chapter 9 of Van Bruggen *et al.* (2025).

Indirect N_2O emissions resulting from leaching and run-off are estimated using country-specific data on total N input to soil and leaching fraction (estimated at Tier 3 level). The leaching fraction can be found in section 4.2 of Van Bruggen et al. (2025). The leaching fraction applied in the model reflects the specific characteristics of the Dutch agricultural soils, with relatively high water tables. A model (STONE) was adopted to assess this fraction, as described in Velthof and Mosquera (2011), while IPCC default values were used for the N_2O EF.

5.4.3 Uncertainty assessment and time-series consistency

Uncertainty assessment
The uncertainty analysis outlined in Annex 2 provides estimates of uncertainty per IPCC source category. The uncertainty in direct N_2O emissions from inorganic N fertiliser, organic N fertiliser, and manure and dung deposited by grazing animals is estimated at 42%, 69%, and 68%, respectively. The uncertainty in indirect N_2O emissions from N used in agriculture is estimated to be more than 200%; primarily relating to the emission factor uncertainties.

Time-series consistency
A consistent methodology is used throughout the time series; see section 5.4.2. Emissions are calculated as the product of livestock numbers and EFs. Livestock numbers are collected through the Identification and Registration system and in an annual census as published by Statistics Netherlands (CBS). Consistent methods are used in compiling the census to ensure consistency in the collected data.

5.4.4 Category-specific QA/QC

This source category is covered by the general QA/QC procedures discussed in Chapter 1.

5.4.5 *Category-specific recalculations*

Three category-specific recalculations have been performed. The reassessment of the manure transport certificates and the amount of treated manure cause the amount and distribution of animal manure over the different soil types to change. Additionally, as the INITIATOR model was rerun for the years 2000-2022, now including straw in the manure, the manure distribution (animal, inorganic and pasture) changes as well. These changes combined affect the N_2O emissions from manure application by +0.3% to +3.8%. N_2O emissions from pasture manure change by between -1.3% to +0.2%. N_2O emissions from inorganic fertiliser application change by -1.1% to +0.6% (Van Bruggen et al. 2025).

The Initiator model does not account for the years prior to 2000. In 2025, it will be assessed whether a time series correction can be implemented for the years 1990-1999.

Emissions from crop residues (3Da4) were recalculated for the years 2006-2022. The rate of grassland renewal was erroneously found to be including natural grassland. This means that the renewal rate of grassland excluding natural grassland is higher as natural grasslands are not allowed to be renewed. N_2O emissions from crop residues increased by between 0.12% and 0.57%. N_2O emissions decreased in 2022 as the final renewal rates were used instead of the preliminary rates. The source of the grassland renewal rate for the years 1990-2005 did not have to change as it did not include natural grasslands.

Lastly, N_2O emissions from mineralisation/immobilisation associated with loss/gain of soil organic matter (3Da5) have been recalculated as the losses of organic matter content were recalculated by the LULUCF sector for the entire timeseries. N_2O emissions from mineralisation/immobilisation associated with loss/gain of organic matter changed by between -0.83% and +0.01%.

5.4.6 *Category-specific planned improvements*

There are currently no planned improvements.

5.5 Liming (3G)

5.5.1 *Category description*

The source category Liming includes emissions of CO_2 from the application of limestone (calcium carbonate) and dolomite (calcium-magnesium carbonate) to agricultural soils. Limestone and dolomite are applied to maintain a suitable pH range for crop and grass production. CO_2 emissions from liming decreased by 86.3% between 1990 and 2023 as a result of a decrease in limestone and dolomite use (Table 5.11).

Table 5.11 Overview of the sector Liming (3G) in the base year and the last two years of the inventory (in Tg CO_2 eq.). The middle column shows the change (%) of the last year of the inventory compared to the base year. On the right side of the table, the contribution of the last year inventory's emissions of the category to the sector, to the total national emissions of the specific gas and to the total national emissions (in CO_2 eq) are provided.

Sector/category	Gas	Key	1990	2022	2023	2023 vs 1990	Contribution of the category in 2023 (%) to the		
			Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
3G. Liming	CO_2	non key	0.183	0.033	0.025	-86.3%	0.1%	0.0%	0.0%

Category 3G Liming is not a key category.

Limestone and dolomite make up 40–60% of the calcium-containing fertilisers used in agriculture. The remaining percentage (30%–55% of the total) consists mainly of sugar beet factory lime. CO_2 emissions related to the latter are balanced by the CO_2 sink in sugar production and are therefore not accounted for. More information can be found in section 2.2.3.1 of Honig et al. (2025).

5.5.2 *Methodological issues*

Data on liming is derived from annually updated statistics on fertiliser use. The annual amounts of applied limestone and dolomite are converted into CO_2 emissions, in line with the calculations in the 2006 IPCC Guidelines.

Limestone and dolomite amounts reported in CaO (calcium oxide) equivalents are multiplied by the EFs for limestone (440 kg CO_2/ton pure limestone) and for dolomite (477 kg CO_2/ton pure dolomite). This method complies with IPCC Tier 1 methodology. More detailed descriptions of the methodologies and EFs used can be found in Chapter 15 of Van der Zee et al. (2025).

5.5.3 *Uncertainty assessment and time-series consistency*

Uncertainty assessment

The analysis outlined in Annex 2 provides estimates of uncertainties by IPCC source category. The uncertainty in CO_2 emissions from liming of soils is calculated at c. 25%. The uncertainty in the activity data is estimated to be 25% and the uncertainty in the EFs is 1%. When considered over a longer time span, all carbon applied through liming is emitted.

Time-series consistency

The methodology used to calculate CO_2 emissions from limestone and dolomite application for the 1990–2023 period is consistent over time. Statistics on calcium-containing fertiliser use are collected by Wageningen Economic Research and published on the website agrimatie.nl (direct link: http://agrimatie.nl/KunstMest.aspx?ID=16927).

5.5.4 *Category-specific QA/QC and verification*

The source categories are covered by the general QA/QC procedures discussed in Chapter 1.

5.5.5 *Category-specific recalculations*

Every year, preliminary numbers of limestone and dolomite application are used for the last year in the inventory. The final usage of limestone and dolomite in 2022 differs from the preliminary numbers, resulting in a 2% increase of CO_2 emissions in 2022.

5.5.6 *Category-specific planned improvements*

The preliminary application rates of the liming products in 2023 will be replaced with the final application rates.

5.6 Urea application (3H)

5.6.1 *Category description*

During the production of urea, CO_2 is trapped from the atmosphere. This CO_2 is subsequently released during the application of urea. The entrapment is attributed to the production. The CO_2 emissions resulting from the application of urea on Dutch farmland are attributed to the Agriculture sector. Between 1990 and 2002 urea usage was low, with small yearly fluctuations. After 2002 urea usage increased peaking in 2013. After 2013 urea usage shows large yearly fluctuations, but remain at a high level, compared to the 1990's. Carbon dioxide emissions from urea application increased by 4393% from 1990 to 2023 (Table 5.12).

Table 5.12 Overview of the sector Urea application (3H) in the base year and the last two years of the inventory (in Tg CO_2 eq.). The middle column shows the change (%) of the last year of the inventory compared to the base year. On the right side of the table, the contribution of the last year inventory's emissions of the category to the sector, to the total national emissions of the specific gas and to the total national emissions (in CO_2 eq) are provided.

Sector/category	**Gas**	**Key**	**1990**	**2022**	**2023**	**2023 vs 1990**	**Contribution of the category in 2023 (%) to the**		
			Emissions in Tg CO_2 eq			**%**	**sector**	**total gas**	**total CO_2 eq**
3H. Urea Application	CO_2	non key	0.002	0.060	0.068	4393.4%	0.4%	0.1%	0.0%

Category 3H urea application is not a key category.

5.6.2 *Methodological issues*

Data on urea application are derived from annually updated statistics on fertiliser use. Urea fertilisers often contain other N compounds. As there is no information on the percentage of urea in urea fertilisers the calculations assume that urea fertilisers only consist of urea. The amounts of annually applied urea are converted into CO_2 emissions in line with the calculations in the 2006 IPCC Guidelines.

The amount of urea is multiplied by the EF for urea (0.2 kg CO_2/kg urea). This method follows the IPCC Tier 1 methodology. More detailed descriptions of the methodology and EF used can be found in Chapter 16 of Van der Zee et al. (2025).

5.6.3 *Uncertainty assessment and time-series consistency*

Uncertainty assessment

The analysis outlined in Annex 2 provides estimates of uncertainties by IPCC source category. The uncertainty in CO_2 emissions from urea application is calculated at 25%. The uncertainty in the activity data is estimated to be 25% and the uncertainty in the EFs is 1%. When considered over a longer time span, all carbon applied through liming is emitted.

Time-series consistency

The methodology used to calculate CO_2 emissions from urea application is consistent over time. Statistics on urea application are collected by the agricultural census.

5.6.4 *Category-specific QA/QC and verification*

The source categories are covered by the general QA/QC procedures discussed in Chapter 1.

5.6.5 *Category-specific recalculations*

Every year, preliminary numbers of urea application are used for the last year in the inventory. The final usage of urea in 2022 differs from the preliminary numbers, resulting in a 5% increase of CO_2 emissions in 2022.

5.6.6 *Category-specific planned improvements*

The preliminary application rate of urea in 2023 will be replaced by the final application rate.

6 Land use, land use change and forestry (CRT sector 4)

Major changes in the LULUCF sector compared to the National Inventory Report 2024

Emissions:	In 2023, total reported LULUCF emissions increased by 6% compared to 2022. Compared to the base year, emissions in 2023 were 14.9% lower. As a result of methodological changes described in this NIR 2025, emissions in the LULUCF sector for the year 1990 decreased by 18.5% compared to the NIR 2024. For 2022, they decreased by 31.4% compared to the NIR 2024.
New Key categories:	No changes in key categories compared to the NIR 2024
Methodologies:	In the NIR 2025, three methodological changes have been implemented. All three result in recalculations for the whole time series. The methodological changes are as follows: 1) The emission factor for drained organic soils for all land uses was updated to match new scientific insight from a national research programme on emissions from (drained) organic soils. 2) The area of drainage ditches on organic soils was updated for the land uses Cropland, Grassland, Trees outside Forest and Forest land, from Tier 1 to country specific Tier 2 data. 3) For mineral soil, for all land uses, the soil carbon stocks were updated based on a national soil monitoring campaign from 2018. The number of aggregated soil types has been decreased to reduce the uncertainty in soil organic carbon stocks.

6.1 Overview of the sector and background information

6.1.1 General overview of shares and trends in sources and sinks

This chapter describes the 2025 GHG inventory for the Land use, land use change and forestry (LULUCF) sector. It covers both the sources and sinks of CO_2 from land use, land use change, and forestry. Emissions of nitrous oxide (N_2O) from the cultivation of organic soils are included in the Agriculture sector (category 3D), except for N_2O emissions from Forest land, which are reported in CRT Table 4(II). Direct N_2O emissions from nitrogen mineralisation associated with loss/gain of soil organic matter in all land categories (CRT table 4(III)) are included here, except those from Cropland remaining cropland, which are also included in the Agriculture sector. Methane (CH_4) emissions from drainage ditches in drained Forest land, Cropland, agricultural grasslands and Trees outside Forest on organic soils are reported in CRT Table 4(II) as a specific category under organic soils for these land use categories. Emissions of CH_4 from open water are reported under Wetlands in CRT Table 4(II).

Land use in the Netherlands is dominated by agriculture (approximately 54%), followed by settlements (15%) and forestry (9%); 3% comprises dunes, nature reserves, wildlife areas, heather, and reed swamp. The remaining area (19%) is open water (information based on the 2021 land use maps used for LULUCF reporting, see Van Baren et al., 20255).

The soils in the Netherlands are dominated by mineral soils, mainly sandy soils, and clay soils (of fluvial or marine origin). Organic soils, used mainly as meadowland, cover about 11% of the land area, one third of them being peaty soils.

The Netherlands has an intensive agricultural system with high inputs of nutrients and organic matter. The majority of agricultural land is grassland (48%) or arable farming land (27%). The remaining land is fallow or used for horticulture, fruit trees, etcetera. In 2023, 70% of grassland was permanent grassland (of which 9% is high nature value grassland); the remaining 21% is temporary grassland, on which grass and fodder maize are cultivated in rotation (Statistics Netherlands, 2024[6]). Since 1990, the agricultural land area has decreased by about 5%, mainly because of conversion to settlements/infrastructure and nature.

Table 6.1 presents the sources and sinks in the LULUCF sector in 1990, 2022 and 2023. For 1990 and 2023, total net emissions are 4.4 Tg CO_2-eq and 3.8 Tg CO_2-eq, respectively. The results for 2022 have been added to give insight into annual changes.

Sector 4 (LULUCF) accounted for about 2.62% of net national total CO_2 equivalent emissions in 2022.

CO_2 emissions from the drainage of peat soils and peaty soils were the major source in the LULUCF sector and total 5.13 Tg CO_2 in 2023 (6.12 Tg CO_2 in 1990). This drainage results in peat oxidation and is due to agricultural and urban water management; it is the chief contributor to the net emissions of Cropland (4B), Grassland (4C) and Settlements (4E). Additionally, drainage ditches on organic soils added 8.6 Gg CH_4 (0.24 Tg CO_2-eq) in 2023, compared to 10.2 Gg CH_4 (0.29 Tg CO_2-eq) in 1990.

Forests constitute the major net CO_2 sink with -2.1 Tg CO_2 in 2023, which includes Forest land remaining Forest land (4A1) and Land converted to Forest land (4A2). Compared to 2022 the net CO_2 sink stayed stable.

[6] CBS Statline Landbouwtelling; oppervlakte gewassen, aantal dieren, arbeidskrachten en bijbehorend aantal bedrijven. https://opendata.cbs.nl/portal.html?_la=nl&_catalog=CBS&tableId=81302ned&_theme=203. Accessed 18 December 2024.

Table 6.1 Overview of the Land use, land use change and forestry (LULUCF) sector in the base year and the last two years of the inventory (in Tg CO_2 eq.). The middle column shows the change (%) of the last year of the inventory compared to the base year. On the right side of the table, the contribution of the last year inventory's emissions of the category to the sector, to the total national emissions of the specific gas and to the total national emissions (in CO_2 eq) are provided.

Sector/category	Gas	Key	1990	2022	2023	2023 vs 1990	Contribution of the category in 2023 (%) to the		
			Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
4. Total Land use Categories	CO_2		3.7	2.8	3.1	-16.4%	81.9%	2.6%	2.1%
	CH_4		0.6	0.6	0.6	1.9%	15.5%	0.5%	0.4%
	N_2O		0.1	0.1	0.1	-13.8%	2.7%	0.1%	0.1%
	All		4.4	3.5	3.8	-13.9%	100.0%	3.2%	2.6%
4A. Forest land	CO_2	L,T	-2.2	-2.1	-2.1	7.7%	-54.3%	-1.7%	-1.4%
4A1. Forest land remaining Forest Land	CO_2		-1.4	-1.4	-1.4	2.5%	-35.8%	-1.1%	-0.9%
4A2. Land converted to Forest Land	CO_2		-0.8	-0.7	-0.7	16.3%	-18.5%	-0.6%	-0.5%
4B. Cropland	CO_2	L,T	3.2	2.2	2.4	-24.5%	62.8%	2.0%	1.6%
4B1. Cropland remaining Cropland	CO_2		1.4	0.7	0.8	-43.6%	21.0%	0.7%	0.5%
4B2. Land converted to Cropland	CO_2		1.7	1.5	1.6	-9.1%	41.7%	1.3%	1.1%
4C. Grassland	CO_2	L,T	1.7	1.2	1.3	-23.3%	34.9%	1.1%	0.9%
4C1. Grassland remaining Grassland	CO_2		2.4	2.0	2.2	-9.9%	57.4%	1.8%	1.5%
4C2. Land converted to Grassland	CO_2		-0.7	-0.8	-0.9	-23.8%	-22.4%	-0.7%	-0.6%
4D. Wetlands	CO_2		0.02	-0.02	-0.02	-221.7%	-0.6%	0.0%	0.0%
	CH_4		0.3	0.3	0.3	19.1%	9.1%	0.3%	0.2%
4D1. Wetlands remaining Wetlands	CO_2		IE,NA, NO	IE,NA, NO	IE,NA, NO		0.0%	0.0%	0.0%
	CH_4		0.2	0.3	0.3	29.5%	0.1%	0.3%	0.2%
4D2. Land converted to Wetlands	CO_2		0.02	-0.02	-0.02	-221.7%	-0.6%	0.0%	0.0%
	CH_4		0.05	0.04	0.04	-26.6%	1.1%	0.0%	0.0%
	All		0.3	0.3	0.3	29.5%	8.5%	0.3%	0.2%
4E. Settlements	CO_2	L,T	1.0	1.1	1.1	14.8%	29.9%	0.9%	0.8%
4E1. Settlements remaining Settlements	CO_2		0.2	0.4	0.4	116.5%	10.5%	0.3%	0.3%

Sector/category	Gas	Key	1990	2022	2023	2023 vs 1990	Contribution of the category in 2023 (%) to the		
			Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
4E2. Land converted to Settlements	CO2		0.8	0.7	0.7	-8.4%	19.4%	0.6%	0.5%
4F. Other land	CO_2	L,T	0.1	0.2	0.2	82.4%	5.9%	0.2%	0.2%
4F1. Other land remaing other Land	CO_2		0.0	0.0	0.0		0.0%	0.0%	0.0%
4F2. Land converted to Other Land	CO_2		0.1	0.2	0.2	82.4%	5.9%	0.2%	0.2%
4G. Harvested wood products	CO_2		-0.1	0.1	0.1	281.5%	3.3%	0.1%	0.1%
National Total GHG emissions (incl. CO_2 LULUCF)	CO_2		167.7	130.8	120.6	-28.1%			
	CH_4		36.5	18.6	18.4	-49.5%			
	N_2O		16.1	6.7	6.6	-59.0%			
	Total		227.5	157.0	146.4	-35.6%			

Emissions of CH_4 are only presented explicitly for open water under wetlands. Other emissions of CH_4 and emissions of N_2O are only presented for the total as the subdivision into the separate land use categories will mostly result in emissions that are smaller than 0.1 Tg CO_2-eq.

Key categories

When taking LULUCF categories into account in the key category analysis, the inventory comprises the following key categories:

4A	Forest land	CO_2
4B	Cropland	CO_2
4B	Cropland	N_2O
4C	Grassland	CO_2
4C	Grassland	CH_4
4E	Settlements	CO_2
4F	Other land	CO_2

6.1.2 *Methodology and coverage*

Details of the methodologies applied to estimating CO_2 emissions and removals in the LULUCF sector in the Netherlands are given in a methodological background document (Van Baren et al., 2025).

The methodology of the Netherland for assessing emissions from LULUCF is primarily based on the 2006 IPCC Guidelines (IPCC, 2006), and the 2019 refinement to the 2006 IPCC guidelines (IPCC, 2019). It follows a carbon stock change approach that is based on inventory data subdivided into appropriate pools and land use types, and a wall-to-wall approach for the estimation of area per category of land use. For the calculation of CH_4 emissions from open water under the Wetland category, from drainage ditches in peat meadows (Grassland) and

Cropland on organic soils, the guidelines from the 2013 IPCC Wetlands supplement (IPCC, 2014) were applied.

The information on the activities and land use categories covers the entire territorial (land and water) surface area of the Netherlands. The inventory includes six land use categories: Forest land (4A); Cropland (4B); Grassland (4C); Wetlands (4D) (including open water); Settlements (4E) and Other land (4F). Category (4G) Harvested wood products (HWP) (4G), provides information on carbon gains and losses from the HWP carbon pool.

Spatially explicit land use and land-use conversion data ('remaining' or 'land converted to') is presented in a matrix (see section 6.3) in accordance with the geographically explicit Approach 3 described in Chapter 3 of Volume 4 of the 2006 IPCC Guidelines.

The land use category Grassland is subdivided in two sub-categories: Grassland (non-TOF) and Trees outside forests (TOF) (see section 6.2 and Van Baren et al., 2025). The sub-category Grassland (non-TOF) is the aggregation of the main sub-categories Grassland (i.e. predominantly grass vegetation), Nature (mainly heathland and peat moors) and Orchards. All IPCC categories are applicable to the Netherlands.

TOF are units of land that do not meet the minimum area requirement for the forest definition, but otherwise fulfil those requirements in terms of tree cover and tree height. Therefore, this category is included under Grassland. In terms of carbon stocks and their changes, the TOF category, however, is similar to Forest land.

Conversions of land use from, to, and between Grassland (non-TOF) and TOF are monitored separately, and subsequent calculations of carbon stock changes differ from one another (see Van Baren et al., 2025).

An overview of the completeness of reporting by the Netherlands is provided in Table 6.2. In this table, pools for which carbon stock changes are reported are indicated in bold type, with the appropriate tier level in brackets. 'NO' is used for pools for which there are no carbon stock changes. 'IE' indicates that carbon stock changes are included elsewhere. Pools for which carbon stock changes are not estimated are marked 'NE', with an indication of the significance of the respective source or sink ('s' = significant, 'n.s.' = not significant) and a reference to the section where this is justified in this NIR.

The notation key NA is used in cases with a Tier 1 assumption of carbon stock equilibrium.

CH_4 emissions from flooded lands under Wetlands are reported using a Tier 1 methodology and default emission factors (see section 6.7.2).

Table 6.2 Carbon stock changes reported in the national inventory per land use (conversion) category

From To↓	**FL**	**CL**	**GL**	**WL**	**Sett**	**OL**
FL	BG (T2) BL (T2) DD (T2) DW (T2) Litt (T2) MS (NA) OS (T2) FF (T1)	BG (T2) BL (T2) DD (T2) DW (T2) Litt (T2) MS (T2) OS (T2) FF (IE)	BG (T2) BL (T2) DD (T2) DW (T2) Litt (T2) MS (T2) OS (T2) FF (IE)	BG (T2) BL (T2) DD (T2) DW (T2) Litt (T2) MS (T2) OS (T2) FF (IE)	BG (T2) BL (T2) DD (T2) DW (T2) Litt (T2) MS (T2) OS (T2) FF (IE)	BG (T2) BL (T2) DD (T2) DW (T2) Litt (T2) MS (T2) OS (T2) FF (IE)
CL	BG (T1) BL (T2) DD (T2) DM (T2) MS (T2) OS (T2) WF (IE)	BG (NA, n.s. 6.5.1) BL (NA, n.s., 6.5.1) DD (T2) DM (NA, n.s., 6.5.1) MS (T3) OS (T2, T3) WF (IE)	BG (T1) BL (T1) DD (T2) DM (NA, n.s., 6.5.1, 6.6.1) MS (T2) OS (T2) WF (IE)	BG (T1) BL (NO) DD (T2) DM (NA, n.s., 6.5.1, 6.7.1) MS (T2) OS (T2) WF (IE)	BG (T1) BL (NO) DD (T2) DM (NA, n.s. 6.5.1, 6.8.1) MS (T2) OS (T2) WF (IE)	BG (T1) BL (NO) DD (T2) DM (NA, n.s. 6.5.1, 6.9.1) MS (T2) OS (T2) WF (IE)
GL	BG (T1, T2) BL (T2) DD (T2) DM (T2) MS (T2) OS (T2) WF (IE)	BG (T1, T2) BL (T1, T2) DD (T2) DM (NA, 6.5.1, 6.6.1) MS (T2) OS (T2) WF (IE)	BG (T2) BL (T1, T2) DD (T2) DM (NO, NA, n.s 6.6.1) MS (T3) OS (T2, T3) WF (T1)	BG (T1, T2) BL (NO) DD (T2) DM (NA, n.s 6.6.1, 6.7.1) MS (T2) OS (T2) WF (IE)	BG (T1, T2) BL (NO) DD (T2) DM (NA, n.s 6.6.1, 6.8.1) MS (T2) OS (T2) WF (IE)	BG (T1, T2) BL (NO) DD (T2) DM (NA, n.s. 6.6.1, 6.9.1) MS (T2) OS (T2) WF (IE)

From To↓	FL	CL	GL	WL	Sett	OL
WL	BG (NE, n.s. 6.7.1) BL (T2) DM (T2) MS (T2) OS (T2) WF (IE)	BG (NE, n.s. 6.7.1) BL (T1) DM (NE, 6.5.1, 6.7.1) MS (T2) OS (T2) WF (IE)	BG (NE, n.s. 6.7.1) BL (T1, T2) DM (NE, 6.6.1, 6.7.1) MS (T2) OS (T2) WF (IE)	BG (NE, n.s. 6.7.1) BL (NE, n.s. 6.7.1) DM (NE, n.s. 6.7.1) MS (NA) OS (NO) WF (IE)	BG (NE, n.s. 6.7.1) BL (NO) DM (NE, n.s 6.7.1, 6.8.1) MS (T2) OS (NO) WF (IE)	BG (NE, n.s. 6.7.1) BL (NO) DM (NE, n.s 6.7.1, 6.9.1) MS (T2) OS (NO) WF (IE)
Sett	BG (NE, n.s. 6.8.1) BL (T2) DM (T2) MS (T2) OS (T2) WF (NO)	BG (NE, n.s. 6.8.1) BL (T1) DM (NA, 6.5.1, 6.8.1) MS (T2) OS (T2) WF (NO)	BG (NE, n.s. 6.8.1) BL (T1, T2) DM (NA, 6.6.1, 6.8.1) MS (T2) OS (T2) WF (NO)	BG (NE, n.s. 6.8.1) BL (NO) DM (NA, 6.7.1, 6.8.1) MS (T2) OS (T2) WF (NO)	BG (NA, n.s. 6.8.1) BL (NA, n.s. 6.8.1) DM (NA, 6.8.1) MS (NA) OS (T2) WF (NO)	BG (NE, n.s. 6.8.1) BL (NO) DM (NA, 6.8.1, 6.9.1) MS (T2) OS (T2) WF (NO)
OL	BG (NO, n.s. 6.9.1) BL (T2) DM (T2) MS (T2) OS (NO) WF (NO)	BG (NO, n.s. 6.9.1) BL (T1) DM (NA, 6.5.1, 6.9.1) MS (T2) OS (T2) WF (NO)	BG (NO, n.s. 6.9.1) BL (T1, T2) DM (NA, 6.6.1, 6.9.1) MS (T2) OS (T2) WF (NO)	BG (NO, n.s. 6.9.1) BL (NO) DM (NA, 6.7.1, 6.9.1) MS (T2) OS (NO) WF (NO)	BG (NO, n.s. 6.9.1) BL (NO) DM (NA, 6.8.1, 6.9.1) MS (T2) OS (T2) WF (NO)	NA

Carbon stock changes included are BG: Biomass Gain; BL: Biomass Loss; DD: Drainage Ditches (<3 m) on organic soils with methane emissions; DW: Dead Wood; Litt: Litter; DM: Dead organic Matter; MS: Mineral Soils; OS: Organic Soils; FF: Forest Fires; WF: Other Wildfires. Land use types are: FL: Forest Land; CL: Cropland; GL: Grassland; TOF: Trees Outside Forests; WL: Wetland; Sett: Settlements; OL: Other Land.
Pools for which carbon stock changes are reported are indicated in bold type, with the appropriate tier level in brackets. See the indicated sections for further justification for the use of the notation key 'NA' in the case of non-significant (n.s.) pools

Forest land, Cropland, Grassland and Settlements are key categories; grassland is so due to the significant CH_4 emissions from peat soils (see sections 6.5.1, 6.6.1 and 6.8.1).

Carbon stock changes in biomass and dead organic matter
The specific methodologies applied to calculating carbon stock changes in living biomass and dead organic matter are provided in the sub-chapters dealing with the land use categories: Forest land (6.4), Cropland (6.5), Grassland (6.6), Wetlands (6.7), Settlements (6.8) and Other land (6.9). Methodologies for harvested wood products are provided in section 6.10.

Carbon stock changes in mineral soils
The Netherlands uses a Tier 3 approach to assess carbon stock changes in mineral soils for Cropland remaining cropland and Grassland remaining grassland under agricultural use. For mineral soils under the other 'remaining' land use categories a Tier 1 assumption of dynamic equilibrium is assumed, which is reported as NA in the CRT. A Tier 2 approach is used for calculating carbon stock changes in land use conversions on mineral soils.

Cropland remaining cropland and Grassland remaining grassland
Changes in carbon stocks in mineral soils for Cropland remaining cropland and Grassland remaining grassland are calculated by means of the RothC model (version 26.3, Coleman and Jenkinson 2014) that is applied on a national scale, as described in Lesschen et al. (2021). For more details on the methodology, see section 11.2.2 in Van Baren et al. (2025). The model provides dynamic carbon stock changes over time that depend on a number of input variables. The most important input data are crop areas, input of organic fertilisers, use of cover crops, removal of straw and soil carbon content. A consistent time series of the input data has been made for the 1990-2023 period. Calculations are performed at 4-digit zip code level, comprising about 3,400 units with agricultural land. Further details on the input data can be found below.

- Climate data: Monthly data for the 1990-2023 period is available per KNMI zone (14 zones) in the Netherlands.
- Crop areas are based on 'Basisregistratie landbouwpercelen' (BRP, base layer for the Land Parcel Information System (LPIS) in the Netherlands) and aggregated to 40 crop categories. Detailed data has been available from 2005 onwards, while for the 1990-2004 period, national data was downscaled on the basis of the crop distribution data from 2005.
- Crop yield is based on harvest statistics from Statistics Netherlands (CBS), for the most common crops at provincial level and other crops at national level.
- Organic fertiliser supply is based on data from the Initiator model, which is also used in the National Emission Model for Agriculture (NEMA) for reporting on the Agriculture sector. A distinction is made between grazing and fertiliser application on grassland and cropland. This data has been available from 2000 onwards, while for the 1990-1999 period, data from Statistics Netherlands was used. This data is based on nitrogen applications and converted using average C/N ratios to carbon.

- Compost inputs are derived from data from the Agriculture sector, which includes data on the nitrogen inputs from compost. This is only a small supply source of carbon compared to manure.
- For cover crops (green manures and catch crops), detailed data from LPIS has been available from 2017 onwards, while for the period before, only national total areas are available, which were obtained from NEMA.
- Straw removal is based on national average data from the 'Bedrijven Informatie Netwerk' (BIN, the Dutch data for the EU Farm Accountancy Data Network (FADN)[7]) for wheat and barley straw. This information has been available from 2005 onwards, while the 2005-2007 average was used for the 1990-2004 period. For other straw crops, a fixed percentage was applied, as described in Lesschen et al. (2021)

Lesschen et al. (2021) used soil carbon data from the 2018 Soil Sampling Programme (Knotters et al., 2022), but this only considers spatial variation in soil carbon to a limited extent. Therefore, a new soil carbon map was created on the basis of digital soil mapping, in which data from the Soil Sampling Programme was used and linked to a wide range of other data, such as land use and topography. A pH map of the Netherlands has previously been made, using this same digital soil mapping method, see Helfenstein et al. (2022). This new soil organic carbon map has a resolution of 25 m and was aggregated to average soil organic carbon (SOC) contents under mineral grassland and arable soils has been calculated per 4-digit zip code area. In the last step, the results of the model are aggregated per main soil type (sand, clay, loess, and soils with human-induced organic rich topsoil (*eerdgrond*)) to annual average carbon stock changes per ha Cropland or Grassland.

The SOC balance calculations with RothC have been performed on the basis of the actual monthly climate data from the Royal Netherlands Meteorological Institute (KNMI). As the model is quite sensitive to the climate parameters, the annual variability of the SOC balance was considerable (-0.41 to +0.25 ton C/ha), we therefore opted to use the five-year average SOC balance for C fluxes in the Cropland remaining cropland and Grassland remaining grassland categories. This five-year period is in line with the five-year accounting periods of the EU LULUCF regulation and also with the national forest inventory, which is based on a five-year cycle. The five-year average SOC balance is calculated using the actual year and the four preceding years, e.g. the value for 2023 is based on the average of the 2019-2023 period.

Land use conversions on mineral soils
For land use conversions on mineral soils, the approach is based on the overlay of the land use maps with the 2014 update of the Dutch soil map, combined with the soil carbon stocks quantified for each land-use and soil type combination (see section 3.5 in Van Baren et al., 2025).

For the Netherlands, the national soil survey (CC-NL) of 2018 (Knotters et al., 2022), which is an update of the older soil survey of soil map units (Finke et al., 2001), is the basis for quantifying carbon emissions

[7] https://agriculture.ec.europa.eu/data-and-analysis/farm-structures-and-economics/fadn_en

from land use changes on mineral soils. The CC-NL, which covers about 1150 locations at two different depths (0-30 cm and 30-100 cm). SOC stocks in the upper 30 cm were determined based on the measured SOC content and soil bulk densities derived via a pedo-transfer function (Knotters et al., 2022)y. The data was classified into seven soil types and three land use categories at the time of sampling.

Samples were taken on Forest land, Cropland and Grassland. For conversions involving other land uses, estimates were made using the 2006 IPCC Guidelines. The assumptions were:

- For conversion to settlements: 50% is paved and has a soil carbon stock of 80% of that of the former land use, 50% consists of grassland or wooded land with corresponding soil carbon stock.
- For Wetlands converted to or from forest, there is no change in carbon stock.
- For Other land, the carbon stock is zero (conservative assumption).

The 2006 IPCC Guidelines prescribe a twenty-year transition period in which carbon stock changes take place. This transition period in mineral soils means that land use changes in 1971 will still have a small effect on reported carbon stock changes in 1990. These pre-1990 land use changes are represented by the use of a 1970 land use map. This also means that the twenty-year transition period is included in land that was converted to another land use before 1990.

Carbon stock changes in organic soils

On the basis of the definition of organic soils in the 2006 IPCC Guidelines, two types of organic soils are considered. First, peat soils with a peat layer of at least 40 cm within the first 120 cm, and second, peaty soils (Dutch: *moerige gronden*) with a peat layer of 5–40 cm within the first 80 cm. Nationally also a distinction is made between two different kind of organic soil areas being: coastal and upland peatlands. Coastal, contributing to around 72% of the total organic soils area, is mainly located along the coastline of the Netherlands (from southwest to the north) and consists of the area that was historically prone to flooding by storm surge from the sea. At the moment all organic soils up to one meter above sea level are regarded as coastal peatlands (Erkens & Melman, 2020). Upland peatlands are the organic soils in the rest of the Netherlands and are elevated above one meter sea level. Upland peatlands are found in the the provinces of North Brabant and Drenthe, where peatlands are found in valley systems, or on watersheds.

The development of organic soil area between 1990 and 2014 and between 2014 and 2040 was assessed using overlays of three soil maps: the initial map with the average year of sampling dated 1977; a 2014 update on the spatial extent of organic soils; and a forecast map with projected spatial extent of organic soils in 2040 (see Van Baren et al., 2025 for details). Drainage of (cultivated) organic soils results in oxidation and loss of organic matter and thus loss of peat and peaty soils. As a result, the reported total area of organic soils decreased from 528 kha in 1977 to 500 kha in 1990, and to 437 kha in 2014. The total area of organic soils for the intermediate years was interpolated between 1977 and 2014. To assess the (loss of) extent of organic soils after 2014, an updated forecast map of the extent of peat and peaty soils by 2040 was used (Erkens et al., 2021; for more details, see Van Baren et al. 2025). For intermediate years, the total area of organic soils was interpolated from the two maps of 2014 and 2040.

Overlays with the land use maps provide information on areas of organic soils under the various land use categories. Carbon stock losses resulting from drainage of peat and peaty soils are determined for areas of Cropland, Grassland under agricultural use (excluding nature grasslands), Settlements and part of the Forest land (see specification below). These areas are intersected by drainage ditches that cover in total 1.4% of the area of Cropland on organic soil, and 5.8% for Grassland, 9.6% for Trees outside Forest and 2.8% for Forest land. For these ditches, CH_4 emissions are calculated instead of CO_2 emissions (see section on 'emissions and removals from drainage and rewetting and other management of organic soils' below). More detailed information is provided in Van Baren et al. (2025).

On the basis of the available models and datasets, two different approaches for calculating the emission factors for cultivated coastal (72% of total organic soil area) and cultivated upland peatlands (28% of total organic soil area) have been developed. Within these approaches peat soils and peaty soils were distinguished and treated differently (see Van Baren et al., 2025).

For drained coastal peatlands, calculated outcomes of the multi-model ensemble Subsurface Organic Matter Emission Registration System (SOMERS, Erkens et al., 2022) were used. SOMERS provides results for emissions for both coastal peat soils and peaty soils, utilising a 10-year reference weather condition period (2010-2019) to account for weather fluctuations. For the land management (parcelling, ditch water level, land level elevation) the situation of 2022 is used.

For CO_2 emissions from upland peat soils, the methodology is described in Kuikman et al. (2005). This method is based on subsidence rates resulting from the oxidation of organic matter. Estimated total annual emissions from cultivated soils are converted to an annual EF per ha peat soil to report emissions from peat soils for the land use (change) categories Grassland, Cropland and Settlements . Using an intermediary peat map from 2004, this resulted in an average EF for peat of 25.7 tons CO_2 ha^{-1} both in 1990 and 2004, .
For peaty soils in the uplands, another approach was used on the basis of a large dataset of soil profile descriptions over time. From this dataset, the average loss rate of peat was derived from the change in peat layer thickness over time. Also in this case, two EFs were assessed on the basis of the areas of peaty soils present on the 2004 map or the 2014 map. On the basis of both these maps, the EF for peaty soils was determined to be 13 tons CO_2 ha^{-1}, which has been applied to the whole time series.

The total emissions for the peat soils in the coastal peatlands and upland peatlands are summed from the two methods described above to derive a total emission for the Netherlands. The total emission is

subsequently divided by the area of peat soils in order to obtain an implied emission factor. This resulted in an IEF of 14.60 tons CO_2 ha^{-1} which is applied over the whole time series.
Also for peaty soils this was done resulting in an IEF of 13.77 tons CO_2 ha^{-1} which is applied over the whole time series.

Drainage of organic soils is not usually applied in forestry in the Netherlands. However, since afforestation usually occurs on land with previous agricultural land use, the possibility that the old drainage systems from the agricultural sites are still active cannot be completely excluded. Therefore, to account for possible emissions, the area of forest planted on organic soils that were previously in agricultural use, and where drainage systems may still be (partially) functioning was estimated at 24.2% of the total forest area on peat soils and 22.0% of the total forest area on peaty soils (see section 11.3 in Van Baren et al. (2025)). The implied emission factor as explained above was calculated by also taking into account the area of Forest on drained organic peatlands. Additionally, the associated emissions of N_2O were calculated using a Tier 1 approach with the Tier 1 EF for boreal and temperate organic nutrient-rich (0.6 kg N_2O-N ha^{-1}) and nutrient-poor (0.1 kg N_2O-N ha^{-1}) forest soils. For the 1990–2017 period, an average of 79% of the forests on peat soil was on nutrient-rich peat soils and 21% on nutrient-poor peat soils (see Van Baren et al., 2025); 100% of the forests on peaty soils were on nutrient-rich peaty soils. These ratios were subsequently applied to the Tier 1 EFs resulting in average EFs of 0.495 kg N_2O-N ha^{-1} for N_2O emissions from drained peat soils under Forest land, and 0.6 kg N_2O-N ha^{-1} for peaty soils.

Detailed information on calculations for peat and peaty soils is provided in Van Baren et al. (2025).

Emissions and removals from drainage and rewetting and other management of organic soils (CRT Table 4(II))
CO_2 emissions resulting from drainage are included as carbon stock changes in organic soils under the various land use categories. Methane (CH_4) emissions from drainage ditches in drained Forest land, Cropland and agricultural grasslands on organic soils are reported in CRT Table 4(II) using a Tier 2 approach from the 2013 IPCC wetland supplement (IPCC 2014). For the activity data an extraction of ditches (< 3m) from the "Large-scale Topography Basic Registry (BGT)" (Dutch: *Basisregistratie Grootschalige Topografie (BGT)*[8]), which is a detailed digital map of all physical objects in the Netherlands, has been made and overlayed with the land-use map and soil map. From this analysis for the land-uses Cropland, Grassland, Trees outside Forest and Forest land a new percentage of ditch area was calculated. For more details see section 11.3.2 of van Baren et al. (2025).

A country-specific emission factor of 518 kg CH_4 ha^{-1} yr^{-1} is applied to these areas on the basis of a case study for the Netherlands by Peacock et al. (2021). This value is similar to the default emission factor for drainage ditches in shallow drained temperate grassland (i.e. 527 kg

[8] https://www.geobasisregistraties.nl/basisregistraties/grootschalige-topografie

CH_4 ha^{-1} yr^{-1}) in Table 2.3 of the 2013 IPCC wetland supplement (IPCC 2014).

Rewetting and other management does not occur on a large scale in the Netherlands.

Direct nitrous oxide emissions from disturbance associated with land use conversions (CRT Table 4(III))
Nitrous oxide (N_2O) emissions from soils resulting from disturbance associated with land use conversions were calculated for all land use conversions using a Tier 2 methodology (Van Baren et al., 2025). The default EF of 0.01 kg N_2O-N/kg N was used. Average C:N ratios for three aggregated soil types based on measurements by Van Baren et al. (2025), were used. For all other aggregated soil types, the default C:N ratio of 15 (IPCC, 2006: section 11.16) was used. For aggregated soil types where conversion of land use resulted in a net gain of carbon, N_2O emissions were set to zero.

Biomass burning (CRT Table 4(IV))
For *Controlled biomass burning* in all land use categories, the emissions of CO_2, CH_4 and N_2O are reported as 'IE' and 'NO'. The area of and emissions from the occasional burning carried out in the interest of nature management are included under wildfires. Other controlled burning, such as the burning of harvest residues, is not allowed in the Netherlands (see Paragraph 3.2.15[9] of the "Besluit activiteiten leefomgeving" of the "The Environment and Planning Act").

Wildfires are rare in the Netherlands and only recently, limited information of extent and intensity of fires has become available. Therefore, the emissions of CO_2, CH_4 and N_2O from wildfires are reported using a Tier 1 methodology. The area of wildfires is based on a historical series from 1980 to 1992. Emissions from forest fires are reported under Forest land remaining Forest land even though some of it may be on Land converted to forest land. Emissions from other wildfires are reported under Grassland remaining grassland, even though they may be occurring on other land use categories. Under the other land use categories, wildfires are reported as IE.

6.1.3 Changes in this year and recalculations for years previously reported
This year, three methodological changes have been implemented, resulting in modifications to the carbon stock changes and associated emissions and removals along (part of) the time series:
- Updated emission factor for drained organic soils for all land uses.
- Updated area of ditches on organic soils for the land uses Cropland, Grassland, Trees outside Forests and Forest land, from Tier 1 estimation to a country specific Tier 2 estimate.
- Updated carbon stocks in mineral soils for all land uses and reduction of the number of aggregated soil types

[9] https://iplo.nl/regelgeving/regels-voor-activiteiten/milieubelastende-activiteiten-hoofdstuk-3-bal/activiteiten/afvalverbranding-plaatsvindt-ippc-installatie/

Updated emission factors for drained organic soils for all land uses
The emission factor for drained organic soils for all land uses has been updated following insights from a national research programme on emissions from drained organic soils "Netherlands Research Programme on Greenhouse Gas Dynamics in Peatlands and Organic Soils (NOBV)[10]". This research program has set up a measuring network on cultivated coastal peatlands since 2020, consisting of automated transparent chambers (e.g. Aben et al., 2024) and eddy covariance towers (e.g. Buzacott et al., 2024). To upscale the measurement outcomes, two process-based models were newly developed: i) a hydrological model PP2D (PeatParcel 2D), and ii) a carbon model AAP (Aerobe Afbraak Potentie; 'Aerobic decomposition potential') which have been calibrated and tested against measurements (see van Baren et al. (2025) section 11.3.1). Both are coupled and part of the multi model ensemble SOMERS (Subsurface Organic Matter Emission Registration System; Erkens et al., 2022). SOMERS is deployed to calculate greenhouse gas emissions (currently only CO_2) from organic soils at land parcel level. A specific model interface has been built to be able to use SOMERS output for the national greenhouse gas inventory. Currently, SOMERS is used to calculate CO_2 emissions under current water management. See paragraph 11.3.1 of Van Baren et al. (2025) for more detailed background information.

The models within SOMERS currently only are parameterised to calculate greenhouse gas emissions (CO_2) for drained organic soils in the coastal zone (72% of total organic soil area) of the Netherlands (Erkens & Melman, 2020). As there are also drained organic soils in the upland part of the Netherlands (mainly in the northeastern and south of the Netherlands, 28% of total organic soil area). The updated emissions derived from SOMERS have been combined with the previous method (see paragraph 6.1.2. on Carbon stock changes in organic soils) to calculate a country-covering implied emission factor which has been applied to the whole time series, see table 6.1 for the updated (implied) emission factors. This means the long-term trend of decreasing emissions from organic soils since 1990 is solely the result of the slow decline in extent of organic soils due to peat oxidation and its subsequent loss. The total emissions from all organic soils are shown in Figure 6.1. Total CO_2 emissions decreased on average with 947 kt CO_2 over the whole time series compared to the old method. The coming years this method will be further developed to take yearly variation and effect of mitigation measures into account.

In Table 6.1 the previous EF using the previous method from the NIR 2024 and current IEF using the new method for organic soils are shown. The previous method used an empirical relationship between the average lowest groundwater level and subsidence, and a conversion factor from subsidence to CO_2 (Van den Akker et al., 2008). Although this method is suitable for obtaining a first-order estimate of CO_2 emissions, it is not based on actual CO_2 measurements in the coastal peatlands as is done in the new method. For more detailed explanations on the differences between the outcomes of the previous method and

[10] https://www.nobveenweiden.nl/en/

the current method, see Erkens et al. (2022). For a discussion on the greenhouse gas measurement outcomes in the Netherlands within the international context, see Aben et al. (2024).

Table 6.1. Emissions factor used for all organic soils. NIR 2024 versus NIR 2025

	ton CO2/ha/year		
Soil	**NIR24**	**NIR25**	
Peat	-19.03	14.60	-
Peaty	-13.02	13.77	-

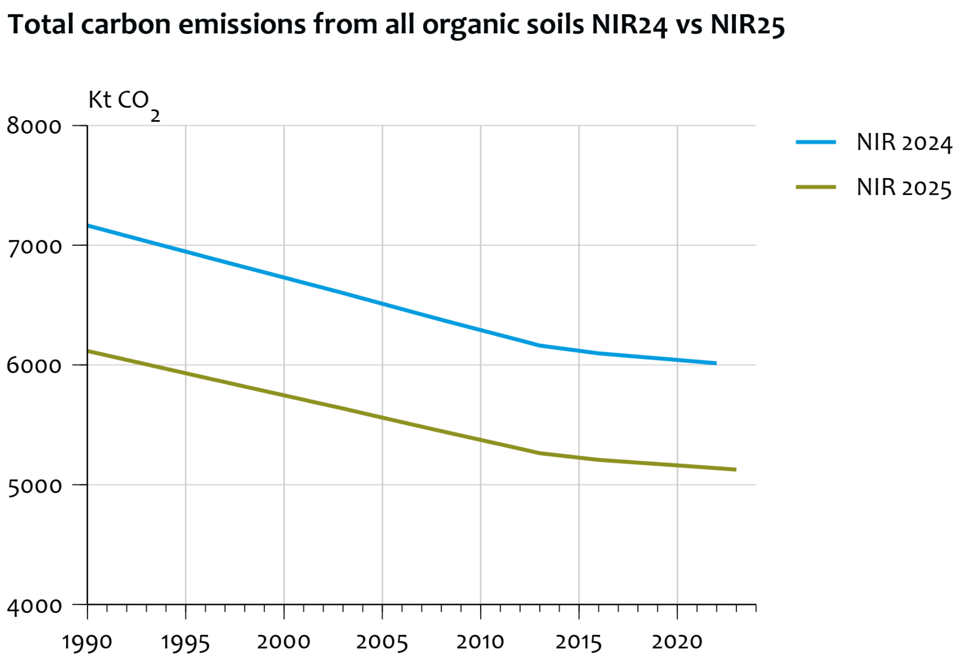


Figure 6.1. Total CO2 emissions from organic soils from all land uses as reported in the NIR 2024 and 2025.

Updated area of ditches on organic soils for the land-uses Cropland, Grassland, Trees outside Forests and Forest land
The IPCC Tier 1 method assuming 5% of organic lands to be ditches smaller than 3 meter has been updated to a country-specific Tier 2 method. An extraction of ditches (< 3m) from the “Large-scale Topography Basic Registry (BGT)” (Dutch: *Basisregistratie Grootschalige Topografie (BGT)*[11]), which is a detailed digital map of all physical objects in the Netherlands, has been made and overlayed with the land-use map and soil map. From this analysis for the land-uses Cropland, Grassland, Trees outside Forest and Forest land a new percentage of ditch area was calculated, see table 6.2. For more details see section 11.3.2 of van Baren et al. (2025).

[11] https://www.geobasisregistraties.nl/basisregistraties/grootschalige-topografie

Table 6.2. Percentage of area of drained organic soils per land-use assumed to be ditches smaller than 3 m.

Land-use	Percentage
Cropland	1.4%
Grassland	5.8%
Trees outside forest	9.6%
Forest land	2.8%
Total	**4.9%**

Updated carbon stocks in mineral soils for all land uses and reduction of the number of aggregated soil types
In 2018 a national soil monitoring survey was performed, in which soil carbon stocks were determined, and other soil properties were analysed (Knotters et al., 2022). This monitoring survey was repeated in 2024. The soil carbon stocks were determined following a standardised sampling approach for the topsoil (0-30 cm) and subsoil (30-100 cm). Based on the topsoil sampling, new SOC stocks per soil type were determined. These SOC stocks have been used for the SOC modelling with RothC for Cropland remaining Cropland and Grassland remaining Grassland since the NIR 2023. To be consistent and to utilise the most recent values available, the SOC stocks for the stock change calculations in mineral soils for land use changes (the "converted to" categories) were updated as well.

In addition to this update, the number of aggregated soil types was also reduced. Previously, ten different soil types were distinguished, the Dutch classification of main soil types. However, some are small in area and were represented by only a few sampling locations and some soil types did not differ significantly in SOC stock, e.g. marine and river clay soils. Therefore, in the NIR 2025 the soil types were aggregated into six main soil types: sand, clay, loamy,soils with human-induced organic rich topsoil (Dutch: *eerdgrond*), and two organic soil types: peat soils and peaty soils (see Table 6.3). For the mineral soil types, a new average SOC stock was determined, based on the 2018 survey. This results in a larger number of sampling locations per soil type, which reduces the uncertainty in the SOC stock per soil type. See also section 11.2.1 of Van Baren et al. (2025) for more information.

The update of carbon stocks only has an effect when land is converted to another land use. The biggest impact on the emissions is seen in land converted to Grassland and Cropland. As can be seen in Figure 6.2 emissions from cropland increased in the NID25 compared to the NIR24 for land converted to Cropland on mineral soils, this is balanced out by higher negative emissions from land converted to grassland on mineral soils. For the other land uses a similar trend was observed.

Table 6.3. Reclassification of soil types.

Old classification	New classification
Brick soils, old clay soils, River clay soils, marine clay soils	Clay soils

Old classification	New classification
Sandy soils without lime, Podzol soils, Sandy soils with lime	Sandy soils
Loamy soilys	Loamy soils
"Eerdgrond"	Soils with human-induced organic rich topsoil (Dutch: eerdgrond)
Peat soils	Peat soils
Peaty soils	Peaty soils

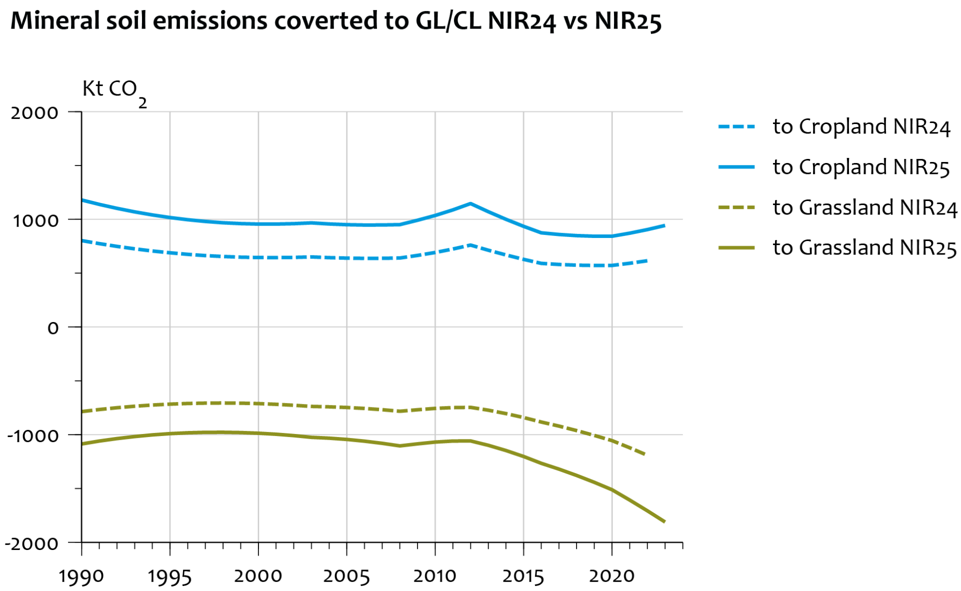


Figure 6.2. Mineral soil CO_2 emissions from land converted to grassland and cropland. NIR 24 versus NIR 25.

6.2 Land use definitions and the land representation approach(es) used and their correspondence to the land use, land-use change and forestry categories

This section provides an overview of land use definitions and the classification systems used in the Netherlands, and how they correspond to the land use, land use change, and forestry categories that need to be covered. The Netherlands has defined the various land use categories in line with the descriptions provided in the 2006 IPCC Guidelines. For more detailed information, see Van Baren et al. (2025).

Forest land (4A)
The Netherlands has chosen to define the land use category Forest land as 'all land with woody vegetation, now or expected in the near future (e.g. clear-cut areas to be replanted, young afforestation areas)'. The following criteria define this category:

- Forests are patches of land exceeding 0.5 ha, with:
  - a minimum width of 30 m;
  - a tree crown cover of at least 20%; and
  - a tree height of at least 5 m, or, if this is not the case, these thresholds are likely to be achieved at the particular site.

This definition conforms to FAO reporting standards and was within the ranges set by the Kyoto Protocol.

Cropland (4B)
The Netherlands has chosen to define Cropland as 'arable land and nurseries (including tree nurseries)'. Intensively managed grasslands are not included in this category; they are reported under Grassland. For part of the Netherlands' agricultural land, rotation between Cropland and Grassland is frequent, but data on where exactly this occurs is not available. Currently, the situation on the topographical map is used as a guideline, with lands under agricultural crops and classified as arable lands at the time of recording reported under Cropland, and lands with grass vegetation at the time of recording classified as Grassland.

Grassland (4C)
From the NIR 2018 onwards, two distinct sub-categories have been identified within the Grassland category, and these are spatially explicitly assessed. These are (1) Trees outside forests (TOF) and (2) Grassland (non-TOF). Both are explained below.

Trees outside forests (TOF)
Trees outside forests (TOF) are wooded areas that comply with the Forest land definition except for their surface area (<0.5 ha or less than 30 m width). These represent fragmented forest plots as well as groups of trees in parks and natural terrains, and most woody vegetation lining roads and fields.

Grassland (non-TOF)
Any type of terrain that is predominantly covered by grass vegetation is reported under Grassland (non-TOF). The category also includes vegetation that falls below, and is not expected to reach, the thresholds used in the Forest land category. It is further split into the following sub-categories:

- Grassland vegetation, i.e. all areas predominantly covered by grass vegetation (whether natural, recreational, or cultivated);
- Nature, i.e. all natural areas not covered by grassland vegetation. This mainly consists of heathland and peat moors and may have the occasional tree as part of the typical vegetation structure.
- Orchards, i.e. areas with standard fruit trees, dwarf varieties or shrubs. These do not conform to the Forest land definition and, while agro-forestry systems are mentioned in the definition of Cropland, the main undergrowth of orchards in the Netherlands is grass. Therefore, orchards are reported under Grassland (non-TOF). A separate carbon stock for orchards is being estimated as part of an area-weighted averaged carbon stock in grasslands (see section 6.6 and Van Baren et al. (2025)).
  In the calculations, orchards are not explicitly spatially included. Instead, statistics on areas of orchards are used. See Van Baren et al. (2025) for details.

Wetlands (4D)
The Netherlands is characterised by wet areas. Many of these areas are covered by grassy vegetation and those are included under Grassland.

Some wetlands are covered by rougher vegetation, consisting of wild grasses or shrubs, and those are reported in the sub-category Nature, under Grassland. Forested wetlands (e.g. willow coppices) are included in Forest land.
As a result, only reed marshes and open water bodies in the Netherlands are included in the Wetland land use category. This includes natural open water in rivers, but also man-made open water in canals, ditches, and artificial lakes. It includes bare areas that are under water only part of the time as a result of tidal influences, and very wet areas without vegetation. It also includes 'wet' infrastructure for boats, i.e. waterways as well as the water in harbours and docks.

Since the submission of the NIR 2024, the Wetlands land use category has been further stratified with the 'Flooded Land' category containing the sub-categories: reservoirs, freshwater ponds, and canals and ditches. These Wetlands categories used to be reported as Open water, therefore the total area of Wetlands has not changed compared to previous submissions.

- Reservoirs: inland sweet water lakes larger than 8 ha. Excludes the IJsselmeer and Markermeer.
- Freshwater ponds: inland sweet water ponds smaller than 8 ha.
- Canals and ditches (> 3 m): constructed linear waterbodies.

Reservoirs and freshwater ponds have only been included when they were created after 1900. All canals and ditches are included. See Van Baren et al. (2025) sections 2.5 and 3.2 for details. In the CRT the stratification to these different Wetland types has not been made yet in Table 4.D but emissions are included under Other Wetland. In Table 4(II) emissions are included under Flooded land but not stratified further.

Settlements (4E)
In the Netherlands, the main categories included under the Settlements category are (1) built-up areas and (2) urban areas and transport infrastructure. Built-up areas include any constructed item, independent of the type of construction material, that is (expected to be) permanent, is fixed to the soil surface, and serves as a place of residence or location for trade, traffic and/or work. It includes houses, blocks of houses, and apartments, office buildings, shops and warehouses, as well as filling stations and greenhouses.

Urban areas and transport infrastructure includes all roads, whether paved or not – with the exception of forest roads – these are included in the official forest definition. They also include train tracks, (paved) open spaces in urban areas, car parks, and graveyards. Though some of the latter categories are covered by grass, the distinction cannot be made from a study of maps. As grass graveyards are not managed as grassland, their inclusion in the land use category Settlements conforms better to the rationale of the land use classification.

Other land (4F)
The Netherlands uses this land use category to report surfaces of bare soil not included in any other category. This mostly includes almost bare sands and the earliest stages of succession on sand in coastal areas (beaches, dunes and sandy roads), or uncultivated land alongside rivers.

It does not include bare areas that emerge from shrinking and expanding water surfaces; these are included in Wetland. In general, the amount of carbon in Other land is limited.

Land-use change matrices
Data for the matrices is derived from the land use maps as presented in chapter 6.3.

Table 6.9 Land use and land use change matrix aggregated to the six UNFCCC land use categories for the 1970-1990 period (ha) with Grassland (GL) divided into GL (non-TOF) and GL (TOF)

	BN 1990							
HGN 1970	**FL**	**CL**	**GL (non-TOF)**	**G (TOF)**	**WL**	**Sett**	**OL**	***Total***
FL	300,044	4,313	15,753	1,274	1,079	6,144	726	329,333
CL	22,133	687,295	182,415	2,094	11,176	50,894	195	956,202
GL-non TOF	28,182	297,694	1,243,850	4,896	21,533	86,068	1,174	1,683,396
GL-TOF	1,697	1,249	4,039	10,361	175	2,207	107	19,836
WL	1,350	4,762	15,077	156	753,597	4,527	3,648	783,118
Sett	7,734	24,237	44,055	1,943	3,659	259,450	485	341,564
OL	1,109	132	2,774	77	3,117	312	33,227	40,747
Total	*362,249*	*1,019,682*	*1,507,962*	*20,801*	*794,336*	*409,602*	*39,563*	*4,154,195*

Table 6.10 Land use and land use change matrix aggregated to the six UNFCCC land use categories for the 1990–2004 period (ha) with Grassland (GL) divided into GL (non-TOF) and GL (TOF)

	BN 2004							
BN 1990	**FL**	**CL**	**GL (non-TOF)**	**G (TOF)**	**WL**	**Sett**	**OL**	***Total***
FL	334,348	1,220	14,592	2,852	1,503	7,035	699	362,249
CL	12,527	739,425	176,854	2,039	6,823	81,813	201	1,019,682
GL-non TOF	18,075	196,624	1,190,957	4,474	18,642	78,283	907	1,507,962
GL-TOF	2,350	386	3,314	11,335	318	2,988	110	20,801
WL	888	596	9,094	328	777,801	2,837	2,791	794,336
Sett	1,456	1,626	10,993	1,078	1,391	392,936	122	409,602
OL	552	8	2,547	98	2,583	630	33,144	39,563
Total	*370,196*	*939,885*	*1,408,352*	*22,206*	*809,061*	*566,522*	*37,974*	*4,154,195*

Table 6.11 Land use and land use change matrix aggregated to the six UNFCCC land use categories for the 2004–2009 period (ha) with Grassland (GL) divided into GL (non-TOF) and GL (TOF)

	BN 2013							
BN2009	**FL**	**CL**	**GL (non-TOF)**	**GL (TOF)**	**WL**	**Sett**	**OL**	***Total***
FL	360,356	1,319	6,257	1,483	699	3,327	204	*373,645*
CL	2,484	794,119	116,032	311	1,410	10,743	28	*925,126*
GL-non TOF	8,095	145,435	1,194,348	1,590	10,850	30,922	516	1,391,756
GL-TOF	1,346	219	1,532	17,212	164	1,582	31	22,086
WL	651	305	6,183	112	803,194	1,353	1,948	813,746
Sett	2,535	3,199	20,664	815	4,477	557,496	135	589,323
OL	444	1	970	49	1,825	328	34,897	38,512
Total	*375,912*	*944,597*	*1,345,986*	*21,572*	*822,619*	*605,751*	*37,759*	*4,154,195*

Table 6.12 Land use and land use change matrix aggregated to the six UNFCCC land use categories for the 2009–2013 period (ha) with Grassland (GL) divided into GL (non-TOF) and GL (TOF)

	BN 2009							
BN 2004	**FL**	**CL**	**GL (non-TOF)**	**GL (TOF)**	**WL**	**Sett**	**OL**	***Total***
FL	357,622	352	5,223	1,514	703	4,575	208	370,196
CL	2,012	813,514	108,507	296	1,796	13,732	27	939,885
GL-non TOF	7,129	106,576	1,243,564	1,706	10,615	37,714	1,047	1,408,352
GL-TOF	1,701	137	1,198	16,892	126	2,122	30	22,206
WL	374	177	9,633	92	796,581	1,441	762	809,061
Sett	4,598	4,368	23,125	1,556	3,035	529,603	237	566,522
OL	209	2	506	29	890	137	36,201	37,974
Total	*373,645*	*925,126*	*1,391,756*	*22,086*	*813,746*	*589,323*	*38,512*	*4,154,195*

Table 6.13 Land use and land use change matrix aggregated to the six UNFCCC land use categories for the 2013–2017 period (ha) with Grassland (GL) divided into GL (non-TOF) and GL (TOF)

	BN 2017							
BN 2013	**FL**	**CL**	**GL (non-TOF)**	**GL (TOF)**	**WL**	**Sett**	**OL**	***Total***
FL	356,773	1,665	9,353	2,022	804	4,890	404	375,912
CL	903	762,661	170,219	246	1,676	8,868	24	944,597
GL-non TOF	4,822	103,147	1,197,260	1,504	9,191	28,670	1,394	1,345,986
GL-TOF	1,141	205	1,658	16,548	146	1,834	41	21,572
WL	837	291	6,717	192	807,543	4,340	2,700	822,619
Sett	1,036	2,583	21,378	711	1,571	578,275	196	605,751
OL	215	7	735	34	1,415	484	34,869	37,759
Total	*365,726*	*870,559*	*1,407,320*	*21,256*	*822,346*	*627,360*	*39,628*	*4,154,195*

Table 6.14 Land use and land use change matrix aggregated to the six UNFCCC land use categories for the 2017–2021 period (ha) with Grassland (GL) divided into GL (non-TOF) and GL (TOF)

	BN 2021							
BN 2017	**FL**	**CL**	**GL (non-TOF)**	**GL (TOF)**	**WL**	**Sett**	**OL**	***Total***
FL	356,579	675	5,115	1,157	263	1,578	359	365,726
CL	762	707,797	154,279	130	1,023	6,541	27	870,559
GL-non TOF	4,398	125,580	1,251,360	870	5,473	18,691	948	1,407,320
GL-TOF	693	218	1,502	17,928	82	739	96	21,256
WL	301	332	4,394	65	812,759	1,471	3,024	822,346
Sett	707	2,103	18,554	371	1,545	603,850	229	627,360
OL	361	5	2,967	42	2,258	166	33,828	39,628
Total	*363,801*	*836,710*	*1,438,171*	*20,563*	*823,403*	*633,037*	*38,511*	*4,154,195*

As can be observed from the land use change matrices above, land use is dynamic in a densely populated country like the Netherlands. For example, conversion of Grassland to Cropland and Cropland to

Grassland is especially common. Temporary rotations of this sort are frequent, but the total areas of Grassland and Cropland remain relatively stable.

When comparing the five land use change matrices, the different lengths of time between the available land use maps should be considered, as this has an effect on the annualised land use changes. The long period between 1990 and 2004 means that some interannual changes, such as Cropland–Grassland rotations are not captured. For instance, Cropland might be converted to Grassland in 1992, and converted back to Cropland in 1995, but these changes will not be visible using the 1990 and 2004 land use maps. The more recent maps are closer together timewise and thus are better able to capture short-term rotations between Grassland and Cropland.

Between 1970 and 2013, forest area steadily increased, followed by a sharp decline between 2013 and 2017. In the 2017-2021 period, there was also a net loss of forest area, but the gross changes make clear that deforestation rates more than halved in comparison to the 2013-2017 period.

More detailed analyses of the land use maps (see Schelhaas et al., 2021) make clear that between 2004 and 2017, deforestation rates increased for two principal reasons. First, deforestation took place as part of nature development, and specifically Natura 2000 development, under which areas of heathland and shifting sand have increased at the cost of Forest land. Second, farmers' contracts under the set-aside forest regulation and other national regulations from the 1980s aimed at temporarily increasing forest production capacity and addressing the perceived over-production in agriculture, came to an end in 1995, with the result that forests established in the 1980s and early 1990s are now being converted back into agricultural land use.

Despite the relatively high deforestation rates in earlier periods, until 2013 the rate of afforestation exceeded the deforestation rate. From the 2013–2017 matrix, it can be inferred, however, that afforestation rates have decreased considerably, resulting in a net decrease in forest area since 2013. In principle, deforestation needs to be compensated by afforestation of an equal area elsewhere. An exception to this rule was for conversion to priority nature on the basis of ecological arguments, e.g. through Natura 2000 development or management plans. In such cases, forest conversion could take place without compensation. There were also signs that there is a lack of monitoring and enforcement of the compensation rule at local government level. In the meantime, the latest land use change matrix indicates that in the years between 2017 and 2021, net deforestation occurred, but at a considerably lower rate than between 2013-2017. As a result of increased policy attention, in 2020 a new forest strategy was implemented with the aim to increase forest area in the Netherlands by 10% compared to the 2017 level. It now also ensures compensation in cases where forest is converted to other priority nature types. This effect will be visible in future land use changes.

6.3 Information on approaches used for representing land areas and on land use databases used for the inventory preparation

One consistent approach has been used for all land use categories. The Netherlands applies full and spatially explicit land use mapping that allows geographical stratification at 25 m x 25 m (0.0625 ha) pixel resolution (Kramer et al., 2009). This corresponds to the wall-to-wall approach used for reporting under the UNFCCC (approach 3 in Chapter 3 of IPCC, 2006).

Harmonised and validated digital topographical maps representing land use on 1 January 1970, 1990, 2004, 2009, 2013, 2017 and 2021 were used for wall-to-wall map overlays (Van Baren et al., 2025; Kramer and Clement, 2015; Kramer and Clement, 2016 Kramer et al. 2007, 2009; Kramer & Clement, 2022; Kramer & Los, 2022), resulting in six national-scale land use and land use change matrices covering the following periods: 1970-1990 (Table 6.9), 1990–2004 (Table 6.10), 2004–2009 (Table 6.11), 2009–2013 (Table 6.12), 2013–2017 (Table 6.13) and 2017-2021 (Table 6.14). In order to create change matrices beyond the availability of the land use maps, an extrapolation of the trend between the land use maps of 2017 and 2021 is conducted. Here, the change rate per land use, soil type and whether a land use trajectory is stable is taken into account to extrapolate towards a desired reporting year. When a new land use map comes available, this is used instead of the extrapolation. The information on the activities and land use categories covers the entire territorial (land and water) surface area of the Netherlands. The sum of all land use categories is constant over time. For more details, see Van Baren et al. (2025).

The land use maps used for 1970 and 1990 are based on maps of historic land use in the Netherlands ('Historisch grondgebruik Nederland, HGN), while later maps are based on the Nature Base maps originally used for monitoring nature development in the Netherlands. After 2009, these maps were no longer used for monitoring nature development, but in order to guarantee consistency in the land use change matrix for LULUCF reporting, they are still produced on request as a basis for the LULUCF land use change monitoring (see Van Baren et al. (2025) for more details).

The classification of forest areas on the underlying topographical maps that is used to compile the LULUCF maps accounts for management interventions to prevent harvested areas from being classified as deforestation. Additional information on (planned) destinations of areas and subsidy schemes is used to support the classification.

An overlay was produced with all land-use and soil maps, resulting in an array of trajectories showing land use in the maps (1970, 1990, 2009, 2013, 2017, 2021), and soil in the maps (1977, 2014), plus the area on which this sequence occurred. For trajectories that changed from one mineral soil type to another, we assumed the 1977 value to be the same as the 2014 value, as the new map is considered to be more accurate than the old one. Subsequently, the resulting array of trajectories was aggregated, so that only unique trajectories remained. For all trajectories with an area smaller than 10 ha that changed land use from

1970 to 1990, the 1970 land use was reclassified to the 1990 land use. In this way, the inaccuracies in the 1970 map are ignored, while maintaining the overall land use transition trend for the 1970-1990 period. This procedure concerned 2.0% of the total land area.

Subsequently, the resulting array of trajectories was aggregated, so that only unique trajectories remained.
Please note that for comparison purposes with CRT tables, map dates are always 1 January of the year indicated and hence reflect the situation at the end of the previous inventory year.

6.4 Forest land (4A)

6.4.1 Category description

Reported in this category of land use are CO_2 emissions and sinks caused by changes in forests. All forests in the Netherlands are classified as temperate: 19.5% coniferous, 44.8% broadleaved, with the remainder a mixture of the two. The share of mixed and broadleaved forests has grown strongly in recent decades (Schelhaas et al., 2022[12]). In the Netherlands, with its high population density and strong pressure on land, all forests are managed. Consequently, no sub-division is applied between managed and unmanaged forest land. Where such a sub-division is asked for in the CRT, the notation key NO is used in the tables for unmanaged forests.

Units of land that meet all the requirements for Forest land except the minimum area (0.5 ha) or width (30 m) are reported as Trees outside forests (TOF) under the Grassland category.

The Forest land category includes three sub-categories:

- Forest land remaining forest land (4A1): includes estimates of changes to the carbon stock in various carbon pools in Forest land;
- Land converted to Forest land (4A2): includes estimates of changes in land use to Forest land during the twenty-year transition period, since 1970;
- Forest land converted to other land use categories (4B2, 4C2, 4E2, 4F2): includes emissions related to the conversion of Forest land to all other land use categories (deforestation).

6.4.2 Methodological issues

Removals and emissions of CO_2 from forestry and changes in woody biomass stock are estimated using a country-specific Tier 2 methodology. The chosen approach follows the 2006 IPCC Guidelines, which suggest a stock difference approach. The basic assumption is that the net flux can be derived by converting the change in growing stock volumes in the forest into volumes of carbon. Detailed descriptions of the methods and EFs used can be found in the methodological background report for the LULUCF sector (Van Baren et al., 2025). The Netherlands' national inventory follows the carbon cycle of a managed forest and wood products system. Changes in carbon stock are

[12] Report on the 7th Forest Inventory with results in Dutch only. For an English summary of the results and an English summary flyer 'State of the Forests in the Netherlands', see: https://edepot.wur.nl/576640

calculated for above-ground biomass (AGB), below-ground biomass (BGB), dead wood and litter in forests.

National Forest Inventories
Data on forests is based on five National Forest Inventories (NFI) carried out in 1988–1991 (HOSP: Schoonderwoerd and Daamen, 1999), 2001–2005 (NFI-5: Daamen and Dirkse, 2005), 2012–2013 (NFI-6: Schelhaas et al., 2014), 2017-2021 (NFI-7: Schelhaas et al, 2022) and 2023 being the second year of five from the NFI-8. As these most accurately describe the state of Dutch forests, they were applied in the calculations for Forest land remaining forest land, Land converted to forest land, and Forest land converted to other land use. Thus, they represent the state of the forest at five moments in time (1st of January); 1992 (HOSP), 2006 (NFI-5), 2014 (NFI-6), 2022 (NFI-7) and 2024 (NFI-8).

Changes in carbon stocks in living biomass in forests were calculated using plot-level data from the HOSP, NFI-5 NFI-6,NFI-7 and the first two years of NFI-8 inventories. From the NFI-7 onwards, a continuous forest inventory with permanent sample plots will be carried out. This means that the calculations for the carbon stock will change from the NFI-8 onwards. NFI-7 contains data measured from 2017-2021 covering the whole Dutch forest; the first year of the NFI-8 measured the same plots in 2023 as were measured in 2018. The data used for the carbon stock calculations with date 2024 contains forest measurements from 2019-2023 to represent the whole Dutch forest. In addition, changes in activity data were assessed using several databases of tree biomass information, with allometric equations to calculate AGB, BGB and forest litter.

More detailed descriptions of the methods and EFs used can be found in chapter 4 of Van Baren et al. (2025).

6.4.2.1 Forest land remaining forest land

The net change in carbon stocks for Forest land remaining forest land is calculated as the difference in carbon contained in the forest between two points in time. Carbon in the forest is derived from the growing stock volume, making use of other forest traits routinely determined in forest inventories. With the repeated measures, changes in biomass and carbon stocks were assessed for the 1992–2006, 2006–2014 and 2014-2022 periods and annually from 2022, with the continuous forest inventory using a five-year moving average. The annual changes during the years in between these periods were determined using linear interpolation.

An exception was made for units of Forest land remaining forest land that were afforested between twenty and thirty years ago. These are reported under Forest land remaining forest land, but the calculation of living biomass, dead wood and litter carbon stock changes in these units follows the approach for Land converted to forest land (see section 6.4.2.2).

Living biomass
For each plot measured during the NFIs, information is available on the tree species, their standing stock (stem volumes), and the forest area they represent. Based on this, the biomass is estimated directly for each tree measured using the following calculation steps (for more details see Van Baren et al., 2025):

1) Using the species-specific wood density, based on IPCC default values, the stem volume is converted to stem biomass. The other biomass compartments (foliage, branches and roots) are estimated using the allometric equations that include only diameter at breast height (DBH) as independent variable, provided in a study by Forrester et al. (2017) based on a Europe-wide dataset of biomass observations. Total tree biomass is calculated as the sum of all compartments, and totals per ha are calculated from the individual biomasses and the plot size. For the HOSP dataset (1990; see Van Baren et al. (2025) for details), individual tree observations are not available. A species-specific BCEF at the plot level was derived from the NFI-5 data (average year 2006), using the reported main species, and applied it to the plot-level volume estimations for the HOSP.
2) Average growing stocks (in m^3 ha^{-1}), average BCEFs (tonnes biomass m^{-3}), and average root-to-shoot ratios are calculated (see Table 6.15 and Van Baren et al. (2025)). These are weighted for the representative area of each of the NFI plots for each NFI.
3) On the basis of the distribution of total biomass per hectare between coniferous and broadleaved trees, the relative share of coniferous and broadleaved forest is determined.
4) The average growing stock, average BCEFs, average root-to-shoot ratios, and shares of coniferous and broadleaved forests are linearly interpolated between the NFIs to estimate these parameters for all the intermediate years.
5) The average annual above-ground and below-ground biomasses (tonnes dry matter ha^{-1}) are estimated by combining annual average growing stock, BCEF, and root-to-shoot ratios.
6) Using the relative share of coniferous and broadleaved forests and the differentiated T1 carbon fractions for conifers and broad-leaved species, aboveground and belowground biomass is converted to carbon amounts.

The result of this assessment provides the average net carbon stock changes in living (aboveground and belowground) biomass for an average ha of forest in the Netherlands. This is multiplied by the area of Forest land remaining forest land in a given year to assess the total net carbon stock changes in living biomass for Forest land remaining forest land in that year.
Losses from wood harvesting are not taken into account separately, as these are already included in the differences in the average carbon stocks between the forest inventories. However, since the harvested wood is part of the gross changes in carbon stocks, it is added to the net changes as calculated in the steps above to assess gross carbon stock gains in living biomass and, simultaneously, it is considered under the gross carbon stock losses in living biomass for reporting gains and losses (see section 4.2.1 in Van Baren et al. (2025) for details). The net effect remains the same as assessed in the steps above.

In several review reports, the ERT referred to the apparent high growth rates of biomass in Dutch forests indicating that it is among the highest in Annex I countries. Dutch experts consider this a misinterpretation of the results. Although the increase in growing stock in Dutch forests appears to be higher than in other countries, the volume growth rates are not. However, the low harvest intensities in the Netherlands, with only about 55% of the increment being harvested, and the specific age class structure of Dutch forests (see Schelhaas et al. (2022)[13], and annex 5 in Van Baren et al. (2025)), result in a strong net increase in growing stock over time.

Table 6.15 Average growing stock (GS; m^3 ha^{-1}), BCEF (tonnes d.m. per m^3 stemwood volume) aboveground biomass (AGB; tonnes dry matter ha^{-1}), belowground biomass (BGB; tonnes d.m. ha^{-1})

Year	Growing stock (m^3 ha^{-1})	BCEF (tonnes d.m. m^{-3})	AGB (tonnes d.m. ha^{-1})	BGB (tonnes d.m. ha^{-1})
1990	152	0.712	108	24
1991	155	0.713	110	24
1992	158	0.713	113	25
1993	161	0.714	115	25
1994	164	0.714	117	26
1995	167	0.715	119	26
1996	170	0.715	121	26
1997	172	0.716	123	27
1998	175	0.716	126	27
1999	178	0.717	128	27
2000	181	0.718	130	28
2001	184	0.718	132	28
2002	187	0.719	134	29
2003	190	0.719	137	29
2004	193	0.720	139	29
2005	196	0.720	141	30
2006	199	0.721	143	30
2007	201	0.724	145	31
2008	203	0.727	148	31
2009	206	0.730	150	32
2010	208	0.733	152	32
2011	210	0.735	155	32
2012	213	0.738	157	33
2013	215	0.741	159	33
2014	217	0.744	162	34
2015	219	0.748	164	34
2016	220	0.751	165	35
2017	222	0.755	167	35
2018	223	0.759	169	36

[13] Available at: https://edepot.wur.nl/571720) providing information on age class distribution (Chapter 7, "Kiemjaar"), harvesting (Chapter 15, "Velling") and growing stock (Chapter 16, "Mutaties houtvoorraad"). A flyer with key figures explained in English is available at https://edepot.wur.nl/576640, including information on age, growing stock and harvests.

Year	Growing stock (m^3 ha^{-1})	BCEF (tonnes d.m. m^{-3})	AGB (tonnes d.m. ha^{-1})	BGB (tonnes d.m. ha^{-1})
2019	224	0.762	171	36
2020	226	0.766	173	36
2021	227	0.769	175	37
2022	229	0.773	177	37
2023	230	0.775	178	37
2024	231	0.777	180	38

All values are dated the 1st of January of the specified year. Values in between the years are linearly interpolated

Dead wood
Dead wood volume is available from the forest inventory datasets. The calculation of carbon stock changes in dead wood in forests follows the approach for the calculation of carbon emissions from living biomass, i.e. using a thirty-year transition period from the moment of land use change towards Forest land, and is conducted for lying and standing deadwood (see Van Baren et al. (2025)). For deadwood, a wood density was used equal to 60% of the values for fresh wood.

Litter
As of the NIR 2024, the carbon stock changes in litter in forests follow the same approach as the calculation of carbon emissions from living biomass with one difference. The build-up period to full carbon stock is the same for litter, thirty years after the land use change, but after these thirty years, no change in carbon stock is reported. For Forest land remaining forest land, this means that after ten years of being in the remaining category, no carbon stock changes are reported anymore.

Data for the carbon stock of litter is a combination of litter thickness measurements from the NFIs and carbon content measurements from De Jong et al. (2023). For the full method description, see section 4.2.1 in Van Baren et al. (2025).

Effects of wood harvests on biomass gains and losses
Net carbon stock changes in biomass in Forest land remaining forest land are based on the information from the forest inventories. As a result, the effect of harvesting wood on carbon in the remaining forest biomass is already implicitly included in the carbon stock differences between the various forest inventories. Thus, the gross gains in biomass between the inventories were higher than calculated from the inventories' stock differences. Therefore, the carbon in the biomass of the harvested wood in a given year was added to the carbon stock changes in living biomass. At the same time, this identical amount of carbon was reported under carbon stock losses from living biomass, resulting in the net change as determined from the carbon stock differences between the forest inventories. As a consequence, the net stock change is gradual, but the gains and losses are more erratic. See Van Baren et al. (2025) for more details.

Forest fires
In the Netherlands, no recent statistics are available on the occurrence and intensity of wildfires in forests (forest fires). The area of burned forest is based on a historical series from 1980 to 1992 for which the annual number of forest fires and the total area burned is available (Wijdeven et al., 2006). The average annual area (37.8 ha) from the 1980–1992 period has been used for all years from 1990 onwards (Van Baren et al., 2025).

Emissions of CO_2, CH_4 and N_2O from forest fires are reported at Tier 2 level according to the method described in the 2006 IPCC Guidelines (IPCC, 2006: equation 2.27). The mass of fuel for forest fires is based on the average annual carbon stock in living biomass, litter, and dead wood (Tables 6.15 and 6.16). These values change annually, depending on forest growth and harvesting. Because burned sites are also part of the NFI, the loss of carbon due to forest fires is covered in the carbon stock changes derived from the NFI. Yet forest fires are very infrequent, mostly cover small areas, and have a relatively mild impact on biomass. As a result, it is not clear if the NFI fully covers information on forest fires and their emissions. The approach followed may thus include some double counting of these emissions, and is therefore considered conservative.

With the available data, it is not possible to distinguish between forest fires in Forests remaining forests and Land converted to forest land. Therefore, total emissions from forest fires are reported in CRT Table 4(IV) under 'wildfires for forests remaining forests'.

The UNFCCC reviewer of the NIR 2019 suggested available geospatial techniques for the identification of forest fires such as the European Forest Fire Information System (EFFIS) as a possible data source to improve fire activity data after 1992. An earlier attempt to improve wildfire activity data by testing various remote sensors and geospatial techniques showed that the potential for remote sensing is limited in the case of the Netherlands (see Roerink and Arets, 2016). Because forest fires are infrequent, usually have a low intensity, and cover relatively small areas, none of the geospatial approaches was very effective in detecting the relevant forest fires and wildfires. Moreover, the cost of monitoring and analysis was considered to be disproportionate to the potential quality improvement for the GHG inventory (see Roerink and Arets, (2016), and Van Baren et al. (2025) for more details).

We have investigated other possible improvements in wildfire statistics in the Netherlands using the EFFIS data reported in its annual fire reports from 2000. Until 2017, the Netherlands did not submit a report to EFFIS, but the EFFIS reports also include independent rapid damage assessments to provide reliable and harmonised estimates of the areas affected by forest fires in collaborating countries. Although the Netherlands is included in these assessments, EFFIS's resolution of fire detection of 50 ha (older years), or, more recently, 30 ha, is larger than the area of most forest and wildfires in the Netherlands. As a result, they remain largely undetected in the EFFIS system. Since 2004, only fourteen wildfires have been included in the EFFIS data for the Netherlands (see section 12.3 in Van Baren et al. (2025), for more details). Because an average area of 37.5 ha is taken into account in the calculations emissions for wild fires have been reported. We will further explore possible sources of improved wildfire activity data by combining geospatial analyses with the information registered by the Netherlands Fire Service. Given the currently small extent of wildfires in the Netherlands, an important prerequisite will be that such approaches should be cost-effective and proportionate to the expected emissions from wildfires.

Emissions from fertiliser use in forests
Fertilisers are minimally applied in forestry in the Netherlands. Therefore, in CRT Table 4(I) direct nitrous oxide (N_2O) emissions from nitrogen (N) inputs for Forest land remaining forest land are reported as NO.

6.4.2.2 Land converted to forest land

Removals and emissions of CO_2 from forestry and changes in woody biomass stock are estimated using a country-specific Tier 2 methodology. The approach chosen follows the 2006 IPCC Guidelines.

Living biomass
Changes in carbon stocks in AGB and BGB in Land converted to forest land are estimated using the following set of assumptions and calculation steps:

1. The EF is calculated for each annual set of newly established units of Forest land separately. Thus, the specific age of the reforested/afforested units of land is taken into account.
2. At the time of afforestation, carbon stocks in AGB and BGB are zero.
3. The specific growth curve of new forests is unknown, but analyses of NFI plot data make clear that carbon stocks in newly planted forests reach the carbon stock of average forests in thirty years. Consequently, carbon stocks in AGB or BGB on units of newly established Forest land increase annually by the difference between the carbon stock in AGB or BGB at that time and the carbon stock in AGB or BGB of the average forest under Forest land remaining forest land, divided by the number of years left to reach an age of thirty years. This will result in twenty years of this build-up of carbon being reported in Land converted to Forest land and ten years in Forest land remaining Forest land.

For Cropland and Grassland converted to forest land, biomass loss in the year of conversion is calculated using Tier 1 default values.
Conversion from Grassland (TOF) to Forest land may occur when areas surrounding units of Trees outside forests are converted to Forest land and the total forested area becomes larger than the lower limit of the forest definition (i.e. 0.5 ha). For these conversions from Trees outside forests to Forest land, it is assumed that the biomass remains and the forest continues to grow as in Forest land remaining forest land.

Litter and dead wood
The specific accumulation of dead wood and litter in newly established forest plots is unknown, but from NFI measurements, the litter thickness and presence of deadwood is known. Therefore, the carbon build-up in

litter and dead wood follows the approach for the calculation of carbon emissions from living biomass (see Van Baren et al. (2025)).

Emissions from forest fires
All emissions from forest fires are included under Forest land remaining forest land and are reported here as IE.

Emissions from fertiliser use in forests
Fertilisers are minimally applied in forestry in the Netherlands. Therefore, in CRT Table 4(I), direct N_2O emissions from N inputs for Land converted to forest land are reported as NO.

6.4.2.3 Forest land converted to other land use categories

Living biomass
It is assumed that with the change from Forest land to other land use categories, all carbon stored in aboveground and belowground biomass, as well as in dead wood and litter is lost. For living biomass, the amount of carbon lost depends on the accumulated carbon since the forest was established, whereas for units of land in the Land converted to forest land category and in Forest land remaining forest land established less than thirty years ago, the carbon stocks are determined by the young forest approach as explained above in sections 6.4.2.1 and 6.4.2.2 (see also section 4.2.2 in Van Baren et al. (2025).

Conversion from Forest land to Grassland (TOF) occurs when surrounding forest is converted to other land uses and the remaining forest area becomes smaller than the lower limit of the forest definition (i.e. 0.5 ha). For these conversions from Forest land to Trees outside forests, it is assumed that no loss of biomass occurs. However in the CRT it is shown as a loss but an equal amount of gain in biomass is reported in TOF converted to Forest Land.

Table 6.16 Emission factors (EF) for dead organic matter carbon stocks in mature (> 30 year) Forest land (Mg C ha^{-1})

Year	EF dead wood (Mg C/ha)	EF litter (Mg C/ha)
1990	0.38	28.5
1991	0.40	28.6
1992	0.41	28.7
1993	0.49	28.7
1994	0.56	28.8
1995	0.63	28.8
1996	0.70	28.9
1997	0.77	29.0
1998	0.84	29.0
1999	0.91	29.1
2000	0.98	29.1
2001	1.05	29.2
2002	1.12	29.3
2003	1.19	29.3

Year	EF dead wood (Mg C/ha)	EF litter (Mg C/ha)
2004	1.26	29.4
2005	1.33	29.4
2006	1.40	29.5
2007	1.46	30.2
2008	1.52	31.0
2009	1.58	31.7
2010	1.64	32.5
2011	1.70	33.2
2012	1.76	33.9
2013	1.82	34.7
2014	1.88	35.4
2015	1.99	35.3
2016	2.10	35.1
2017	2.21	35.0
2018	2.33	34.8
2019	2.44	34.7
2020	2.55	34.5
2021	2.66	34.4
2022	2.77	34.2
2023	2.88	34.2
2024	2.96	34.2

All values represent the stock on the 1st of January for the specified year

Dead wood
Total emissions from the dead wood component following deforestation are calculated by multiplying the total area deforested by the average carbon stock in dead wood, as estimated by the calculations for Forest land remaining forest land. Thus, it is assumed that, with deforestation, all carbon stored in dead wood is lost to the atmosphere. National averages are used as there is no record of the spatial occurrence of specific forest types. This loss is also applied to Grassland (TOF) (see section 4.2.3 in Van Baren al. (2025) and resulting emission factors in Table 6.16), which includes both standing and lying dead wood.

Litter
Total emissions from the litter component following deforestation are calculated by multiplying the total area deforested by the average carbon stock in litter, as estimated by the calculations for Forest land remaining forest land. National averages are used for the EFs as there is no record of the spatial occurrence of specific forest types.

The average carbon stock in the litter layer has been estimated at the national level (De Jong et al., 2023). Litter thickness data from the NFIs and carbon content estimates from De Jong et al. (2023) are combined to calculate carbon content for litter. See Van Baren et al. (2025) for the full methodology.

The assessment of carbon stocks and related changes in litter in Dutch forests was based on extensive datasets on litter thickness and carbon content in litter (see Van Baren et al. (2025): section 4.2.1). Carbon stock changes per area of litter pool of the area of deforestation is high compared to those reported by other parties. These high values are related to the large share of the forest area that is on poor Pleistocene soils characterised by relatively thick litter layers. Additional information on geomorphological aspects is provided in Schulp et al. (2008) and De Waal et al. (2012) (see section 4.2.3 in Van Baren et al. (2025) and resulting emission factors in Table 6.16).

6.4.3 *Uncertainty assessment and time-series consistency*

Uncertainty assessment

The analysis in Annex 2 presented in Table A2.3 provides estimates of uncertainty by IPCC source category that are based on error propagation. This analysis combines uncertainty estimates of forest statistics, land use and land use change data (topographical data), and the uncertainties in the method used to calculate the annual growth in carbon increase and removals. The uncertainty range in CO_2 emissions from 4A (Forest land) is calculated at +10% to -12%. For N_2O and CH_4 uncertainties are much higher, up to 400% for N_2O, due to large uncertainties in emission factors. See Van Baren et al. (2025) for details.
The Netherlands also applies an improved uncertainty assessment to the LULUCF sector as a whole with better representation of uncertainties in the land use matrix, using Monte Carlo simulations for combining different types of uncertainties (see Chapter 14 of Van Baren et al. (2025) for details).

Time-series consistency

To ensure time series consistency in Forest land remaining forest land, the same approach to activity data, land use area, and emissions calculation is used for all years up to the reporting year. More detailed information is provided in section 6.4.2.1.

To ensure time series consistency in Land converted to forest land, the same approach to activity data, land use area, and emissions calculation is used for all years. More detailed information is provided in section 6.4.2.2.

6.4.4 *Category-specific QA/QC and verification*

The source categories are covered by the general QA/QC procedures discussed in Chapter 1. Additional Forest land-specific QA/QC includes:

- During the measurements of the four forest inventories, specific QA/QC measures were implemented to prevent errors in measurements and reporting (see Van Baren et al. (2025)).

6.4.5 *Category-specific recalculations*

All three methodological changes as described in 6.1.3. have an effect on Forest land and resulted in recalculations for the whole time series. The updated emission factors for drained organic soils has an effect on the carbon pool organic soils. The updated area of drainage ditches has an effect on the carbon emissions of organic soils and on methane emissions. The last methodological change has an effect on the carbon pool of mineral soils.

6.4.6 *Category-specific planned improvements*

No category-specific improvements have been planned.

6.5 Cropland (4B)

6.5.1 *Category description*

Emissions resulting from the disturbance of mineral soils due to land use changes to Cropland and emissions resulting from the lowering of the ground water table in organic soils under Cropland are significant, and are calculated separately for areas of Cropland remaining cropland and Land converted to cropland (see Van Baren et al., 2025). As a result of these high emissions from mineral soils and drained organic soils, the Cropland category is a key source. The carbon stock gains and losses in living biomass in Grassland converted to Cropland also strongly contribute to the emissions and removals in the Cropland category, but this contribution remains below the threshold of 25% of gains/losses in the category for it to be a significant pool under the Cropland category.

Because Cropland in the Netherlands mainly consists of annual cropland where annual biomass gains are harvested each year, no net accumulation of carbon stocks in biomass over time is expected in Cropland (IPCC, 2006). On the basis of estimates using the Tier 1 EFs, the carbon pool biomass gains and dead organic matter (DOM) in Cropland remaining cropland and Land converted to cropland can be considered not significant. Therefore, following the Tier 1 method in the 2006 IPCC Guidelines, carbon stock changes in living biomass are not estimated for Cropland remaining cropland.

Even if we apply the unrealistically high average EF for biomass gains and losses of Land converted to cropland to the area of Cropland remaining cropland, the resulting carbon stock changes remain well below the significance level (i.e. 25% of gains/losses in the category). Therefore, in CRT Table 4.B, these carbon stock changes are reported with the notation key NA.

There are significant carbon stock changes in biomass in orchards, which in the Netherlands predominantly consist of fruit trees. Because of the mainly grassy vegetation between trees, orchards are included under Grassland (see section 6.6).

Dead organic matter in annual cropland is expected to be negligible and, applying a Tier 1 method, it is assumed that dead wood and litter stocks (DOM) are not present in Cropland (IPCC, 2016). Therefore, carbon stock gains in DOM are not estimated in land use conversions to Cropland, nor are carbon stock losses in conversions from Cropland to other land uses.

Carbon stock losses for conversions to Cropland depend on the carbon stocks in DOM in the ‘converted from’ land use category. Currently, carbon stocks in DOM are only included under Forest land.

6.5.2 *Methodological issues*

With regard to soil emissions, a twenty-year transition period starting in 1990 is included, while carbon stock changes in biomass are considered to be instantaneous on conversion. In CRT Table 4.B, the area associated with the transition period for soil is reported.

Living biomass

The value of emissions and removals of CO_2 from carbon stock changes in living biomass for Land converted to cropland is calculated using a Tier 1 approach. This value is also used for determining emissions for Cropland converted to other land use categories (4A2, 4C2, 4D2, 4E2, 4F2).

Soils

Carbon stock changes in mineral soils for Cropland remaining cropland are calculated using a Tier 3 methodology, applying the RothC model. Carbon stock changes in mineral soils for land use changes involving Cropland and emissions from drained organic soils under Cropland are calculated using Tier 2 methodologies. More information on the methodologies is provided in section 6.1.2 and more details are provided in Chapter 11 of Van Baren et al. (2025).

6.5.3 *Uncertainty assessment and time-series consistency*

Uncertainty assessment

The analysis in Annex 2 Table A2.3 provides estimates of uncertainties for each IPCC source category that are based on error propagation. The uncertainties in the Dutch analysis of carbon levels depend on the factors that feed into the calculations (calculation of the organic substances in the soil profile and conversion to a national level) and data on land use and land use change (topographical data). The uncertainty range in the CO_2 emissions for 4B Cropland) is calculated at 45%. For N_2O and CH_4, uncertainties are much higher, due to uncertainties in emission factors (see Van Baren et al. (2025) for details).
The Netherlands also applies an improved uncertainty assessment to the LULUCF sector as a whole with better representation of uncertainties in the land use matrix, using Monte Carlo simulations for combining different types of uncertainties (see Chapter 13 in Van Baren et al. (2025) for details).

Time-series consistency

To ensure time series consistency, the same approach to activity data and land use area is used for all the years up to 2021.

6.5.4 *Category-specific QA/QC and verification*

The source categories are covered by the general QA/QC procedures discussed in Chapter 1.

6.5.5 *Category-specific recalculations*

All three methodological changes as described in 6.1.3. have an effect on Cropland and resulted in recalculations for the whole time series. The updated emission factors for drained organic soils have an effect on the carbon pool organic soils. The updated area of drainage ditches has an effect on the carbon emissions of organic soils and on methane emissions. The last methodological change has an effect on the carbon pool of mineral soils.

6.5.6 Category-specific planned improvements
Organic soil emission calculations are planned to be developed further in the coming years.

6.6 Grassland (4C)

6.6.1 Category description
Under the Grassland category, two main sub-categories are identified: (1) Trees outside forests (TOF) and (2) Grassland (non-TOF); see section 6.2. Conversions of land use to, from, and between Grassland (non-TOF) and TOF are separately monitored, and each takes a different approach to calculating the carbon stock changes.

Trees outside forests (TOF)
The Trees Outside Forests (TOF) category is determined in a spatially explicit way and experiences carbon stock changes similar to those of Forest land (see section 6.4.2 and Van Baren et al., (2025)). For land use conversion to TOF, the same biomass increase and associated changes in carbon stocks are assumed as for Land converted to forest land.
For conversions from TOF to other land uses, however, no losses of dead wood or litter are assumed. As the patches are smaller and any edge effects thus larger than in forests, the uncertainty regarding dead wood and litter accumulation is even higher for TOF than for Forest land. Moreover, for small patches and linear woody vegetation, the chance of dead wood removal is high, and disturbance effects on litter may prevent accumulation. Therefore, the conservative estimate of no carbon accumulation in these pools has been applied.

Conversion from Forest land to TOF may occur if connected surrounding units of Forest land are converted to other land uses and the remaining area no longer complies with the forest definition. Such units of land are considered to remain with tree cover, but losses of carbon in dead wood and litter will occur.

Grassland (non-TOF)
As described for Cropland, emissions resulting from the lowering of the ground water table in organic soils under Grassland (non-TOF) are significant. Therefore, these are explicitly calculated for areas of Grassland remaining grassland (non-TOF) and Land converted to grassland (non-TOF) (see Van Baren et al., 2025).

For carbon stock changes in living biomass in grassland vegetation and nature remaining in these categories, a Tier 1 method is applied, assuming no change in carbon stocks (IPCC, 2006; for details see Van Baren et al., 2025). In orchards, an increase in carbon stocks can be expected as the fruit trees age (see section 6.6.2 below). As a result of changing areas of grassland vegetation and orchards, the average carbon stocks in Grassland remaining grassland (non-TOF) change between years, reflected in the carbon stock changes in biomass in Grassland remaining grassland (non-TOF).

Carbon stock gains in living biomass for Land converted to grassland (non-TOF) are calculated using a Tier 1 approach (see section 6.6.2). Carbon stocks in Grassland (non-TOF) depend on carbon stocks per unit of area of grassland vegetation, nature and orchards and the relative contribution made by these categories to the Grassland (non-TOF) area. This value is also used to determine carbon stock losses in biomass for Grassland converted to other land use categories.

Dead organic matter (DOM) in grassland and orchards is expected to be negligible. While dead wood and litter may be formed in orchards, common orchard management that includes pruning and the removal of dead wood and litter will prevent build-up of large amounts of DOM. Even if we applied a value of 10% of annual carbon stock gains in biomass as an estimate of carbon stock gains in DOM in the same sub-category for which NE is currently used, this would make up only 1% of the carbon stock gains and losses in the Grassland category. Therefore, the Tier 1 approach is used (IPCC, 2006), assuming no build-up of DOM, which is reported as 'NE'.

This means that the carbon stock gains in DOM are not included in land use conversions to Grassland (non-TOF), nor are the carbon stock losses included in conversions from Grassland (non-TOF) to other land use categories. Carbon stock losses for conversions to Grassland (non-TOF) will depend on the carbon stocks in DOM in the 'converted from' land use category. Currently, carbon stocks in DOM are only included under Forest land.

Land converted to grassland that changes from one Grassland (non-TOF) category to another within the twenty-year transition period (i.e. from grassland vegetation to nature or the other way around, see Van Baren et al., (2025), is still reported in the land converted to Grassland (non-TOF) category until the end of the twenty-year transition period.

Conversions between Grassland (non-TOF) and TOF
Whereas conversions between Grassland (non-TOF) and TOF are reported under Grassland remaining grassland, the two categories are considered separately in the calculations.

Conversions from Grassland (non-TOF) to TOF will result in the loss of Grassland (non-TOF) biomass in the year of conversion and subsequent growth of biomass (in the form of trees) in TOF. Conversion from TOF to Grassland (non-TOF) will involve a loss of carbon stocks in biomass from TOF and an increase in carbon stocks in Grassland (non-TOF), as applies to conversions from other land use categories. The changes in carbon stocks in mineral soils will also be included using a twenty-year transition period, similar to conversions between Forest land and Grassland (non-TOF).

6.6.2 *Methodological issues*

With regard to soil emissions, a twenty-year transition period is included starting from 1990, while carbon stock changes in biomass are considered to be instantaneous on conversion. In the CRT, the area associated with the transition period for soil is reported.

Living biomass

Grassland non-TOF

Carbon stock changes due to changes in biomass in land use conversions to and from Grassland (non-TOF) are calculated using Tier 1 default carbon stocks. For the whole Grasslands (non-TOF) category, including grassland vegetation, nature and orchards, an average carbon stock per unit of land is calculated from the carbon stocks per unit area of grassland vegetation, nature and orchards, weighted for their relative contribution to the Grassland (non-TOF) category. Therefore, average carbon stocks for Grassland (non-TOF) will vary over time as a result of varying relative contributions of the various vegetation types to the total Grassland (non-TOF) area (see Table 6.17).

Default values for dry matter and carbon factors are used to determine carbon stocks in living biomass in grassland vegetation and nature. Combined, these amount to 6.4 ton C per ha (Van Baren et al., 2025). Carbon stocks in living biomass in orchards are based on an average age of trees in orchards[14] and a Tier 1 biomass accumulation rate of 2.1 ton C ha^{-1} yr^{-1} (IPCC, 2006). The average age of fruit orchards changed over time from 10.4 years in 1997 to 13 years in 2017[15]. Between the measurement years (1997, 2002, 2007, 2012 and 2017), the age developments were interpolated and linearly extrapolated before and after on the basis of the two adjacent measured ages. Subsequently, the average ages of fruit orchard trees are multiplied by the Tier 1 biomass accumulation of 2.1 tonnes ha^{-1} yr^{-1} to calculate the average carbon stock in orchard biomass (tC ha^{-1}) (Table 6.17). Areas of orchards published by Statistics Netherlands (CBS) between 1992 and 2016[16] and from 2017 onwards[17] are used to assess the area-weighted average carbon stocks in Grassland non-TOF (Table 6.17). The two Statistics Netherlands time series used include mostly the same fruit tree categories. Only in the case of other stone fruit trees ('overige steenvruchtbomen'), the more recent time series also include, on average, 700 ha of high-standard fruit trees, which were not recorded separately before. Because of the relatively small effect, this is estimated to have no net emissions (around -4 kt CO_2), it was decided not to correct this.
Net carbon stock changes in both mineral and organic soils for land use changes involving Grassland are calculated using the methodology provided in Van Baren et al. (2025).

[14] https://opendata.cbs.nl/statline/#/CBS/nl/dataset/81735NED/table?ts=1517993072950
[15] https://opendata.cbs.nl/statline/#/CBS/nl/dataset/81735NED/table?ts=1517993072950
[16] https://opendata.cbs.nl/statline/#/CBS/nl/dataset/70671NED/table?fromstatweb
[17] https://opendata.cbs.nl/statline/#/CBS/nl/dataset/84470NED/table?ts=1582625476425

Table 6.17 Area and carbon stocks (CS) in living biomass for orchards and grass vegetation and combined average carbon stocks per area of Grassland (non-TOF)

	Orchard			Grass vegetation		Total		Average
Year	**Area (kha)**	**CS ha^{-1} (tC)**	**CS (tC)**	**Area (kha)**	**CS (tC)**	**Area (kha)**	**CS (tC)**	**CS (tC/ha)**
1990	25.0	22.7	566.9	1,426.4	9,117.7	1,451.4	9,684.5	6.67
1991	24.7	22.6	557.3	1,419.7	9,074.9	1,444.4	9,632.2	6.67
1992	24.4	22.5	548.3	1,413.0	9,032.0	1,437.4	9,580.3	6.67
1993	24.2	22.4	540.9	1,406.2	8,988.7	1,430.4	9,529.6	6.66
1994	24.1	22.3	537.3	1,399.3	8,944.3	1,423.4	9,481.6	6.66
1995	23.1	22.2	512.8	1,393.3	8,905.9	1,416.4	9,418.7	6.65
1996	22.9	22.1	506.5	1,386.5	8,862.4	1,409.4	9,368.8	6.65
1997	23.0	22.0	504.9	1,379.4	8,817.4	1,402.4	9,322.3	6.65
1998	22.4	21.9	489.7	1,373.0	8,776.4	1,395.4	9,266.1	6.64
1999	21.9	21.8	476.5	1,366.5	8,734.9	1,388.4	9,211.4	6.63
2000	20.5	21.7	444.4	1,360.9	8,699.0	1,381.4	9,143.4	6.62
2001	19.5	21.6	420.6	1,354.9	8,660.7	1,374.4	9,081.3	6.61
2002	19.2	21.5	413.3	1,348.2	8,617.6	1,367.4	9,030.9	6.60
2003	18.4	21.8	400.9	1,342.0	8,578.2	1,360.4	8,979.1	6.60
2004	18.3	22.1	405.0	1,338.5	8,555.8	1,356.9	8,960.9	6.60
2005	18.1	22.4	405.3	1,335.2	8,534.6	1,353.3	8,939.9	6.61
2006	18.2	22.7	412.6	1,331.6	8,511.3	1,349.7	8,923.9	6.61
2007	18.5	23.0	424.4	1,327.7	8,486.8	1,346.2	8,911.2	6.62
2008	18.6	23.3	432.8	1,324.0	8,463.2	1,342.6	8,896.0	6.63
2009	18.8	23.6	442.8	1,312.1	8,387.2	1,330.9	8,830.0	6.63
2010	18.6	23.8	442.4	1,300.7	8,314.0	1,319.2	8,756.4	6.64
2011	18.3	24.1	441.4	1,289.3	8,241.0	1,307.6	8,682.4	6.64
2012	17.9	24.4	437.4	1,278.0	8,168.7	1,295.9	8,606.1	6.64
2013	18.2	25.0	455.4	1,292.5	8,261.4	1,310.7	8,716.8	6.65
2014	18.3	25.6	468.2	1,307.2	8,355.4	1,325.4	8,823.6	6.66
2015	18.5	26.2	485.2	1,321.7	8,448.4	1,340.2	8,933.6	6.67
2016	19.1	26.8	512.4	1,335.9	8,539.1	1,355.0	9,051.5	6.68
2017	18.6	27.4	508.5	1,344.5	8,593.9	1,363.0	9,102.4	6.68
2018	18.4	28.0	515.2	1,352.6	8,646.1	1,371.0	9,161.3	6.68
2019	18.4	28.6	525.0	1,360.7	8,697.5	1,379.1	9,222.5	6.69
2020	18.0	29.2	525.1	1,369.1	8,751.1	1,387.1	9,276.2	6.69
2021	17.9	29.8	531.9	1,377.4	8,804.0	1,395.2	9,335.9	6.69
2022	17.8	30.4	541.8	1,383.86	8845.7	1,401.7	9,387.5	6.70
2023	17.0	31.0	525.7	1394.3	8912.3	1,411.3	9,438.0	6.69

Trees outside forests
For Trees Outside Forests (TOF), no separate data on growth or increment is available. It is therefore assumed that TOF grow at the

same rates as forests under Forest land (see section 6.4 and Van Baren et al., 2025). The only difference between the two categories is the size of the stand (<0.5 ha for TOF), so this seems a reasonable assumption. It is also assumed that no build-up of dead wood or litter occurs and that no harvesting takes place. Instead, all the wood included in the national harvest statistics is assumed to be harvested from Forest land.

Wildfires
There are no recent statistics available on the occurrence and intensity of wildfires in the Netherlands. Emissions of CO_2, CH_4 and N_2O from wildfires are reported according to the Tier 1 method described in the 2006 IPCC Guidelines.

The area of wildfires is based on a historical series from 1980 to 1992, for which the annual number of forest fires and the total burned area are available (Wijdeven et al., 2006). Forest fires are reported under Forest land (see section 6.4.2). The average annual area of other wildfires is 210 ha (Arets et al., 2023). This includes all land use categories. Most wildfires in the Netherlands, however, are associated with heath and grassland. All other emissions from wildfires, except forest fires, are therefore included under Grassland remaining grassland. CO_2, CH_4 and N_2O emissions from wildfires are based on the default carbon stock in living biomass on Grassland (non-TOF).

Area of cultivated organic soils
In drained areas with cultivated organic soils, the 5.8% reduction for drainage ditches is considered, as no carbon stock losses and associated CO_2 emissions are calculated for them. While in CRT Table 4.C the total area of organic soil is included, the carbon stock changes are based only on the cultivated areas minus 5.8% for drainage ditches. This explains the differences between the areas of organic soils reported under Cropland and Grassland in the LULUCF sector on the one hand, and the areas reported in CRT Table 3.D in the Agriculture sector on the other. To improve transparency, a comparison between the various areas is presented in Table 6.18.

Table 6.18 Areas (kha) of peat and peaty soil in total Grassland (non-TOF) compared with the part considered to be drained cultivated grassland reported in CRT Table 3.D.

Year	Area grassland (non-TOF)			Area drained cultivated grassland		
	Peat	Peaty	Total	Peat	Peaty	Total
	kha					
1990	217,194	93,429	310,624	204,597	88,011	292,608
1991	215,648	92,879	308,526	203,140	87,492	290,632
1992	214,108	92,329	306,437	201,690	86,974	288,663
1993	212,581	91,777	304,358	200,251	86,454	286,705
1994	211,063	91,221	302,284	198,822	85,930	284,752
1995	209,552	90,684	300,236	197,398	85,424	282,822
1996	208,041	90,140	298,181	195,975	84,912	280,887
1997	206,537	89,600	296,137	194,558	84,403	278,961
1998	205,039	89,061	294,100	193,147	83,895	277,043
1999	203,560	88,513	292,073	191,753	83,379	275,133

Year	Area grassland (non-TOF)			Area drained cultivated grassland		
	Peat	Peaty	Total	Peat	Peaty	Total
	kha					
2000	202,088	87,977	290,066	190,367	82,875	273,242
2001	200,614	87,431	288,044	188,978	82,360	271,338
2002	199,158	86,903	286,060	187,606	81,862	269,469
2003	197,712	86,382	284,094	186,245	81,372	267,616
2004	196,180	85,836	282,016	184,802	80,857	265,659
2005	194,649	85,280	279,930	183,360	80,334	263,694
2006	193,131	84,718	277,849	181,929	79,804	261,733
2007	191,613	84,170	275,783	180,499	79,289	259,788
2008	190,111	83,599	273,711	179,085	78,751	257,835
2009	189,158	82,985	272,143	178,187	78,172	256,358
2010	188,205	82,372	270,576	177,289	77,594	254,883
2011	187,261	81,766	269,027	176,400	77,024	253,423
2012	186,329	81,137	267,467	175,522	76,431	251,954
2013	185,846	81,804	267,651	175,067	77,060	252,127
2014	185,707	82,400	268,107	174,936	77,621	252,557
2015	185,558	82,986	268,544	174,796	78,173	252,969
2016	185,385	83,583	268,968	174,633	78,735	253,368
2017	185,259	83,608	268,866	174,514	78,759	253,272
2018	185,128	83,632	268,760	174,391	78,781	253,172
2019	185,002	83,671	268,673	174,272	78,818	253,090
2020	184,861	83,713	268,575	174,140	78,858	252,997
2021	184,730	83,770	268,500	174,016	78,911	252,927
2022	184,594	83,810	268,404	173,888	78,949	252,837
2023	184,452	83,857	268,309	173,754	78,993	252,747

All areas are dated on 1 January of the years indicated.

6.6.3 *Uncertainty assessment and time-series consistency*

Uncertainty assessment

The analysis in Annex 2 Table A2.3 provides estimates of uncertainties by IPCC source category, based on error propagation. The uncertainty range for CO_2 emissions in category 4C Grassland (non-TOF) is calculated at 75%. For CH_4 and N_2O uncertainties are much higher, mainly due to uncertainties in emission factors (see Van Baren et al. (2025) for details). The Netherlands also applies an improved uncertainty assessment to the LULUCF sector as a whole with better representation of uncertainties in the land use matrix, using Monte Carlo simulations for combining different types of uncertainties (see Chapter 14 of Van Baren et al. (2025) for details). There is currently no Monte Carlo uncertainty assessment that is based on the TOF category, but uncertainties are likely to be similar to those of Forest land – except that the uncertainty relating to the land use map may be larger as a result of the inherently small patches of TOF.

Time-series consistency

To ensure time series consistency, the same approach to activity data, land use area and emissions calculation is used for all years. Removals in the later years are the result of carbon stock gains in mineral soil that are mainly due to the relatively large areas of Cropland converted to grassland since 2013. Interannual changes in implied EFs in mineral soils are the result of shifts in trends of land use changes. Carbon stock changes in mineral soils are based on combinations of land use change and soil type. Therefore, the mix of combinations of land use changes and soil types include changes over time. Moreover, actual annual land use changes, mixed with the timing of the twenty-year transition periods for carbon stock changes in soils, further affects the interannual changes in the implied EFs calculated on the basis of the total area in a certain conversion category (e.g. Cropland converted to grassland).

6.6.4 Category-specific QA/QC and verification

The source categories are covered by the general QA/QC procedures discussed in Chapter 1.

6.6.5 Category-specific recalculations

All three methodological changes as described in 6.1.3. have an effect on Grassland and resulted in recalculations for the whole time series. The updated emission factors for drained organic soils has an effect on the carbon pool organic soils. The updated area of drainage ditches has an effect on the carbon emissions of organic soils and on methane emissions. The last methodological change has an effect on the carbon pool of mineral soils.

6.6.6 Category-specific planned improvements

Organic soil emission calculations are planned to be developed further in the coming years.

6.7 Wetlands (4D)

6.7.1 Category description

The Wetland land use category mainly consists of open water. Therefore for 4D1 (Wetland remaining wetland) no changes in carbon stocks in living biomass and soil have been estimated. For land use conversions from Wetland to other land uses, no carbon stock losses in living biomass are assumed to occur; these will be reported as not occurring (NO). For land use changes from Forest land, Cropland and Grassland to Wetland (4D2), losses in carbon stocks in living biomass and net carbon stock changes in soils are included.

Because the Wetland category is mainly open water, dead organic matter (DOM) is assumed to be negligible. Therefore, no carbon stock gains in DOM are included in land use conversions to Wetland, nor are carbon stock losses included in conversions from Wetland to other land use categories. Carbon stock losses for conversions to Wetland will depend on the carbon stocks in DOM in the ‘converted from’ land use category. Currently, carbon stocks in DOM are only included under Forest land.

In the Netherlands, land use on peat areas is mainly Grassland, Cropland, or Settlements. Emissions from drainage in peat areas are included in carbon stock changes in organic soils for these land use categories.

6.7.2 *Methodological issues*

Living biomass

Carbon stocks in living biomass and DOM on flooded land and in open water are considered to be zero. For conversion from other land uses to Wetland, the Netherlands applies a stock difference method, assuming that all the carbon in biomass and organic matter that existed before conversion is emitted.

Emissions from fertiliser use in Wetland

The Wetland land use category mainly consists of open water, on which no direct nitrogen inputs occur. Therefore, in CRT Table 4(I), direct N_2O emissions from N inputs for Wetland are reported as NO.

Wetlands activity data

Starting with the submission of the NIR 2024, a Tier 1 approach for Wetlands is applied. To achieve this, a water type map (Clement & Puijenbroek,. 2010) was used to reclassify Wetlands, which in previous submissions used to be reported as Open water. Reservoirs, freshwater ponds, canals, and ditches were classified. In a first step, Tier 1 methodologies are now applied to that part of the open water that is human-made, i.e. all canals and ditches, and reservoirs and freshwater ponds created since 1900. For these water bodies, it is clear that the emissions have an anthropogenic cause. Further description of the method is provided in section 3.2 of Van Baren et al. (2025). In the current submission of 2025, the various areas are not specified in the CRT. Therefore, emissions from flooded land (reservoirs, freshwater ponds, canals and ditches) are all reported under Open water at the moment. Areas for the various wetland categories per year are presented in Table 6.19.

Table 6.19 Areas (ha) of the different sub-categories for the land use category Wetlands

Year	Open water	Reed	Reser-voirs	Fresh-water ponds	Canals	Ditches	Total Wet-lands
1990	741,698	21,292	6,060	5,771	14,763	5,804	795,388
1991	741,942	21,740	6,063	5,787	14,891	6,016	796,439
1992	742,185	22,189	6,066	5,803	15,019	6,228	797,491
1993	742,429	22,638	6,070	5,819	15,147	6,440	798,543
1994	742,672	23,087	6,073	5,836	15,275	6,652	799,595
1995	742,916	23,536	6,076	5,852	15,403	6,865	800,646
1996	743,160	23,984	6,079	5,868	15,531	7,077	801,698
1997	743,403	24,433	6,082	5,884	15,658	7,289	802,750
1998	743,647	24,882	6,085	5,900	15,786	7,501	803,802
1999	743,891	25,331	6,088	5,916	15,914	7,713	804,854
2000	744,134	25,780	6,092	5,932	16,042	7,926	805,905
2001	744,378	26,228	6,095	5,948	16,170	8,138	806,957
2002	744,621	26,677	6,098	5,964	16,298	8,350	808,009
2003	744,865	27,126	6,101	5,980	16,426	8,562	809,061
2004	745,713	26,891	6,098	5,970	16,544	8,781	809,998
2005	746,562	26,656	6,096	5,960	16,661	9,000	810,934
2006	747,410	26,420	6,093	5,950	16,779	9,219	811,871
2007	748,258	26,185	6,091	5,940	16,896	9,438	812,808
2008	749,107	25,950	6,088	5,930	17,014	9,656	813,745
2009	751,274	26,027	6,086	5,913	17,000	9,664	815,964
2010	753,442	26,104	6,083	5,895	16,986	9,672	818,182
2011	755,609	26,181	6,081	5,878	16,973	9,679	820,400
2012	757,777	26,258	6,079	5,860	16,959	9,687	822,619
2013	757,731	26,369	6,075	5,846	16,937	9,594	822,551
2014	757,686	26,479	6,071	5,831	16,915	9,500	822,482
2015	757,640	26,590	6,067	5,817	16,893	9,407	822,414
2016	757,595	26,700	6,063	5,803	16,871	9,314	822,346
2017	758,084	26,638	6,054	5,795	16,833	9,205	822,610
2018	758,573	26,575	6,045	5,788	16,796	9,097	822,874
2019	759,062	26,512	6,036	5,781	16,758	8,988	823,138
2020	759,551	26,450	6,028	5,774	16,720	8,880	823,402
2021	760,027	26,398	6,019	5,763	16,679	8,774	823,659
2022	760,502	26,346	6,010	5,752	16,639	8,669	823,917
2023	760,977	26,294	6,001	5,741	16,598	8,563	824,174

Methane and carbon dioxide emissions from Flooded Land
Methane and carbon dioxide emissions from all land uses converted to Flooded land and remaining Flooded land are calculated using a Tier 1 approach from the 2019 refinements to the 2006 IPCC guidelines (IPCC 2019). For the climate zone definition, Cool Temperate is used. Carbon dioxide emissions only occur on land converted to Reservoirs. Methane emissions from ditches and canals on organic soils are calculated using a country-specific emission factor from Peacock et al. (2021). For details on the method used, see Van Baren et al. (2025).

6.7.3 *Uncertainty assessment and time-series consistency*

Uncertainty assessment

The analysis in Annex 2 Table A2.3 provides estimates of uncertainties according to IPCC source categories that are based on error propagation The uncertainty range in the CO_2 emissions for 4D Wetlands is calculated at 75% (see Van Baren et al. (2025) for details).
The Netherlands also applies an improved uncertainty assessment to the LULUCF sector as a whole, with better representation of uncertainties in the land use matrix, using Monte Carlo simulations for combining different types of uncertainties (see Chapter 14 of Van Baren et al. (2025) for details).

Time-series consistency

To ensure time series consistency, the same approach to activity data, land use area and emissions calculation has been used for all years.

6.7.4 *Category-specific QA/QC and verification*

The source categories are covered by the general QA/QC procedures discussed in Chapter 1.

6.7.5 *Category-specific recalculations*

No recalculations have been performed this year.

6.7.6 *Category-specific planned improvements*

Improved and higher-tier approaches for assessing emissions and removals from Wetlands are being assessed. This will result in improved methodologies to be included in future NIRs. This is expected to be a stepwise process with successive improvements in successive years. At the moment all data and emissions on flooded land is included under other wetlands in Table4.D, in future submissions this will be divided in flooded land categories.

6.8 Settlements (4E)

6.8.1 *Category description*

In peat soils under Settlements, the lowering of the groundwater table also causes oxidation of peat that, in turn, results in high emissions. Together with loss of carbon stocks in biomass resulting from conversion of Forest land to settlement and Grassland to settlement, these are significant sources of CO_2.

Although Settlements also include areas with grass and trees, biomass gains and losses are expected to be in balance. Therefore, the Netherlands applies the Tier 1 method, assuming no change in carbon stocks in biomass in 4E1 (Settlements remaining settlements). Moreover, thanks to the high resolution of the land use grid, areas of land of 25 x 25 m or more within urban areas meeting the criteria for Forest land, Grassland or Trees outside forests, will be reported under those land use categories and not under Settlements (see Van Baren et al., 2025).. In other words, the major pools of carbon in urban areas are covered by other land use categories.

As no additional data is available on carbon stocks in biomass and DOM in Settlements, and because conversions to Settlements are more frequent than conversions from Settlements to other land uses, it is more conservative not to report carbon stock gains and losses for biomass and DOM in Settlements resulting from conversions to and from Settlements.

It is also assumed that no carbon stock changes occur in mineral soils under Settlements remaining settlements. For conversions from other land uses to Settlements, the Netherlands applies a stock difference method, assuming that all the carbon in living biomass and organic matter that existed before conversion is emitted at once.

6.8.2 *Methodological issues*

The methodology for calculating carbon stock losses in biomass for Forest land converted to settlements is provided in section 6.4. Sections 6.5 (Cropland) and 6.6 (Grassland) describe the methodology for calculating carbon stock losses in biomass for conversions from Cropland and Grassland to Settlements. Land use conversions from Wetlands or Other land to Settlements will result in no changes in carbon stocks in living biomass.

Emissions from fertiliser use in Settlements

Under Settlements, direct N_2O emissions from the use of fertilisers and compost by private consumers and hobby farmers are reported under 3Da1 (Inorganic N fertilisers) and 3Da2 (Organic N fertilisers). 3Da1 and 3Da2 also include fertilisers used outside agriculture, see chapter 5.4 Agricultural soils (3D).

6.8.3 *Uncertainty assessment and time-series consistency*

Uncertainty assessment

The analysis in Annex 2 Table A2.3 provides estimates of uncertainties for each IPCC source category that are based on error propagation. The uncertainty range in CO_2 emissions for 4E Settlements is calculated at 70%. For N_2O, uncertainties are much higher, due to uncertainties in emission factors (see Van Baren et al. (2025) for details). The Netherlands also applies an improved uncertainty assessment to the LULUCF sector as a whole, providing a better representation of uncertainties in the land use matrix, using Monte Carlo simulations for combining different types of uncertainties (see Chapter 14 of Van Baren et al. (2025) for details).

Time-series consistency

To ensure time series consistency, the same approach to activity data, land use area and emissions calculation is used for all years.

6.8.4 *Category-specific QA/QC and verification*

The source categories are covered by the general QA/QC procedures discussed in Chapter 1.

6.8.5 *Category-specific recalculations*

Two of the methodological changes as described in 6.1.3. have an effect on Settlements and resulted in recalculations for the whole time series. The updated emission factors for drained organic soils has an effect on the carbon pool organic soils. The last methodological change has an effect on the carbon pool of mineral soils.

6.8.6 *Category-specific planned improvements*

Look into the possibility of including biomass at a higher Tier.

6.9 Other land (4F)

6.9.1 *Category description*

In the Netherlands, the land use category 4F (Other land) is used to report areas of bare soil not included in any other category. These include coastal dunes and beaches with little or no vegetation, inland dunes and sand drifts, i.e. areas where the vegetation has been removed to create spaces for early succession species (and which are kept bare by the wind). Inland bare sand dunes have developed as a result of heavy overgrazing. For a long time, this was combatted by forest planting. These inland dunes and shifting sands, however, provided a habitat to some species that have now become rare. As a conservation measure in certain areas, these habitats have now been restored by removing vegetation and topsoil.

No carbon stock changes occur on Other land remaining other land. For units of land converted from other land uses to the Other land category, the Netherlands assumes that all the carbon in living biomass and DOM that existed before conversion is lost and no gains on Other land exist. Carbon stock changes in mineral and organic soils on land converted to Other land are calculated and reported.

Similarly, land use conversions from Other land to the other land use categories involve no carbon stock losses from biomass or DOM.

6.9.2 *Methodological issues*

The methodology for calculating carbon stock changes in biomass for Forest land converted to settlements is provided in section 6.4. Sections 6.5 (Cropland) and 6.6 (Grassland) provide the methodology for calculating carbon stock changes in biomass in conversions from Cropland and Grassland to Other land. Land use conversions from Wetland or Settlements to Other Land will result in no changes in carbon stocks in living biomass.

6.9.3 *Uncertainty assessment and time-series consistency*

Uncertainty assessment

The analysis in Annex 2 Table A2.3 provides estimates of uncertainties for each IPCC source category that are based on error propagation The uncertainty in CO_2 emissions for 4F Other Land is calculated at 150%. Uncertainties for N_2O emission are even higher, due to the uncertainties in emission factors (see Van Baren et al. (2025) for details). The Netherlands also applies an improved uncertainty assessment to the LULUCF sector as a whole, providing a better representation of uncertainties in the land use matrix, using Monte Carlo simulations for combining different types of uncertainties (see Chapter 14 in Van Baren et al. (2025) for details).

Time-series consistency

To ensure time series consistency, the same approach to activity data, land use area, and emissions calculation is used for all years.

6.9.4 *Category-specific QA/QC and verification*

The source categories are covered by the general QA/QC procedures discussed in Chapter 1.

6.9.5 *Category-specific recalculations*

No recalculations have been performed this year.

6.9.6 *Category-specific planned improvements*

No improvements have been planned.

6.10 Harvested wood products (4G)

6.10.1 *Category description*

The Netherlands calculates sources and sinks from Harvested wood products (HWP) on the basis of the change in the pool, as suggested in the 2013 IPCC KP guidance (IPCC, 2014). These HWP emissions and removals are reported in the CRT using Approach B2.

6.10.2 *Methodological issues*

The approach taken to calculate the HWP pools and fluxes follows guidance in section 2.8 of the 2013 IPCC KP guidance (IPCC, 2014). Carbon from HWP allocated to Deforestation is reported using instantaneous oxidation (Tier 1) as the calculation method. The remainder of the carbon is added to the respective HWP pools. As no country-specific methodologies or half-life constants exist, the calculation for the HWP pools follows the Tier 2 approach outlined in the 2013 IPCC KP guidance (i.e. applying equations 2.8.1–2.8.6 in that guidance) (Van Baren et al., 2025).

Four categories of HWP are taken into account: Sawnwood, Wood panels, Other industrial round wood, and Paper and paperboard. Emissions from wood harvested for energy purposes are included in carbon stock losses in living biomass under Forest land remaining forest land, but are not used as an inflow to the HWP pool. As a result, these emissions are accounted for on the basis of instantaneous oxidation.

The distribution of material inflow into the various HWP pools is based on the data reported from 1961 onwards to the FAO for its statistics on imports, production, and exports of the various wood product categories (see CRT Table 4.Gs2), including those for industrial round wood and wood pulp as a whole.

To assess carbon amounts in the various HWP categories, the default carbon conversion factors for the aggregated HWP categories Sawnwood, Wood-based panels, and Paper and paperboard from the 2013 IPCC KP guidance (see Table 6.20) have been used. For the category Other industrial round wood, the values for Sawnwood have been used, as the latter category includes certain types of round wood use, such as the use of whole stems as piles in building foundations and road and waterworks, and as fences and poles. These are considered applications with a long to very long lifetime, for which the thirty-five-year half-life is considered appropriate.

To calculate the inflow of domestically produced paper, equation 2.8.2 from the 2013 IPCC KP guidance (IPCC, 2014) is applied to reported quantities of production, imports and exports of paper and paperboard. However, after 1993 the result give a negative value, indicating that there is no more production of pulp from domestic wood. In line with the instructions in the 2013 IPCC KP guidance (IPCC, 2014) these negative values are set to zero.

The paper and cardboard produced in the Netherlands is produced from imported cellulose (wood pulp) and recycled waste paper (Teeuwen et al., 2023). Therefore, using the production approach to HWP implies that no gains in paper and paperboard are expected.

Table 6.20 Tier 1 default carbon conversion factors and half-life factors for the HWP categories

HWP category	C conversion factor (Megagram C per m^3 air dry volume)	Half-lives (years)
Sawn wood	0.229	35
Wood-based panels	0.269	25
Other industrial round wood	0.229	35
Paper and paperboard	0.386	2

6.10.3 *Uncertainty assessment and time-series consistency*

Uncertainty assessment

The analysis in Annex 2 Table A2.3 provides estimates of uncertainties for each IPCC source category that are based on error propagation. As both activity data and emission factors have low uncertainty, the total uncertainty in the CO_2 emissions for 4G Harvested wood products is calculated at around 1% (see Van Baren et al. (2025) for details).

The Netherlands also includes HWP in the improved uncertainty assessment of the LULUCF sector as a whole, using Monte Carlo simulations to combine different types of uncertainties (see Chapter 14 of Van Baren et al. (2025) for details).

Time-series consistency

Annual changes in carbon stocks in HWP are erratic by nature because they depend on highly variable inputs of wood production, imports, and exports. Net CO_2 emissions and removals in the 1990–2023 period range between -68 Gg CO_2 (removals) and 232 Gg CO_2.

6.10.4 *Category-specific QA/QC and verification*

The source categories are covered by the general QA/QC procedures discussed in Chapter 1.

6.10.5 *Category-specific recalculations*

No recalculations have been performed this year.

6.10.6 *Category-specific planned improvements*

No category-specific improvements are foreseen.

7 Waste (CRT sector 5)

Major changes in the Waste sector compared to the National Inventory Report 2024	
Emissions:	In 2023, total GHG emissions from the Waste sector further decreased by 3.8% compared to 2021 and by 82.6% compared to 1990.
New Key categories:	No changes in key categories compared to the NIR2024
Methodologies and recalculations:	In category 5B biological treatment of waste the amount of methane from manure digestion has been recalculated for the years 2017-2022.
	In category 5D wastewater handling, there were a number of small recalculations due to final or revised activity data (see chapter 7.5.5)

7.1 Overview of the sector and background information

The national inventory of the Netherlands comprises four source categories in the Waste sector:

- solid waste disposal on land (5A): CH_4 (methane) emissions;
- composting and digesting of biomass waste (including manure) (5B): CH_4 and N_2O (nitrous oxide) emissions;
- treatment of waste, including municipal waste incineration plants (5C): CO_2 and N_2O emissions (included in 1A1a);
- wastewater treatment and discharge (5D): CH_4 and N_2O emissions.

Table 7.1 Overview of the sector Waste (5) in the base year and the last two years of the inventory (in Tg CO_2 eq.). The middle column shows the change (%) of the last year of the inventory compared to the base year. On the right side of the table, the contribution of the last year inventory's emissions of the category to the sector, to the total national emissions of the specific gas and to the total national emissions (in CO_2 eq) are provided.

Sector/category	Gas	Key	1990	2022	2023	2023 vs 1990	Contribution of the category in 2023 (%) to the		
			Emissions in Tg CO_2 eq			%	sector	total gas	total CO_2 eq
5 Waste	CH_4		15.8	2.4	2.3	-85.7%	79.5%	12.3%	1.5%
	N_2O		0.5	0.6	0.6	5.9%	20.5%	8.8%	0.4%
	All		16.3	2.9	2.8	-82.6%	100.0%		1.9%
5A. Solid Waste Disposal on land	CH_4	L,T	15.3	2.0	1.9	-87.5%	67.2%	10.4%	1.3%
5B. Biological treatment of solid waste	CH_4	T	0.0	0.1	0.1	2726.3%	4.8%	0.7%	0.1%
	N_2O	0	0.0	0.1	0.1	1169.6%	2.6%	1.1%	0.1%
	All		0.01	0.20	0.21	1873.5%	7.4%		0.1%
5D. Wastewater treatment and discharge	N_2O	L	0.5	0.5	0.5	-6.2%	17.9%	7.7%	0.3%
	CH_4		0.4	0.2	0.2	-49.3%	7.5%	1.2%	0.1%
	All		1.0	0.7	0.7	-25.0%	25.4%		0.5%
Total national emissions (incl LULUCF)	CO_2		167.7	130.8	120.6	-28.1%			
	CH_4		36.5	18.6	18.4	-49.5%			
	N_2O		16.1	6.7	6.6	-59.0%			
	Total		227.5	157.0	146.4	-35.6%			

Table 7.1 presents the contribution made by the emissions from the Waste sector to total GHG emissions in the Netherlands, as well as the key sources in this sector by level, trend, or both. The list of all (key and non-key) sources in the Netherlands is included in Annex 1.

CO_2 emissions from the anaerobic decay of waste in landfill sites are not included as these are considered to be part of the carbon cycle rather than a net source. The Netherlands does not report emissions from waste incineration facilities for municipal waste in the Waste sector under category 5C, but under CRT 1A1a. These facilities also produce electricity and/or heat used for energy purposes (to comply with IPCC reporting guidelines). Methodological issues concerning this source category are briefly discussed in section 7.4. The methodology is described in detail in the methodology report (Honig et al., 2025).

In 2023, the Waste sector accounted for 1.9% of national total emissions (including LULUCF), compared to 7.2% in 1990. Emissions of CH_4 and N_2O accounted for 79.5% and 20.5% of CO_2 equivalent emissions from this sector, respectively. Emissions of CH_4 from waste, of which 85% originates from landfills (5A Solid waste disposal on land), accounted for 10.4% of total CH_4 emissions in 2023. N_2O emissions from the Waste sector originate from biological treatment of solid waste and from wastewater treatment. Fossil fuel-related emissions from waste incineration, mainly CO_2, are included in fuel combustion emissions from the Energy sector (1A1a).

Between 1990 and 2023, emissions from the Waste sector decreased by 82.6% (from 16.3 Tg CO_2-eq in 1990 to 2.8 Tg CO_2-eq in 2023; see Figure 7.1), mainly due to an 87.5% reduction in CH_4 from landfills. Between 2022 and 2023, CH_4 emissions from landfills decreased by 5.8%.

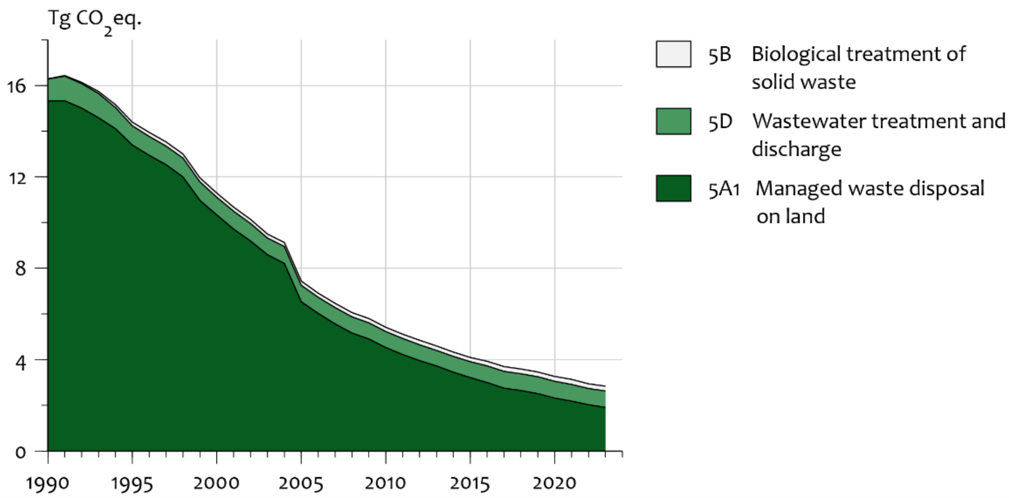


Figure 7.1 Sector 5 Waste – trend and emissions levels of source categories, 1990–2023

Decreased methane emissions from landfills since 1990 are the result of:
- increased recycling of waste;
- a considerable reduction in the amount of municipal solid waste (MSW) disposal at landfills;
- a decreasing organic waste fraction in the waste disposed;
- increased methane recovery from landfills (from 4% in 1990 to 14% in 2023).

As indicated above, emissions from waste incineration (5C) are included in category 1A1a Other fossil fuels (see section 3.2.4.1). Emissions from municipal waste incineration accounted for 0.6 Tg CO_2-eq in 1990 (601 Gg CO_2 and 0.07 Gg N_2O emissions). In 2023, these emissions accounted for approximately 2.6 Tg CO_2-eq (2,547 Gg CO_2 and 0.38 Gg N_2O).

7.2 Solid waste disposal on land (5A)

7.2.1 Category description

In 2023, there were nineteen operational landfill sites in the Netherlands. In the past, waste was landfilled on a few thousand sites; these older sites still contribute to the national emissions of methane. As a result of anaerobic degradation of organic material in the landfill body, all landfills produce CH_4 and CO_2. Landfill gas comprises about 50% (vol.) CH_4 and 50% (vol.) CO_2. Due to a light overpressure, landfill gas migrates into the atmosphere. CH_4 recovery currently occurs at 53 sites in the Netherlands. The gas is extracted before it is emitted into the atmosphere and is subsequently used as an energy source or flared off. In either case, the CH_4 in the extracted gas is not released into the atmosphere. The CH_4 may be degraded (oxidised) to some extent by bacteria when it passes through the landfill cover; this results in lower CH_4 emissions.

The anaerobic degradation of organic matter in landfills can take many decades. Not all factors influencing this process are known. Each landfill site has unique characteristics including concentration and type of organic matter, moisture, and temperature, among others. The chief factors determining the decrease in net CH_4 emissions are lower quantities of organic carbon deposited in landfills (organic carbon content multiplied by the total amount of landfilled waste) and higher methane recovery rates from landfills (see sections 7.2.2 and 7.2.3).

In 2023, solid waste disposal on land accounted for 67.4% of total emissions from the Waste sector and 1.3% of total national CO_2 equivalent emissions (see Table 7.1).

Dutch policies are directly aimed at reducing the amount of waste sent to landfill sites. As a result, many older and smaller sites were closed in the 1990s. This required enhanced prevention of waste production and increased recycling of waste, followed by incineration. In the early 1990s, the government introduced bans on the landfilling of certain categories of waste; for example, the organic fraction of household waste. Another means of reducing landfilling was raising landfill taxes in line with the higher costs of incinerating waste.[18] As a result of this policy, the amount of waste sent to landfills decreased from 14 million tons in 1990 to 2.2 million tons in 2023, thereby reducing emissions from this source category.

7.2.2 *Methodological issues*

A more detailed description of the method and EFs used can be found in section 2.3.2.2 of Honig et al. (2025).
Data on the amount of waste disposed at landfill sites is mainly derived from the annual survey performed by the Working Group on Waste Registration (WAR) at all landfill sites in the Netherlands. This data is documented in Ministerie Infrastructuur en Waterstaat (2025) , which also presents the annual amount of CH_4 recovered from landfill sites.

In order to calculate CH_4 emissions from all landfill sites, it is assumed for modelling purposes that all waste is disposed at one landfill site. As stated above, however, characteristics of individual sites can vary substantially. CH_4 emissions from this 'national landfill' were then calculated using a first-order decomposition model (first-order decay function) with an annual input of the total amounts deposited, the characteristics of the landfilled waste, and the amount of landfill gas extracted. This is equivalent to the IPCC Tier 2 methodology. Since landfills are a key category of CH_4 emissions, the present methodology is in line with the 2006 IPCC Guidelines (IPCC, 2006).

The parameters used in the landfill emissions model are as follows:
- Total amount of landfilled waste;

[18] In extreme circumstances, e.g. an increase in demand for incineration capacity due to unprecedented supply, the regional government can grant an exemption from these 'obligations'.

- fraction of degradable organic carbon (DOC) (see Table 7.2 for a detailed time series);
- CH_4 generation (decomposition) rate constant (k-value): 0.094 up to and including 1989, decreasing to 0.0693 in 1995, further decreasing to 0.05 in 2005 (IPCC default value), and remaining constant thereafter; this corresponds to a half-life of 14.0 years;
- CH_4 oxidation factor for managed landfills (IPCC default value): 10%;
- fraction of DOC actually dissimilated (DOCF): 0.58 until 2004 (see Oonk et al., 1994), annually determined from 2005 onwards on the basis of the composition of waste disposed. This is in linewith the 2019 IPCC refinements;
- methane correction factor (MCF): 1.0 (IPCC default value);
- fraction of methane in landfill gas produced: 57.4% for the years up to 2004 (see Oonk, 2016), decreasing by 50% in 2005 (IPCC default value), and remaining constant thereafter;
- amount of recovered landfill gas, published in the annual report titled 'Waste processing in the Netherlands' Ministerie Infrastructuur en Waterstaat, 2025);
- time delay from deposit of waste to start production of methane gas: set at 6 months (IPCC default value). On average, waste landfilled in year x starts to contribute to methane emissions in year x+1.

A selection of these parameters are discussed in the following sub-sections.

Amount of waste landfilled
Table 7.2 provides an overview of landfilled waste, its degradable organic carbon content (DOC) and the fraction of the degradable organic content that actually dissimilates.

Table 7.2 Amounts of waste landfilled, degradable organic carbon content and degradable organic carbon that dissimilates

Year	Amount landfilled (Mton)	Degradable organic carbon (kg/ton)	Degradable organic carbon that dissimilates (%)
1945	0.1	132	58
1950	1.2	132	58
1955	2.3	132	58
1960	3.5	132	58
1965	4.7	132	58
1970	5.9	132	58
1975	8.3	132	58
1980	10.6	132	58
1985	16.3	132	58
1990	13.9	131	58
1995	8.2	125	58
2000	4.8	110	58
2005	3.5	62	41

Year	Amount landfilled (Mton)	Degradable organic carbon (kg/ton)	Degradable organic carbon that dissimilates (%)
2010	2.1	33	34
2011	1.9	31	37
2012	3.3	32	29
2013	2.7	33	34
2014	2.2	34	35
2015	2.3	43	40
2016	2.8	52	40
2017	2.9	56	39
2018	3.2	51	38
2019	2.8	49	34
2020	2.4	43	32
2021	2.1	38	31
2022	2.1	37	31
2023	2.2	37	30

Between 1945 and 1970, a number of municipalities kept detailed records of their waste collection. In addition, information was available about which municipalities had their waste incinerated or composted. All other municipal waste was landfilled.

This information, in combination with data on landfilling from various sources (SVA, 1973; Statistics Netherlands, 1988, 1989; Nagelhout, 1989) and data on the years 1950, 1955, 1960, 1965 and 1970 determined and published by Van Amstel et al. (1993), was used to compile the dataset, with the assumption that during the Second World War hardly any waste was landfilled. These data are also used in the first order decay model, while missing years (1945–1950, 1951–1954, 1956–1959, 1961–1964 and 1966–1969) have been interpolated linearly (Spakman et al., 2003).

Accurate data on production and waste treatment are available from 1970 onwards (Spakman et al., 2003). Landfill site operators systematically monitor the amount of waste dumped (weight and composition) at each waste site. Since 1993, monitoring has occurred by weighing the amount of waste dumped and by regulating dumping via compulsory environmental permits.

Data on the amounts of waste dumped since 1991 is supplied by the WAR (Rijkswaterstaat) and included in the annual report 'Waste processing in the Netherlands'. Information on how this data is gathered and the scope of the information used can be found in these reports, available from the WAR since 1991 (Ministry of Infrastructure & Water Management, 2025).

Since 2005, landfill operators have been obliged to register their waste according to European Waste List (EWL) codes. Landfill operators also use EWL codes for the annual survey by the WAR so the WAR has a complete overview of the landfilled waste for every EWL code.

Fraction of degradable organic carbon
The amount of degradable organic carbon (DOC) for the 1945–1990 period was determined at 132 kg/ton (Spakman et. al., 2003). In the 1991–1997 period, the fraction of degradable organic carbon (DOCf) value slowly declined due to the start of separate organic waste collection from households in 1992 and the introduction of landfill bans for municipal waste in 1995.

Rijkswaterstaat gathers information on the amounts and composition of a large number of waste flows as part of its work to draw up its annual 'Netherlands Waste in Figures' report (Ministerie Infrastructuur en Waterstaat, 2025). The results of several other research projects also helped to determine the composition of the waste dumped. This method was used until 2004. In the 2000–2004 period, effects of the policy of reducing the amount of DOC being landfilled (especially in waste from households) resulted in a decrease in the DOC value from 110 kg/ton in 2000 to 74 kg/ton in 2004.

From 2005 onwards, all landfilled waste has been included in the figures. This includes waste streams with a low DOC content (contaminated soil, dredging spoils) or no DOC at all (inert waste). This results in a low average DOC value of a ton of landfilled waste compared with the IPCC default values.

An amount of degradable carbon is determined for each EWL code (Cuperus et al., 2011), and DOC values are allotted to ten different groups of waste streams. Each type of waste (corresponding to an EWL code) that is allowed to be landfilled (liquid waste may not be landfilled, for example) is allocated to one of the groups. Each group has an individual DOC content. As an illustration, Table 7.3 presents the waste stream groups, their DOC values and the amounts landfilled in 2023. Table 7.4 presents the amounts landfilled per waste stream group in the period 2005-2023.

Table 7.3 Amount of waste landfilled in 2023 and DOC value of each group

Waste stream group	Amount landfilled (Mg)	DOC value (kg/Mg)	Total DOC landfilled (Mg)
Waste from households	22,625	182	4,118
Bulky household waste	0	NO	0
Commercial waste	0	NO	0
Cleansing waste	3,288	43.4	143
Waste that contains high level of DOC	43,498	112	4,872
Stabilised organic waste	174,285	130	22,657
Waste that contains low level of DOC	1,100,648	44	48,429
Contaminated soil	227,404	11.5	2,615
Dredging spoils	24,348	42.4	1,032

Waste stream group	Amount landfilled (Mg)	DOC value (kg/Mg)	Total DOC landfilled (Mg)
Inert waste	650,043	0	0
Wood waste	118	430	51
Total	**2,246,257**		**83,916**

Table 7.4 Amount of waste 2005-2023 by waste stream group (Gg)

Waste stream group	2005	2010	2015	2020	2021	2022	2023
Waste from households	347	22	153	34	20	20	23
Bulky household waste	22	0	0	0	0	0	0
Cleansing waste	62	6	5	7	2	7	3
Waste that contains high content of DOC	97	26	80	61	54	48	43
Stabilised organic waste	555	159	167	351	265	233	174
Waste that contains low content of DOC	965	604	738	913	769	766	1,101
Contaminated soil	735	633	218	205	215	252	227
Dredging spoils	232	194	140	23	19	29	24
Inert Waste	486	481	841	815	800	738	650
Wood waste	7	0	0	1	2	2	0
Total	**3,509**	**2,126**	**2,342**	**2,409**	**2,145**	**2,094**	**2,246**

The DOC values were determined from the composition of mixed household waste (Cuperus et al., (2011): Table B3.2), the composition of other waste streams (Cuperus et al., (2011): Annex 3) and expert judgement. The average DOC value of a ton of waste landfilled is calculated by dividing the total DOC landfilled by the amount landfilled.

Degradable organic carbon that decomposes (DOCf)

The fraction of degradable organic carbon that decomposes (DOCf) is an estimate of the amount of carbon ultimately released from solid waste disposal sites (SWDS) and reflects the fact that some degradable organic carbon does not decompose or degrades very slowly under anaerobic conditions in the SWDS.

Before 2005, a country-specific value of 0.58 was used (Oonk et al., 1994). An attempt in 2011 to validate the country-specific parameters (DOCf and k-value) for the model was unsuccessful (Cuperus et al., 2011). The method to determine the DOCf factor was refined in the 2019 IPCC refinements. Research shows that various components of biodegradable waste dissimilate differently within a landfill under anaerobic conditions. For example, organic kitchen and garden waste and sewage sludge are dissimilated by 70%, while wood only does so by 10%.

From 2005 onwards, the DOCf factor has been calculated annually (see Table 7.2). By multiplying the composition of the waste by the dissimilation factor per component, the DOCf factor can be calculated. In this calculation only biodegradable components are taken into account. Non-biodegradable components are excluded, while the amount of biodegradable organic carbon already corrects this. Table 7.5 presents the calculated DOCf factor per waste stream.

Table 7.5 Calculated DOCf factor by waste stream group

Waste stream group	DOCf value per waste stream group
Waste from households	0.58
Bulky household waste	0.40
Cleansing waste	0.50
Waste that contains high level of DOC	0.70
Stabilised organic waste	0.30
Waste that contains low level of DOC	0.21
Contaminated soil	0.50
Dredging spoils	0.50
Inert Waste	0.50
Wood waste	0.10

k-value

The k-value is a rate constant related to the half-life value for waste to decay to half its initial mass. The assumption is that the majority of degradable waste landfilled in the Netherlands consists of paper, wood, and textiles (slowly degrading) and not of sewage sludge or food waste (rapid degrading). Paper, wood and textiles can, for example, be found in construction and demolition waste and in waste from shredding vehicles and electronic equipment.

The IPCC default value lies between 0.03 and 0.06 for slowly degrading waste (wood, paper, textiles) in a wet and temperate climate zone.
In the 1989-2004 period, a country-specific value for k (0.094) was determined by means of a validation of a landfill gas model (Oonk, 1994). Due to changing waste composition as a result of waste policies in the early 1990s, the value was changed to 0.0693 for the years 1990-2004. A new attempt to validate the landfill gas model to derive improved parameters (Cuperus et al., 2011) was unsuccessful. Therefore, a default value of 0.05 for the k-value has been used in the Dutch model from 2005 onwards. The value of 0.05 is in the range for slowly degrading waste in a wet and temperate climate zone (table 3.3 in IPCC 2006, chapter solid waste disposal).

Degradable waste is not landfilled in large quantities in the Netherlands. There is still a quantity of landfilled mixed municipal waste (EWL code 200301). In theory, this code applies to several waste streams, e.g. waste from households and commercial waste. In fact, in recent years, only commercial waste has been landfilled, because waste from households is incinerated.

If residues from waste treatment have to be landfilled, in most cases, this is because they are not combustible or recyclable. In some cases, waste incinerator operators argue that the caloric value is too high as well, mainly due to a high content of plastics in the residues. Residues do not generally contain rapidly degrading waste such as food waste or sewage sludge.

Other waste streams landfilled in large quantities, such as contaminated soil (EWL code 170504) and sludges from physicochemical treatment (EWL code 190206: in fact, mainly residues from soil remediation), have a low DOC value. It is reasonable to assume that these residues only contain slowly degrading waste, because the organic content is stabilised.

Methane correction factor (MCF)
All sites in operation after World War II can be regarded as being managed in conformity with the IPCC Guidelines, according to which they must have controlled waste placement (i.e. waste is directed to specific deposition areas and there is a degree of control over scavenging and the outbreak of fire) and feature at least one of the following: (i) cover material; (ii) mechanical compacting; or (iii) levelling.

Many landfill sites are situated near urban areas. In order to prevent odour and scavenging animals (birds, rats), the management of landfill sites has been closely monitored since the start of the 20th century. A major study conducted in 2005 (NAVOS, 2005) investigated about 4,000 old landfill sites and concluded that:

- From 1930, a method of placing the waste in defined layers and covering it with ashes, soil, sand or dirt from street sweeping became common practice.
- In the early 1970s, the waste sector introduced a 'code of practice' in which a method of environmentally friendly landfilling was described.
- During the 1970s and early 1980s, national legislation introduced an obligation to landfill in a controlled manner. Some old permits for landfill sites (from the early 1970s) contained obligations to compact and cover the waste and to deposit waste in specific parts of the site covering a certain maximum size instead of using the whole area simultaneously. Several permits also paid attention to fire prevention.

On the basis of these findings, waste disposal sites can be generally considered as having been managed throughout the relevant period. Therefore the Netherlands uses the MCF of 1 in its model, following the default-value for managed landfills (table 3.1 in IPCC 2006, chapter solid waste disposal).

A few landfill sites are semi-aerobic. At three selected landfill sites, research is currently being conducted into how the site should be managed after it is closed. This is the responsibility of the regional authorities. A few parts of these landfills are semi-aerobic, but emissions from all waste landfilled at these sites are included in the emissions from anaerobic landfills.

Fraction of methane generated in landfill gas
Most models of CH_4 formation in landfills and emissions from landfills are based on landfills of municipal solid waste. This type of waste was landfilled in the Netherlands until the early 1990s, but Dutch waste policy has changed since then. The landfilling of waste with large amounts of biodegradables (such as household waste) was first discouraged and then banned. Food and garden waste are now collected separately and composted. Other types of household waste are mostly incinerated and or recycled. As a result, existing models have been extrapolated to deal with this changed waste composition.

Another explanation for a lower fraction of methane generated in landfill gas is the reduced methane content in the landfill gas being formed. Landfill gas is produced from a broad range of materials. Cellulose and hemicellulose, for example, produce gas with a theoretical methane concentration of about 50%. Proteins and fats, however, produce gas with a significantly higher methane concentration. When waste is landfilled, it is conceivable that the more readily degradable components decompose first, resulting in a methane concentration that gradually declines, e.g. from 57% to approximately 50%. Since less and less readily degradable material is landfilled in the Netherlands, it is possible that the observed decline is at least partially the result of a decline in CH_4 concentration in the gas formed (Oonk, 2011).

On the basis of measurements by Coops et al. (1995), the amount of methane in landfill gas was determined at 60%. In earlier research, the amount of CO_2 absorbed in seepage water was not included. Research by Oonk (2016), estimated that 2–10% of the CO_2 is removed by the leachate. In the calculations, 10% of the CO_2 is removed, resulting in a fraction of methane in landfill gas of 57.4% for the 1990–2004 period. From 2005 onwards, the IPCC default value of 50% methane has been used.

Recovered landfill gas
The amounts of recovered landfill gas are recorded annually by the WAR. The WAR also collects data on the distribution of recovered gas between landfill gas engines and flares by all operators of landfill sites. Emissions from gas engines are reported under CRT 1A4a.

At almost all landfill sites, the amount of recovered landfill gas is measured. Only the percentage of methane in older landfill sites is occasionally estimated. In 2023, the methane content and amount of recovered landfill gas at four landfill sites was estimated. Table 7.6 presents the amounts of recovered landfill gas, the average methane content, and the amount flared or used for energy purposes.

Table 7.6 Amount of landfill gas recovery

Parameter	1990	2000	2005	2015	2020	2021	2022	2023
Free emission of landfill gas (million m^3)	1,564	1,055	770	376	270	254	236	220
Free emission of methane (kton)	547	369	233	115	83	78	72	68
Recovered landfill gas (million m^3)	64	162	130	60	51	46	46	47
Amount used for energy purposes (million m^3)	48	119	98	43	23	20	22	24
Amount combusted in flares (million m^3)	16	43	32	17	28	27	23	22
Percentage of methane in recovered landfill gas (%)	57.4	57.4	53.2	49.6	46.1	45.6	45.5	40.4
Amount recovered methane (kton)	25	63	47	20	16	14	14	13
Amount recovered methane useful applied (kton)	19	46	35	15	7	6	7	7
Amount recovered methane flared (kton)	6	17	12	6	9	8	7	6

Use of country-specific values before 2005

Between 1990 and 2004, the Netherlands used a landfill gas model containing country-specific values. The country-specific values for DOCf and the k-value were derived from the study by Oonk et al. (1994). The k-value was later adjusted in a study by Spakman, (2003) due to the changes in the composition and degradability of the waste. In 2010, the Netherlands tried to validate the country-specific values by means of a study by Tauw. The conclusion of this study (Cuperus et al., 2011) was that it was not possible to validate the country-specific values. Therefore, the landfill model has used the IPCC default values for DOCf and the k-value from 2005 onwards. The assumption was made that the country-specific values were still applicable until 2004.

Changing parameters over time

Trend information on IPCC Tier 2 method parameters that change over time is provided in Table 7.7. The integration time for the emissions calculation is defined as the period from 1945 to the year for which the calculation is made.

Table 7.7 Parameters used in the IPCC Tier 2 method that change over time (additional information on solid waste handling)

Parameter	1990	2000	2005	2010	2015	2020	2022	2023
Fraction DOC in landfilled waste	0.13	0.11	0.06	0.03	0.04	0.04	0.04	0.04
CH_4 generation rate constant (k)	0.09	0.07	0.05	0.05	0.05	0.05	0.05	0.05
Number of SWDS recovering CH_4	45	55	50	53	54	52	53	52
Fraction CH_4 in landfill gas	0.57	0.57	0.5	0.5	0.5	0.5	0.5	0.5

7.2.3 *Uncertainty assessment and time-series consistency*

Uncertainty assessment

The uncertainty analysis in Annex 2 provides estimates of uncertainties by IPCC source category and gas that are based on error propagation. The uncertainty in CH_4 emissions from SWDS is estimated at approximately 24%. The uncertainty in the activity data and the EF is estimated to be 0.4% and 24%, respectively. For a more detailed analysis of these uncertainties, see Rijkswaterstaat, (2014).

Time-series consistency

The estimates for all years are calculated from the same model, which means that the methodology is consistent throughout the time series. The time series consistency of the activity data is very good, due to the continuity in the data provided.

7.2.4 *Category-specific QA/QC and verification*

The source categories are covered by the general QA/QC procedures discussed in Chapter 1, and the specific QA/QC described in the document on the QA/QC of outside agencies (Wanders, 2021).

In general, the QA/QC procedures within the Waste sector are:

- checking activity data against other sources within the monitoring of waste, for example the notifications of landfill operators at the 'Landelijk Meldpunt Afvalstoffen';
- checking trends in the resulting emissions.

Several explanations are given for differences between deposited amounts in the WAR and data at Eurostat:
1) For Eurostat, the start of the cycle is used and then how the waste is processed is estimated. In the WAR, landfill operators are asked to estimate how much waste is landfilled.
2) A number of waste materials dumped deep underground are included in the Eurostat data. In the WAR these quantities are missing.
3) Waste landfilled abroad (for example, highly leachable waste or residues from waste processing) are not included in the WAR but are included in the Eurostat data.

7.2.5 *Category-specific recalculations*

There are some updated figures with regard to the amount of extracted landfill gas and the amount of waste landfilled. These figures have a very small effect on the total emissions.

7.2.6 *Category-specific planned improvements*

No improvements have been planned.

7.3 Biological treatment of solid waste (5B)

7.3.1 *Category description*

This source category consists of CH_4 and N_2O emissions from:

- the composting and digesting of separately collected organic waste from households;
- organic waste from gardens and horticulture;
- emissions from manure from agriculture.

Emissions from the small-scale composting of garden waste and food waste by households are not estimated, as these are assumed to be negligible.

The amount of composted and digested organic waste increased from almost nothing in 1990 to 3.6 million tons in 2023. In 2023, this treatment accounted for 7.1% of the emissions in the Waste sector (see Table 7.1). The biological treatment of solid waste is a key source of CH_4 emissions.

7.3.2 *Methodological issues*

Detailed information on activity data and EFs can be found in section 2.3.2.3 in Honig et al. (2025).

The activity data for the amount of organic waste composted at industrial composting facilities derives mainly from the annual survey performed by the WAR at all industrial composting sites in the Netherlands (Ministerie Infrastructuur en Waterstaat, 2025). Amounts of organic waste treated by green waste composting plants were collected from the Landelijk Meldpunt Afvalstoffen, which registers waste numbers, as required by Dutch legislation. All amounts are based on a wet weight basis.

The amount of animal manure used in digesters is based on registered manure transports (data from the Netherlands Enterprise Agency; RVO). The emissions are calculated using the National Emissions Model Agriculture (NEMA) described in Chapter 5, and the methodology report for agricultural emissions (Van der Zee et al., 2025).

Table 7.8 Total amount of treated collected organic waste from households and green waste from gardens and companies (Tg)

Year	Organic waste from households		Green waste from gardens and enterprises	
	Composted	Digested	Composted	Digested
	(5B1a)	(5B2a)	(5B1b)	(5B2b)
1990	228	-	-	-
1995	1,409	44	2,057	-
2000	1,498	70	2,473	2
2005	1,326	41	2,770	14
2009	1,178	81	2,648	0
2010	1,066	154	2,424	13
2011	1,091	182	2,384	25
2012	1,009	292	2,417	30
2013	942	331	2,299	42
2014	911	445	2,086	59
2015	882	475	1,992	85
2016	966	465	2,321	78
2017	1,027	465	2,335	107
2018	1,044	448	2,376	94
2019	1,103	457	2,192	84
2020	1,237	461	2,180	73

Year	Organic waste from households		Green waste from gardens and enterprises	
	Composted	Digested	Composted	Digested
2021	1,280	419	2,246	68
2022	1,101	422	1,929	73
2023	1,207	400	1,928	70

In 2010, an independent study on the EFs was conducted (DHV, 2010). The EFs were compared with those in other, predominantly European, countries. The current EF is backed up by most of the data considered relevant, as discussed in the 2010 study by DHV. DHV used studies of measurements carried out at German, Dutch and Austrian composting plants (DHV, 2010).

The EF for green waste from gardens and enterprises composted in the open air is derived from a study by the Austrian Umweltbundesamt (Lampert et al., 2011).

7.3.3 *Uncertainty assessment and timeseries consistency*

Uncertainty assessment

Emissions from this source category are calculated using an average EF obtained from the literature. The uncertainty in annual CH_4 and N_2O emissions is estimated at 73% and 59%, respectively. The uncertainty is mainly determined by uncertainties in the EF (72% for CH_4 and 58% for N_2O); whereas the uncertainty in the activity data is about 10%. For a more detailed analysis of these uncertainties, see Rijkswaterstaat (2014).

Time-series consistency

Due to the continuity in the data provided, the time series consistency of the activity data is very good.

7.3.4 *Category-specific QA/QC and verification*

The source categories are covered by the general QA/QC procedures, discussed in Chapter 1, and the specific QA/QC described in the document for the QA/QC of outside agencies (Wanders, 2021).
In general, the QA/QC procedures within the Waste sector are:

- checking activity data against other sources within the monitoring of waste;
- checking trends in the resulting emissions;
- checking EFs against EFs in other European countries.

7.3.5 *Category-specific recalculations*

The amount of digested manure has been reanalysed for the years 2010-2022. More manure was found to have been digested between 2017 and 2022 than previously thought. This results in small increases of methane emissions manure digestion ranging from + 946 kg methane (+0.1%)(+26 tons CO_2-eq) in 2017 to +161ton methane (+10.1%)(+4502 tons CO_2-eq) in 2022.

7.3.6 *Category-specific planned improvements*

No improvements have been planned.

7.4 Waste incineration (5C)

7.4.1 Category description

This category mainly comprises emissions from activities of the waste incineration facilities that process municipal solid waste and other waste streams.

In general, open burning of waste does not occur in the Netherlands, as it is prohibited by law. However, bonfires (wood burning) are occasionally allowed, and since 2020, they have been included in the inventory. Bonfires occur mainly at New Year's Eve and Easter. They are fuelled by biomass waste (wooden pallets, organic degradable waste, pruning woods). Due to regulations during the COVID-19 period, many bonfires were cancelled in 2020 and 2021. During the process of open burning, emissions of N_2O and CH_4 occur. This is a minor source.

Emissions from the source category Waste incineration, such as occur in Waste Incinerations plants (WIPs), are included in category 1A1 (Energy industries) as part of the source 1A1a (Public electricity and heat production). This is because all municipal waste incineration facilities in the Netherlands also produce electricity and/or heat for energy purposes. According to the 2006 IPCC Guidelines, these activities should be included in category 1A1a (Public electricity and heat production: Other fuels); see section 3.2.4.

This sector comprises no key categories.

7.4.2 Methodological issues

The number of bonfires in the Netherlands fluctuates per year, mainly depending on how strongly tradition is respected and the local weather at the time. Activity data is based on an inventory of large bonfires (including the actual size of these bonfires) as reported in the media, combined with an overview of smaller bonfires (with an average size). Either pruning wood and pallets are burnt in these bonfires. Emission factors are taken from the IPCC 2006 Guidelines (Volume 5, chapter 5 for pruning wood and Volume 2, chapter 2, table 2.5 for pallet wood) Detailed information on activity data and EFs (waste incineration in WIPs) can be found in section 38 of Visschedijk et al. (2025).

7.4.3 Uncertainty assessment and time-series consistency

Uncertainty Bonfires

Uncertainties in the bonfire-related emissions (both CH_4 and N_2O) are high: over 300%. This relates to uncertainties in activity data as well as in EFs.

Time-series consistency

Consistent methodologies have been used throughout the time series for this source category. Time series consistency of the activity data is considered to be very good, due to the continuity of the data provided by the WAR.

7.4.4 Category-specific QA/QC and verification

The data on the amounts of waste incinerated is also checked when performing the annual R1 test. Incineration plants must provide incinerated amounts and energy figures for the R1 test. The results of this test determine whether an incinerator is a recovery plant or a disposal plant.

The source categories are covered by the general QA/QC procedures, discussed in Chapter 1, and the specific QA/QC described in the document for the QA/QC of outside agencies (Wanders et al, 2021).

7.4.5 Category-specific recalculations

There have been no category-specific recalculations.

7.4.6 Category-specific planned improvements

EFs for household waste are planned to be updated; especially the carbon content, the biogenic part of carbon, the energy content and the biogenic part of the energy, and the biogenic part of the mass of several components of household waste.

7.5 Wastewater handling (5D)

7.5.1 Category description

This source category includes emissions from industrial wastewater, domestic (urban) wastewater, septic tanks and indirect emissions as a result of discharges. In 2023, only 0.35% of the Dutch population was not connected to a closed sewer system, and these households were obliged to treat wastewater in a small-scale on-site treatment system (a septic tank or a more advanced system).

Subcategory **5D1 Domestic wastewater handling**: In 2023, urban wastewater (the mixture of domestic, industrial and commercial wastewater, including urban run-off) was treated aerobically in 313 public wastewater treatment plants (WWTPs). During wastewater treatment, the biological breakdown of degradable organic compounds (DOC) and nitrogen compounds results in CH_4 and N_2O emissions. The treatment of the residual wastewater sludges is mainly accomplished by anaerobic digesters. Incidental venting of biogas also results in CH_4 emissions.
Following eventual on-site sludge digestion and dewatering processes, almost all sludges from domestic WWTPs are incinerated in mono-incinerators, or co-incinerated in either power plants or exported to cement factories in neighbouring countries. For a time series of final treatment of sludges from domestic WWTP, see Statline Urban wastewater treatment (2024). In this table, data on 2023 will be added by the end of March 2025.

Subcategory **5D2 Industrial wastewater handling** includes CH_4 emissions from the operational anaerobic industrial WWTPs (IWWTPs) (2023: 46 plants) as well as N_2O emissions from aerobic biological industrial WWTPs (2023: 147 plants).

Subcategory **5D3 Septic tanks and indirect emissions from discharges to surface water**:
The discharge of effluents, as well as other direct discharges from households and companies, result in indirect N_2O and CH_4 emissions from surface water due to the natural breakdown of residual nitrogen compounds and residual organic compounds. As 0.35% of the resident population is still connected to a septic tank, CH_4 emissions from septic

tanks are also calculated, but these are very small compared with those from public WWTPs.

N_2O emissions from category 5D (see Tables 7.1 and 7.9) contributed about 7.7 % of total N_2O emissions in 2023 and 0.3% in total CO_2 equivalent emissions. In the 1990–2023 period, N_2O emissions from domestic wastewater treatment (5D1) increased by 14%. N_2O emissions from industrial wastewater treatment (5D2) increased by 19%. Indirect N_2O emissions from surface waters (5D3) decreased by 69%. Overall, the N_2O emissions from category 5D decreased by 6% compared to 1990.

The contribution of 5D Wastewater handling to national total CH_4 emissions in 2023 was 1.2%, or 0.15% of total GHG emissions in CO_2 equivalents. Since 1994, CH_4 emissions from public WWTPs have decreased due to the 1990 introduction of a new sludge stabilisation system in one of the largest WWTPs. As the operation of the plant took a few years to optimise, venting emissions were higher in the introductory period (1991–1994) than under subsequent normal operating conditions. During the 1990–2023 period, CH_4 emissions from category 5D wastewater handling decreased by 49%. The amount of wastewater and sludge being treated has not changed much over time. Therefore, the annual changes in methane emissions can be explained by varying fractions of methane being vented incidentally instead of flared or used for energy purposes. It should be noted that emissions from the combustion of biogas at wastewater treatment facilities are allocated to category 1A4 (Fuel combustion – other sectors) because this combustion is partly used for heat or power generation at the treatment plants.

Table 7.9 presents the trend in GHG emissions from the various types of wastewater handling.

Table 7.9 Wastewater handling emissions of CH_4 and N_2O (Gg/year)

	1990	**2000**	**2010**	**2015**	**2020**	**2022**	**2023**
CH_4 domestic WWTP[1)]	5.84	4.36	4.69	4.45	4.78	4.50	4.39
CH_4 industrial WWTP	0.29	0.39	0.38	0.38	0.39	0.36	0.36
CH_4 septic tanks	3.93	1.99	0.68	0.63	0.52	0.441	0.41
Indirect CH_4 from effluents	4.99	3.14	2.46	2.22	2.32	2.22	2.47
Net CH_4 emissions	15.05	9.88	8.21	7.69	8.01	7.48	7.63
CH_4 recovered[2)] and/or flared	33.2	40.6	45.3	49.6	60.2	61.3	60.7
N_2O domestic WWTP	1.41	1.46	1.52	1.54	1.62	1.60	1.61
N_2O industrial WWTP	0.13	0.13	0.09	0.11	0.14	0.14	0.15
Indirect N_2O from effluents	0.501	0.302	0.174	0.168	0.167	0.156	0.156
Total N_2O emissions	2.04	1,89	1.79	1.82	1.92	1.90	1.92

1) Including emissions caused by venting of biogas at public WWTPs.
2) Includes use for energy purposes on site at public WWTPs only and/or flared as well as off-site use.

This sector comprises the following key category:

5D	Wastewater treatment and discharge	N_2O

7.5.2 *Methodological issues*

Activity data and EFs

Most of the activity data on domestic wastewater treatment is collected by Statistics Netherlands via annual questionnaires that cover all public WWTPs and is presented in StatLine (Statistics Netherlands, 2024); see also Statline for detailed statistics on wastewater treatment. Table 7.10 outlines the development in the main activity data with respect to domestic wastewater treatment.

Data on anaerobic and aerobic industrial WWTPs also stems from Statistics Netherlands (Statistics Netherlands, 2018) but that time series only covers the 1990-2016 period. For2017-2022 the data are reconstructed in this submission using information from a new AER reporting module, resulting in in actual timely data on the population of industrial WWTPs for the years 20162023. On the basis of these new results, the activity data on 2016-2022 were reconstructed.

Due to varying weather conditions, the volumes of treated domestic wastewater and of the total load of DOC and total nitrogen of domestic wastewater can fluctuate from year to year, depending on the amount of run-off rainwater that enters the sewerage systems. In the method developed for calculating methane emissions of domestic WWT, the DOC (or total organics in wastewater, TOW) is based on an organic load expressed in terms of chemical oxygen demand (COD). In the calculation of the COD of sewage sludge, the average content of 1.4 kg COD per kg organic dry solids is used (STOWA, 2014). Organic dry solids weights are determined by measurements of sewage sludge at all public WWTPs.

Nitrogen loads in the incoming wastewater of domestic WWTPs are determined by measurements at all WWTPs. This is already a longstanding standard procedure and covers the whole 1990-2023 time series. All this data has been collected by Statistics Netherlands.

It can be concluded from Table 7.10 that in the last years, the DOC of treated domestic wastewater and sludge produced has shown minor fluctuations over time. In 2023, methane emissions from domestic WWTPs decreased by 2%% compared to 2022. Interannual changes in CH_4 emissions can often be explained by varying fractions of CH_4 being vented instead of flared or used for energy purposes.

Emissions from the source category Septic tanks have steadily decreased since 1990. This can be explained by the increased number of households connected to the sewerage system in the Netherlands (and therefore no longer using septic tanks; see Table 7.10).

Total direct discharges of N have also decreased steadily, due to improved wastewater treatment and prevention measures.

Detailed information on activity data and EFs can be found in section 2.3.2.4 in Honig et al. (2025).

Table 7.10 Activity data on domestic and industrial wastewater handling and discharges to surface water

Domestic (urban) WWTPs:

	Unit	1990	2000	2010	2015	2020	2022	2023
Domestic (urban) WWTPs:								
Treated volume	Mm^3/yr	1,711	2,034	1,934	1,957	1,938	1,808	2,245
TOW as COD1) load	Gg/year	933	921	953	999	1,056	1,011	1,003
Nitrogen load	Gg/year	81.4	84.7	87.9	89.1	93.7	92.4	93.0
Sludge DOC as COD1)2)	Gg/year	365	431	476	505	533	524	529
Sludge dry solids to digesters	Gg/year	246	285	327	351	400	405	398
Biogas recovered 3)	mio m^3/yr	74	87.9	98.5	107	130	132	131
Biogas flared	mio m^3/yr	8.96	6.15	7.36	7.41	9.79	6.97	6.29
Biogas vented	1,000 m^3/yr	2,524	284	1,066	82.3	131	78.5	68.5
Actual PE load WWTP4)	1,000	23,798	23,854	24,745	25,686	27,031	26,146	26,036

Industrial WWTPs:

	Unit	1990	2000	2010	2015	2020	2022	2023
TOW as COD1) anaerobic WWTPs	Gg/year	144	194	192	190	194	181	181
Biogas recovered3)	Mio m^3/year					71.1 5)	68.6 5)	69.0 5)
Nitrogen load to aerobic WWTPs	Gg/year	7.42	7.26	5.46	6.61	8.06	8.02	8.78

Septic tanks:

	Unit	1990	2000	2010	2015	2020	2022	2023
Resident population 6)	1,000	14,952	15,926	16,615	16,940	17,442	17,701	17,877
inhabitants with septic tank	% of pop.	4	1.9	0.62	0.57	0.45	0.35	0.35

Discharges to surface water:

	Unit	1990	2000	2010	2015	2020	2022	2023
Nitrogen discharges7), total	Gg/yr	63.79	38.45	22.13	21.35	21.28	19.90	19.90
- Via effluents from UWWTP8)	Gg/yr	42.68	30.44	17.69	17.05	16.96	15.82	15.82
- Via industrial discharges9)	Gg/yr	12.71	4.51	2.36	2.29	2.02	1.97	1.97
- Via other direct discharges10)	Gg/yr	8.40	3.51	2.07	2.01	2.30	2.11	2.11
COD discharges, total	Gg/yr	178	112	87.8	79.2	83.5	79.1	88.3
- Via effluents from UWWTPs	Gg/yr	131	91.0	75.5	69.8	72.3	67.2	76.4

	Unit	1990	2000	2010	2015	2020	2022	2023
- Via industrial discharges	Gg/yr	46.8	21.1	12.3	9.48	11.2	11.9	11.9

1) Chemical oxygen demand.
2) Primary and secondary sludge produced, before eventual sludge digestion.
3) Sum of measured biogas, total for energy conversion, flaring, venting and external deliveries.
4) PE = Pollution Equivalents, representing the total load of biodegradable substances in the mixture of domestic and industrial wastewater treated in urban WWTPs (UWWTPs).
5) Total amount of biogas recovered; partly estimated.
6) Average population over a year.
7) Sum of domestic and industrial discharges of N in wastewater to surface water.
8) Including discharges from combined sewer overflows and storm water sewers.
9) All direct discharges of companies to surface waters.
10) Direct discharges of households, agricultural companies and traffic activities.

CH_4 emissions from domestic wastewater treatment (5D1)
In 2023, 99.7% of the population was connected to closed sewer systems, which were in turn connected to 313 public WWTPs. All public WWTPs in the Netherlands are of the advanced aerobic treatment type, with nutrient removal steps. In addition, sludge digestion is carried out in the larger plants. In these plants, sludges from smaller plants (in the vicinity) are digested also.

For the category 5D1 (Domestic wastewater treatment), CH_4 emissions from three types of processes are calculated:

1. Wastewater treatment process emissions: small amounts of methane can be formed during certain wastewater treatment process steps, and, for example, there can be small emissions from the influent cellars, anaerobic zones created for phosphorus removal, and anaerobic pockets in zones with poor aeration.
2. Anaerobic sludge digestion emissions: in addition to the methane recovered and used for energy processes, uncontrolled CH_4 emissions can arise from sludge digestion process equipment.
3. Emissions from incidental venting of biogas: the incidental venting of biogas produced in anaerobic sludge digesters is also a source of CH_4 emissions.

Detailed information on activity data and EFs can be found in sections 2.3.2.4.2 and 2.3.2.4.3 of Honig et al. (2025). The calculation of emissions from these processes is summarised below.

1. Wastewater treatment process emissions
Methane emissions from the wastewater treatment process are calculated using a Tier1 method with the default emission factor and country-specific activity data. The default emission factor for centralised aerobic treatment is 0.0075 kg CH_4/kg COD and is now based on the maximum CH_4 producing capacity (B_0) and methane correction factor (MCF) from the 2019 Refinement to the 2006 IPCC Guidelines (IPCC, 2019).

The country-specific activity data on the influent COD, as well as the amounts of sludge produced in all public WWTPs, are derived from the annual survey conducted by Statistics Netherlands among the Water Boards and are based on monitoring at the WWTPs following strict procedures. For the years from 1990 until present, data on influent COD is available for each treatment plant.

Data on the sludge produced annually is available for the years 1990 until 2016, for 2018, 2020, 2022 and 2023. Due to a re-evaluation of the statistical programme, this data has only been inventoried for even years from 2016-2022. For odd years (2017, 2019 and 2021), the data from the previous year is used as a best estimate; see also section 2.3.2.4.2 of Honig et al. (2025).

The COD of sludge is calculated using the conversion factor 1.4 kg COD per kg organic solids (STOWA, 2014). Organic solids are calculated as total dry solids minus the inorganic fraction. The total dry solids are measured at each public WWTP; the inorganic fraction is calculated on the basis of measurements of the ash content.

Table 7.10 gives the time series of the values of influent COD, and the COD of sludge produced.

2. Anaerobic sludge digestion emissions
Emissions of CH_4 from anaerobic sludge digestion are re-calculated for the whole time series using the default TIER 1 method from the 2019 Refinement (IPCC, 2019) and are based on an EF per kg dry solids of ingoing sludge of the digesters, being 0.002 kg CH_4/kg ingoing dry solids. The emissions are calculated per WWTP with sludge digestion facilities. In 2023, 65 urban WWTPs (UWWTPs) were equipped with sludge digesters. See also section 2.3.2.4.2 of Honig et al. (2025).

Default activity data on the ingoing dry solids amount at public WWTPs with sludge digesters is derived from the annual survey conducted by Statistics Netherlands among the Water Boards.

3. Emissions from incidental venting of biogas
Incidental venting of biogas at public WWTPs is recorded by the plant operators and reported to Statistics Netherlands. In 2023, the amount of CH_4 emitted by the venting of biogas was 0.0301 Gg CH_4, equalling 0.7% of total CH_4 emissions from the category Domestic wastewater. In the last decade, this value ranged between 0.3% and 9%, so the venting of biogas in 2023 was relatively low.

Recovered biogas is largely used for energy generation purposes, but a small amount is flared, vented, or delivered to third parties. Table 7.10 provides data on the recovery of CH_4 (total) and CH_4 combusted via flaring. See also section 2.3.2.4.3 of Honig et al. (2025).

CH_4 emissions from anaerobic industrial wastewater treatment (5D2)
For the period 1990-2016 the activity data for this subcategory stem from a yearly survey by Statistics Netherlands which stopped in 2017. In this submission the population and activity data of IWWTPs for the period 2016-2022 could be updated because the Annual Environmental Reporting system was extended with a module for IWWTPs. This resulted in small changes in methane emissions for the years 2016-2022 compared to the previous submission (see also 7.5.5).

From the newly available data it turned out that some anaerobic plants have to be added to the population of plants in years before 2016. But also, the activity data for these plants have to be estimated. This update of the years before 2016 will be done in the 2026 submission. When the whole time-series is reconstructed and accurate data on COD in influent wastewater is available or estimated, it will be also possible to switch to the methodology of the 2019 Refinement for this specific emission source.

In the calculation of methane emissions from anaerobic industrial wastewater treatment, the Netherlands thus still uses country-specific activity data for the TOW, as well as a country-specific fraction for losses of methane by leakage. Recovered biogas is generally used as fuel in energy processes. Emissions from biogas combustion are included in the Energy sector. A more detailed description of the method and the EF used can be found in section 2.3.2.4.5 in Honig et al. (2025).

In the Netherlands, no information is available on the actual load of COD treated in the IWWTPs. The TOW has thus to be determined in an alternative way. The TOW is estimated by using statistics on the design capacity of the IWWTPs and an assumed average loading rate of 80% of the design capacity (Oonk, 2004). The design capacity is expressed in terms of a standardised value for quantifying organic pollution in industrial wastewater: Pollution Equivalents (PE). One PE equals an amount of 40 kg COD per year. Data on the design capacity is available from Statistics Netherlands (2018). TOW (expressed as COD) is thus calculated as:
TOW = P.E. * 0.8 * 40
Where:
P.E. = total design capacity in Pollution Equivalents
0.8 = average loading rate (80%)
40 = kg COD per P.E. per year (factor to calculate from P.E. to COD).

Using the default maximum CH_4 producing capacity (B_o) of 0.25 kg CH_4/kg COD, a default Methane Conversion Factor of 0.8 and a methane loss (Mrind) of 1% from the digestion process, the Emission Factor is calculated as B_o * MCF * Mrind= 0.002 kg CH_4/kg COD. A further description of the method and the EF used can be found in section 2.3.2.4.5 in Honig et al. (2025). Table 7.10 provides the time series of total TOW for IWWTPs.

In 2023, 76% of the anaerobic capacity was installed in the food and beverage industry. Other sectors with anaerobic wastewater treatment are waste processing facilities (8%), the chemical industry (10%), and the paper and cardboard industry (5%).

Numerical estimate of the recovered CH_4 in anaerobic industrial wastewater treatment plants available for 2019-2023
In response to a 2016 review question, it was investigated whether the data on biogas production from industrial anaerobic wastewater treatment plants can be derived or estimated from information becoming available via the individual Annual Emission (e-PRTR) Reports. This could only be carried out for the period 2019-2023(see also Table 7.10).

The total amount of IWWTP biogas recovered in 2023 equalled 60.6 million m^3, but this only includes data from 32 out of the 46 anaerobic IWWTPs, equalling 88% of total TOW treated. For the remaining 14 plants, no data is available, but on the basis of the amount of TOW, this missing volume can be estimated at an additional 8.4 million m^3. Total recovery can then be estimated at 69.0 million m^3 biogas.

No specific information is available on the methane content of biogas from anaerobic industrial wastewater treatment plants. If the average value for biogas from domestic wastewater sludge digestion (0.44 kg CH_4/m^3 biogas, see Honig et al., 2024) is used, a total recovery of 30.4 Gg CH_4 can be calculated for 2023. Applying a loss by leakage of 1% of total CH_4 recovered (Honig et al., 2024), this results in an emission of

0.304 Gg CH_4. This figure can be compared with the current country-specific method, resulting in an emission of 0.362 Gg CH_4 (19% higher). Given the uncertain factors of both methods, this difference is acceptable.

The methane (CH_4) implied emission factor (IEF) is based on gross CH_4 emissions and is calculated as follows:
IEF = Gross CH_4 emission (= Net CH_4 emission + CH_4 recovered or flared) / total organic product.
For the years 1990-2018, there is no data on the CH_4 recovery, resulting in a relatively low IEF. But from 2019 onwards, availability of data on CH_4 recovery has caused a higher numerator in the calculation of the IEF and thus a higher IEF.

CH_4 emissions from septic tanks (5D3)
Emissions of methane from septic tanks are calculated using IPCC default values for B_o and MCF and the IPCC value of TOW of 60 g BOD (biological oxygen demand) per connected person per day (IPCC, 2006: Table 6.4). Detailed information on activity data and EFs can be found in section 2.3.2.4.4 of Honig et al. (2025).

Table 7.10 presents the time series of the percentage of the population connected to septic tanks. This percentage decreased from 4% in 1990 to 0.35% in 2023. This data derives from surveys, estimates and expert judgement by various organisations in the Netherlands, such as Rioned, (2009, 2016), WHO (2024) and the National Water Authorities.

Indirect CH_4 emissions from surface water as a result of discharge of domestic and industrial effluents (5D3, Wastewater effluents)
Indirect methane emissions from surface water as a result of discharge of domestic and industrial effluents are calculated using the Tier 1 default emission factor of 0.028 kg CH_4/kg COD discharged as provided in the 2019 Refinement of the IPCC 2006 Guidelines (IPCC, 2019).

The country-specific activity data on kg COD discharged per year via industrial and domestic effluents is derived from the wastewater statistics (see Statline) and from the Netherlands' PRTR database. These COD loads to surface water are based on frequent monitoring of all domestic WWTPs and of all industrial discharges. Detailed information on the method and activity data can be found in section 2.3.2.4.8 of Honig et al. (2025).

N_2O emissions from centralized wastewater treatment (5D1)
N_2O emissions from domestic wastewater handling are calculated with methodology provided by the 2019 Refinement (IPCC, 2019), but the Dutch Tier2 method uses a country-specific emission factor of 0.011 kg N_2O-N/kg N (De Haas & Andrews, 2022) and country-specific activity data on the total influent loads of nitrogen at all domestic WWTPs in the Netherlands. The activity data derives from the wastewater statistics (see Statline) and is based on frequent monitoring of the incoming wastewater at all domestic WWTPs. Detailed information on the method and activity data can be found in section 2.3.2.4.2 of Honig et al. (2025).
The influent data on total nitrogen includes the loads from households, from industrial and commercial activities as well as the loads from urban

run-off into the sewerage system. This means that the total incoming nitrogen load at domestic wastewater treatment plants does not have to be calculated on the basis of standard parameters and coefficients. In equation 6.10 from the 2019 Refinement document, the total nitrogen load in the influent can thus replace all the terms in the right part of the equation. Table 7.10 provides a time series of total nitrogen load of the influent. In 2023, total nitrogen in the influent equalled 93.0 million kg N.

As wastewater treated at public WWTPs is a mixture of household wastewater, (urban) run-off rainwater and wastewater from industries and services, the N_2O emissions are reported under category 5D1 (Domestic and commercial wastewater). Moreover, as the Netherlands does not make use of equation 6.10 to calculate total nitrogen loads, the standard parameters on population, protein consumption, fraction of nitrogen in protein, fraction of non consumed protein and fraction of industrial nitrogen are reported as 'NA' in the additional information table of CRTT Table 5.D.

N_2O emissions from aerobic industrial wastewater treatment (5D2)
For the calculation of N_2O emissions from aerobic industrial wastewater treatment, a Tier2 method is used on the basis of an adjusted emission factor of 0.011 kg N_2O-N/kg N (De Haas & Andrews, 2022) and country-specific activity data on the total influent loads of nitrogen at all industrial aerobic WWTPs in the Netherlands.

The activity data stems from a time series of aerobic industrial wastewater plants derived from statistics on industrial wastewater sludges (see Statline), as well as from data on total nitrogen discharged from the Dutch PRTR database. In this submission the population of aerobic IWWTPs was improved for the period 2016-2022 (see also paragraph 7.5.5).
For most of the IWWTPs an effluent load could be coupled. For the remaining installations, the effluent load was estimated on the basis of the size of the plant and derived estimators like total nitrogen discharged per population equivalent design capacity. Subsequently, influent nitrogen loads were estimated using the default removal rate of 0.40 for secondary treatment, as provided by Table 6.10.c in the IPCC 2019 Refinement document.
A more detailed description of the method, the EF used as well as the activity data can be found in section 2.3.2.4.6 of Honig et al. (2025).

Indirect N_2O emissions from surface water as a result of discharge of domestic and industrial effluents (5D3, Wastewater effluents)
For the calculation of indirect (or better: 'delayed') N_2O emissions from wastewater effluents, the Netherlands uses the default EF of 0.005 kg N_2O-N/kg N discharged (IPCC, 2019) and country-specific activity data on $N_{Effluent,DOM}$.

The country-specific activity data on kg N discharged per year via industrial, domestic and commercial effluents is derived from the wastewater statistics (see Statline) and from the Netherlands' PRTR database (regarding both sources: 2023 data is not yet published). For 2023 we used data on 2022 as best estimate.

Most of the effluent loads of total nitrogen are determined by frequent monitoring of treated wastewater flows or – in the case of discharges from sewer overflows – estimated with a model. The loads do not have to be estimated with standard factors. This means that equation 6.8 (updated) of the 2019 Refinement document, is not used.
As the Netherlands does not make use of the right part of equation 6.8 and related equation 6.10, information on population, protein consumption, fraction of nitrogen in protein, fraction of non-consumed protein and fraction of industrial nitrogen values are reported as 'NA' in the additional information table of CRT Table 5.D.

Detailed information on the method used can be found in section 2.3.2.4.7 in Honig et al. (2025). Table 7.10 provides a time series of the activity data: total N discharges.

Emissions not calculated within category 5D
Within category 5D the following emissions are not estimated (NE) or not occurring (NO):

Direct N_2O emissions from septic tanks (5D3: NO)
Direct emissions of N_2O from septic tanks are not calculated since they are unlikely to occur, given the anaerobic circumstances in these tanks. Indirect N_2O emissions from septic tank effluents are included in CRTT category 5D3 (Indirect N_2O emissions from surface water as a result of discharge of domestic and industrial effluents).

CH_4 emissions from industrial sludge treatment (5D2: NE)
From a recent survey among IWWTPs conducted by Statistics Netherlands in 2016, it can be concluded that anaerobic sludge digestion within industries is applied at only 2 industrial WWTP. This data has not been published on www.cbs.statline.nl for reasons of confidentiality.
Via a rough estimate, it was calculated that the methane emissions from this source amounts to approximately 6.2 tons of CH_4 per year, equalling 0.00085% of national methane emissions in 2016. Forthcoming CH_4 emissions are therefore reported as NE for 1990-2023.

7.5.3 *Uncertainty assessment and time-series consistency*

Uncertainty assessment
The uncertainty analysis in Annex 2 provides estimates of uncertainties by IPCC source category and gas that are based on error propagation. The uncertainty in annual N_2O and CH_4 emissions from wastewater handling is estimated to be 29% and 41%, respectively.

The uncertainty in activity data for domestic WWT is based on expert judgement (Ramirez, 2006) and is estimated to be 25%. The annual loads of $DOC_{influent}$, DOC_{sludge} $N_{influent}$ and $N_{effluent}$ are calculated on the basis of wastewater and sludge sampling and analysis, as well as flow measurements at all the WWTPs; all these measurements can involve uncertainty.
For industrial WWT the uncertainty in activity data is based on IPCC (2019) and is estimated to be 30%.

The uncertainty in the EFs for CH_4 differs per type of emission source and is estimated to be between 32% and 300% IPCC (2019). For N_2O, the uncertainty also varies per emission source and is estimated to be between 15% and 100% (IPCC, 2019; De Haas & Andrews, 2022).

An international study (GWRC, 2011), in which the Dutch public wastewater sector participated, showed that N_2O EFs, in particular, are highly variable between WWTPs as well as at the same WWTP during different seasons or even at different times of day. Moreover, the same study concluded that the use of a generic EF (such as the IPCC default) to estimate N_2O emissions from an individual WWTP is inadequate.
Currently, the Dutch wastewater sector is conducting an extensive monitoring program at Dutch Urban Wastewater Treatment Plants. One of the goals is to gain insight in the factors that influence N_2O emissions. Of course monitoring results will also be used to develop country specific emission factors. Results will be expected in 2-3 years time.

Time-series consistency

The same methodology has been used to estimate emissions annually, providing good time series consistency. The time series consistency of the activity data is very good, due to the continuity in the data provided by Statistics Netherlands.

7.5.4 *Category-specific QA/QC and verification*

The source categories are covered by the general QA/QC procedures, as discussed in Chapter 1. Statistical data is covered by the specific QA/QC procedures of Statistics Netherlands (CBS).

The Dutch wastewater sector will continue research into more precisely determining the factors and circumstances that result in the formation of CH_4 and N_2O in public WWTPs.

7.5.5 *Category-specific recalculations*

There were a number of small recalculations due to final or revised activity data. Basic methods did not change for category 5D. Table 7.11 provides an overview of the differences compared to the previous submission.

Methane emissions from the domestic wastewater treatment process (5D1) have been recalculated for 2022 due to final activity data on the COD influent minus the COD in the sludge produced. Compared to the previous submission the CH_4 emission decreased with 0.16 Gg (-3.5%).
Due to final data on the inhabitants connected to septic tanks (5D3) for 2022, the CH_4 emission from septic tanks decreased by –0.000072 Gg CH_4 (-0.02%) compared to the previous submission.

In 2021 and 2022, the indirect CH_4 emissions from surface water as a result of the discharge of domestic and industrial effluents (5D3. Wastewater effluents) increased by respectively 0.015 Gg (+0.6%) and 0.037 Gg (+1.7%) compared to the previous submission. This change is also caused by replacing provisional by final activity data.

In 2022, the indirect N_2O emissions from surface water as a result of the discharge of domestic and industrial effluents (5D3) increased by 0.00028 Gg N_2O (+0.18%) compared to the previous submission.

A new data-source for Industrial wastewater treatment (the AER module; see 7.5.2 category 5D2) resulted in an adjustment of the population of anaerobic and aerobic biological industrial wastewater treatment plants and related activity data for CH_4 as well as N_2O emissions, for the years 2016-2022. See table 7.11.

Table 7.11 Differences as a result of recalculations in sector 5D wastewater handling, compared to previous submission

	Unit	2016	2017	2018	2019	2020	2021	2022
5D1 CH_4 from domestic WWTP	Gg	-	-	-	-	-	-	-0.159
5D2 CH_4 from anaerobic IWWTP	Gg	0008	-0.006	-0.006	-0.023	-0.023	-0.056	-0.046
5D3 CH_4 from septic tanks	Gg	-	-	-	-	-	-	0.0001
5D3 indirect CH_4 from surface water	Gg	-	-	-	-	-	0.015	0.037
Total difference CH_4	**Gg**	**0.008**	**-0.006**	**-0.006**	**-0.023**	**-0.023**	**-0.041**	**-0.168**
	%	**0.1%**	**-0.1%**	**-0.1%**	**-0.3%**	**-0.3%**	**-0.5%**	**-2.2%**
5D2 N_2O from aerobic IWWTP	Gg	0.026	0.029	0.023	0.026	0.026	0.024	0.022
5D3 indirect N_2O from surface water	Gg	-	-	-	-	-	-	00003
Total difference N_2O	**Gg**	**0.026**	**0.029**	**0.023**	**0.026**	**0.026**	**0.024**	**0.022**
	%	**1.4%**	**1.5%**	**1.2%**	**14%**	**1.4%**	**1.2%**	**1.2%**

Overall effect of all recalculations is that CH_4 emissions from category 5D increased with 0.1% in 2016 and decreased with 2.2% in 2022. Total N_2O emissions of category 5D increased in 2016 with 1.4% and in 2022 with 1.2%.

7.5.6 *Category-specific planned improvements*

Regarding indirect emissions of CH_4 from surface waters as a result of discharge of wastewaters: In the previous submission it was mentioned that the aim was to make a distinction between types of receiving surface water (stagnant waters versus rivers) for the whole timeseries. Especially for the first 2 decades, the basic information is incomplete. It will require a lot of time to compile for the whole time series the nature of all receiving waters. This has to be done per company, per discharge point. This is not feasible, so this improvement will not be established.

In this submission the population and activity data of IWWTPs for the period 2016-2022 could be updated because the Annual Environmental Reporting system was extended with a module for IWWTPs.
From the newly available data it turned out that some plants have to be added to the population of plants in years before 2016. But also, the activity data for these plants have to be updated.

So, for CH_4 emissions from industrial anaerobic wastewater treatment and N_2O from aerobic IWWTP's, the time series of IWWT's and related activity data may undergo very slight adjustments for the period 2000-2015 in the next submission, in addition to the improvement of the population of IWWTP's for the period 2016-2022 (this submission).

After the time-series of the anaerobic plants is adjusted also for the older years (2000-2015), the next step will be the introduction of the methodology of the 2019 refinement for CH_4 emissions from anaerobic IWWTPs. This is expected to be established in the next (NIR 2026) submission.

8 Other (CRF sector 6)

The Netherlands allocates all GHG emissions to sectors 1 to 5. Therefore, no sources of GHG emissions are included in sector 6.

9 Indirect carbon dioxide and nitrous oxide emissions

9.1 Description of sources of indirect emissions in the GHG inventory

Methane, carbon monoxide (CO), and NMVOC emissions are oxidised to CO_2 in the atmosphere. This chapter describes indirect CO_2 emissions as a result of this atmospheric oxidation.

As the Netherlands already assumes 100% oxidation during the combustion of fuels, only process emissions of NMVOC (mainly from product use) are used to calculate indirect CO_2 emissions. These process emissions originate from the use and/or evaporation of NMVOC in the following sectors:

1. Energy (energy, transport, and refineries);
2. IPPU (consumers, Commercial and governmental institutions, industry, and construction and building industries);
3. Agriculture (manure storage, manure application, silage storage, cultivating crops);
   Indirect CO_2 emissions from agriculture originate from NMVOC in pesticides. These emissions are accounted for in the CRT under 'other product use' (2. IPPU).
4. Waste (managed waste disposal sites, open burning of waste, domestic waste water).

Indirect CO_2 emissions decreased from 0.92 Tg in 1990 to 0.43 Tg in 2023, mainly as a result of the Dutch policy to reduce NMVOC emissions.

The source category 6 Indirect emissions (CO_2) is a key category.

Table 9.1 Overview of Indirect CO_2 emissions in the base year and the last two years of the inventory (in Tg CO_2 eq.). The middle column shows the change (%) of the last year of the inventory compared to the base year. On the right side of the table, the contribution of the last year inventory's emissions of the category to the sector, to the total national emissions of the specific gas and to the total national emissions (in CO_2 eq) are provided.

Sector/category	**Gas**	**1990**	**2022**	**2023**	**2023 vs 2022**	**Contribution of the category in 2023 (%) to the**		
		Emissions in Tg CO_2 eq			**%**	**sector**	**total gas**	**total CO_2 eq**
Indirect CO_2 emissions	CO_2	0.92	0.46	0.43	-5.4	0.3%	0.4%	0.3%

The Netherlands does not report indirect emissions of N_2O from sources other than agriculture and LULUCF.

9.2 Methodological issues

Indirect CO_2 emissions are calculated as follows:
*CO_2 (in Gg) = NMVOC emission (in Gg) * C * 44/12*

Where:
C = default IPCC carbon content (C) of 0.6

NMVOC emissions data per sector is obtained from the Dutch PRTR.

9.3 Uncertainty assessment and time series consistency

On the basis of expert judgement, the uncertainty in NMVOC emissions is estimated at c. 25% and the uncertainty in carbon content at 10%, resulting in an uncertainty in CO_2 emissions of approximately 27%. Consistent methodologies and activity data have been used to estimate indirect CO_2 emissions.

9.4 Category-specific QA/QC and verification

The source categories are covered by the general QA/QC procedures discussed in Chapter 1.

9.5 Category-specific recalculations

There have been no category-specific recalculations.

9.6 Category-specific planned improvements

No improvements have been planned.

10 Recalculations and improvements

Major recalculations and improvements compared to the National Inventory Report 2024

For the NIR 2025, the most recent data (2023) has been added to the inventory and corresponding CRT's using the new Enhanced Transparency Framework (ETF) tooling.

As a result of recommendations of the (yearly) submission from the internal and external reviews (UNFCCC and EU), improvements have been made to both the inventory and the NIR.

Recalculations have been performed as a result of changes of method and/or on the basis of new, improved activity data and/or improved EFs. Furthermore, error corrections of the data in the previous submission have been performed, resulting in changes in emissions over the entire 1990–2023 period.

For details of the effects of and justification for the recalculations, see Chapters 3–7.

10.1 Explanation of and justification for recalculations, including in response to the review process

For the NIR 2025, the Netherlands used the ETF GHG Inventory reporting tool (February 2025) v0.1.

Previous ERT reviews of the UNFCCC and the EU review reports suggested there was still room for improvement in the Dutch GHG inventory. Where possible (and deemed necessary), the review recommendations have been incorporated in this NID and CRT, and accordingly, in the methodology reports.

The UNFCCC review issues (mainly of the most recent one in October 2022) are listed in Annex 10, including the actions undertaken to resolve them.

Besides these externally induced improvements, additional improvements have been made as a result of our own QA/QC program:

- methodological changes and data improvements;
- changes in source allocation;
- error corrections.

Methodological changes and data improvements

The improvements to QA/QC activities in the Netherlands implemented in recent years (process of assessing and documenting methodological changes) are still in place. This process includes a brief checklist for timely discussion on proposed changes for the 2025 inventory with relevant experts and information users (among others, policy makers). This process improves the peer review and timely documentation of the

background to and justifications for changes made in the current inventory.
The most significant recalculations in this submission (compared to the NIR 2024) are:

- *Energy sector:*
  - As in every year, the inventory follows all changes/improvement in the national energy statistics affecting the emissions of CO_2, CH_4 and N_2O. Major changes in energy consumption and allocation were implemented for the years 2015 -2022. These changes also induced changes in plant-specific EFs. The changes in national energy statistics also impact CO_2 emissions in 2.B.10.b.
  - The CO_2, CH_4 and N_2O emissions from transport and non-road mobile machinery (NRMM) changed (categories 1.A.2 to 1.A.4) over the total time series due to two improvements:
  - LPG sales data were improved over the entire time series, for both non-road mobile machinery (NRMM) and road traffic. The LPG sales data has improved over the entire time series. Previously, it was incorrectly assumed that the category LPG for road traffic included also non-road mobile machinery (NRMM) and the data was therefore erroneously subtracted from the LPG sales to road traffic. LPG for NRMM is included separately in the energy statistics. Consequently, the amount of LPG for road traffic increases, as it is not corrected for NRMM anymore.
  - The emission factors CH_4 and N_2O for road traffic were updated. Until last submission, the emission factors had not been adjusted to the bottom-up data (IEFs) in recent years. The emission calculations for 1.B.2.b.v Gas distribution are improved as a result of monitoring and improvement actions for the Oil and Gas Methane Partnership (OGMP). Investigations lead to additional emission estimates for specific processes, causing an increase of the CH_4 emissions for the full time series.

The above recalculations and error correction changed the total CO_2-eq emissions in the Energy sector by +0.23% in 1990 to +0.3% in 2022 compared to previous submission.

- *IPPU sector:*
  - A factor 1000 error in CO_2 emissions in 2A3 for 2022 was corrected, leading to an increase in CO_2 emissions.
  - Improved activity data for 2022 led to a recalculation and an increase in CO_2 and CH_4 emissions from paraffin wax use in 2.D.2.
  - N_2O emissions in 2.G.3.a N_2O use for medical applications were updated for 2020-2022. Before, emissions were kept constant due to the lack of updated activity data. Now updated activity data became available for 2022. For the years 2020-2021, emissions were obtained by interpolating 2019 and 2022.
  - A methodology change for HFC emissions in category 2F6, resulting in changes in emissions for 2015-2023.
  - Error corrections for the HFC emissions in 2F1, leading to a decrease in HFC emissions for 2020, 2021, and 2022.

The above recalculations changed the total CO_2-eq emissions in the IPPU sector by less than -0.004% in 1990 to –0.7% in 2022 compared to previous submission.

- *Agriculture sector:*
    - Update of transport certificates of manure and the amount of treated manure for the years 2010-2022. This affects N_2O and CH_4 emissions from manure management (3.B.), as well as NH_3 emissions and therefore also indirect N_2O emissions from manure in sector 3.B.5.
    - Methane emissions from poultry manure increased because of a recalculation, as the Biochemical Methane Potential has been corrected (3.B.4.).
    - Methane emissions from dairy cattle manure have increased as the volatile solids excretion has been updated for the years 2017-2020 (3.B.1).
    - The N_2O emissions related to crop residues have been recalculated for the years 2006-2022 (3.D.1.d). The area of grassland renewal has been updated.
    - The N_2O emissions related to losses/gains in soil organic matter content have been recalculated based on new insights from the LULUCF sector (3.D.1.e.).
    - Final usage rates of inorganic fertilisers, compost, liming and urea differ from the preliminary rates. This affects the N_2O emissions from Agricultural soils (3D), Liming (3G) and Urea application (3H).

The above recalculations changed the total CO_2-eq emissions in the Agriculture sector by +0.03 % in 1990 and by –0.15 % in 2022 compared to previous submission.

- *LULUCF sector:*
    - This year, three methodological changes have been implemented, resulting in modifications to the carbon stock changes and associated emissions and removals along the time series:
    - Update of the emission factor for drained organic soils for all land uses, to match new scientific insights. This leads to a strong decrease in emissions over the full time-series.
    - The area of drainage ditches on organic soils was updated for the land uses Cropland, Grassland, Trees outside Forest and Forest land, from Tier 1 to country specific Tier 2 data.
    - For all land uses, the soil carbon stocks for mineral soil were updated, based on a national soil monitoring campaign from 2018. The number of aggregated soil types has been decreased to reduce the uncertainty in soil organic carbon stocks.

The above recalculations changed the total CO_2-eq emissions in the LULUCF sector by –17.7% in 1990 and by –31.4 % in 2022 compared to previous submission.

- *Waste sector:*
    - The amount of methane from manure digestion (category 5B biological treatment of solid waste) has been recalculated for the years 2017 to2022. This led to a small increase of methane emissions.

- For category 5D wastewater handling, there were a number of small recalculations for both CH_4 and N_2O emissions due to final or revised activity data for the years 2016-2022. Basic methods did not change.

The above recalculations changed the total of CO_2-eq emissions in the Waste sector by 0.0% in 1990 and by 0.2% in 2022 compared to previous submission.

Additional to the above changes, small changes in emissions occur every year (compared to the previous submission) due to the availability of final statistics for activity data (for this submission, in 2022 and in some cases, earlier years).

Small changes in emissions may also result from the fact that we compared emissions with emissions in CRT 2024. The CRT 2024 contained rounding errors for some sectors w.r.t CRF 2024, due to first time use of the ETF-tooling. These rounding errors are solved again in CRT 2025, leading to similar rounding of values as in CRF 2024 again. However, as we compare CRT 2024 and CRT 2025, these rounding errors may show up here as small recalculations.
The total changes in GHG emissions per sector compared to the previous submission are presented in Table 10.1 (in Gg CO_2-eq) for the years 1990, 2000, 2010, 2020, and 2022. Positive values represent recalculations which increased the emissions compared to the 2024 submission and negative values represent decreased emissions in the 2025 submission.
Recalculations in the Energy, IPPU, LULUCF and Waste sectors dominate the changes in the National emissions compared to the 2024 submission.

The decrease in total GHG emissions for all years is below –0.9% GHG compared to the 2024 submission.

Table 10.1 Summary of recalculations for the 1990–2022 period (Gg CO_2-eq)

Gas(es)		1990	2000	2010	2020	2022
CO_2, CH_4, N_2O	1.A.1 Energy Industries	0.0	0.0	0.0	28.9	15.7
CO_2, CH_4, N_2O	1.A.2. Manufacturing industries and construction	-105.3	-152.9	-34.9	108.4	-25.1
CO_2, CH_4, N_2O	1.A.3. Transport	152.1	140.2	185.5	114.7	41.6
CO_2, CH_4, N_2O	1.A.4. Other sectors	182.1	224.1	113.2	141.9	171.3
CO2, CH4	1.B.2. Oil and natural gas	125.3	126.6	130.8	122.4	95.9
CO_2	2.A. Mineral industry	0.0	0.0	0.0	0.0	66.5
CO_2, CH_4, N_2O	2.B. Chemical industry	0.0	1.2	0.1	0.3	63.7
CO_2	2.C. Metal industry	-1.0	0.0	0.0	0.0	0.0
CO_2, CH_4	2.D. Non-energy products from fuels and solvent use	0.0	0.0	0.1	0.2	36.6
CO_2, CH_4, N_2O	2.G. Other product manufacture and use	0.0	-2.1	-0.5	-3.0	-4.2
HFC, PFC, SF_6	2.B. Chemical industry	0.0	-0.1	0.0	0.0	0.0

Gas(es)		1990	2000	2010	2020	2022
HFC	2.F. Product uses as ODS substitutes	0.0	0.0	0.0	-16.4	-256.4
CH_4, N_2O	3.B Manure management	6.2	28.0	10.3	-1.3	-8.9
N_2O	3.D Agricultural soils	1.5	4.4	8.6	13.2	-22.0
CO_2	3.G Liming	0.0	0.0	0.0	0.0	0.7
CO_2	3.H Urea application	0.0	0.0	0.0	0.0	2.9
CO_2, CH_4, N_2O	4 LULUCUF	-953.3	-914.7	-840.3	-1005.0	-1590.1
CH_4, N_2O	5.B Biological treatment of solid waste	0.0	0.0	0.0	3.5	4.5
CH_4, N_2O	5.D Waste water Handling	0.0	0.0	0.0	6.2	1.1
Total Difference		**-592.3**	**-544.4**	**-427.1**	**-484.2**	**-1406.1**
	*Total emissions NIR 2024**	228134	225187	219868	168784	158444
	Total emissions NIR 2025*	**227544**	**224649**	**219441**	**168300**	**157038**

*: including LULUCF and indirect CO_2 emissions

CRF vs. CRT
The NIR 2024 was written based on the numbers in the CRF 2024. Later, this CRF was transformed to the new CRT format, using the ETF-tool. In this recalculations chapter, we compare the emissions in CRT 2025 to CRT 2024. Therefore, small changes with respect to the CRF 2024 as discussed in NIR 2024 may exist.

10.2 Implications for emission and removal levels

This section summarises the implications of the changes described in Section 10.1 for the emissions levels reported in the GHG emissions inventory.

For the base year 1990, the recalculations resulted in a decreased GHG emission total compared to the previous submission of -0.26% (including LULUCF and indirect CO_2).

For 2022, the recalculated emissions decreased by –0.89% compared to the previous submission (including LULUCF and indirect CO_2).

Table 10.1 is not presenting the emissions changes per individual gas. In Table 10.2 the changes per individual gas and per sector in 1990 and 2022 are elaborated.

Table 10.2 Summary of the emission changes due to recalculations per gas and sector (Gg CO2-eq) for 1990 and 2022, compared to the NIR 2024

CO_2	**1990**	**2022**
1 Energy	235.8	107.0
2 IPPU	-1.0	166.8
3 Agriculture	0.0	3.6
4 LULUCF	-952.9	-1601.1
5 Waste	NA	NA
Indirect emissions	0.0	0.0
CH_4		
1 Energy	118.3	92.3
2 IPPU	0.0	0.0
3 Agriculture	6.2	-8.3
4 LULUCF	-20.5	-2.7
5 Waste	0.0	-0.2
N_2O		
1 Energy	0.1	100.1
2 IPPU	0.0	-4.2
3 Agriculture	1.5	-22.6
4 LULUCF	20.2	13.7
5 Waste	0.0	5.8
HFC's		
2 IPPU	0.0	-256.4
PFC's		
2 IPPU	0.0	0.0
SF6		
2 IPPU	0.0	0.0

In relation to the abovementioned changes (and others), figures for emissions from precursor gases changed over the entire time series. The explanation for the recalculations can be found in the IIR report (Staats et al., 2025).

10.3 Implications for emission and removal trends, including time-series consistency

The recalculations (including error corrections) have further improved both the accuracy and the time series consistency of the estimated emissions.
Table 10.3 presents the changes made due to the recalculations for 1990, 2000, 2010, 2015, 2020, and 2022 (compared to the CRT2024).
It appears from Table 10.3 that the recalculations (including LULUCF) changed national emissions in 2020 and 2022 to a small extent (-0.3% and -0.9%, respectively), compared to the previous CRT. Changes to the 1990 emissions (base year) are in the same order of magnitude (- 0.3%).

*Table 10.3 Differences between the NIR 2024 and NIR 2025 for the 1990–2022 period due to recalculations (Units: **Tg CO_2-eq**; for F-gases: **Gg CO_2-eq**)*

Gas	Source	1990	2000	2010	2020	2022
CO_2 [Tg]	NIR 2025	166.8	175.9	186.3	139.6	130.3
	NIR 2024	167.5	177.8	187.0	140.3	131.6
	Difference	*-0.4%*	*-1.0%*	*-0.4%*	*-0.5%*	*-1.0%*
CH_4 [Tg CO2-eq]	NIR 2025	36.5	27.9	22.3	19.5	18.6
	NIR 2024	36.4	27.7	22.2	19.4	18.5
	Difference	*0.3%*	*0.5%*	*0.5%*	*0.6%*	*0.4%*
N_2O [Tg CO2-eq]	NIR 2025	16.1	14.4	7.9	7.5	6.7
	NIR 2024	16.1	14.3	7.8	7.4	6.6
	Difference	*0.1%*	*0.1%*	*1.6%*	*1.7%*	*1.4%*
PFCs [Gg CO2-eq]	NIR 2025	2396.6	1715.2	290.5	61.8	52.4
	NIR 2024	2396.6	1715.3	290.5	61.8	52.4
	Difference	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*
HFCs [Gg CO2-eq]	NIR 2025	4697.2	4029.3	1978.0	1026.9	779.9
	NIR 2024	4697.2	4029.3	1977.9	1043.2	1036.3
	Difference	*0.0%*	*0.0%*	*0.0%*	*-1.6%*	*-24.7%*
SF_6 [Gg CO2-eq]	NIR 2025	213.1	235.6	108.1	128.4	125.5
	NIR 2024	213.1	234.6	108.1	128.4	125.5
	Difference	*0.0%*	*0.4%*	*0.0%*	*0.0%*	*0.0%*
Total [Tg CO_2-eq.]	NIR 2025	227.5	224.6	219.4	168.3	157.0
	NIR 2024	228.1	225.2	219.9	168.8	158.4
	Difference	*-0.3%*	*-0.2%*	*-0.2%*	*-0.3%*	*-0.9%*

10.4 Areas of improvement and/or capacity-building in response to the review process

10.4.1 Response to the review process

Public and peer review

The NIR is subject to a (when possible, annual) process of a general public review and a peer review.

The peer review, carried out by an independent expert party, pays special attention to a specific sector or topic, and checks the report for transparency, readability and consistency with 2006 IPCC Guidelines (IPCC, 2006).

The peer review of the NIR 2024 (DNV, 2024) looked at GHG emissions from the IPPU sector, with a focus on 2A 'Mineral Industry' and 2B 'Chemical Industry', and excluding 2F 'Product Uses as Substitutes for Ozone Depleting Substances'. The exclusion of category 2F was due to overlap with a different research project regarding F-gasses in the production/usage of foams and aerosols, which was being undertaken in parallel by TAUW as commissioned by the NIE in consultation with RIVM (see below).

Overall, the NIR section on IPPU was considered to provide a comprehensive GHG inventory which demonstrates compliances with the TACCC principles and alignment with the IPCC guidelines. Nonetheless, the peer review did offer a number of recommendations which would strengthen current reporting of the IPPU sector. For instance, due to the extensive scope of the NIR and methodology report, links to other sections can at times lead to content appearing under unexpected headings, so it was suggested to improve readability and consistency by placing key details under the appropriate sub-section. The recommendations as mentioned in the peer review report were collated and maintained within the overarching NIR issue list as relevant, in order to track the implementation of recommended improvements in the preparation of the NIR 2025 and subsequent submissions.

Additional study

Alongside the peer review, an additional study was commissioned to follow up on previous review recommendations regarding HFC emissions (I.30, 2021; I.26-I.27, 2022) and to identify potential areas of improvement in the current methodology. Within the category 2F, the subcategory 'foams' and 'aerosols' were prioritized for this study, as these are estimated to be by far the largest contributors within this category. This study was undertaken by TAUW, which resulted in a report with recommendations and a suggested approach to improve the emission estimate in this category (TAUW, 2024), which were incorporated in the NIR 2025.

Peer reviews in past years have focused on the following sectors and categories:

- Agriculture (CLM, 2023)
- Energy (CE Delft, 2022)
- LULUCF (South Pole, 2021)
- Waste and wastewater (Oonk, 2020)

- Transport (VITO, 2019);
- Reference approach and waste incineration (CE Delft, 2018);
- N_2O and CO_2 emissions from Agriculture (Kuikman, 2017);
- Energy (excluding transport) (CE Delft, 2014);
- Industrial process emissions (Royal HaskoningDHV, 2013);
- LULUCF (Somogyi, 2012);
- Waste (Oonk, 2011);
- Transport (Hanschke et al., 2010);
- Combustion and process emissions in industry (Neelis and Blinde, 2009);
- Agriculture (Monteny, 2008).

In general, the conclusion of these peer reviews has been that the Dutch NIR adequately describes how the Netherlands calculates the emissions of greenhouse gases. The major recommendations refer to the readability and transparency of the NIR, with some suggestions for textual improvement.

Public review
A public review was conducted which sought to focus on methane emissions in the Energy, Agriculture and Waste sectors, with the point of attention being whether the calculations of methane emissions were sufficiently clear across the relevant NIR chapters. The preferred format is a commenting round in writing. Due to the detailed nature of the inventory and relatively specific expertise required to follow certain topics, the request was sent out through the contact persons of involved institutions to nominate any contacts with relevant expertise in the particular field of study (but who are themselves not directly involved in the inventory process). This commenting round resulted in a limited – albeit useful – response, perhaps due to the relatively broad, cross-sectoral nature of the topic; and the usual challenges new readers may face in engaging with the particular format and subject matter of the NIR. Suggestions were discussed and incorporated as relevant, while measures to improve the response rate will be considered as a follow-up action.

UNFCCC review
A UNFCCC review was last conducted on the NIR 2022. The final review report was received in May 2023 and is used to structure Annex 10, which includes responses to each of the findings, as well as relevant developments since subsequent submissions.

ESR review and EU initial checks
Until 2022, an annual ESD review was conducted by an EU expert review team in line with Article 19(1) of Regulation (EU) No 525/2013 (the 'Monitoring Mechanism Regulation', MMR.
In 2025, 2027 and 2032 comprehensive EU ESR reviews will be conducted in line with the Regulation 2018/1999 on governance of the Energy Union and climate action in order to determine the annual targets of net GHG emissions reductions of the Member States.
During the years that no comprehensive reviews take place, potential issues are still identified during the initial checks of the draft NIR from

15 January. These issues can potentially result in improvements of (the descriptions in) the NIR.

10.4.1.1 Completeness of the NIR

The Netherlands' GHG emission inventory includes all sources identified by the revised Intergovernmental Panel on Climate Change (IPCC) Guidelines (IPCC, 2006), and for a significant part the 2019 Refinement to the 2006 IPCC Guidelines, with the exception of the following, very minor, sources:

- CO_2 from asphalt roofing (2A4d), due to negligible amounts (below threshold);
- CO_2 from road paving (2A4d), due to negligible amounts (below threshold);
- CH_4 from enteric fermentation in poultry (3A4), due to missing EFs;
- N_2O from septic tanks (5D3), due to missing method and negligible amounts (below threshold);
- Part of CH_4 from industrial wastewater (5D2 sludge), due to negligible amounts;
- Precursor emissions (i.e. CO, NO_x, NMVOC) and SO_2) from memo item 'International bunkers' (international transport), as these emissions are not part of the national total.

For more detailed information on this issue, see Annex 6.

10.4.1.2 Completeness of ETF tables

As the Industrial processes source categories in the Netherlands often relate to only a few companies, it is generally not possible to report detailed and disaggregated data. Activity data is confidential and not reported when a source category comprises three or fewer companies. During (in-country) reviews, however, this data will be made available to the ERT on request.

10.4.1.3 Planned improvements

The Netherlands' National System was established at the end of 2005, in line with the requirements of the Kyoto Protocol and the EU Monitoring Mechanism, as a result of the implementation of a monitoring improvement programme (see Section 1.6). The conclusion of the initial review (2007) was that the Netherlands' National System had been established in accordance with the guidelines for National Systems set out in Article 5, section 1 of the Kyoto Protocol (decision 19/CMP.1) and that it met the requirements for the implementation of the general functions of a National System, as well as the specific functions of inventory planning, inventory preparation, and inventory management. The latest UNFCCC review from 2022 confirmed that the Netherlands' inventory and inventory process are still in line with the rules for National Systems.

Notwithstanding the transition from the Kyoto Protocol to the Paris Agreement and the replacement of the EU Monitoring Mechanism by the Governance Regulation of the Energy Union, the national arrangements for the preparation of the inventory (including quality assurance and control procedures) must still be implemented and maintained, similar to the previous requirements. With regard to quality assurance and quality control procedures, the QA/QC programme for the Netherlands' national arrangements was revised and updated in 2023, as detailed further below (Quality assurance and quality control , RVO, 2023).

Monitoring improvement
The National System includes an annual evaluation and improvement process. The evaluation is based on experience in previous years and the results of UN and EU reviews, peer reviews, and audits. Where needed, improvements are included in the update of the QA/QC programme (RVO, 2023).

QA/QC program
The QA/QC program was revised and updated. Previously, this programme covered a fixed period of about one year and the entire document was updated on a yearly basis. From 2023 onwards, a slightly revised structure has been incorporated.

As the core aspects of the QA/QC programme are cyclical, the program is described with a more indefinite time frame to enable a broader time-horizon. Outcomes of specific QA/QC activities continue to be reported in the relevant sections of the NIR. At the same time, the annual experiences from reviews and improvement actions will also still be captured at a more granular level in the annual internal memo 'Main QA/QC experiences inventory' (RVO) shared with the NIE Advisory Board (this document will be held available for reviews). This internal document describes in a concise manner the key actions taken that year and reflection on the implementation thereof, as well as incorporating learnings from (bi)annual reviews and evaluations. Any practical considerations therein will subsequently feed into finetuning of the overall QA/QC programme. As such, the program will continue to be reviewed as part of the evaluation and improvement cycle and is to be updated as appropriate in line with relevant reporting guidelines from the EU and UNFCCC.

The QA/QC program continues the assessment of long-term improvement options on the basis of the 2006 IPCC Guidelines and the 2019 Refinement to the 2006 IPCC Guidelines. Improvement actions for new methodologies and changes of EF will be performed as governed by the annual Work Plan (RIVM, 2024).

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Annex 1 Key categories

A1.1 Introduction

As explained in the 2006 Guidelines (IPCC, 2006), a key source category is prioritised within the national inventory system because its estimate has a significant influence on a country's total inventory of direct GHGs in terms of the absolute level of emissions, the trend in emissions or both.

For the identification of key categories in the Netherlands' inventory (Key Category Analysis or KCA), national emissions are allocated to the Intergovernmental Panel on Climate Change's potential key source list, as presented in table 4.1 in Chapter 4 of the 2019 IPCC Guidelines (Volume 1). For KCA, no major modifications with respect to the 2006 IPCC Guidelines have occurred but a simplification of the equation to perform key category analysis using trend assessment (Approach 1 without uncertainties)

As suggested in the guidance, carbon dioxide (CO_2) emissions from stationary combustion (1A1, 1A2 and 1A4) are aggregated by fuel type. CO_2, methane (CH_4) and nitrous oxide (N_2O) emissions from mobile combustion – road vehicles (1A3) – are assessed separately. Other mobile sources are not assessed separately by gas. Fugitive emissions from oil and gas operations (1B) are important sources of GHG emissions in the Netherlands. The most important gas/source combinations in this category are separately assessed. Emissions in other IPCC sectors are disaggregated, as suggested by the IPCC.

The first step of the KCA (IPCC Approach 1 method) consists of ranking the list of source category/gas combinations according to their contribution to annual national total emissions and to the national total trend. In approach 1, key categories are identified using a pre-determined cumulative emission threshold. Key categories are those that, when listed in descending order of magnitude, add up to 95% of the total national inventory level. The second step of the KCA (IPCC Approach 2 method) requires the incorporation of the uncertainty per category before ordering the list of shares. Here, a total contribution of up to 90% to the overall uncertainty has been used to avoid the inclusion of too many small sources. In this case, total uncertainties per category are calculated using error propagation, using the uncertainty estimates for both data and emission factors as presented in Annex 2 (for details of the uncertainty analysis see the methodology reports (RIVM reports 2024-0014, 2024-001).
Table A1.1 presents the key sources that are added when uncertainties are included (Approach 2 analysis). Table A1.2 shows the results of both approaches. In this table, a key source is indicated with '1'. The approach 1 method (without uncertainties) results in 40 categories for annual level assessment (emissions in 2023) and 45 categories for the trend assessment, out of a total of 124 source categories. The inclusion of uncertainties results in 43 categories for annual level assessment

(emissions in 2023) and 40 categories for the trend assessment out of a total of 124 source categories.

A combination of approach 1 and 2 for both level and trend assessment shows a total of 63 key categories. As expected, the incorporation of uncertainty in the level and trend assessments increases the importance of highly uncertain sources.

Table A1.1 Additional key categories after incorporation of uncertainty data

Category	**Name**	**Gas**	**Key category**
1A1	Energy Industries: all fuels	N2O	Key(,T2)
1A4b	Residential:all fuels	CH4	Key(L2,)
2A2	Lime production	CO2	Key(L2,T2)
2B10	Other	N2O	Key(L2,T2)
2F6	Other	HFC	Key(,T2)
3B5	Indirect emissions	N2O	Key(L2,T2)
4B	Cropland	N2O	Key(L2,)
4C	Grassland	CH4	Key(L2,)

Annex 1 also includes information on key categories in 1990; Table A1.3 shows the results.

Since 1990 is the base year, key sources can only be based on a level assessment. This results in 48 key sources (level 1 and 2, including LULUCF).

*Table A1.2 Key category list identified by level and trend assessments for **2023** emissions, **including** LULUCF sources.*

CRT	Source category	Gas	Key source	Approach 1 level recent year (excl.uncertainty)	Approach 1 trend (excl.uncertainty)	Approach 2 level recent year (incl. uncertainty,error propagation)	Approach 2 trend (incl. uncertainty, error propagation)
1A1	Energy Industries: all fuels	CH4	Non key	0	0	0	0
1A1	Energy Industries: all fuels	N2O	Key(,T2)	0	0	0	1
1A1a	Public Electricity and Heat Production: liquids	CO2	Non key	0	0	0	0
1A1a	Public Electricity and Heat Production: solids	CO2	Key(L,T)	1	1	1	1
1A1a	Public Electricity and Heat Production: gaseous	CO2	Key(L1,T1)	1	1	0	0
1A1a	Public Electricity and Heat Production: other fuels: waste incineration	CO2	Key(L,T)	1	1	1	1
1A1b	Petroleum Refining: liquids	CO2	Key(L,T)	1	1	1	1
1A1b	Petroleum Refining: gaseous	CO2	Key(L1,T1)	1	1	0	0
1A1c	Manufacture of Solid Fuels: solids	CO2	Key(L,)	1	0	1	0
1A1c	Manufacture of Solid Fuels: gaseous	CO2	Key(L1,T1)	1	1	0	0
1A2	Manufacturing Industries and Construction: liquids	CO2	Key(L,T)	1	1	1	1
1A2	Manufacturing Industries and Construction: solids	CO2	Key(L,T)	1	1	1	1
1A2	Manufacturing Industries and Construction: gaseous	CO2	Key(L,T1)	1	1	1	0
1A2	Manufacturing Industries and Construction: all fuels	CH4	Non key	0	0	0	0
1A2	Manufacturing Industries and Construction: all fuels	N2O	Non key	0	0	0	0
1A3 excl 1A3b	Other	CH4	Non key	0	0	0	0
1A3 excl 1A3b	Other	N2O	Non key	0	0	0	0

CRT	Source category	Gas	Key source	Approach 1 level recent year (excl.uncertainty)	Approach 1 trend (excl.uncertainty)	Approach 2 level recent year (incl. uncertainty,error propagation)	Approach 2 trend (incl. uncertainty, error propagation)
1A3a	Domestic aviation	CO2	Non key	0	0	0	0
1A3b	Road transportation: gasoline	CO2	Key(L,T)	1	1	1	1
1A3b	Road transportation: diesel oil	CO2	Key(L,T)	1	1	1	1
1A3b	Road transportation: LPG	CO2	Key(,T)	0	1	0	1
1A3b	Road transportation: gaseous	CO2	Non key	0	0	0	0
1A3b	Road transportation	CH4	Non key	0	0	0	0
1A3b	Road transportation	N2O	Key(L2,T)	0	1	1	1
1A3c	Railways	CO2	Non key	0	0	0	0
1A3d	Domestic navigation	CO2	Key(L1,T1)	1	1	0	0
1A3e	Other	CO2	Non key	0	0	0	0
1A4 excl 1A4c	Liquids	CO2	Key(L1,T)	1	1	0	1
1A4	Solids	CO2	Non key	0	0	0	0
1A4	Other Sectors: all fuels	N2O	Non key	0	0	0	0
1A4a	Commercial/Institutional: gaseous	CO2	Key(L,)	1	0	1	0
1A4a	Commercial/Institutional: all fuels	CH4	Non key	0	0	0	0
1A4b	Residential gaseous	CO2	Key(L,T)	1	1	1	1
1A4b	Residential:all fuels	CH4	Key(L2,)	0	0	1	0
1A4c	Agriculture/Forestry/Fisheries: liquids	CO2	Key(L,)	1	0	1	0
1A4c	Agriculture/Forestry/Fisheries: gaseous	CO2	Key(L,T1)	1	1	1	0
1A4c	Agriculture/Forestry/Fisheries: all fuels	CH4	Key(L,T)	1	1	1	1
1A5b	Military use: liquids	CO2	Non key	0	0	0	0
1A5b	Military use: liquids	CH4	Non key	0	0	0	0
1A5b	Military use: liquids	N2O	Non key	0	0	0	0

CRT	Source category	Gas	Key source	Approach 1 level recent year (excl.uncertainty)	Approach 1 trend (excl.uncertainty)	Approach 2 level recent year (incl. uncertainty,error propagation)	Approach 2 trend (incl. uncertainty, error propagation)
1B1b	Solid fuel transformation	CO2	Non key	0	0	0	0
1B1b	Solid fuel transformation	CH4	Non key	0	0	0	0
1B2	Fugitive emissions from oil and gas operations	CO2	Key(L1,T1)	1	1	0	0
1B2a	Oil	CH4	Non key	0	0	0	0
1B2b	Natural gas	CH4	Non key	0	0	0	0
1B2c	Venting and flaring	CH4	Key(,T)	0	1	0	1
2A1	Cement production	CO2	Key(,T1)	0	1	0	0
2A2	Lime production	CO2	Key(L2,T2)	0	0	1	1
2A3	Glass production	CO2	Non key	0	0	0	0
2A4a	Ceramics	CO2	Non key	0	0	0	0
2A4b	Other uses of soda ash	CO2	Non key	0	0	0	0
2A4d	Other	CO2	Key(L,T)	1	1	1	1
2B	Fluorochemical production	HFC	Key(,T)	0	1	0	1
2B1	Ammonia production	CO2	Key(L,T1)	1	1	1	0
2B10	Other	CO2	Key(L,T)	1	1	1	1
2B10	Other	N2O	Key(L2,T2)	0	0	1	1
2B2	Nitric acid production	N2O	Key(,T)	0	1	0	1
2B4	Caprolactam production	N2O	Key(,T)	0	1	0	1
2B7	Soda ash production	CO2	Non key	0	0	0	0
2B8	Petrochemical and carbon black production	CO2	Key(L,T)	1	1	1	1
2B8	Chemical industry: Petrochemical and carbon black production	CH4	Key(L2,T)	0	1	1	1
2B9	Fluorochemical production	PFC	Non key	0	0	0	0
2C1	Iron and steel production	CO2	Non key	0	0	0	0
2C3	Aluminium production	CO2	Key(,T1)	0	1	0	0

CRT	Source category	Gas	Key source	Approach 1 level recent year (excl.uncertainty)	Approach 1 trend (excl.uncertainty)	Approach 2 level recent year (incl. uncertainty,error propagation)	Approach 2 trend (incl. uncertainty, error propagation)
2C3	Aluminium production	PFC	Key(,T1)	0	1	0	0
2D1	Lubricant use	CO2	Non key	0	0	0	0
2D2	Paraffin wax use	CO2	Key(L2,T)	0	1	1	1
2D2	Paraffin wax use	CH4	Non key	0	0	0	0
2D3	Other	CO2	Non key	0	0	0	0
2E	Electronic Industry	PFC	Non key	0	0	0	0
2F1	Refrigeration and airconditioning	HFC	Key(L,T)	1	1	1	1
2F6	Other	HFC	Key(,T2)	0	0	0	1
2G	Other product manufacture and use	CO2	Non key	0	0	0	0
2G	Other product manufacture and use	CH4	Non key	0	0	0	0
2G	Other product manufacture and use	N2O	Non key	0	0	0	0
2G2	SF6 use	SF6	Non key	0	0	0	0
2H	Other industrial	CO2	Non key	0	0	0	0
3A1	Mature dairy cattle	CH4	Key(L,T)	1	1	1	1
3A1	Other mature cattle	CH4	Non key	0	0	0	0
3A1	Young cattle	CH4	Key(L,)	1	0	1	0
3A2, 3A4	Other	CH4	Key(L,)	1	0	1	0
3A3	Swine	CH4	Key(L,)	1	0	1	0
3B1	Mature dairy cattle	CH4	Key(L,T)	1	1	1	1
3B1	Other mature cattle	CH4	Non key	0	0	0	0
3B1	Growing cattle	CH4	Key(L1,)	1	0	0	0
3B1	Mature dairy cattle	N2O	Non key	0	0	0	0
3B1	Other mature cattle	N2O	Non key	0	0	0	0
3B1	Growing cattle	N2O	Non key	0	0	0	0
3B2	Sheep	N2O	Non key	0	0	0	0

CRT	Source category	Gas	Key source	Approach 1 level recent year (excl.uncertainty)	Approach 1 trend (excl.uncertainty)	Approach 2 level recent year (incl. uncertainty,error propagation)	Approach 2 trend (incl. uncertainty, error propagation)
3B2, 3B4	Other	CH4	Non key	0	0	0	0
3B3	Swine	CH4	Key(L,T)	1	1	1	1
3B3	Swine	N2O	Non key	0	0	0	0
3B4	Poultry	CH4	Key(,T)	0	1	0	1
3B4	Other livestock	N2O	Non key	0	0	0	0
3B5	Indirect emissions	N2O	Key(L2,T2)	0	0	1	1
3Da	Direct emissions from agricultural soils	N2O	Key(L,T)	1	1	1	1
3Db	Indirect emissions from managed soils	N2O	Key(L,T)	1	1	1	1
3G	Liming	CO2	Non key	0	0	0	0
3H	Ureum use	CO2	Non key	0	0	0	0
4A	Forest Land	CO2	Key(L,T)	1	1	1	1
4A	Forest Land	N2O	Non key	0	0	0	0
4A	Forest Land	CH4	Non key	0	0	0	0
4B	Cropland	CO2	Key(L,T)	1	1	1	1
4B	Cropland	N2O	Key(L2,)	0	0	1	0
4B	Cropland	CH4	Non key	0	0	0	0
4C	Grassland	CO2	Key(L,T)	1	1	1	1
4C	Grassland	N2O	Non key	0	0	0	0
4C	Grassland	CH4	Key(L2,)	0	0	1	0
4D	Wetlands	CO2	Non key	0	0	0	0
4D	Wetlands	N2O	Non key	0	0	0	0
4E	Settlements	CO2	Key(L,T)	1	1	1	1
4E	Settlements	N2O	Non key	0	0	0	0
4F	Other Land	CO2	Key(L2,T2)	0	0	1	1

CRT	Source category	Gas	Key source	Approach 1 level recent year (excl.uncertainty)	Approach 1 trend (excl.uncertainty)	Approach 2 level recent year (incl. uncertainty,error propagation)	Approach 2 trend (incl. uncertainty, error propagation)
4F	Other Land	N2O	Non key	0	0	0	0
4H	Other	N2O	Non key	0	0	0	0
4G	Harvested wood products	CO2	Non key	0	0	0	0
5A	Solid waste disposal	CH4	Key(L,T)	1	1	1	1
5B	Biological treatment of solid waste: composting	CH4	Key(,T2)	0	0	0	1
5B	Biological treatment of solid waste: composting	N2O	Non key	0	0	0	0
5C	Open burning of waste	CH4	Non key	0	0	0	0
5C	Open burning of waste	N2O	Non key	0	0	0	0
5D	Wastewater treatment and discharge	CH4	Non key	0	0	0	0
5D	Wastewater treatment and discharge	N2O	Key(L,)	1	0	1	0
6	Indirect CO2	CO2	Key(,T1)	0	1	0	0
	SUM			40	45	43	40

*Table A1.3 Key source list identified by level assessments for **1990** emissions (**including** LULUCF sources)*

CRT	Source category	Gas	Key source	Approach 1 level 1990 (excl. uncertainty)	Approach 2 level 1990 (incl. uncertainty, error propagation)
1A1	Energy Industries: all fuels	CH4	Non key	0	0
1A1	Energy Industries: all fuels	N2O	Non key	0	0
1A1a	Public Electricity and Heat Production: liquids	CO2	Non key	0	0
1A1a	Public Electricity and Heat Production: solids	CO2	Key(L,)	1	1
1A1a	Public Electricity and Heat Production: gaseous	CO2	Key(L1,)	1	0
1A1a	Public Electricity and Heat Production: other fuels: waste incineration	CO2	Key(L1,)	1	0
1A1b	Petroleum Refining: liquids	CO2	Key(L,)	1	1
1A1b	Petroleum Refining: gaseous	CO2	Key(L1,)	1	0
1A1c	Manufacture of Solid Fuels: solids	CO2	Key(L,)	1	1
1A1c	Manufacture of Solid Fuels: gaseous	CO2	Key(L1,)	1	0
1A2	Manufacturing Industries and Construction: liquids	CO2	Key(L,)	1	1
1A2	Manufacturing Industries and Construction: solids	CO2	Key(L,)	1	1
1A2	Manufacturing Industries and Construction: gaseous	CO2	Key(L,)	1	1
1A2	Manufacturing Industries and Construction: all fuels	CH4	Non key	0	0
1A2	Manufacturing Industries and Construction: all fuels	N2O	Non key	0	0
1A3 excl 1A3b	Other	CH4	Non key	0	0
1A3 excl 1A3b	Other	N2O	Non key	0	0
1A3a	Domestic aviation	CO2	Non key	0	0
1A3b	Road transportation: gasoline	CO2	Key(L,)	1	1
1A3b	Road transportation: diesel oil	CO2	Key(L,)	1	1

CRT	Source category	Gas	Key source	Approach 1 level 1990 (excl. uncertainty)	Approach 2 level 1990 (incl. uncertainty, error propagation)
1A3b	Road transportation: LPG	CO2	Key(L1,)	1	0
1A3b	Road transportation: gaseous	CO2	Non key	0	0
1A3b	Road transportation	CH4	Non key	0	0
1A3b	Road transportation	N2O	Non key	0	0
1A3c	Railways	CO2	Non key	0	0
1A3d	Domestic navigation	CO2	Key(L1,)	1	0
1A3e	Other	CO2	Non key	0	0
1A4 excl 1A4c	Liquids	CO2	Key(L,)	1	1
1A4	Solids	CO2	Non key	0	0
1A4	Other Sectors: all fuels	N2O	Non key	0	0
1A4a	Commercial/Institutional: gaseous	CO2	Key(L,)	1	1
1A4a	Commercial/Institutional: all fuels	CH4	Non key	0	0
1A4b	Residential gaseous	CO2	Key(L,)	1	1
1A4b	Residential:all fuels	CH4	Key(L2,)	0	1
1A4c	Agriculture/Forestry/Fisheries: liquids	CO2	Key(L,)	1	1
1A4c	Agriculture/Forestry/Fisheries: gaseous	CO2	Key(L,)	1	1
1A4c	Agriculture/Forestry/Fisheries: all fuels	CH4	Non key	0	0
1A5b	Military use: liquids	CO2	Non key	0	0
1A5b	Military use: liquids	CH4	Non key	0	0
1A5b	Military use: liquids	N2O	Non key	0	0
1B1b	Solid fuel transformation	CO2	Non key	0	0
1B1b	Solid fuel transformation	CH4	Non key	0	0
1B2	Fugitive emissions from oil and gas operations	CO2	Key(L1,)	1	0
1B2a	Oil	CH4	Non key	0	0
1B2b	Natural gas	CH4	Key(L2,)	0	1
1B2c	Venting and flaring	CH4	Key(L,)	1	1

CRT	Source category	Gas	Key source	Approach 1 level 1990 (excl. uncertainty)	Approach 2 level 1990 (incl. uncertainty, error propagation)
2A1	Cement production	CO2	Non key	0	0
2A2	Lime production	CO2	Non key	0	0
2A3	Glass production	CO2	Non key	0	0
2A4a	Ceramics	CO2	Non key	0	0
2A4b	Other uses of soda ash	CO2	Non key	0	0
2A4d	Other	CO2	Key(L2,)	0	1
2B	Fluorochemical production	HFC	Key(L,)	1	1
2B1	Ammonia production	CO2	Key(L,)	1	1
2B10	Other	CO2	Key(L,)	1	1
2B10	Other	N2O	Non key	0	0
2B2	Nitric acid production	N2O	Key(L,)	1	1
2B4	Caprolactam production	N2O	Key(L1,)	1	0
2B7	Soda ash production	CO2	Non key	0	0
2B8	Petrochemical and carbon black production	CO2	Key(L2,)	0	1
2B8	Chemical industry: Petrochemical and carbon black production	CH4	Key(L2,)	0	1
2B9	Fluorochemical production	PFC	Non key	0	0
2C1	Iron and steel production	CO2	Non key	0	0
2C3	Aluminium production	CO2	Non key	0	0
2C3	Aluminium production	PFC	Key(L1,)	1	0
2D1	Lubricant use	CO2	Non key	0	0
2D2	Paraffin wax use	CO2	Non key	0	0
2D2	Paraffin wax use	CH4	Non key	0	0
2D3	Other	CO2	Non key	0	0
2E	Electronic Industry	PFC	Non key	0	0
2F1	Refrigeration and airconditioning	HFC	Non key	0	0
2F6	Other	HFC	Non key	0	0

CRT	Source category	Gas	Key source	Approach 1 level 1990 (excl. uncertainty)	Approach 2 level 1990 (incl. uncertainty, error propagation)
2G	Other product manufacture and use	CO2	Non key	0	0
2G	Other product manufacture and use	CH4	Non key	0	0
2G	Other product manufacture and use	N2O	Non key	0	0
2G2	SF6 use	SF6	Non key	0	0
2H	Other industrial	CO2	Non key	0	0
3A1	Mature dairy cattle	CH4	Key(L,)	1	1
3A1	Other mature cattle	CH4	Non key	0	0
3A1	Young cattle	CH4	Key(L,)	1	1
3A2, 3A4	Other	CH4	Non key	0	0
3A3	Swine	CH4	Key(L2,)	0	1
3B1	Mature dairy cattle	CH4	Key(L,)	1	1
3B1	Other mature cattle	CH4	Non key	0	0
3B1	Growing cattle	CH4	Non key	0	0
3B1	Mature dairy cattle	N2O	Non key	0	0
3B1	Other mature cattle	N2O	Non key	0	0
3B1	Growing cattle	N2O	Non key	0	0
3B2	Sheep	N2O	Non key	0	0
3B2, 3B4	Other	CH4	Non key	0	0
3B3	Swine	CH4	Key(L,)	1	1
3B3	Swine	N2O	Non key	0	0
3B4	Poultry	CH4	Key(L2,)	0	1
3B4	Other livestock	N2O	Non key	0	0
3B5	Indirect emissions	N2O	Key(L2,)	0	1
3Da	Direct emissions from agricultural soils	N2O	Key(L,)	1	1
3Db	Indirect emissions from managed soils	N2O	Key(L,)	1	1
3G	Liming	CO2	Non key	0	0
3H	Ureum use	CO2	Non key	0	0

CRT	Source category	Gas	Key source	Approach 1 level 1990 (excl. uncertainty)	Approach 2 level 1990 (incl. uncertainty, error propagation)
4A	Forest Land	CO2	Key(L,)	1	1
4A	Forest Land	N2O	Non key	0	0
4A	Forest Land	CH4	Non key	0	0
4B	Cropland	CO2	Key(L,)	1	1
4B	Cropland	N2O	Key(L2,)	0	1
4B	Cropland	CH4	Non key	0	0
4C	Grassland	CO2	Key(L,)	1	1
4C	Grassland	N2O	Non key	0	0
4C	Grassland	CH4	Non key	0	0
4D	Wetlands	CO2	Non key	0	0
4D	Wetlands	N2O	Non key	0	0
4E	Settlements	CO2	Key(L,)	1	1
4E	Settlements	N2O	Non key	0	0
4F	Other Land	CO2	Non key	0	0
4F	Other Land	N2O	Non key	0	0
4H	Other	N2O	Non key	0	0
4G	Harvested wood products	CO2	Non key	0	0
5A	Solid waste disposal	CH4	Key(L,)	1	1
5B	Biological treatment of solid waste: composting	CH4	Non key	0	0
5B	Biological treatment of solid waste: composting	N2O	Non key	0	0
5C	Open burning of waste	CH4	Non key	0	0
5C	Open burning of waste	N2O	Non key	0	0
5D	Wastewater treatment and discharge	CH4	Non key	0	0
5D	Wastewater treatment and discharge	N2O	Non key	0	0
6	Indirect CO2	CO2	Key(L,)	1	1
	SUM			39	39

A1.2 Changes in key categories compared to previous submission

Due to the use of emissions data for 2023, there are some changes in key categories in comparison with the previous NIR: Three categories that were key in the previous submission are no longer a key category:

1A1a	Public Electricity and Heat Production: liquids	CO_2
1A3b	Road transportation: gaseous	CO_2
1A3e	Other	CO_2

The Netherlands includes one extra key category compared to the key source analysis for the 2022 data:

1A3b	Road transportation	N_2O

A1.3 Changes in key categories 2023 compared to 1990

Table A1.4 shows the result of a comparison of the key categories in 1990 (level) and 2023 (level and trend). A comparison based on a level assessment only, shows 4 additional key categories in 2023 compared to 1990. Twelve additional categories (shaded in table A1.4) are added, when also the trend analysis is considered.

Table A1.4 additional key categories in 2023 (compared to 1990)

1A1	Energy Industries: all fuels	N2O	Key(,T2)
1A3b	Road transportation	N2O	Key(L2,T)
1A4c	Agriculture/Forestry/Fisheries: all fuels	CH4	Key(L,T)
2A1	Cement production	CO2	Key(,T1)
2A2	Lime production	CO2	Key(L2,T2)
2B10	Other	N2O	Key(L2,T2)
2C3	Aluminium production	CO2	Key(,T1)
2D2	Paraffin wax use	CO2	Key(L2,T)
2F1	Refrigeration and airconditioning	HFC	Key(L,T)
2F6	Other	HFC	Key(,T2)
3A2, 3A4	Other	CH4	Key(L,)
3B1	Growing cattle	CH4	Key(L1,)
4C	Grassland	CH4	Key(L2,)
4F	Other Land	CO2	Key(L2,T2)
5B	Biological treatment of solid waste: composting	CH4	Key(,T2)
5D	Wastewater treatment and discharge	N2O	Key(L,)

A1.4 Approach 1 key category assessment (level and trend excluding uncertainties)

In Table A1.5 the source ranking is done according to the contribution to the 2023 annual emissions total and in Table A1.6 according to the base-year-to-2023 trend. This results in 40 level key sources and 45 trend key sources.

*Table A1.5 Source ranking using IPCC Approach 1 **level** assessment for 2023 emissions, including LULUCF (amounts in Gg CO_2-eq). Lines in **bold** represent the key sources.*

CRT Category		Gas	2023 estimate (Gg CO_2-eq)	Level assessment %	Cumulative total %
1A1a	**Public Electricity and Heat Production: gaseous**	**CO2**	**12725.3**	**8.5**	**8.5**
1A3b	**Road transportation: diesel oil**	**CO2**	**12388.8**	**8.2**	**16.7**
1A3b	**Road transportation: gasoline**	**CO2**	**12180.0**	**8.1**	**24.8**
1A2	**Manufacturing Industries and Construction: gaseous**	**CO2**	**11934.1**	**7.9**	**32.8**
1A4b	**Residential gaseous**	**CO2**	**11208.6**	**7.5**	**40.2**
1A1a	**Public Electricity and Heat Production: solids**	**CO2**	**10625.5**	**7.1**	**47.3**
1A1b	**Petroleum Refining: liquids**	**CO2**	**7916.4**	**5.3**	**52.6**
2B10	**Other**	**CO2**	**7507.0**	**5.0**	**57.6**
3A1	**Mature dairy cattle**	**CH4**	**6116.2**	**4.1**	**61.6**
1A4c	**Agriculture/Forestry/Fisheries: gaseous**	**CO2**	**5606.9**	**3.7**	**65.4**
1A4a	**Commercial/Institutional: gaseous**	**CO2**	**4948.8**	**3.3**	**68.7**
3Da	**Direct emissions from agricultural soils**	**N2O**	**3704.1**	**2.5**	**71.1**
1A2	**Manufacturing Industries and Construction: solids**	**CO2**	**3265.8**	**2.2**	**73.3**
1A1a	**Public Electricity and Heat Production: other fuels: waste incineration**	**CO2**	**2547.9**	**1.7**	**75.0**
4B	**Cropland**	**CO2**	**2388.1**	**1.6**	**76.6**
4A	**Forest Land**	**CO2**	**2070.8**	**1.4**	**78.0**
3A1	**Young cattle**	**CH4**	**2050.6**	**1.4**	**79.3**
2B1	**Ammonia production**	**CO2**	**1979.0**	**1.3**	**80.7**
5A	**Solid waste disposal**	**CH4**	**1909.5**	**1.3**	**81.9**
1A2	**Manufacturing Industries and Construction: liquids**	**CO2**	**1786.3**	**1.2**	**83.1**
1A4c	**Agriculture/Forestry/Fisheries: liquids**	**CO2**	**1707.5**	**1.1**	**84.2**
3B1	**Mature dairy cattle**	**CH4**	**1641.4**	**1.1**	**85.3**
3B3	**Swine**	**CH4**	**1569.9**	**1.0**	**86.4**
1A1b	**Petroleum Refining: gaseous**	**CO2**	**1375.1**	**0.9**	**87.3**

CRT Category		Gas	2023 estimate (Gg CO_2-eq)	Level assessment %	Cumulative total %
4C	**Grassland**	**CO2**	**1329.4**	**0.9**	**88.2**
4E	**Settlements**	**CO2**	**1136.8**	**0.8**	**88.9**
1A4c	**Agriculture/Forestry/Fisheries: all fuels**	**CH4**	**1053.0**	**0.7**	**89.6**
1B2	**Fugitive emissions from oil and gas operations**	**CO2**	**972.9**	**0.6**	**90.3**
1A1c	**Manufacture of Solid Fuels: gaseous**	**CO2**	**944.9**	**0.6**	**90.9**
1A3d	**Domestic navigation**	**CO2**	**914.9**	**0.6**	**91.5**
1A1c	**Manufacture of Solid Fuels: solids**	**CO2**	**664.3**	**0.4**	**92.0**
1A4 excl 1A4c	**Liquids**	**CO2**	**596.5**	**0.4**	**92.4**
5D	**Wastewater treatment and discharge**	**N2O**	**507.8**	**0.3**	**92.7**
3Db	**Indirect emissions from managed soils**	**N2O**	**502.6**	**0.3**	**93.0**
3A2, 3A4	**Other**	**CH4**	**500.8**	**0.3**	**93.4**
2A4d	**Other**	**CO2**	**493.2**	**0.3**	**93.7**
2B8	**Petrochemical and carbon black production**	**CO2**	**484.6**	**0.3**	**94.0**
3B1	**Growing cattle**	**CH4**	**472.5**	**0.3**	**94.3**
2F1	**Refrigeration and airconditioning**	**HFC**	**460.2**	**0.3**	**94.6**
3A3	**Swine**	**CH4**	**452.3**	**0.3**	**94.9**
6	Indirect CO2	CO2	432.7	0.3	95.2
1B2b	Natural gas	CH4	356.8	0.2	95.5
2B8	Chemical industry: Petrochemical and carbon black production	CH4	354.1	0.2	95.7
1A3b	Road transportation: LPG	CO2	331.2	0.2	95.9
1A1a	Public Electricity and Heat Production: liquids	CO2	302.8	0.2	96.1
1A4b	Residential:all fuels	CH4	299.7	0.2	96.3
1A3b	Road transportation	N2O	293.4	0.2	96.5
2B10	Other	N2O	281.4	0.2	96.7
2D2	Paraffin wax use	CO2	252.4	0.2	96.9
4C	Grassland	CH4	226.5	0.2	97.0
1A5b	Military use: liquids	CO2	224.3	0.1	97.2
4F	Other Land	CO2	224.1	0.1	97.3
5D	Wastewater treatment and discharge	CH4	213.7	0.1	97.5

CRT Category		Gas	2023 estimate (Gg CO_2-eq)	Level assessment %	Cumulative total %
1A1	Energy Industries: all fuels	N2O	204.4	0.1	97.6
3B5	Indirect emissions	N2O	196.3	0.1	97.7
2A2	Lime production	CO2	188.6	0.1	97.9
3B1	Mature dairy cattle	N2O	163.6	0.1	98.0
2F6	Other	HFC	146.5	0.1	98.1
1A3b	Road transportation: gaseous	CO2	138.3	0.1	98.2
5B	Biological treatment of solid waste: composting	CH4	135.3	0.1	98.3
4G	Harvested wood products	CO2	124.5	0.1	98.3
3B1	Growing cattle	N2O	119.3	0.1	98.4
3A1	Other mature cattle	CH4	117.6	0.1	98.5
1A1	Energy Industries: all fuels	CH4	109.0	0.1	98.6
1B2c	Venting and flaring	CH4	107.9	0.1	98.6
2G2	SF6 use	SF6	105.3	0.1	98.7
2A4a	Ceramics	CO2	104.3	0.1	98.8
2A4b	Other uses of soda ash	CO2	102.9	0.1	98.8
2D1	Lubricant use	CO2	92.2	0.1	98.9
3B4	Other livestock	N2O	87.2	0.1	99.0
2B	Fluorochemical production	HFC	81.8	0.1	99.0
3B4	Poultry	CH4	81.2	0.1	99.1
3B3	Swine	N2O	73.7	0.0	99.1
5B	Biological treatment of solid waste: composting	N2O	73.6	0.0	99.2
1A3e	Other	CO2	73.1	0.0	99.2
3H	Ureum use	CO2	68.1	0.0	99.3
2A3	Glass production	CO2	67.9	0.0	99.3
2B2	Nitric acid production	N2O	67.8	0.0	99.4
1A3c	Railways	CO2	67.6	0.0	99.4
4B	Cropland	N2O	67.0	0.0	99.4
2B4	Caprolactam production	N2O	66.1	0.0	99.5
1B1b	Solid fuel transformation	CO2	65.9	0.0	99.5
1A2	Manufacturing Industries and Construction: all fuels	CH4	61.4	0.0	99.6

CRT Category		Gas	2023 estimate (Gg CO_2-eq)	Level assessment %	Cumulative total %
1A4a	Commercial/Institutional: all fuels	CH4	59.8	0.0	99.6
1A3b	Road transportation	CH4	58.9	0.0	99.7
2G	Other product manufacture and use	N2O	56.0	0.0	99.7
2G	Other product manufacture and use	CH4	50.4	0.0	99.7
1A4	Other Sectors: all fuels	N2O	50.1	0.0	99.8
1A2	Manufacturing Industries and Construction: all fuels	N2O	38.5	0.0	99.8
2E	Electronic Industry	PFC	36.6	0.0	99.8
2D3	Other	CO2	36.1	0.0	99.8
1A3a	Domestic aviation	CO2	29.1	0.0	99.9
2H	Other industrial	CO2	26.8	0.0	99.9
3B2, 3B4	Other	CH4	26.0	0.0	99.9
3G	Liming	CO2	25.1	0.0	99.9
4D	Wetlands	CO2	24.0	0.0	99.9
4E	Settlements	N2O	18.8	0.0	99.9
1B2a	Oil	CH4	15.5	0.0	99.9
4B	Cropland	CH4	12.6	0.0	100.0
4F	Other Land	N2O	11.2	0.0	100.0
3B1	Other mature cattle	CH4	8.9	0.0	100.0
2C1	Iron and steel production	CO2	8.5	0.0	100.0
1A3 excl 1A3b	Other	CH4	8.3	0.0	100.0
1A3 excl 1A3b	Other	N2O	6.8	0.0	100.0
2B9	Fluorochemical production	PFC	5.3	0.0	100.0
1B1b	Solid fuel transformation	CH4	4.9	0.0	100.0
1A5b	Military use: liquids	N2O	3.2	0.0	100.0
5C	Open burning of waste	CH4	2.9	0.0	100.0
4A	Forest Land	CH4	2.4	0.0	100.0
3B1	Other mature cattle	N2O	2.4	0.0	100.0
4A	Forest Land	N2O	2.3	0.0	100.0
4D	Wetlands	N2O	1.6	0.0	100.0
5C	Open burning of waste	N2O	1.6	0.0	100.0

CRT Category		Gas	2023 estimate (Gg CO_2-eq)	Level assessment %	Cumulative total %
3B2	Sheep	N2O	1.4	0.0	100.0
4C	Grassland	N2O	0.6	0.0	100.0
2G	Other product manufacture and use	CO2	0.6	0.0	100.0
1A5b	Military use: liquids	CH4	0.6	0.0	100.0
2D2	Paraffin wax use	CH4	0.4	0.0	100.0
1A4	Solids	CO2	0.2	0.0	100.0
2C3	Aluminium production	CO2	0.0	0.0	100.0
2A1	Cement production	CO2	0.0	0.0	100.0
2B7	Soda ash production	CO2	0.0	0.0	100.0
2C3	Aluminium production	PFC	0.0	0.0	100.0
4H	Other	N2O	0.0	0.0	100.0
		Total	150230.8		

*Table A1.6 Source ranking using IPCC Approach 1 **trend** assessment for 2023 emissions compared to the base year, **including** LULUCF (Gg CO_2-eq). Lines in **bold** represent the key sources.*

CRT category		Gas	1990 Estimate (Gg CO_2-eq)	2023 Estimate (Gg CO_2-eq)	Trend Assessment %	% Contribution to trend	Cumulative Total %
5A	**Solid waste disposal**	**CH4**	**15320.8**	**1909.5**	**8.2**	**12.2**	**12.2**
1A1a	**Public Electricity and Heat Production: solids**	**CO2**	**25862.2**	**10625.5**	**6.3**	**9.3**	**21.6**
1A3b	**Road transportation: gasoline**	**CO2**	**10660.9**	**12180.0**	**5.4**	**8.0**	**29.6**
1A1a	**Public Electricity and Heat Production: gaseous**	**CO2**	**13329.1**	**12725.3**	**4.2**	**6.2**	**35.8**
1A3b	**Road transportation: diesel oil**	**CO2**	**13008.5**	**12388.8**	**4.1**	**6.0**	**41.9**
2B2	**Nitric acid production**	**N2O**	**5410.9**	**67.8**	**3.5**	**5.2**	**47.1**
2B10	**Other**	**CO2**	**6738.9**	**7507.0**	**3.2**	**4.8**	**51.9**
2B	**Fluorochemical production**	**HFC**	**4697.2**	**81.8**	**3.0**	**4.5**	**56.4**
3A1	**Mature dairy cattle**	**CH4**	**5805.2**	**6116.2**	**2.4**	**3.6**	**60.0**
1A1a	**Public Electricity and Heat Production: other fuels: waste incineration**	**CO2**	**601.5**	**2547.9**	**2.2**	**3.3**	**63.3**
1A4b	**Residential gaseous**	**CO2**	**19894.1**	**11208.6**	**1.7**	**2.6**	**65.9**
2C3	**Aluminium production**	**PFC**	**2373.9**	**0.0**	**1.6**	**2.3**	**68.2**
1A1b	**Petroleum Refining: liquids**	**CO2**	**9968.2**	**7916.4**	**1.5**	**2.2**	**70.4**
1A3b	**Road transportation: LPG**	**CO2**	**2740.4**	**331.2**	**1.5**	**2.2**	**72.6**
1A2	**Manufacturing Industries and Construction: solids**	**CO2**	**6623.4**	**3265.8**	**1.1**	**1.6**	**74.2**
1A4c	**Agriculture/Forestry/Fisheries: all fuels**	**CH4**	**81.3**	**1053.0**	**1.0**	**1.5**	**75.7**
1B2c	**Venting and flaring**	**CH4**	**1669.8**	**107.9**	**1.0**	**1.5**	**77.2**
3B3	**Swine**	**CH4**	**3772.8**	**1569.9**	**0.9**	**1.3**	**78.5**
1A4c	**Agriculture/Forestry/Fisheries: gaseous**	**CO2**	**7328.7**	**5606.9**	**0.9**	**1.3**	**79.8**
3B1	**Mature dairy cattle**	**CH4**	**1212.7**	**1641.4**	**0.9**	**1.3**	**81.1**
1A2	**Manufacturing Industries and Construction: liquids**	**CO2**	**3990.5**	**1786.3**	**0.8**	**1.2**	**82.4**
1A1b	**Petroleum Refining: gaseous**	**CO2**	**1042.2**	**1375.1**	**0.7**	**1.1**	**83.4**

CRT category		Gas	1990 Estimate (Gg CO_2-eq)	2023 Estimate (Gg CO_2-eq)	Trend Assessment %	% Contribution to trend	Cumulative Total %
4A	**Forest Land**	**CO2**	**2241.3**	**2070.8**	**0.6**	**0.9**	**84.4**
4E	**Settlements**	**CO2**	**989.9**	**1136.8**	**0.5**	**0.8**	**85.1**
1B2	**Fugitive emissions from oil and gas operations**	**CO2**	**774.7**	**972.9**	**0.5**	**0.7**	**85.8**
2F1	**Refrigeration and airconditioning**	**HFC**	**0.0**	**460.2**	**0.5**	**0.7**	**86.5**
1A3d	**Domestic navigation**	**CO2**	**726.1**	**914.9**	**0.5**	**0.7**	**87.2**
3Db	**Indirect emissions from managed soils**	**N2O**	**1436.4**	**502.6**	**0.4**	**0.7**	**87.9**
3Da	**Direct emissions from agricultural soils**	**N2O**	**6347.6**	**3704.1**	**0.4**	**0.6**	**88.5**
1A2	**Manufacturing Industries and**	**CO2**	**19044.2**	**11934.1**	**0.4**	**0.6**	**89.1**
1A4 excl 1A4c	**Liquids**	**CO2**	**1546.0**	**596.5**	**0.4**	**0.6**	**89.7**
2B4	**Caprolactam production**	**N2O**	**658.0**	**66.1**	**0.4**	**0.5**	**90.3**
4B	**Cropland**	**CO2**	**3165.0**	**2388.1**	**0.3**	**0.5**	**90.8**
3B4	**Poultry**	**CH4**	**543.8**	**81.2**	**0.3**	**0.4**	**91.2**
2A1	**Cement production**	**CO2**	**415.8**	**0.0**	**0.3**	**0.4**	**91.6**
2B8	**Petrochemical and carbon black production**	**CO2**	**335.6**	**484.6**	**0.3**	**0.4**	**92.0**
2C3	**Aluminium production**	**CO2**	**408.4**	**0.0**	**0.3**	**0.4**	**92.4**
1A3b	**Road transportation**	**N2O**	**89.5**	**293.4**	**0.2**	**0.4**	**92.8**
2B1	**Ammonia production**	**CO2**	**2695.0**	**1979.0**	**0.2**	**0.4**	**93.1**
4C	**Grassland**	**CO2**	**1733.3**	**1329.4**	**0.2**	**0.3**	**93.5**
2D2	**Paraffin wax use**	**CO2**	**102.6**	**252.4**	**0.2**	**0.3**	**93.7**
2A4d	**Other**	**CO2**	**481.2**	**493.2**	**0.2**	**0.3**	**94.0**
1A1c	**Manufacture of Solid Fuels: gaseous**	**CO2**	**1184.2**	**944.9**	**0.2**	**0.3**	**94.3**
6	**Indirect CO2**	**CO2**	**917.2**	**432.7**	**0.2**	**0.2**	**94.5**
2B8	**Chemical industry: Petrochemical and carbon black production**	**CH4**	**301.8**	**354.1**	**0.2**	**0.2**	**94.8**
5D	Wastewater treatment and discharge	N2O	541.1	507.8	0.2	0.2	95.0
1A1a	Public Electricity and Heat Production: liquids	CO2	233.2	302.8	0.2	0.2	95.2

CRT category		Gas	1990 Estimate (Gg CO_2-eq)	2023 Estimate (Gg CO_2-eq)	Trend Assessment %	% Contribution to trend	Cumulative Total %
1A3e	Other	CO2	342.2	73.1	0.2	0.2	95.5
2F6	Other	HFC	0.0	146.5	0.2	0.2	95.7
4F	Other Land	CO2	122.8	224.1	0.1	0.2	95.9
2B10	Other	N2O	219.4	281.4	0.1	0.2	96.1
1A3b	Road transportation: gaseous	CO2	0.0	138.3	0.1	0.2	96.3
5B	Biological treatment of solid waste: composting	CH4	4.8	135.3	0.1	0.2	96.5
3A2, 3A4	Other	CH4	576.4	500.8	0.1	0.2	96.7
1A1	Energy Industries: all fuels	N2O	131.8	204.4	0.1	0.2	96.9
3B1	Growing cattle	CH4	563.3	472.5	0.1	0.2	97.1
1A4	Solids	CO2	162.7	0.2	0.1	0.2	97.2
3G	Liming	CO2	183.2	25.1	0.1	0.1	97.4
2A2	Lime production	CO2	162.7	188.6	0.1	0.1	97.5
4G	Harvested wood products	CO2	68.6	124.5	0.1	0.1	97.6
1A4a	Commercial/Institutional: gaseous	CO2	7757.8	4948.8	0.1	0.1	97.8
3A3	Swine	CH4	584.4	452.3	0.1	0.1	97.9
2G	Other product manufacture and use	N2O	200.0	56.0	0.1	0.1	98.0
1A1c	Manufacture of Solid Fuels: solids	CO2	916.3	664.3	0.1	0.1	98.1
5B	Biological treatment of solid waste: composting	N2O	5.8	73.6	0.1	0.1	98.2
1A3b	Road transportation	CH4	197.1	58.9	0.1	0.1	98.3
3H	Ureum use	CO2	1.5	68.1	0.1	0.1	98.4
5D	Wastewater treatment and discharge	CH4	421.3	213.7	0.1	0.1	98.5
1A1	Energy Industries: all fuels	CH4	77.4	109.0	0.1	0.1	98.6
2A4b	Other uses of soda ash	CO2	68.6	102.9	0.1	0.1	98.7
1A4c	Agriculture/Forestry/Fisheries: liquids	CO2	2545.2	1707.5	0.1	0.1	98.8
4C	Grassland	CH4	262.1	226.5	0.1	0.1	98.8
3B1	Mature dairy cattle	N2O	169.1	163.6	0.1	0.1	98.9
3B4	Other livestock	N2O	53.9	87.2	0.1	0.1	99.0
2B7	Soda ash production	CO2	63.8	0.0	0.0	0.1	99.1

CRT category		Gas	1990 Estimate (Gg CO_2-eq)	2023 Estimate (Gg CO_2-eq)	Trend Assessment %	% Contribution to trend	Cumulative Total %
2D1	Lubricant use	CO2	84.9	92.2	0.0	0.1	99.1
2D3	Other	CO2	0.0	36.1	0.0	0.1	99.2
3B1	Growing cattle	N2O	130.2	119.3	0.0	0.1	99.2
3A1	Other mature cattle	CH4	235.4	117.6	0.0	0.1	99.3
2G2	SF6 use	SF6	213.1	105.3	0.0	0.0	99.3
1B2b	Natural gas	CH4	596.8	356.8	0.0	0.0	99.4
3B5	Indirect emissions	N2O	346.9	196.3	0.0	0.0	99.4
1A4b	Residential:all fuels	CH4	503.7	299.7	0.0	0.0	99.5
1A4a	Commercial/Institutional: all fuels	CH4	52.3	59.8	0.0	0.0	99.5
1A3a	Domestic aviation	CO2	84.2	29.1	0.0	0.0	99.5
2A3	Glass production	CO2	142.4	67.9	0.0	0.0	99.6
2E	Electronic Industry	PFC	22.7	36.6	0.0	0.0	99.6
1A5b	Military use: liquids	CO2	314.0	224.3	0.0	0.0	99.6
1A4	Other Sectors: all fuels	N2O	45.3	50.1	0.0	0.0	99.7
2H	Other industrial	CO2	72.5	26.8	0.0	0.0	99.7
2C1	Iron and steel production	CO2	43.7	8.5	0.0	0.0	99.7
1A2	Manufacturing Industries and Construction: all fuels	CH4	65.7	61.4	0.0	0.0	99.8
1A2	Manufacturing Industries and Construction: all fuels	N2O	32.0	38.5	0.0	0.0	99.8
3A1	Young cattle	CH4	3138.0	2050.6	0.0	0.0	99.8
2A4a	Ceramics	CO2	140.1	104.3	0.0	0.0	99.8
2G	Other product manufacture and use	CH4	57.8	50.4	0.0	0.0	99.9
4B	Cropland	N2O	83.7	67.0	0.0	0.0	99.9
4D	Wetlands	CO2	19.7	24.0	0.0	0.0	99.9
1A3c	Railways	CO2	90.7	67.6	0.0	0.0	99.9
3B1	Other mature cattle	CH4	24.8	8.9	0.0	0.0	99.9
3B3	Swine	N2O	124.7	73.7	0.0	0.0	99.9
4F	Other Land	N2O	6.5	11.2	0.0	0.0	99.9

CRT category		Gas	1990 Estimate (Gg CO_2-eq)	2023 Estimate (Gg CO_2-eq)	Trend Assessment %	% Contribution to trend	Cumulative Total %
1A3 excl 1A3b	Other	CH4	2.7	8.3	0.0	0.0	100.0
1B1b	Solid fuel transformation	CO2	110.4	65.9	0.0	0.0	100.0
2B9	Fluorochemical production	PFC	0.0	5.3	0.0	0.0	100.0
4E	Settlements	N2O	21.9	18.8	0.0	0.0	100.0
1B1b	Solid fuel transformation	CH4	12.3	4.9	0.0	0.0	100.0
1A3 excl 1A3b	Other	N2O	6.1	6.8	0.0	0.0	100.0
3B2	Sheep	N2O	6.4	1.4	0.0	0.0	100.0
3B1	Other mature cattle	N2O	6.2	2.4	0.0	0.0	100.0
3B2, 3B4	Other	CH4	37.8	26.0	0.0	0.0	100.0
4B	Cropland	CH4	21.5	12.6	0.0	0.0	100.0
4A	Forest Land	CH4	2.3	2.4	0.0	0.0	100.0
1B2a	Oil	CH4	22.8	15.5	0.0	0.0	100.0
2G	Other product manufacture and use	CO2	0.2	0.6	0.0	0.0	100.0
4D	Wetlands	N2O	1.9	1.6	0.0	0.0	100.0
4A	Forest Land	N2O	3.0	2.3	0.0	0.0	100.0
2D2	Paraffin wax use	CH4	0.2	0.4	0.0	0.0	100.0
5C	Open burning of waste	N2O	2.1	1.6	0.0	0.0	100.0
5C	Open burning of waste	CH4	4.2	2.9	0.0	0.0	100.0
4C	Grassland	N2O	0.8	0.6	0.0	0.0	100.0
1A5b	Military use: liquids	N2O	4.9	3.2	0.0	0.0	100.0
1A5b	Military use: liquids	CH4	0.9	0.6	0.0	0.0	100.0
4H	Other	N2O	0.0	0.0	0.0	0.0	100.0
	Total		231848	150231			

A1.5 Approach 2 key category assessment including uncertainties (error propagation)

Using the uncertainty estimate for each key source as a weighting factor (see Annex 2), the key source assessment was performed again.

The inclusion of uncertainty data in both level and trend assessment results in 63 key sources on a total of 124 sources. Among them are seven LULUCF sources: 4A Forest land CO_2, 4B Cropland CO_2, 4B Cropland N_2O, 4C Grassland CO_2, 4C Grassland CH_4, 4E Settlements CO_2 and 4F Other Land CO_2. Table A1.7 and A1.8 show the results of the inclusion of uncertainty data in the level and trend assessment respectively.

*Table A1.7 Source ranking using IPCC Approach 2 **level** assessment for 2023 emissions, including LULUCF (Gg CO_2-eq). Lines in **bold** represent the key sources.*

CRT category		Gas	Gg CO_2-eq 2023	Share %	Uncertainty estimate%	Level * uncertainty%	Share L*U%	Cum. Share L*U%
2B10	**Other**	**CO2**	**6738.9**	**5.0**	**28.9**	**1.4**	**9.0**	**9.0**
1A1b	**Petroleum Refining: liquids**	**CO2**	**9968.2**	**5.3**	**25.6**	**1.3**	**8.4**	**17.3**
3Da	**Direct emissions from agricultural soils**	**N2O**	**6347.6**	**2.5**	**36.2**	**0.9**	**5.5**	**22.9**
3Db	**Indirect emissions from managed soils**	**N2O**	**1436.4**	**0.3**	**216.4**	**0.7**	**4.5**	**27.4**
4B	**Cropland**	**CO2**	**3165.0**	**1.6**	**44.0**	**0.7**	**4.3**	**31.7**
4C	**Grassland**	**CO2**	**1733.3**	**0.9**	**75.0**	**0.7**	**4.1**	**35.8**
3A1	**Mature dairy cattle**	**CH4**	**5805.2**	**4.1**	**15.1**	**0.6**	**3.8**	**39.7**
3B5	**Indirect emissions**	**N2O**	**346.9**	**0.1**	**400.4**	**0.5**	**3.2**	**42.9**
4E	**Settlements**	**CO2**	**989.9**	**0.8**	**69.0**	**0.5**	**3.2**	**46.2**
1A1a	**Public Electricity and Heat Production: solids**	**CO2**	**25862.2**	**7.1**	**6.4**	**0.4**	**2.8**	**49.0**
1A2	**Manufacturing Industries and Construction: solids**	**CO2**	**6623.4**	**2.2**	**19.5**	**0.4**	**2.6**	**51.6**
3B1	**Mature dairy cattle**	**CH4**	**1212.7**	**1.1**	**38.1**	**0.4**	**2.6**	**54.2**
1A4b	**Residential gaseous**	**CO2**	**19894.1**	**7.5**	**5.0**	**0.4**	**2.3**	**56.5**
1A4c	**Agriculture/Forestry/Fisheries: all fuels**	**CH4**	**81.3**	**0.7**	**49.0**	**0.3**	**2.1**	**58.6**
1A1c	**Manufacture of Solid Fuels: solids**	**CO2**	**916.3**	**0.4**	**69.7**	**0.3**	**1.9**	**60.5**
5A	**Solid waste disposal**	**CH4**	**15320.8**	**1.3**	**23.7**	**0.3**	**1.9**	**62.4**
2B1	**Ammonia production**	**CO2**	**2695.0**	**1.3**	**21.2**	**0.3**	**1.7**	**64.1**

CRT category		Gas	Gg CO_2-eq 2023	Share %	Uncertainty estimate%	Level * uncertainty%	Share L*U%	Cum. Share L*U%
3B3	Swine	CH4	3772.8	1.0	24.4	0.3	1.6	65.7
2A4d	Other	CO2	481.2	0.3	76.6	0.3	1.6	67.3
1A2	Manufacturing Industries and Construction: gaseous	CO2	19044.2	7.9	3.0	0.2	1.5	68.8
1A3b	Road transportation: diesel oil	CO2	13008.5	8.2	2.8	0.2	1.4	70.2
1A3b	Road transportation: gasoline	CO2	10660.9	8.1	2.8	0.2	1.4	71.6
2B8	Petrochemical and carbon black production	CO2	335.6	0.3	70.7	0.2	1.4	73.1
4F	Other Land	CO2	122.8	0.1	152.0	0.2	1.4	74.5
1A4c	Agriculture/Forestry/Fisheries: gaseous	CO2	7328.7	3.7	5.0	0.2	1.2	75.6
4B	Cropland	N2O	83.7	0.0	400.0	0.2	1.1	76.7
2D2	Paraffin wax use	CO2	102.6	0.2	102.0	0.2	1.1	77.8
2B8	Chemical industry: Petrochemical and carbon black production	CH4	301.8	0.2	70.7	0.2	1.0	78.8
((4A	Forest Land	CO2	2241.3	1.4	12.0	0.2	1.0	79.9
1A4c	Agriculture/Forestry/Fisheries: liquids	CO2	2545.2	1.1	12.8	0.1	0.9	80.8
2B10	Other	N2O	219.4	0.2	70.0	0.1	0.8	81.6
3A1	Young cattle	CH4	3138.0	1.4	9.3	0.1	0.8	82.4
1A1a	Public Electricity and Heat Production: other fuels: waste incineration	CO2	601.5	1.7	7.4	0.1	0.8	83.1
3A3	Swine	CH4	584.4	0.3	40.5	0.1	0.8	83.9
1A2	Manufacturing Industries and Construction: liquids	CO2	3990.5	1.2	10.2	0.1	0.8	84.7
4C	Grassland	CH4	262.1	0.2	79.0	0.1	0.7	85.4
2F1	Refrigeration and airconditioning	HFC	0.0	0.3	38.5	0.1	0.7	86.1
1A4b	Residential:all fuels	CH4	503.7	0.2	57.1	0.1	0.7	86.8
5D	Wastewater treatment and discharge	N2O	541.1	0.3	30.0	0.1	0.6	87.5
1A4a	Commercial/Institutional: gaseous	CO2	7757.8	3.3	3.0	0.1	0.6	88.1
1A3b	Road transportation	N2O	89.5	0.2	50.0	0.1	0.6	88.7
2A2	Lime production	CO2	162.7	0.1	75.2	0.1	0.6	89.3
3A2, 3A4	Other	CH4	576.4	0.3	27.3	0.1	0.6	89.8

CRT category		Gas	Gg CO_2-eq 2023	Share %	Uncertainty estimate%	Level * uncertainty%	Share L*U%	Cum. Share L*U%
1B2b	Natural gas	CH4	596.8	0.2	37.8	0.1	0.6	90.4
1A4 excl 1A4c	Liquids	CO2	1546.0	0.4	22.4	0.1	0.6	90.9
1A1a	Public Electricity and Heat Production: gaseous	CO2	13329.1	8.5	1.0	0.1	0.5	91.5
6	Indirect CO2	CO2	917.2	0.3	26.9	0.1	0.5	92.0
3B1	Mature dairy cattle	N2O	169.1	0.1	68.2	0.1	0.5	92.4
1A1	Energy Industries: all fuels	N2O	131.8	0.1	51.2	0.1	0.4	92.9
5D	Wastewater treatment and discharge	CH4	421.3	0.1	41.7	0.1	0.4	93.2
3B1	Growing cattle	CH4	563.3	0.3	17.9	0.1	0.4	93.6
2F6	Other	HFC	0.0	0.1	53.9	0.1	0.3	93.9
4E	Settlements	N2O	21.9	0.0	400.0	0.1	0.3	94.2
2A4a	Ceramics	CO2	140.1	0.1	70.7	0.0	0.3	94.5
3B1	Growing cattle	N2O	130.2	0.1	61.2	0.0	0.3	94.8
1A1a	Public Electricity and Heat Production: liquids	CO2	233.2	0.2	22.5	0.0	0.3	95.1
2D1	Lubricant use	CO2	84.9	0.1	70.7	0.0	0.3	95.4
5B	Biological treatment of solid waste: composting	CH4	4.8	0.1	47.6	0.0	0.3	95.6
1A4	Other Sectors: all fuels	N2O	45.3	0.0	119.1	0.0	0.2	95.9
1B2c	Venting and flaring	CH4	1669.8	0.1	51.7	0.0	0.2	96.1
2A4b	Other uses of soda ash	CO2	68.6	0.1	50.0	0.0	0.2	96.3
1A1c	Manufacture of Solid Fuels: gaseous	CO2	1184.2	0.6	5.4	0.0	0.2	96.5
1B2	Fugitive emissions from oil and gas operations	CO2	774.7	0.6	5.2	0.0	0.2	96.7
1A3d	Domestic navigation	CO2	726.1	0.6	5.3	0.0	0.2	96.9
3B4	Other livestock	N2O	53.9	0.1	54.8	0.0	0.2	97.1
4F	Other Land	N2O	6.5	0.0	400.0	0.0	0.2	97.3
5B	Biological treatment of solid waste: composting	N2O	5.8	0.0	59.0	0.0	0.2	97.5
3B3	Swine	N2O	124.7	0.0	53.4	0.0	0.2	97.7
1A2	Manufacturing Industries and Construction: all fuels	N2O	32.0	0.0	94.0	0.0	0.1	97.8
2G2	SF6 use	SF6	213.1	0.1	33.5	0.0	0.1	98.0
2A3	Glass production	CO2	142.4	0.0	50.0	0.0	0.1	98.1

CRT category		Gas	Gg CO_2-eq 2023	Share %	Uncertainty estimate%	Level * uncertainty%	Share L*U%	Cum. Share L*U%
1A1	Energy Industries: all fuels	CH4	77.4	0.1	30.3	0.0	0.1	98.2
3B4	Poultry	CH4	543.8	0.1	40.1	0.0	0.1	98.4
1A3b	Road transportation	CH4	197.1	0.0	50.0	0.0	0.1	98.5
2G	Other product manufacture and use	CH4	57.8	0.0	50.0	0.0	0.1	98.6
3A1	Other mature cattle	CH4	235.4	0.1	20.9	0.0	0.1	98.7
1A4a	Commercial/Institutional: all fuels	CH4	52.3	0.0	37.8	0.0	0.1	98.8
1A2	Manufacturing Industries and Construction: all fuels	CH4	65.7	0.0	36.0	0.0	0.1	98.9
2B4	Caprolactam production	N2O	658.0	0.0	30.5	0.0	0.1	99.0
4D	Wetlands	CO2	19.7	0.0	76.0	0.0	0.1	99.0
1A3b	Road transportation: LPG	CO2	2740.4	0.2	5.4	0.0	0.1	99.1
3H	Ureum use	CO2	1.5	0.0	25.0	0.0	0.1	99.2
1A1b	Petroleum Refining: gaseous	CO2	1042.2	0.9	1.0	0.0	0.1	99.3
1A5b	Military use: liquids	CO2	314.0	0.1	6.1	0.0	0.1	99.3
3B2, 3B4	Other	CH4	37.8	0.0	46.7	0.0	0.1	99.4
1B2a	Oil	CH4	22.8	0.0	71.0	0.0	0.0	99.4
4B	Cropland	CH4	21.5	0.0	79.0	0.0	0.0	99.4
2B	Fluorochemical production	HFC	4697.2	0.1	12.1	0.0	0.0	99.5
1B1b	Solid fuel transformation	CO2	110.4	0.0	15.0	0.0	0.0	99.5
2D3	Other	CO2	0.0	0.0	26.9	0.0	0.0	99.6
2E	Electronic Industry	PFC	22.7	0.0	25.5	0.0	0.0	99.6
5C	Open burning of waste	CH4	4.2	0.0	316.2	0.0	0.0	99.6
4A	Forest Land	N2O	3.0	0.0	400.0	0.0	0.0	99.7
1A3 excl 1A3b	Other	N2O	6.1	0.0	132.1	0.0	0.0	99.7
2G	Other product manufacture and use	N2O	200.0	0.0	14.8	0.0	0.0	99.8
1A3b	Road transportation: gaseous	CO2	0.0	0.1	5.0	0.0	0.0	99.8
4D	Wetlands	N2O	1.9	0.0	400.0	0.0	0.0	99.8
3G	Liming	CO2	183.2	0.0	24.6	0.0	0.0	99.8
2B2	Nitric acid production	N2O	5410.9	0.0	7.8	0.0	0.0	99.9

CRT category		Gas	Gg CO_2-eq 2023	Share %	Uncertainty estimate%	Level * uncertainty%	Share L*U%	Cum. Share L*U%
5C	Open burning of waste	N2O	2.1	0.0	316.2	0.0	0.0	99.9
1A3 excl 1A3b	Other	CH4	2.7	0.0	50.1	0.0	0.0	99.9
1A5b	Military use: liquids	N2O	4.9	0.0	120.5	0.0	0.0	99.9
3B1	Other mature cattle	CH4	24.8	0.0	32.7	0.0	0.0	99.9
1A3a	Domestic aviation	CO2	84.2	0.0	9.4	0.0	0.0	99.9
4C	Grassland	N2O	0.8	0.0	400.0	0.0	0.0	99.9
4A	Forest Land	CH4	2.3	0.0	79.0	0.0	0.0	99.9
3B1	Other mature cattle	N2O	6.2	0.0	77.8	0.0	0.0	100.0
3B2	Sheep	N2O	6.4	0.0	112.0	0.0	0.0	100.0
1A3c	Railways	CO2	90.7	0.0	2.2	0.0	0.0	100.0
1A3e	Other	CO2	342.2	0.0	2.0	0.0	0.0	100.0
2H	Other industrial	CO2	72.5	0.0	5.4	0.0	0.0	100.0
4G	Harvested wood products	CO2	68.6	0.1	1.0	0.0	0.0	100.0
2B9	Fluorochemical production	PFC	0.0	0.0	20.0	0.0	0.0	100.0
1B1b	Solid fuel transformation	CH4	12.3	0.0	11.2	0.0	0.0	100.0
2C1	Iron and steel production	CO2	43.7	0.0	5.8	0.0	0.0	100.0
2D2	Paraffin wax use	CH4	0.2	0.0	111.8	0.0	0.0	100.0
1A5b	Military use: liquids	CH4	0.9	0.0	81.7	0.0	0.0	100.0
2G	Other product manufacture and use	CO2	0.2	0.0	53.9	0.0	0.0	100.0
1A4	Solids	CO2	162.7	0.0	50.2	0.0	0.0	100.0
2C3	Aluminium production	CO2	408.4	0.0	5.4	0.0	0.0	100.0
2A1	Cement production	CO2	415.8	0.0	11.0	0.0	0.0	100.0
2B7	Soda ash production	CO2	63.8	0.0	5.0	0.0	0.0	100.0
2C3	Aluminium production	PFC	2373.9	0.0	0.0	0.0	0.0	100.0
4H	Other	N2O	0.0	0.0	0.0	0.0	0.0	100.0
	SUM		150230					

Compared to the Approach 1 level key sources, 1A1a Public Electricity and Heat Production: gaseous (CO_2), with the highest share in the national total, is not at the top of the list when uncertainty estimates are included. As Table A1.7 shows, 3 smaller but more uncertain sources are among the top five level key sources:
2B10 Other CO2
1A1b Petroleum Refining: liquids CO2
3Da Direct emissions from agricultural soils N2O
The uncertainty in these emissions is estimated in the range of 25-60%, an order of magnitude higher than the 1% uncertainty for CO_2 from 1A1a Public Electricity and Heat Production: gaseous.

*Table A1.8 Source ranking using IPCC Approach 2 **trend** assessment for 2023 emissions compared to the base year, including LULUCF (Gg CO_2-eq). Lines in **bold** represent the key sources.*

CRT category		Gas	Gg CO_2-eq 1990	Gg CO_2-eq 2022	Trend assessment%	Uncertainty estimate %	Trend * uncertainty%	% Contr. to trend	Cumulative%
5A	**Solid waste disposal**	**CH4**	**15320.8**	**1909.5**	**8.2**	**23.7**	**195.2**	**16.0**	**16.0**
3Db	**Indirect emissions from managed soils**	**N2O**	**1436.4**	**502.6**	**0.4**	**216.4**	**95.2**	**7.8**	**23.7**
2B10	**Other**	**CO2**	**6738.9**	**7507.0**	**3.2**	**28.9**	**93.2**	**7.6**	**31.4**
1B2c	**Venting and flaring**	**CH4**	**1669.8**	**107.9**	**1.0**	**51.7**	**51.7**	**4.2**	**35.6**
1A4c	**Agriculture/Forestry/Fisheries: all fuels**	**CH4**	**81.3**	**1053.0**	**1.0**	**49.0**	**50.3**	**4.1**	**39.7**
1A1a	**Public Electricity and Heat Production: solids**	**CO2**	**25862.2**	**10625.5**	**6.3**	**6.4**	**40.0**	**3.3**	**43.0**
1A1b	**Petroleum Refining: liquids**	**CO2**	**9968.2**	**7916.4**	**1.5**	**25.6**	**38.3**	**3.1**	**46.1**
2B	**Fluorochemical production**	**HFC**	**4697.2**	**81.8**	**3.0**	**12.1**	**37.0**	**3.0**	**49.1**
3A1	**Mature dairy cattle**	**CH4**	**5805.2**	**6116.2**	**2.4**	**15.1**	**36.6**	**3.0**	**52.1**
4E	**Settlements**	**CO2**	**989.9**	**1136.8**	**0.5**	**69.0**	**35.1**	**2.9**	**55.0**
3B1	**Mature dairy cattle**	**CH4**	**1212.7**	**1641.4**	**0.9**	**38.1**	**33.5**	**2.7**	**57.7**
2B2	**Nitric acid production**	**N2O**	**5410.9**	**67.8**	**3.5**	**7.8**	**27.6**	**2.3**	**60.0**
4F	**Other Land**	**CO2**	**122.8**	**224.1**	**0.1**	**152.0**	**22.6**	**1.8**	**61.8**
3B3	**Swine**	**CH4**	**3772.8**	**1569.9**	**0.9**	**24.4**	**21.9**	**1.8**	**63.6**
1A2	**Manufacturing Industries and Construction: solids**	**CO2**	**6623.4**	**3265.8**	**1.1**	**19.5**	**20.6**	**1.7**	**65.3**
2D2	**Paraffin wax use**	**CO2**	**102.6**	**252.4**	**0.2**	**102.0**	**19.5**	**1.6**	**66.9**

CRT category		Gas	Gg CO_2-eq 1990	Gg CO_2-eq 2022	Trend assessment%	Uncertainty estimate %	Trend * uncertainty%	% Contr. to trend	Cumulative%
2B8	Petrochemical and carbon black production	CO2	335.6	484.6	0.3	70.7	19.4	1.6	68.5
2F1	Refrigeration and airconditioning	HFC	0.0	460.2	0.5	38.5	18.2	1.5	70.0
1A1a	Public Electricity and Heat Production: other fuels: waste incineration	CO2	601.5	2547.9	2.2	7.4	16.4	1.3	71.3
4C	Grassland	CO2	1733.3	1329.4	0.2	75.0	15.9	1.3	72.6
1A3b	Road transportation: gasoline	CO2	10660.9	12180.0	5.4	2.8	15.3	1.3	73.9
4B	Cropland	CO2	3165.0	2388.1	0.3	44.0	15.2	1.2	75.1
3Da	Direct emissions from agricultural soils	N2O	6347.6	3704.1	0.4	36.2	15.2	1.2	76.3
2A4d	Other	CO2	481.2	493.2	0.2	76.6	14.3	1.2	77.5
1A3b	Road transportation	N2O	89.5	293.4	0.2	50.0	12.1	1.0	78.5
3B5	Indirect emissions	N2O	346.9	196.3	0.0	400.4	11.7	1.0	79.5
2B8	Chemical industry: Petrochemical and carbon black production	CH4	301.8	354.1	0.2	70.7	11.5	0.9	80.4
1A3b	Road transportation: diesel oil	CO2	13008.5	12388.8	4.1	2.8	11.5	0.9	81.3
2B4	Caprolactam production	N2O	658.0	66.1	0.4	30.5	11.3	0.9	82.3
3B4	Poultry	CH4	543.8	81.2	0.3	40.1	11.2	0.9	83.2
2B10	Other	N2O	219.4	281.4	0.1	70.0	10.0	0.8	84.0
1A4 excl 1A4c	Liquids	CO2	1546.0	596.5	0.4	22.4	9.3	0.8	84.8
1A4b	Residential gaseous	CO2	19894.1	11208.6	1.7	5.0	8.7	0.7	85.5
1A2	Manufacturing Industries and Construction: liquids	CO2	3990.5	1786.3	0.8	10.2	8.4	0.7	86.1
2F6	Other	HFC	0.0	146.5	0.2	53.9	8.1	0.7	86.8
1A3b	Road transportation: LPG	CO2	2740.4	331.2	1.5	5.4	8.0	0.7	87.5
4A	Forest Land	CO2	2241.3	2070.8	0.6	12.0	7.6	0.6	88.1
5B	Biological treatment of solid waste: composting	CH4	4.8	135.3	0.1	47.6	6.5	0.5	88.6

CRT category		Gas	Gg CO_2-eq 1990	Gg CO_2-eq 2022	Trend assessment%	Uncertainty estimate %	Trend * uncertainty%	% Contr. to trend	Cumulative%
2A2	**Lime production**	**CO2**	**162.7**	**188.6**	**0.1**	**75.2**	**6.4**	**0.5**	**89.1**
1A1	**Energy Industries: all fuels**	**N2O**	**131.8**	**204.4**	**0.1**	**51.2**	**6.3**	**0.5**	**89.7**
1A4	Solids	CO2	162.7	0.2	0.1	50.2	5.4	0.4	90.1
4B	Cropland	N2O	83.7	67.0	0.0	400.0	5.3	0.4	90.5
2B1	Ammonia production	CO2	2695.0	1979.0	0.2	21.2	5.1	0.4	90.9
1A1c	Manufacture of Solid Fuels: solids	CO2	916.3	664.3	0.1	69.7	5.1	0.4	91.4
5D	Wastewater treatment and discharge	N2O	541.1	507.8	0.2	30.0	4.8	0.4	91.7
4C	Grassland	CH4	262.1	226.5	0.1	79.0	4.6	0.4	92.1
6	Indirect CO2	CO2	917.2	432.7	0.2	26.9	4.5	0.4	92.5
1A4c	Agriculture/Forestry/Fisheries: gaseous	CO2	7328.7	5606.9	0.9	5.0	4.4	0.4	92.8
1A1a	Public Electricity and Heat Production: gaseous	CO2	13329.1	12725.3	4.2	1.0	4.3	0.4	93.2
5B	Biological treatment of solid waste: composting	N2O	5.8	73.6	0.1	59.0	4.2	0.3	93.5
3B1	Mature dairy cattle	N2O	169.1	163.6	0.1	68.2	3.8	0.3	93.9
3A2, 3A4	Other	CH4	576.4	500.8	0.1	27.3	3.6	0.3	94.1
1A3b	Road transportation	CH4	197.1	58.9	0.1	50.0	3.5	0.3	94.4
1A1a	Public Electricity and Heat Production: liquids	CO2	233.2	302.8	0.2	22.5	3.5	0.3	94.7
3A3	Swine	CH4	584.4	452.3	0.1	40.5	3.1	0.3	95.0
2A1	Cement production	CO2	415.8	0.0	0.3	11.0	3.0	0.2	95.2
2A4b	Other uses of soda ash	CO2	68.6	102.9	0.1	50.0	3.0	0.2	95.5
3B4	Other livestock	N2O	53.9	87.2	0.1	54.8	2.9	0.2	95.7
4F	Other Land	N2O	6.5	11.2	0.0	400.0	2.9	0.2	95.9
2D1	Lubricant use	CO2	84.9	92.2	0.0	70.7	2.7	0.2	96.2
1A4	Other Sectors: all fuels	N2O	45.3	50.1	0.0	119.1	2.5	0.2	96.4
5D	Wastewater treatment and discharge	CH4	421.3	213.7	0.1	41.7	2.5	0.2	96.6
1B2	Fugitive emissions from oil and gas operations	CO2	774.7	972.9	0.5	5.2	2.5	0.2	96.8
1A3d	Domestic navigation	CO2	726.1	914.9	0.5	5.3	2.4	0.2	97.0

CRT category		Gas	Gg CO_2-eq 1990	Gg CO_2-eq 2022	Trend assessment%	Uncertainty estimate %	Trend * uncertainty%	% Contr. to trend	Cumulative%
3G	Liming	CO2	183.2	25.1	0.1	24.6	2.4	0.2	97.2
3B1	Growing cattle	N2O	130.2	119.3	0.0	61.2	2.2	0.2	97.4
3B1	Growing cattle	CH4	563.3	472.5	0.1	17.9	2.0	0.2	97.5
4E	Settlements	N2O	21.9	18.8	0.0	400.0	1.9	0.2	97.7
1A1	Energy Industries: all fuels	CH4	77.4	109.0	0.1	30.3	1.8	0.1	97.8
3H	Ureum use	CO2	1.5	68.1	0.1	25.0	1.7	0.1	98.0
1A2	Manufacturing Industries and Construction: all fuels	N2O	32.0	38.5	0.0	94.0	1.7	0.1	98.1
1A4b	Residential:all fuels	CH4	503.7	299.7	0.0	57.1	1.6	0.1	98.2
2C3	Aluminium production	CO2	408.4	0.0	0.3	5.4	1.5	0.1	98.4
1A2	Manufacturing Industries and Construction: gaseous	CO2	19044.2	11934.1	0.4	3.0	1.3	0.1	98.5
2A3	Glass production	CO2	142.4	67.9	0.0	50.0	1.3	0.1	98.6
1B2b	Natural gas	CH4	596.8	356.8	0.0	37.8	1.2	0.1	98.7
2G2	SF6 use	SF6	213.1	105.3	0.0	33.5	1.1	0.1	98.7
2G	Other product manufacture and use	N2O	200.0	56.0	0.1	14.8	1.1	0.1	98.8
1A4a	Commercial/Institutional: all fuels	CH4	52.3	59.8	0.0	37.8	1.0	0.1	98.9
2D3	Other	CO2	0.0	36.1	0.0	26.9	1.0	0.1	99.0
2A4a	Ceramics	CO2	140.1	104.3	0.0	70.7	1.0	0.1	99.1
1A1c	Manufacture of Solid Fuels: gaseous	CO2	1184.2	944.9	0.2	5.4	1.0	0.1	99.2
4D	Wetlands	CO2	19.7	24.0	0.0	76.0	0.9	0.1	99.2
1A4c	Agriculture/Forestry/Fisheries: liquids	CO2	2545.2	1707.5	0.1	12.8	0.8	0.1	99.3
3A1	Other mature cattle	CH4	235.4	117.6	0.0	20.9	0.7	0.1	99.4
1A1b	Petroleum Refining: gaseous	CO2	1042.2	1375.1	0.7	1.0	0.7	0.1	99.4
1A3b	Road transportation: gaseous	CO2	0.0	138.3	0.1	5.0	0.7	0.1	99.5
1A2	Manufacturing Industries and Construction: all fuels	CH4	65.7	61.4	0.0	36.0	0.7	0.1	99.5
2G	Other product manufacture and use	CH4	57.8	50.4	0.0	50.0	0.7	0.1	99.6
2E	Electronic Industry	PFC	22.7	36.6	0.0	25.5	0.6	0.0	99.6

CRT category		Gas	Gg CO_2-eq 1990	Gg CO_2-eq 2022	Trend assessment%	Uncertainty estimate %	Trend * uncertainty%	% Contr. to trend	Cumulative%
3B3	Swine	N2O	124.7	73.7	0.0	53.4	0.4	0.0	99.7
1A3 excl 1A3b	Other	N2O	6.1	6.8	0.0	132.1	0.4	0.0	99.7
1A3 excl 1A3b	Other	CH4	2.7	8.3	0.0	50.1	0.3	0.0	99.7
3B2	Sheep	N2O	6.4	1.4	0.0	112.0	0.3	0.0	99.8
1A3e	Other	CO2	342.2	73.1	0.2	2.0	0.3	0.0	99.8
1A3a	Domestic aviation	CO2	84.2	29.1	0.0	9.4	0.2	0.0	99.8
3B1	Other mature cattle	CH4	24.8	8.9	0.0	32.7	0.2	0.0	99.8
1A4a	Commercial/Institutional: gaseous	CO2	7757.8	4948.8	0.1	3.0	0.2	0.0	99.8
2B7	Soda ash production	CO2	63.8	0.0	0.0	5.0	0.2	0.0	99.9
3A1	Young cattle	CH4	3138.0	2050.6	0.0	9.3	0.2	0.0	99.9
1A5b	Military use: liquids	CO2	314.0	224.3	0.0	6.1	0.1	0.0	99.9
4D	Wetlands	N2O	1.9	1.6	0.0	400.0	0.1	0.0	99.9
3B1	Other mature cattle	N2O	6.2	2.4	0.0	77.8	0.1	0.0	99.9
4A	Forest Land	N2O	3.0	2.3	0.0	400.0	0.1	0.0	99.9
2C1	Iron and steel production	CO2	43.7	8.5	0.0	5.8	0.1	0.0	99.9
2H	Other industrial	CO2	72.5	26.8	0.0	5.4	0.1	0.0	99.9
4B	Cropland	CH4	21.5	12.6	0.0	79.0	0.1	0.0	99.9
2B9	Fluorochemical production	PFC	0.0	5.3	0.0	20.0	0.1	0.0	99.9
1B1b	Solid fuel transformation	CO2	110.4	65.9	0.0	15.0	0.1	0.0	100.0
4G	Harvested wood products	CO2	68.6	124.5	0.1	1.0	0.1	0.0	100.0
3B2, 3B4	Other	CH4	37.8	26.0	0.0	46.7	0.1	0.0	100.0
4A	Forest Land	CH4	2.3	2.4	0.0	79.0	0.1	0.0	100.0
5C	Open burning of waste	N2O	2.1	1.6	0.0	316.2	0.1	0.0	100.0
1B2a	Oil	CH4	22.8	15.5	0.0	71.0	0.1	0.0	100.0
5C	Open burning of waste	CH4	4.2	2.9	0.0	316.2	0.0	0.0	100.0

CRT category		Gas	Gg CO_2-eq 1990	Gg CO_2-eq 2022	Trend assessment%	Uncertainty estimate %	Trend * uncertainty%	% Contr. to trend	Cumulative%
4C	Grassland	N2O	0.8	0.6	0.0	400.0	0.0	0.0	100.0
2D2	Paraffin wax use	CH4	0.2	0.4	0.0	111.8	0.0	0.0	100.0
1B1b	Solid fuel transformation	CH4	12.3	4.9	0.0	11.2	0.0	0.0	100.0
2G	Other product manufacture and use	CO2	0.2	0.6	0.0	53.9	0.0	0.0	100.0
1A3c	Railways	CO2	90.7	67.6	0.0	2.2	0.0	0.0	100.0
1A5b	Military use: liquids	N2O	4.9	3.2	0.0	120.5	0.0	0.0	100.0
2C3	Aluminium production	PFC	2373.9	0.0	1.6	0.0	0.0	0.0	100.0
1A5b	Military use: liquids	CH4	0.9	0.6	0.0	81.7	0.0	0.0	100.0
4H	Other	N2O	0.0	0.0	0.0	0.0	0.0	0.0	100.0
	Total		231848	150231					

Annex 2 Uncertainty assessment

A2.1 Description of methodology used for estimating uncertainty

In this NIR an Approach 2 assessment has been performed to estimate the uncertainty in total national GHG emissions and emissions trends. The assessment is carried out through error propagation (IPCC Guidelines 2006). Total uncertainty per CRT category is derived from uncertainties in both emission factors (EF) and activity data (AD). Details of the uncertainty analysis can be found in the methodology reports (RIVM reports 2024-0014, 2024-0015, 2024-0016 and 2024-0023 and Van Baren et al. (2024)). Results of this analysis for both level and trend are presented in table A2.1.

Uncertainties for the activity data and EFs are derived from a mixture of empirical data and expert judgement and are presented here as half the 95% confidence interval. The reason for halving the 95% confidence interval is that the value then corresponds to the familiar plus or minus value when uncertainties are loosely quoted as 'plus or minus x%'. Since 2012, all data on uncertainty for each source have been included in the PRTR database. At the start of the NIR compilation, the Task Forces are asked to submit new uncertainty information, which is included in the annual key category analysist of the NIR.

Table A2.1 Level and trend uncertainty estimates (based on error propagation) related to 2023 emissions (trend: 1990 – 2023)

	Uncertainty in emissions level	**Uncertainty in emissions trend**
CO_2	±3%	±1% of 28% decrease
CH_4	±8%	±5% of 50% decrease
N_2O	±30%	±5% of 59% decrease
F-gases	±24%	±3% of 89% decrease
Total	±3%	±1% of 36% decrease

Details of the Approach 2 calculation can be found in Table A2.3. It should be stressed that most uncertainty estimates in Table A2.3 are ultimately based on collective expert judgement and are therefore themselves rather uncertain (usually in the order of 50%). Nevertheless, these estimates help to identify the most important uncertainty sources. For this purpose, a reasonable order-of-magnitude estimate of the uncertainty in activity data and in EFs is usually sufficient. Uncertainty estimates are a means of identifying and prioritizing inventory improvement activities, rather than an objective in themselves.

Part of the uncertainty is due to an inherent lack of knowledge concerning the sources. Another part, however, can be attributed to elements of the inventory whose uncertainty could be reduced over time by dedicated research initiated by either the NIE or other researchers. Table A2.2 ranks the ten sources contributing most to the *trend* uncertainty in the national total emissions including LULUCF in 2023 (based on the Approach 1).

Table A2.2 Ten sources contributing most to trend uncertainty in the national total in 2023 emissions (uncertainty assessment based on error propagation)

CRT cat.	**Category**	**Gas**	**Uncertainty introduced into the trend in total national emissions (%)**
5A	Solid waste disposal	CH_4	16.0
3Db	Indirect emissions from managed soils	N_2O	7.8
2B10	Other	CO_2	7.6
1B2c	Venting and flaring	CH_4	4.2
1A4c	Agriculture/Forestry/Fisheries: all fuels	CH_4	4.1
1A1a	Public Electricity and Heat Production: solids	CO_2	3.3
1A1b	Petroleum Refining: liquids	CO_2	3.1
2B	Fluorochemical production	HFC	3.0
3A1	Mature dairy cattle	CH_4	3.0
4E	Settlements	CO_2	2.9

Table A2.3 Detailed level and trend uncertainty assessment 1990–2023 with the categories of the IPCC potential key source list (without adjustment for correlation sources), including LULUCF. Ranked in order of their contribution to the variance in 2023

CRT category		Gas	CO_2-eq base year (Gg)	CO_2-eq last year (Gg)	AD uncertainty %	AD uncertainty %	EF Uncertainty estimate %	EF Uncertainty estimate %	Combined Uncertainty estimate %	Combined Uncertainty estimate %	Contribution to variance in last year	Inventory trend in national emissions compared to base year %	Uncertainty introduced into the trend in total national emissions %
					(-)	(+)	(-)	(+)	(-)	(+)		(% BY)	*(-) and (+)*
2B10	Other	CO2	6738.9	7507.0	9	9	27	27	29	29	0.23	11	7.6
1A1b	Petroleum Refining: liquids	CO2	9968.2	7916.4	5	5	25	25	26	26	0.20	-21	3.1
3Da	Direct emissions from agricultural soils	N2O	6347.6	3704.1	8	8	35	35	36	36	0.09	-42	1.2
3Db	Indirect emissions from managed soils	N2O	1436.4	502.6	33	33	214	214	216	216	0.06	-65	7.8
4B	Cropland	CO2	3165.0	2388.1	0	0	44	44	44	44	0.05	-25	1.2
4C	Grassland	CO2	1733.3	1329.4	0	0	75	75	75	75	0.05	-23	1.3
3A1	Mature dairy cattle	CH4	5805.2	6116.2	2	2	15	15	15	15	0.04	5	3.0
3B5	Indirect emissions	N2O	346.9	196.3	18	18	400	400	400	400	0.03	-43	1.0
4E	Settlements	CO2	989.9	1136.8	0	0	69	69	69	69	0.03	15	2.9
1A1a	Public Electricity and Heat Production: solids	CO2	25862.2	10625.5	1	1	6	6	6	6	0.02	-59	3.3
1A2	Manufacturing Industries and Construction: solids	CO2	6623.4	3265.8	2	2	19	19	20	20	0.02	-51	1.7
3B1	Mature dairy cattle	CH4	1212.7	1641.4	2	2	38	38	38	38	0.02	35	2.7
1A4b	Residential gaseous	CO2	19894.1	11208.6	5	5	0	0	5	5	0.02	-44	0.7
1A4c	Agriculture/Forestry/Fisheries: all fuels	CH4	81.3	1053.0	5	5	49	49	49	49	0.01	1196	4.1
1A1c	Manufacture of Solid Fuels: solids	CO2	916.3	664.3	26	26	64	64	70	70	0.01	-28	0.4
5A	Solid waste disposal	CH4	15320.8	1909.5	0	0	24	24	24	24	0.01	-88	16.0
2B1	Ammonia production	CO2	2695.0	1979.0	4	4	21	21	21	21	0.01	-27	0.4

CRT category		Gas	CO_2-eq base year (Gg)	CO_2-eq last year (Gg)	AD uncertainty %	AD uncertainty %	EF Uncertainty estimate %	EF Uncertainty estimate %	Combined Uncertainty estimate %	Combined Uncertainty estimate %	Contribution to variance in last year	Inventory trend in national emissions compared to base year %	Uncertainty introduced into the trend in total national emissions %
3B3	Swine	CH4	3772.8	1569.9	9	9	23	23	24	24	0.01	-58	1.8
2A4d	Other	CO2	481.2	493.2	33	33	69	69	77	77	0.01	3	1.2
1A2	Manufacturing Industries and Construction: gaseous	CO2	19044.2	11934.1	3	3	0	0	3	3	0.01	-37	0.1
1A3b	Road transportation: diesel oil	CO2	13008.5	12388.8	2	2	2	2	3	3	0.01	-5	0.9
1A3b	Road transportation: gasoline	CO2	10660.9	12180.0	2	2	2	2	3	3	0.01	14	1.3
2B8	Petrochemical and carbon black production	CO2	335.6	484.6	50	50	50	50	71	71	0.01	44	1.6
4F	Other Land	CO2	122.8	224.1	0	0	152	152	152	152	0.01	82	1.8
1A4c	Agriculture/Forestry/Fisheries: gaseous	CO2	7328.7	5606.9	5	5	0	0	5	5	0.00	-23	0.4
4B	Cropland	N2O	83.7	67.0	0	0	400	400	400	400	0.00	-20	0.4
2D2	Paraffin wax use	CO2	102.6	252.4	100	100	20	20	102	102	0.00	146	1.6
2B8	Chemical industry: Petrochemical and carbon black production	CH4	301.8	354.1	50	50	50	50	71	71	0.00	17	0.9
4A	Forest Land	CO2	-2241.3	-2070.8	0	0	12	12	12	12	0.00	-8	0.6
1A4c	Agriculture/Forestry/Fisheries: liquids	CO2	2545.2	1707.5	13	13	2	2	13	13	0.00	-33	0.1
2B10	Other	N2O	219.4	281.4	49	49	49	49	70	70	0.00	28	0.8
3A1	Young cattle	CH4	3138.0	2050.6	1	1	9	9	9	9	0.00	-35	0.0
1A1a	Public Electricity and Heat Production: other fuels: waste incineration	CO2	601.5	2547.9	4	4	6	6	7	7	0.00	324	1.3
3A3	Swine	CH4	584.4	452.3	6	6	40	40	41	41	0.00	-23	0.3

CRT category		Gas	CO$_2$-eq base year (Gg)	CO$_2$-eq last year (Gg)	AD uncertainty %	AD uncertainty %	EF Uncertainty estimate %	EF Uncertainty estimate %	Combined Uncertainty estimate %	Combined Uncertainty estimate %	Contribution to variance in last year	Inventory trend in national emissions compared to base year %	Uncertainty introduced into the trend in total national emissions %
1A2	Manufacturing Industries and Construction: liquids	CO2	3990.5	1786.3	10	10	2	2	10	10	0.00	-55	0.7
4C	Grassland	CH4	262.1	226.5	0	0	79	79	79	79	0.00	-14	0.4
2F1	Refrigeration and airconditioning	HFC	0.0	460.2	14	14	36	36	38	38	0.00	460237505	1.5
1A4b	Residential:all fuels	CH4	503.7	299.7	10	10	56	56	57	57	0.00	-40	0.1
5D	Wastewater treatment and discharge	N2O	541.1	507.8	26	26	15	15	30	30	0.00	-6	0.4
1A4a	Commercial/Institutional: gaseous	CO2	7757.8	4948.8	3	3	0	0	3	3	0.00	-36	0.0
1A3b	Road transportation	N2O	89.5	293.4	1	1	50	50	50	50	0.00	228	1.0
2A2	Lime production	CO2	162.7	188.6	75	75	5	5	75	75	0.00	16	0.5
3A2. 3A4	Other	CH4	576.4	500.8	17	17	21	21	27	27	0.00	-13	0.3
1B2b	Natural gas	CH4	596.8	356.8	1	1	38	38	38	38	0.00	-40	0.1
1A4 excl 1A4c	Liquids	CO2	1546.0	596.5	22	22	1	1	22	22	0.00	-61	0.8
1A1a	Public Electricity and Heat Production: gaseous	CO2	13329.1	12725.3	1	1	0	0	1	1	0.00	-5	0.4
6	Indirect CO2	CO2	917.2	432.7	25	25	10	10	27	27	0.00	-53	0.4
3B1	Mature dairy cattle	N2O	169.1	163.6	2	2	68	68	68	68	0.00	-3	0.3
1A1	Energy Industries: all fuels	N2O	131.8	204.4	1	1	51	51	51	51	0.00	55	0.5
5D	Wastewater treatment and discharge	CH4	421.3	213.7	13	13	40	40	42	42	0.00	-49	0.2
3B1	Growing cattle	CH4	563.3	472.5	1	1	18	18	18	18	0.00	-16	0.2
2F6	Other	HFC	0.0	146.5	20	20	50	50	54	54	0.00	146459714	0.7
4E	Settlements	N2O	21.9	18.8	0	0	400	400	400	400	0.00	-14	0.2

CRT category		Gas	CO_2-eq base year (Gg)	CO_2-eq last year (Gg)	AD uncertainty %	AD uncertainty %	EF Uncertainty estimate %	EF Uncertainty estimate %	Combined Uncertainty estimate %	Combined Uncertainty estimate %	Contribution to variance in last year	Inventory trend in national emissions compared to base year %	Uncertainty introduced into the trend in total national emissions %
2A4a	Ceramics	CO2	140.1	104.3	50	50	50	50	71	71	0.00	-26	0.1
3B1	Growing cattle	N2O	130.2	119.3	23	23	57	57	61	61	0.00	-8	0.2
1A1a	Public Electricity and Heat Production: liquids	CO2	233.2	302.8	4	4	22	22	22	22	0.00	30	0.3
2D1	Lubricant use	CO2	84.9	92.2	50	50	50	50	71	71	0.00	9	0.2
5B	Biological treatment of solid waste: composting	CH4	4.8	135.3	12	12	46	46	48	48	0.00	2726	0.5
1A4	Other Sectors: all fuels	N2O	45.3	50.1	12	12	119	119	119	119	0.00	11	0.2
1B2c	Venting and flaring	CH4	1669.8	107.9	48	48	19	19	52	52	0.00	-94	4.2
2A4b	Other uses of soda ash	CO2	68.6	102.9	0	0	50	50	50	50	0.00	50	0.2
1A1c	Manufacture of Solid Fuels: gaseous	CO2	1184.2	944.9	2	2	5	5	5	5	0.00	-20	0.1
1B2	Fugitive emissions from oil and gas operations	CO2	774.7	972.9	2	2	5	5	5	5	0.00	26	0.2
1A3d	Domestic navigation	CO2	726.1	914.9	5	5	2	2	5	5	0.00	26	0.2
3B4	Other livestock	N2O	53.9	87.2	13	13	53	53	55	55	0.00	62	0.2
4F	Other Land	N2O	6.5	11.2	0	0	400	400	400	400	0.00	73	0.2
5B	Biological treatment of solid waste: composting	N2O	5.8	73.6	10	10	58	58	59	59	0.00	1170	0.3
3B3	Swine	N2O	124.7	73.7	19	19	50	50	53	53	0.00	-41	0.0
1A2	Manufacturing Industries and Construction: all fuels	N2O	32.0	38.5	5	5	94	94	94	94	0.00	20	0.1
2G2	SF6 use	SF6	213.1	105.3	30	30	15	15	34	34	0.00	-51	0.1
2A3	Glass production	CO2	142.4	67.9	0	0	50	50	50	50	0.00	-52	0.1
1A1	Energy Industries: all fuels	CH4	77.4	109.0	2	2	30	30	30	30	0.00	41	0.1
3B4	Poultry	CH4	543.8	81.2	2	2	40	40	40	40	0.00	-85	0.9
1A3b	Road transportation	CH4	197.1	58.9	1	1	50	50	50	50	0.00	-70	0.3

CRT category		Gas	CO_2-eq base year (Gg)	CO_2-eq last year (Gg)	AD uncertainty %	AD uncertainty %	EF Uncertainty estimate %	EF Uncertainty estimate %	Combined Uncertainty estimate %	Combined Uncertainty estimate %	Contribution to variance in last year	Inventory trend in national emissions compared to base year %	Uncertainty introduced into the trend in total national emissions %
2G	Other product manufacture and use	CH4	57.8	50.4	10	10	49	49	50	50	0.00	-13	0.1
3A1	Other mature cattle	CH4	235.4	117.6	2	2	21	21	21	21	0.00	-50	0.1
1A4a	Commercial/Institutional: all fuels	CH4	52.3	59.8	17	17	34	34	38	38	0.00	14	0.1
1A2	Manufacturing Industries and Construction: all fuels	CH4	65.7	61.4	3	3	36	36	36	36	0.00	-7	0.1
2B4	Caprolactam production	N2O	658.0	66.1	20	20	23	23	30	30	0.00	-90	0.9
4D	Wetlands	CO2	19.7	-24.0	0	0	76	76	76	76	0.00	-222	0.1
1A3b	Road transportation: LPG	CO2	2740.4	331.2	5	5	2	2	5	5	0.00	-88	0.7
3H	Ureum use	CO2	1.5	68.1	25	25	1	1	25	25	0.00	4393	0.1
1A1b	Petroleum Refining: gaseous	CO2	1042.2	1375.1	1	1	0	0	1	1	0.00	32	0.1
1A5b	Military use: liquids	CO2	314.0	224.3	6	6	2	2	6	6	0.00	-29	0.0
3B2. 3B4	Other	CH4	37.8	26.0	27	27	38	38	47	47	0.00	-31	0.0
1B2a	Oil	CH4	22.8	15.5	2	2	71	71	71	71	0.00	-32	0.0
4B	Cropland	CH4	21.5	12.6	0	0	79	79	79	79	0.00	-42	0.0
2B	Fluorochemical production	HFC	4697.2	81.8	0	0	12	12	12	12	0.00	-98	3.0
1B1b	Solid fuel transformation	CO2	110.4	65.9	0	0	15	15	15	15	0.00	-40	0.0
2D3	Other	CO2	0.0	36.1	25	25	10	10	27	27	0.00	36128578	0.1
2E	Electronic Industry	PFC	22.7	36.6	5	5	25	25	25	25	0.00	61	0.0
5C	Open burning of waste	CH4	4.2	2.9	100	100	300	300	316	316	0.00	-32	0.0
4A	Forest Land	N2O	3.0	2.3	0	0	400	400	400	400	0.00	-25	0.0
1A3 excl 1A3b	Other	N2O	6.1	6.8	8	8	132	132	132	132	0.00	12	0.0
2G	Other product manufacture and use	N2O	200.0	56.0	10	10	10	10	15	15	0.00	-72	0.1

CRT category		Gas	CO_2-eq base year (Gg)	CO_2-eq last year (Gg)	AD uncertainty %	AD uncertainty %	EF Uncertainty estimate %	EF Uncertainty estimate %	Combined Uncertainty estimate %	Combined Uncertainty estimate %	Contribution to variance in last year	Inventory trend in national emissions compared to base year %	Uncertainty introduced into the trend in total national emissions %
1A3b	Road transportation: gaseous	CO2	0.0	138.3	5	5	0	0	5	5	0.00	138313133	0.1
4D	Wetlands	N2O	1.9	1.6	0	0	400	400	400	400	0.00	-19	0.0
3G	Liming	CO2	183.2	25.1	25	25	1	1	25	25	0.00	-86	0.2
2B2	Nitric acid production	N2O	5410.9	67.8	5	5	6	6	8	8	0.00	-99	2.3
5C	Open burning of waste	N2O	2.1	1.6	100	100	300	300	316	316	0.00	-24	0.0
1A3 excl 1A3b	Other	CH4	2.7	8.3	11	11	49	49	50	50	0.00	211	0.0
1A5b	Military use: liquids	N2O	4.9	3.2	8	8	120	120	121	121	0.00	-36	0.0
3B1	Other mature cattle	CH4	24.8	8.9	2	2	33	33	33	33	0.00	-64	0.0
1A3a	Domestic aviation	CO2	84.2	29.1	9	9	3	3	9	9	0.00	-65	0.0
4C	Grassland	N2O	0.8	0.6	0	0	400	400	400	400	0.00	-21	0.0
4A	Forest Land	CH4	2.3	2.4	0	0	79	79	79	79	0.00	4	0.0
3B1	Other mature cattle	N2O	6.2	2.4	2	2	78	78	78	78	0.00	-62	0.0
3B2	Sheep	N2O	6.4	1.4	5	5	112	112	112	112	0.00	-78	0.0
1A3c	Railways	CO2	90.7	67.6	1	1	2	2	2	2	0.00	-25	0.0
1A3e	Other	CO2	342.2	73.1	2	2	0	0	2	2	0.00	-79	0.0
2H	Other industrial	CO2	72.5	26.8	2	2	5	5	5	5	0.00	-63	0.0
4G	Harvested wood products	CO2	-68.6	124.5	0	0	1	1	1	1	0.00	-282	0.0
2B9	Fluorochemical production	PFC	0.0	5.3	0	0	20	20	20	20	0.00	5313068	0.0
1B1b	Solid fuel transformation	CH4	12.3	4.9	2	2	11	11	11	11	0.00	-60	0.0
2C1	Iron and steel production	CO2	43.7	8.5	3	3	5	5	6	6	0.00	-80	0.0
2D2	Paraffin wax use	CH4	0.2	0.4	100	100	50	50	112	112	0.00	146	0.0
1A5b	Military use: liquids	CH4	0.9	0.6	8	8	81	81	82	82	0.00	-37	0.0
2G	Other product manufacture and use	CO2	0.2	0.6	50	50	20	20	54	54	0.00	230	0.0
1A4	Solids	CO2	162.7	0.2	50	50	5	5	50	50	0.00	-100	0.4

CRT category		Gas	CO_2-eq base year (Gg)	CO_2-eq last year (Gg)	AD uncertainty %	AD uncertainty %	EF Uncertainty estimate %	EF Uncertainty estimate %	Combined Uncertainty estimate %	Combined Uncertainty estimate %	Contribution to variance in last year	Inventory trend in national emissions compared to base year %	Uncertainty introduced into the trend in total national emissions %
2C3	Aluminium production	CO2	408.4	0.0	2	2	5	5	5	5	0.00	-100	0.1
2A1	Cement production	CO2	415.8	0.0	5	5	10	10	11	11	0.00	-100	0.2
2B7	Soda ash production	CO2	63.8	0.0	0	0	5	5	5	5	0.00	-100	0.0
2C3	Aluminium production	PFC	2373.9	0.0	0	0	0	0	0	0	0.00	-100	0.0
4H	Other	N2O	0.0	0.0	0	0	0	0	0	0	0.00	0	0.0

A2.2 Uncertainties 1990 emissions

Since the late nineties, the Netherlands has set up a programme for improving the quality of the greenhouse gas inventory, motivated by the requirements of the Kyoto Protocol. At the start of this programme, a workshop was held involving all the experts engaged in the inventory programme; at that time still under the lead of the Ministry of Housing, Spatial Planning and the Environment (VROM). The results of this workshop are reported in Van Amstel et al (2000). As far as can be recollected at this time, this was the first systematic attempt to assess the uncertainties of greenhouse gas emissions in the Netherlands. Table A2.5 shows the assessment of the uncertainties in the respective gases at that time, which is based on expert judgement. To enable a comparison with the current Approach 2 analysis, the emissions per source category in 1990 combined with uncertainty insights per source category following the current procedure are added in a separate column.

Table A2.5 Uncertainties Greenhouse Gas emissions in 1990 (Approach 1)

Gas	activity	Emission level base year (Gg)	Uncertainty 1990 (%) 2000	Uncertainty 1990 (%) 2025(1)
CO_2	Energy (sector1)	150.9	2	
	Industrial Processes and Product Use (IPPU, sector2)	12.0	25	
	(Land Use, sector 4)	3.7	(60)	
subtotal		**166.6**	**3**	**2.3**
CH_4	Energy (sector1)	3.7	25	
	Agriculture (sector 3)	16.5	25	
	Waste (sector 5)	15.8	30	
subtotal		**36**	**17**	**4**
N_2O	Energy (sector1)	0.3	75	
	IPPU (sector 2)	6.5	35	
	Agriculture (sector 3)	8.6	75	
subtotal		**15.4**	**34**	**12**
HFC/SF_6	Energy (sector1)	0	50	
	IPPU (sector 2)	0.2	50	
subtotal		**0.2**	**41**	**3**
PFC	IPPU (sector 2)	2.4	100	
subtotal		**2.4**	**100**	**3(2)**
Other sectors	Other (sector 6)	0	50	
Total emissions		**227.2**	**4.4**	**2**

(1) uncertainty 1990 assessed with 2025 methodology
(2) total F-gases

Note that the assessment of uncertainties for 1990 is based on a first order expert judgement, whereas uncertainties nowadays result from a more systematic approach; looking more in depth to the uncertainties on a source category level.

Table A2.5 shows that overall uncertainty for the 1990 emissions is (much) smaller in the 2025 calculation.

Annex 3 Detailed methodological descriptions of individual sources or sink categories

A detailed description of methodologies per source/sink category, including a list of country-specific EFs, can be found in the relevant methodology reports on the website http://english.rvo.nl/nie.

These methodology reports are also integral part of this submission (see Annex 7).

Annex 4 CO_2: the national energy balance for the most recent inventory year

The national energy balance for 2023 in the Netherlands (as used for this submission) can be found on the following pages.

The national energy balance for other years is available online at:
StatLine - Energy balance sheet; supply, transformation and consumption (cbs.nl)

Please note that because of the size, the table underneath has been split up in 2 parts.

Energy Balance the Netherlands 2023, part 1-2

Energy balance sheet the Netherlands 2023	Anthracite	Coking coal	Steam coal	Lignite	Coke-oven cokes	BKB (Braunkohlenbriketts)	Patent fuel	Coal tar	Gas works gas	Coke oven gas	Blast furnace gas	Crude oil	Natural gas liquids	Additives	Other hydrocarbons	Residual gas	Lpg
Energy supply																	
Total Primary Energy Supply (TPES)	0.1	99.2	71.6	0.3	-10.7			-2.3				2349.5	343.5	25.4		11.0	58.8
Indigenous production												13.6	3.8	10.7		11.0	
Imports	0.1	104.3	70.3	0.3	1.0							4151.1	352.5	49.6			154.6
Exports					11.6			2.3				1854.8	14.7	41.0			95.0
Bunkers																	
Stock change		-5.1	1.4		-0.2			0.0				39.5	1.9	6.1			-0.7
Energy consumption																	
Net energy consumption	0.1	99.2	71.6	0.3	-10.7			-2.3				2349.5	343.5	25.4		11.0	58.8
Energy transformation																	
Total energy transformation input		99.1	71.3		35.5					1.7	17.9	2349.5	230.2	25.2		25.7	41.5
Electricity and CHP transformation input			71.3							1.7	17.9					19.7	
Other transformation input		99.1			35.5							2349.5	230.2	25.2		6.0	41.5
Total energy transformation output					50.2			3.2		14.8	27.1	0.0	0.0			201.6	65.5
Electricity/CHP transformation output																	

Energy balance sheet the Netherlands 2023	Anthracite	Coking coal	Steam coal	Lignite	Coke-oven cokes	BKB (Braunkohlenbriketts)	Patent fuel	Coal tar	Gas works gas	Coke oven gas	Blast furnace gas	Crude oil	Natural gas liquids	Additives	Other hydrocarbons	Residual gas	Lpg
Other transformation output					50.2			3.2		14.8	27.1	0.0	0.0			201.6	65.5
Total net energy transformation		99.1	71.3		-14.6			-3.2		-13.1	-9.3	2349.5	230.2	25.2		-175.9	-24.0
Net electricity/CHP transformation			71.3							1.7	17.9					19.7	
Net other transformation		99.1			-14.6			-3.2		-14.8	-27.1	2349.5	230.2	25.2		-195.6	-24.0
Energy sector own use																	
Total energy sector own use										7.1	5.6					87.6	4.2
Production of heat and power																	
Extraction of crude petroleum and gas																	
Coke-oven plants										6.7	0.2						
Blast furnaces										0.4	5.4						
Oil refineries																87.6	4.2
Electricity and gas supply																	
Distribution losses																	
Distribution losses																	
Final consumption																	
Total final consumption	0.1	0.1	0.3	0.3	3.9			0.9		6.0	3.7		113.3	0.2		99.3	78.6
Total final energy consumption	0.0	0.0	0.3	0.3	3.7					6.0	3.7					99.3	9.5
Total industry		0.0	0.3		3.7					6.0	3.7					99.3	0.7

Energy balance sheet the Netherlands 2023	Anthracite	Coking coal	Steam coal	Lignite	Coke-oven cokes	BKB (Braunkohlenbriketts)	Patent fuel	Coal tar	Gas works gas	Coke oven gas	Blast furnace gas	Crude oil	Natural gas liquids	Additives	Other hydrocarbons	Residual gas	Lpg
Iron and steel		0.0			2.9					6.0	3.7						0.0
Chemical and petrochemical																99.3	0.0
Non-ferrous metals																	0.0
Non-metallic minerals		0.0			0.7												0.0
Transport equipment																	0.0
Machinery																	0.1
Mining and quarrying																	0.0
Food and tobacco			0.3														0.0
Paper, pulp and printing																	0.0
Wood and wood products																	0.0
Construction																	0.1
Textile and leather																	0.0
Other industry and non-specified																	0.3
Total transport																	5.0
Domestic aviation																	
Road transport																	5.0
Rail transport																	
Pipeline transport																	
Domestic navigation																	
Non-specified																	

Energy balance sheet the Netherlands 2023	Anthracite	Coking coal	Steam coal	Lignite	Coke-oven cokes	BKB (Braunkohlenbriketts)	Patent fuel	Coal tar	Gas works gas	Coke oven gas	Blast furnace gas	Crude oil	Natural gas liquids	Additives	Other hydrocarbons	Residual gas	Lpg
Total other sectors	0.0			0.3													3.8
Services, waste, water and repair				0.3													1.6
Households	0.0																1.0
Agriculture																	1.2
Fishing																	
Non-specified																	
Total non-energy use	0.1	0.0			0.3			0.9					113.3	0.2			69.1
Industry (excluding the energy sector)	0.1	0.0			0.3			0.9					113.3	0.2			69.1
Of which chemistry and pharmaceuticals													113.3	0.2			69.1
Transport																	
Other sectors																	
Statistical difference																	
Statistical differences																	

Energy Balance the Netherlands 2023, part 2-2

Energy balance sheet the Netherlands 2023	Naphtha	Motor gasoline	Gasoline type jet fuel	Aviation gasoline	Kerosene type jet fuel	Other kerosene	Gas/diesel oil	Fuel oil	White spirit and industrial spirit (SBP)	Lubricants	Bitumen	Paraffin waxes	Petroleum coke	Other petroleum products	Natural gas	Biomass	Non renewable municipal waste	Electricity
Energy supply	***Energy supply***																	
Total Primary Energy Supply (TPES)	224.2	-578.0		-2.8	-388.5	-11.2	-576.0	-293.9	-6.6	-24.7	-33.2	0.4	8.8	-20.0	928.8	166.3	32.1	-20.4
Indigenous production														3.9	354.7	196.6	79.8	
Imports	809.5	273.5		0.0	116.1	26.2	581.2	988.2	91.0	98.8	19.4	8.2	71.6	59.1	1759.1	55.9		70.4
Exports	587.1	871.0		2.9	358.6	36.9	1104.4	930.6	97.3	116.9	52.6	8.0	59.6	89.5	1147.5	83.2	60.8	90.7
Bunkers					139.7		63.5	357.6		4.7					8.6	16.4		
Stock change	1.7	19.6		0.1	-6.3	-0.5	10.7	6.2	-0.3	-1.9	0.1	0.3	-3.3	6.4	-28.9	13.5	13.2	
Energy consumption	***Energy consumption***																	
Net energy consumption	224.2	-578.0		-2.8	-388.5	-11.2	-576.0	-293.9	-6.6	-24.7	-33.2	0.4	8.8	-20.0	932.7	166.3	32.1	-21.1
Energy transformation	***Energy transformation***																	
Total energy transformation input	608.7	5.9		0.0	3.4	9.4	167.8	306.9	63.7	15.2	0.1	0.0		18.7	400.5	160.3	32.1	0.4
Electricity and CHP transformation input							0.4							0.2	378.9	99.6		0.4
Other transformation input	608.7	5.9		0.0	3.4	9.4	167.5	306.9	63.7	15.2	0.1	0.0		18.5	21.5	60.7	32.1	

Energy balance sheet the Netherlands 2023	Naphtha	Motor gasoline	Gasoline type jet fuel	Aviation gasoline	Kerosene type jet fuel	Other kerosene	Gas/diesel oil	Fuel oil	White spirit and industrial spirit (SBP)	Lubricants	Bitumen	Paraffin waxes	Petroleum coke	Other petroleum products	Natural gas	Biomass	Non renewable municipal waste	Electricity
Total energy transformation output	548.5	755.8		2.8	393.8	22.1	977.7	600.8	71.0	46.2	37.1	0.4	16.7	45.3	11.3	46.5	0.0	436.8
Electricity/CHP transformation output																		436.8
Other transformation output	548.5	755.8		2.8	393.8	22.1	977.7	600.8	71.0	46.2	37.1	0.4	16.7	45.3	11.3	46.5	0.0	
Total net energy transformation	60.2	-749.9		-2.8	-390.4	-12.8	-809.8	-293.9	-7.3	-31.0	-37.0	-0.4	-16.7	-26.7	389.1	113.8	32.1	-436.4
Net electricity/CHP transformation							0.4							0.2	378.9	99.6		-436.4
Net other transformation	60.2	-749.9		-2.8	-390.4	-12.8	-810.2	-293.9	-7.3	-31.0	-37.0	-0.4	-16.7	-26.8	10.2	14.2	32.1	
Energy sector own use	***Energy sector own use***																	
Total energy sector own use							0.0						10.7		21.8			30.9
Production of heat and power																		13.7
Extraction of crude petroleum and gas															14.1			5.4
Coke-oven plants																		0.3

Energy balance sheet the Netherlands 2023	Naphtha	Motor gasoline	Gasoline type jet fuel	Aviation gasoline	Kerosene type jet fuel	Other kerosene	Gas/diesel oil	Fuel oil	White spirit and industrial spirit (SBP)	Lubricants	Bitumen	Paraffin waxes	Petroleum coke	Other petroleum products	Natural gas	Biomass	Non renewable municipal waste	Electricity
Blast furnaces															0.5			0.4
Oil refineries							0.0						10.7		6.4			9.6
Electricity and gas supply							0.0								0.7			1.6
Distribution losses									***Distribution losses***									
Distribution losses																		18.1
Final consumption									***Final consumption***									
Total final consumption	164.0	171.9		0.1	1.9	1.6	233.8		0.8	6.3	3.8	0.8	14.8	6.6	521.7	52.5		366.2
Total final energy consumption		171.9		0.1	1.9	0.2	233.8						0.1	1.1	454.7	52.5		366.2
Total industry		0.3				0.0	20.6						0.1	1.1	142.2	5.5		115.2
Iron and steel							0.1						0.1	0.0	6.8			6.9
Chemical and petrochemical							0.1							1.1	51.9	0.3		43.2
Non-ferrous metals							0.0								1.8			3.8
Non-metallic minerals						0.0	0.1							0.0	16.4	0.0		3.9
Transport equipment							0.0								1.5			1.9
Machinery						0.0	0.1								7.7			11.1
Mining and quarrying							0.1							0.0	1.6			0.9
Food and tobacco							0.0							0.0	38.7	1.0		24.2

Energy balance sheet the Netherlands 2023	Naphtha	Motor gasoline	Gasoline type jet fuel	Aviation gasoline	Kerosene type jet fuel	Other kerosene	Gas/diesel oil	Fuel oil	White spirit and industrial spirit (SBP)	Lubricants	Bitumen	Paraffin waxes	Petroleum coke	Other petroleum products	Natural gas	Biomass	Non renewable municipal waste	Electricity
Paper, pulp and printing							0.0							0.0	7.0	1.7		5.9
Wood and wood products							0.0								0.7	0.4		1.1
Construction		0.3					20.1								2.4	1.8		4.1
Textile and leather															2.1			1.4
Other industry and non-specified							0.0								3.5	0.3		6.9
Total transport		170.0		0.1	0.3		182.8								2.7	22.9		14.0
Domestic aviation				0.1	0.3													
Road transport		168.5					170.9								2.4	22.8		7.9
Rail transport							0.9									0.1		6.0
Pipeline transport																		
Domestic navigation		1.5					11.0								0.2	0.0		
Non-specified																		
Total other sectors		1.7			1.6	0.2	30.3								309.9	24.1		237.1
Services, waste, water and repair		0.4					6.0								87.4	3.8		133.6
Households		0.9				0.2	0.3								201.2	16.2		76.8
Agriculture		0.3					17.3								21.3	4.2		26.4

Energy balance sheet the Netherlands 2023	Naphtha	Motor gasoline	Gasoline type jet fuel	Aviation gasoline	Kerosene type jet fuel	Other kerosene	Gas/diesel oil	Fuel oil	White spirit and industrial spirit (SBP)	Lubricants	Bitumen	Paraffin waxes	Petroleum coke	Other petroleum products	Natural gas	Biomass	Non renewable municipal waste	Electricity
Fishing							4.6											
Non-specified					1.6		2.0								0.1			0.4
Total non-energy use	164.0					1.4	0.0		0.8	6.3	3.8	0.8	14.7	5.5	67.0			
Industry (excluding the energy sector)	164.0					1.3	0.0		0.8	2.1	3.8	0.8	14.7	5.5	67.0			
Of which chemistry and pharmaceuticals	164.0					1.3	0.0		0.4			0.4	10.9	5.5	67.0			
Transport										2.7								
Other sectors						0.0				1.5					0.0			
Statistical difference	***Statistical difference***																	
Statistical differences															-3.9	0.0		0.8

Annex 5 The Netherlands’ fuel list and standard CO_2 emission factors. Version January 2025

Colophon

Project name	Annual update of fuel list for the Netherlands
Project number	113569/BL2025
Version number	January 2025
Project leader	P.J. Zijlema
Enclosures	0
Author	P.J. Zijlema

The initial version of this fuel list was approved by the Steering Committee Emission Registration (SCER) in 2004, and the list was subsequently updated on the basis of decisions of the Steering Committee concerning the CO2 emission factor for natural gas at meetings held on 25 April 2006 and 21 April 2009. The Steering Committee Emission Registration delegated the authority for approving this list to the ER/Working Group on Emission Monitoring (WEM) on 21 April 2009.
The present document (the version of January 2025) is approved by WEM, after detailed discussions with the Dutch Emission Authority (NEa) and several institutes that participate in the Emission Register (ER/PRTR) project, a.o:
CBS, Statistics Netherlands,
PBL, Netherlands Environmental Assessment Agency,
RIVM, National Institute for Public Health and the Environment,
RWS, Rijkswaterstaat, an agency of the Dutch Ministry of Infrastructure and the Environment responsible for the design, construction, management and maintenance of the main infrastructure facilities in the Netherlands,
TNO, the Dutch organization for Applied Scientific Research (TNO).

A5.1 Fuel list, version of January 2025

Name (Dutch)	Name (English)	Unit	Net Calorific Value (MJ/unit)				CO_2 EF (kg/GJ)			
			2023	2024	2025	Ref [1)]	2023	2024	2025	Ref [1)]
	A. Liquid Fossil, Primary Fuels									
Ruwe aardolie	Crude oil	kg	42.7	42.7	42.7	CS	73.3	73.3	73.3	IPCC
Orimulsion	Orimulsion	kg	27.5	27.5	27.5	IPCC	77.0	77.0	77.0	IPCC
Aardgascondensaat	Natural Gas Liquids	kg	44.0	44.0	44.0	CS	64.2	64.2	64.2	IPCC
	Liquid Fossil, Secondary Fuels									
Motorbenzine [2)]	Gasoline [2)]	kg	43.3	43.3	43.3	CS	72.2	72.2	72.2	CS
Vliegtuigbenzine	Aviation gasoline	kg	44.0	44.0	44.0	CS	72.0	72.0	72.0	CS
Kerosine luchtvaart [2)]	Jet Kerosene [2)]	kg	43.5	43.5	43.5	CS	71.5	71.5	71.5	IPCC
Petroleum (incl. lampolie)	Other kerosene (incl. lampoil)	kg	43.1	43.1	43.1	CS	71.9	71.9	71.9	IPCC
Leisteenolie	Shale oil	kg	38.1	38.1	38.1	IPCC	73.3	73.3	73.3	IPCC
Gas-/dieselolie [2)]	Gas/Diesel oil [2)]	kg	43.2	43.2	43.2	CS	72.5	72.5	72.5	CS
Zware stookolie	Residual Fuel oil	kg	41.0	41.0	41.0	CS	77.4	77.4	77.4	IPCC
LPG (incl. butaan en propaan)	LPG (incl. butane and propane)	kg	45.2	45.2	45.2	CS	66.7	66.7	66.7	CS
Ethaan	Ethane	kg	45.2	45.2	45.2	CS	61.6	61.6	61.6	IPCC
Nafta's	Naphta	kg	44.0	44.0	44.0	CS	73.3	73.3	73.3	IPCC
Bitumen	Bitumen	kg	41.9	41.9	41.9	CS	80.7	80.7	80.7	IPCC
Smeeroliën	Lubricants	kg	41.4	41.4	41.4	CS	73.3	73.3	73.3	IPCC
Petroleumcokes	Petroleum Coke	kg	35.2	35.2	35.2	CS	97.5	97.5	97.5	IPCC
Raffinaderij grondstoffen	Refinery Feedstocks	kg	43.0	43.0	43.0	IPCC	73.3	73.3	73.3	IPCC
Raffinaderijgas	Refinery Gas	kg	45.2	45.2	45.2	CS	64.4	64.4	64.4	CS
Chemisch restgas	Chemical Waste Gas	kg	45.2	45.2	45.2	CS	61.8	61.8	61.8	CS
Overige oliën	Other oil	kg	40.2	40.2	40.2	IPCC	73.3	73.3	73.3	IPCC
Paraffine	Paraffin Waxes	kg	42.7	42.7	42.7	CS	73.3	73.3	73.3	IPCC
Terpentine	White Spirit and SBP	kg	43.6	43.6	43.6	CS	73.3	73.3	73.3	IPCC
Overige aardolie producten	Other Petroleum Products	kg	42.7	42.7	42.7	CS	73.3	73.3	73.3	IPCC
Fossiele additieven	Fossil fuel additives	kg	44.0	44.0	44.0	CS	73.3	73.3	73.3	IPCC
	B. Solid Fossil, Primary Fuels									
Antraciet	Anthracite	kg	29.3	29.3	29.3	CS	98.3	98.3	98.3	IPCC
Cokeskolen	Coking Coal	kg	28.6	28.6	28.6	CS	94.0	94.0	94.0	CS
Cokeskolen	Coking Coal (used in coke oven)	kg	28.6	28.6	28.6	CS	95.4	95.4	95.4	CS

Name (Dutch)	Name (English)	Unit	Net Calorific Value (MJ/unit)				CO_2 EF (kg/GJ)			
			2023	2024	2025	Ref [1)]	2023	2024	2025	Ref [1)]
Cokeskolen	Coking Coal (used in blast furnaces)	kg	28.6	28.6	28.6	CS	89.8	89.8	89.8	CS
Overige bitumineuze steenkool [3)]	Other Bituminous Coal [3)]	kg	24.7	24.7 [3)]	24.7 [3)]	CS	92.7	92.7	92.7	CS
Sub-bitumineuze steenkool	Sub-Bituminous Coal	kg	18.9	18.9	18.9	IPCC	96.1	96.1	96.1	IPCC
Bruinkool	Lignite	kg	20.0	20.0	20.0	CS	101.0	101.0	101.0	IPCC
Bitumineuze Leisteen	Oil Shale	kg	8.9	8.9	8.9	IPCC	107.0	107.0	107.0	IPCC
Turf	Peat	kg	9.76	9.76	9.76	IPCC	106.0	106.0	106.0	IPCC
	Solid Fossil, Secondary Fuels									
Steenkool- en bruinkoolbriketten	BKB & Patent Fuel	kg	20.7	20.7	20.7	IPCC	97.5	97.5	97.5	IPCC
Cokesoven/ gascokes	Coke Oven/Gas Coke	kg	28.5	28.5	28.5	CS	106.8	106.8	106.8	CS
Cokesovengas	Coke Oven gas	MJ	1.0	1.0	1.0	CS	42.8	42.8	42.8	CS
Hoogovengas	Blast Furnace Gas	MJ	1.0	1.0	1.0	CS	247.4	247.4	247.4	CS
Oxystaalovengas	Oxy Gas	MJ	1.0	1.0	1.0	CS	191.9	191.9	191.9	CS
Fosforovengas	Fosfor Gas	Nm3	11.0	11.0	11.0	CS	143.9	143.9	143.9	CS
Steenkool bitumen	Coal tar	kg	41.9	41.9	41.9	CS	80.7	80.7	80.7	IPCC
	C. Gaseous Fossil Fuels									
Aardgas [4)]	Natural Gas (dry) [4)]	Nm3 ae	31.65	31.65	31.65	CS	56.3[4)]	56.2[4)]	56.2[4)]	CS
Compressed natural gas (CNG) [4)]	Compressed natural gas (CNG) [4)]	Nm3 ae	31.65	31.65	31.65	CS	56.3[4)]	56.2[4)]	56.2[4)]	CS
Liquified natural gas (LNG) [4)]	Liquified natural gas (LNG) [4)]	Nm3 ae	31.65	31.65	31.65	CS	56.3[4)]	56.2[4)]	56.2[4)]	CS
Koolmonoxide	Carbon Monoxide	Nm3	12.6	12.6	12.6	CS	155.2	155.2	155.2	CS
Methaan	Methane	Nm3	35.9	35.9	35.9	CS	54.9	54.9	54.9	CS
Waterstof	Hydrogen	Nm3	10.8	10.8	10.8	CS	0.0	0.0	0.0	CS
	Biomass [4)]									
Biomassa vast	Solid Biomass	kg	15.1	15.1	15.1	CS	109.6	109.6	109.6	IPCC
Houtskool	Charcoal	kg	30.0	30.0	30.0	CS	112.0	112.0	112.0	IPCC
Biobenzine [3)]	Biogasoline [3)]	kg	27.0	27.0[3)]	27.0[3)]	CS	70.8	70.8[3)]	70.8[3)]	CS
Biodiesel [3)]	Biodiesels [3)]	kg	39.2	39.2[3)]	39.2[3)]	CS	73.8	73.8[3)]	73.8[3)]	CS
Overige vloeibare biobrandstoffen	Other liquid biofuels	kg	36.0	36.0	36.0	CS	79.6	79.6	79.6	IPCC
Biomassa gasvormig	Gas Biomass	Nm3	21.8	21.8	21.8	CS	90.8	90.8	90.8	CS
RWZI biogas	Wastewater biogas	Nm3	23.3	23.3	23.3	CS	84.2	84.2	84.2	CS

Name (Dutch)	Name (English)	Unit	Net Calorific Value (MJ/unit)				CO_2 EF (kg/GJ)			
			2023	2024	2025	Ref [1)]	2023	2024	2025	Ref [1)]
Stortgas	Landfill gas	Nm3	19.5	19.5	19.5	CS	100.7	100.7	100.7	CS
Industrieel fermentatiegas	Industrial organic waste gas	Nm3	23.3	23.3	23.3	CS	84.2	84.2	84.2	CS
	D Other fuels									
Afval [3) 6)]	Waste [3) 6)]	kg	9.6	9.6[3)]	9.6[3)]	CS	107.9	107.9[3)]	107.9 [3)]	CS

1) IPCC: default value from the 2006 IPCC Guidelines; CS: country specific
2) This concerns only the fossil part of the fuel
3) The calorific value and/or emission factor for these fuels are updated annually. Since the values for 2024 and 2025 are not yet known, they are set equal to the value for 2023. The figures in the above list may be modified in subsequent versions of the fuel list
4) The emission factors for natural gas, CNG and LNG are updated annually. The values given in this table represent the most up-to-date values for all years concerned.
5) For reporting of emissions from biomass the following rules have to be followed:
    a. Under the Convention (UNFCCC) the emissions from biomass have to be reported as memo-item, using the mentioned emission factors. However, they do not count in the national total of greenhouse gas emissions.
    b. Under EU ETS, combustion of biomass can result in zero emission if certain conditions are met. More information: https://www.emissieautoriteit.nl/onderwerpen/monitoring-emissies/biomassa
6) The percentage biogenic in the heating value is 53%. The percentage biogenic in the emission factor is 64%.

A5.2 Notes on the fuel list

Netherlands Enterprise Agency (RVO) has been publishing the list of fuels and standard CO_2 emission factors for the Netherlands annually since 2004.
This list was completely revised in 2015 as a result of the obligation to follow the *2006 IPCC Guidelines* in all international reports compiled in or after 2015 (the first reporting year of the second Kyoto budget period). The list contains not only calorific values and emission factors taken from the *2006 IPCC Guidelines* but also a number of country-specific values. In 2021 the list has been updated again, taking into account the 2019 Refinement to the 2006 IPCC Guidelines (see Dröge et al, 2021)
The validity of values is governed by the following rules:

- *2006 IPCC* default emission factors are valid from 1990
- The country-specific calorific values and emission factors may be divided into the following four categories:
    - Most country-specific calorific values and emission factors are valid from 1990
    - A limited number of country-specific factors have an old value for the period 1990-2012 and are updated from 2013 and again updated from reporting year 2021.
    - Based on new insights from Statistics Netherlands, the heating values and emission factors for some transport fuels have been updated.
    - The country-specific calorific value and/or emission factor for some fuels (natural gas, biogasoline, biodiesel, other bituminous coal and waste) are updated annually. In the

present document (version January 2025) these values have been updated.

Readers are referred to the TNO reports (Dröge, 2014; Dröge et al, 2021) and the relevant factsheets for further details.
Various relevant institutes, were consulted during the compilation of this list. One of the involved organisations was Statistics Netherlands (CBS), to ensure consistency with the Dutch Energy Balance Sheet.

With effect from 2015, the lists of calorific values and of emission factors will both contain columns for three successive years. In the present version of the fuel list (that for January 2025), the years in question are 2023, 2024 and 2025. The values in these columns are used for the following purposes:

1. **2023**: these values are used in 2025 for calculations concerning the calendar year 2023, which are required for international reports concerning greenhouse gas emissions pursuant to the UN Framework Convention on Climate Change (UNFCCC), the Paris Agreement and the Governance Regulation of the Energy Union (EU 2018/1999). The National Inventory Report for 2025 (NIR 2025) gives full details of greenhouse gas emissions in the Netherlands up to and including 2023. The fuel list forms an integral part of the NIR 2025.
2. **2024**: these values are used in 2025 for reports on energy consumption and CO_2 emission for the calendar year 2024 in the Electronic Environmental Annual Report (e-MJV).
3. **2025**: in 2026, these values will be used in the emission reports for calendar year 2025 by companies that participate in the European CO_2 Emissions Trading System (EU ETS) and have indicated in their monitoring plan that they use the "The Netherlands' list of energy carriers and standard CO_2 emission factors".

Annex 6 Assessment of completeness and (potential) sources and sinks

The Netherlands' emissions inventory focuses on completeness, and accuracy in the most relevant sources. This means that for all 'NE' sources, it was investigated what information was available and whether it could be assumed that a source was really (very) small/negligible. For those sources that turned out not to be small, methods for estimating the emissions were developed during the improvement programme. As a result of this process, it was decided to keep only a very few sources as 'NE', where data for estimating emissions were not available and the source was very small. Of course, (developments in) data on NE sources that indicate any (major) increase in emissions and (new) data sources for estimating emissions are checked/re-assessed on a regular basis; most recently in a study performed by DNV GL (2020).

The Netherlands' GHG emissions inventory includes all sources identified by the 2006 IPCC Guidelines, with the exception of the following (very) minor sources:

- CO_2 from asphalt roofing (2A4d) and CO_2 from road paving (2A4d), both due to negligible amounts (below threshold) and missing activity data: information on the use of bitumen is available only in a division into two groups: the chemical industry and all others. There is no information on the amount of asphalt roofing production and no information on road paving with asphalt. The statistical information on the sales (value) of asphalt roofing and asphalt for road paving ends in 2002.
  As a follow-up to the 2008 review, information was collected from the branch organisation for roofing, indicating that the number of producers of asphalt roofing declined from about 15 in 1990 to fewer than 5 in 2008 and that the import of asphalt roofing increased during that period.
  Information has also been sourced on asphalt production (for road paving), as reported in the progress of the voluntary agreements for energy efficiency. A first estimate indicates that annual CO_2 emissions could be approximately 0.5 kton.
  On the basis of the above, it was assumed that emissions related to these two categories are very low/undetectable and that the effort expended in generating activity data would, therefore, not be cost-effective. So not only the missing activity data, but also the very limited amount of emissions were the rationale behind the decision not to estimate these emissions.
- CH_4 emissions from Other livestock (alpacas) (3A1) are not included in the inventory due to negligible amounts (below threshold). Alpacas are mostly kept as pets or as a tourist attraction. Animal numbers are expected to be in the same range as mules and asses, i.e. no more than a couple of thousand animals. See paragraph 5.1.2 for the detailed justification that the emissions of this source are below threshold.
- CH_4 and N_2O emissions from the decomposition of manure from other livestock (alpacas) (3A2), due to negligible amounts (below threshold, see paragraph 5.1.2 for justification).

- CH_4 from Enteric fermentation: poultry (3A4) Enteric fermentation from poultry is not estimated due to the negligible amount of CH_4 production in this animal category. The 2019 refinement of the IPCC Guidelines (table 10.9) does not provide a default EF for enteric CH_4 emissions from poultry.
- Direct N_2O emissions from septic tanks (5D3, septic tanks): direct emissions of N_2O from septic tanks are not calculated since they are unlikely to occur, given the anaerobic circumstances in these tanks. Indirect N_2O emissions from septic tank effluent are included (IE) in CRF category 5D3 (Indirect N_2O emission from surface water as a result of discharge of domestic and industrial effluents).
- CH_4 emissions from industrial sludge treatment (5D2), due to negligible amounts: data from the survey among IWWTPs conducted by Statistics Netherlands shows that only 2 out of a total of 160 IWWTPs are equipped with anaerobic sludge digestion reactors. These data are not published on www.cbs.statline.nl for reasons of confidentiality. See paragraph 7.5.2 for justification.
- Precursor emissions (i.e. CO, NO_x, NMVOC and SO_2) from Memo item international bunkers (international transport) have not been included as these emissions are not included in national total emissions.

A number of recommendations by DNV GL, relating to the 2019 refinement of the IPCC Guidelines, will be further explored and implemented once these guidelines become mandatory for calculating greenhouse gas emissions.

Annex 7 Additional information to be considered as part of the NIR submission

List A7.1 contains the list of methodology reports that have been submitted to the UNFCCC (in a separate ZIP file) as part of the submission of 15 April 2025. These reports are to be considered as an integrated part of this NIR 2025.

A7.1 List of methodology reports

ENINA (Energy, Industry, Waste):
Methodology for the calculation of emissions to air from the sectors Energy, Industry and Waste
RIVM report 2025-0002
E. Honig, J.A. Montfoort, R. Dröge, S.E.H. van Mil, B. Guis, K. Baas, B. van Huet, O.R. van Hunnik

Transport:
Methodology for the calculation of emissions from the transport sector
RIVM report 2025-0006
H. Witt, G. Geilenkirchen, M. Bolech, S. Dellaert, E. van Eijk, K. Geertjes, M. Kosterman

WESP:
Methodology for the calculation of emissions from product usage by consumers, construction and services
RIVM report 2025-0004
A.J.H. Visschedijk, J.A.J. Meesters, M.M. Nijkamp, W.W.R Koch, B.I. Jansen, R. Dröge

Agriculture:
Methodology for the calculation of emissions from agriculture
RIVM report 2025-0003
Calculations for methane, ammonia, nitrous oxide, nitrogen oxides, non-methane volatile organic compounds, fine particles and carbon dioxide emissions using the National Emission Model for Agriculture (NEMA)
T.C. van der Zee, A. Bleeker, C. van Bruggen, W. Bussink, H.J.C. van Dooren, C.M. Groenestein, J.F.M. Huijsmans, H. Kros, M. van der Most, K. Oltmer, M. Ros, L. Schulte-Uebbing, G.L. Velthof

LULUCF:
Greenhouse gas reporting of the LULUCF sector in the Netherlands
Methodological background, update 2025, WOt-technical report 278,
Doi: 10.18174/687310
S.A. van Baren, E.J.M.M. Arets, G. Erkens, C.M.J. Hendriks, H. Kramer, J.P. Lesschen, M.J. Schelhaas

These reports are also available at the website http://english.rvo.nl/nie

Annex 8 Verification activities of greenhouse gas emissions using atmospheric observations

In this annex, reported Dutch greenhouse gas emissions are compared with emission data derived from atmospheric observations. This comparison not only allows to verify the reported emissions against an independent data source, but also contributes to validation of emission estimates from atmospheric observations. Emission estimates from atmospheric observations for this submission were provided by the Horizon 2020 Europe project PARIS (https://horizoneurope-paris.eu/).

This annex is a first attempt at such a comparison for the Netherlands and not all observations can yet be fully explained. It covers the greenhouse gases methane, nitrous oxide and hydrofluorocarbons from 2018 until 2023. Going forward, the aim is to answer the questions raised by this first analysis and to expand it to more gases and more inversion systems. These verification activities are planned to take place on a yearly basis as part of the overall verification system for the NIR, with significant differences between inventory emission and atmospheric observations pointing to areas that might be deserving of further investigation.

A8.1 Summary

Emission estimates derived from atmospheric observations were compared to reported emissions for methane, nitrous oxide and hydrofluorocarbons. It should be noted that these are both emission estimates relying on assumptions without one being closer to the true emissions in the real world.

For methane, atmospheric observations indicated emissions up to 10 Tg CO_2-eq larger than reported in the NIR. This deviation cannot yet be clearly attributed to either the reported emissions being too low or the atmospheric observations being too high. On the other hand, reported nitrous oxide emissions were only slightly lower than those derived from atmospheric observations, with a deviation of 2-4 Tg CO_2-eq. For hydrofluorocarbons, the atmospheric observations again indicate much higher emissions than reported with a difference of 2 Tg CO_2-eq. However, it appears that parts of the atmospherically observed emissions seem to stem from neighboring countries and were incorrectly assigned to the Netherlands.

A8.2 Data sources and processing

Emission estimates from atmospheric observations were produced and kindly provided by the PARIS project funded by the European Research Council. A detailed description of these datasets and applied methodologies is in preparation by the PARIS consortium and will be published in due course.

In brief, to estimate emissions from these concentration measurements, three different inverse modelling algorithms were used: InTEM (Manning et al. 2023), ELRIS (Henne et al. 2016, Katharopoulos et al. 2023), and RHIME (Ganesan et al. 2014) using the same atmospheric transport model (NAME, Jones et al. 2007). For nitrous oxide, only InTEM and ELRIS were used. As input for the models, prior emissions were taken from the EDGAR emission dataset (v8, European Commission: Joint Research, 2023). For methane, additional natural emissions from WETCHARTS (Bloom et al. 2017) were included.

Atmospheric concentrations of methane and nitrous oxides were derived from *in situ* measurement stations of, among others, the European ICOS network and the UK DECC network. This includes two measurement stations in the Netherlands in Cabauw and Lutjewad. Concentrations of fluorinated gases were measured by affiliates of the AGAGE network. This network of much fewer stations does not include any measurement site in the Netherlands, but one in Tacolneston (UK), on the other side of the English Channel, which provides a reasonable sensitivity to Dutch emissions. For the InTEM results additional measurements from Cabauw were used.

To calculate the national Dutch emissions from these data, emissions in the grid cells within the Netherlands including the 12 mile zone were added up. For grid cells partially in the Netherlands, the emissions were distributed based on the share of the grid cell within the Netherlands. To facilitate comparison between the spatial patterns of the reported emissions and the emissions derived from atmospheric observations, the reported emissions were resampled to the resolution of the atmospheric observations. Error bars indicate 95% confidence intervals. Uncertainties of the inverse modelling outputs are not yet included in this annex.

A8.3 Methane

A comparison of Dutch methane emissions to emission estimates derived from atmospheric observations is shown in figure A8.1. It immediately shows a marked contrast between the reported emissions and those derived from atmospheric observations. While the reported emissions show a slight decrease from 19.98 Tg CO_2-eq in 2018 to 18.43 Tg CO_2-eq in 2023, the atmospheric inversions indicate much higher emissions of 26.6 – 30.1 Tg CO_2-eq for 2018 and 28.4 – 30.3 Tg CO_2-eq for 2023.

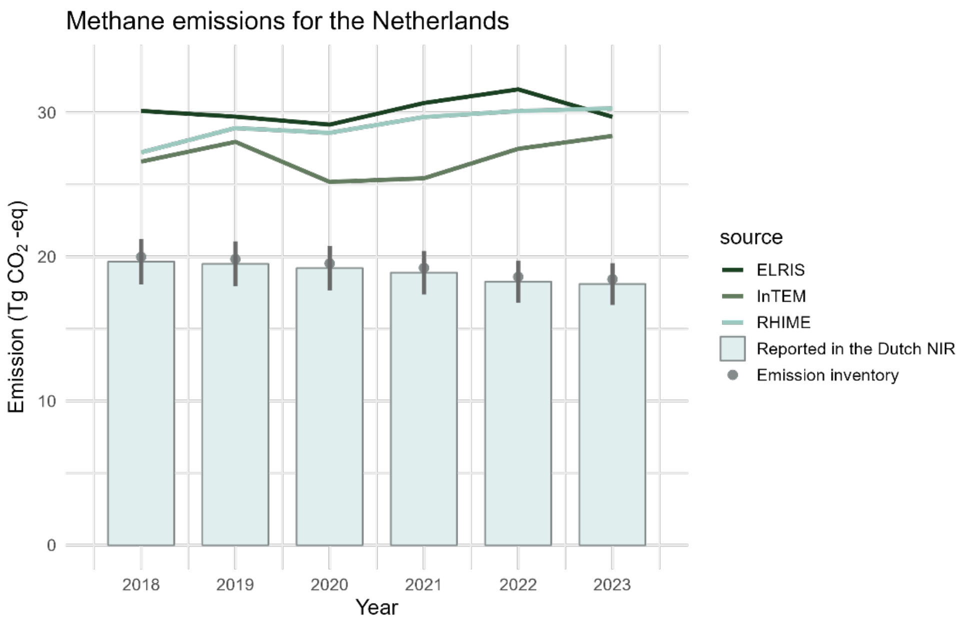

Figure A8.1 Comparison of the reported Dutch methane emissions with emission estimates derived from atmospheric observations of 3 different inverse systems (ELRIS, InTEM, RHIME). Gray bars indicate the emissions as reported in the NID 2025, while the gray dots also includes LULUCF emissions reported as memo-items.

The three inversions show slight differences, with InTEM yielding the lowest emissions. This can also be seen in the emission maps for the three different inversion systems in figure A8.2. Qualitatively, all three inversions show similar results, with relatively evenly distributed emissions without strong emission hotspots and higher emissions towards the east. Furthermore, ELRIS and RHIME also show two areas of methane emissions in the North Sea.

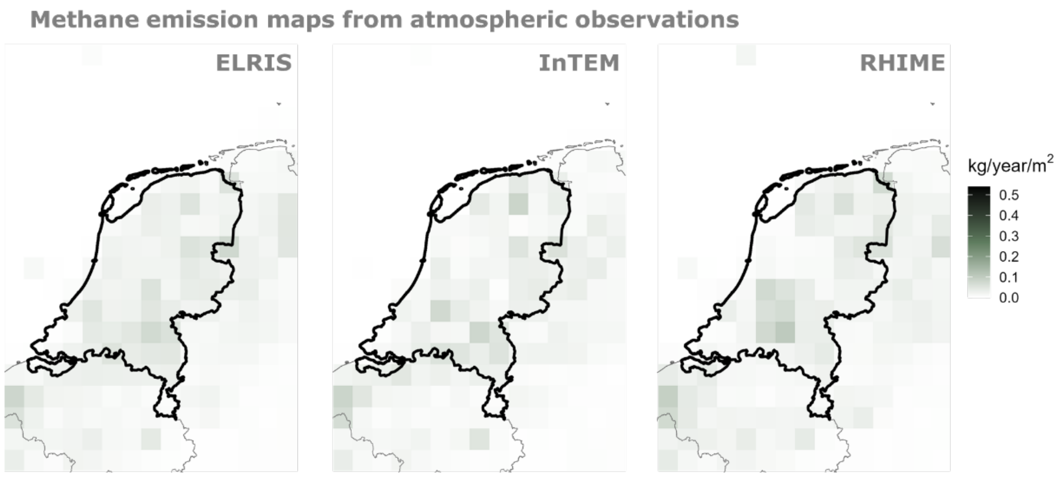

Figure A8.2 Maps of methane emissions for 2022 as obtained by the ELRIS, InTEM and RHIME inversion systems.

As a comparison, the spatial distribution of the inventory emissions is shown in figure A8.3. The high-resolution emission map at 5x5 km reveals individual points with emissions much higher than the background, however, after resampling to the model resolution, these points average out and the spatial pattern resembles the pattern observed in atmospheric observations much closer.

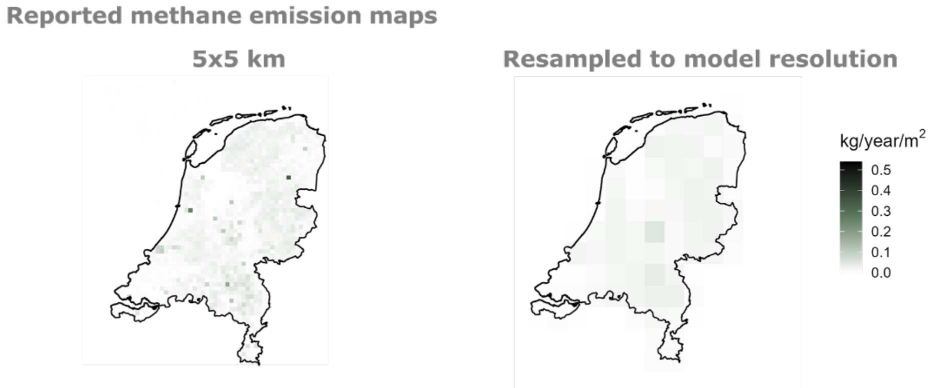

Figure A8.3 Maps of reported methane emissions for 2022 in 5x5 km resolution and resampled to the resolution of figure A8.2

The difference of roughly 10 Tg CO_2-eq between the reported emissions and the atmospheric observations is much larger than the uncertainty of the Dutch reported emissions of roughly 1.5 Tg CO_2-eq. There are several possible explanations for this difference and there might be more than one effect in place.

While the NID reports only anthropogenic emissions, the atmospheric observations cannot distinguish between anthropogenic and natural emissions. While methane emissions from draining ditches in organic soil and from wetlands are reported as LULUCF emissions as a memo-item (meaning they are included in the gray dots in figure A8.1, but not in the gray bars), emissions from other open water bodies, like lakes, rivers, and channels are so far not included in the Dutch reported emissions. However, although the Netherlands have plenty of these water bodies, it is unlikely that these emissions sum up to 10 Tg CO_2-eq. Therefore, these emissions could only explain part of the gap.

Furthermore, it might be possible that methane emissions in the Dutch NID are systematically underestimated for one or multiple sectors. Since the gap is so large, this would need to be a sector with a larger share of the methane emissions, like the key sources agriculture or waste management. This might guide further research to these sectors.

Also, it is possible that emissions from a neighboring country are incorrectly assigned to the Netherlands, when calculating the national total from the atmospheric data. Inspecting the emission maps in figure A8.2, several grid cells directly on the border show high methane emissions, which might be caused by emission sources that are located outside the Netherlands but contribute in this analysis to the Dutch emissions. An improved resolution of the inverse models and further analysis might help to better understand this effect.

Finally, it might also be possible that the difference between the two emission estimate, at least in parts, is not due to the inventory underestimating methane emissions, but to the atmospheric inversions overestimating the Dutch methane emissions. In general, these inverse modelling systems and the underlying transport models were applied in many situations and not found to have clear biases. However, it is still feasible that emissions are overestimated particularly for the Netherlands, with its long coastline and specific location. Further investigation specifically into the Dutch observation sites in Cabauw and Lutjewad might shed light on this effect.

Since the gap between reported emissions and those derived from atmospheric observations is so large, it seems likely that multiple, if not all of the above explanations play a role here. Unfortunately, it is not yet possible to disentangle these different effects, showing that additional research efforts are needed. In particular, increasing the resolution of the emission map produced from atmospheric observation might be very helpful, as highlighted by the loss in details when resampling the inventory emissions as shown in figure A8.3.

A8.4 Nitrous oxide

A comparison of Dutch reported nitrous oxide emissions to emission estimates derived from atmospheric observations is shown in figure A8.4. It shows that atmospheric observations yield slightly higher emissions than are reported, with the gap widening with time. While the reported emissions dropped from 7.8 Tg CO_2-eq in 2018 to 6.5 Tg CO_2-eq in 2023, the atmospheric observations result in 9.0 – 10.6 Tg CO_2-eq in 2018, which stayed approximately constant with 10.0 – 10.2 Tg CO_2-eq in 2023.

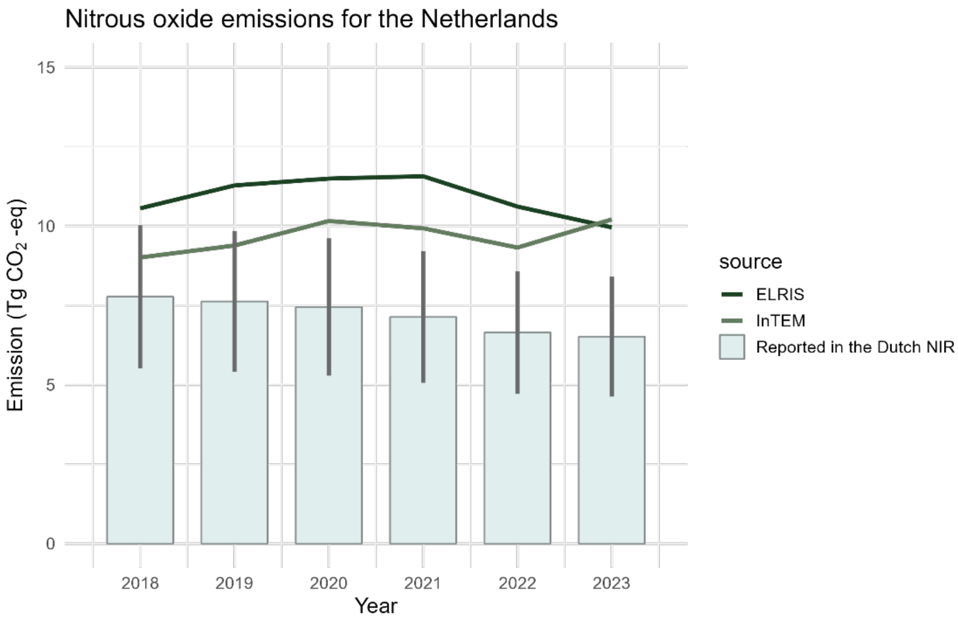

Figure A8.4 Comparison of the reported Dutch nitrous oxide emissions with emission estimates derived from atmospheric observations of 2 different inverse systems (ELRIS and InTEM). Gray bars indicate the emissions as reported in the NID, while the gray dots also includes LULUCF emissions reported as memo-items.

The spatial distribution of nitrous oxide emissions in the Netherlands according to atmospheric observations is shown in figure A8.5. They show qualitative agreement, with a flat background of emissions which would fit the expected soil emissions and a strong hotspot of emissions in the South of the Netherlands, which coincides with a hotspot of the Dutch chemical industry.

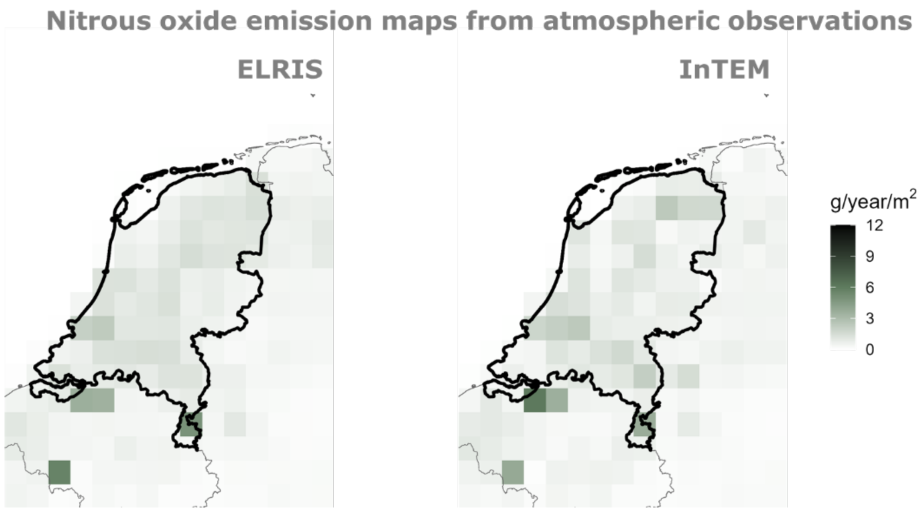

Figure A8.5 Maps of nitrous oxide emissions for 2022 as obtained by the ELRIS and InTEM inversion systems.

As a comparison, the spatial distribution of the reported emissions is shown in figure A8.6. In the high-resolution version at 5x5 km it can be seen that few emission hot spots dominate the emissions. After resampling the reported emissions to the resolution of the emissions derived from atmospheric observations, their similarity becomes more apparent. While the emission hotspot in the South-East is visible in both data sets, the emission hotspot in the South-West of the Netherlands is notably not visible in the reported emissions.

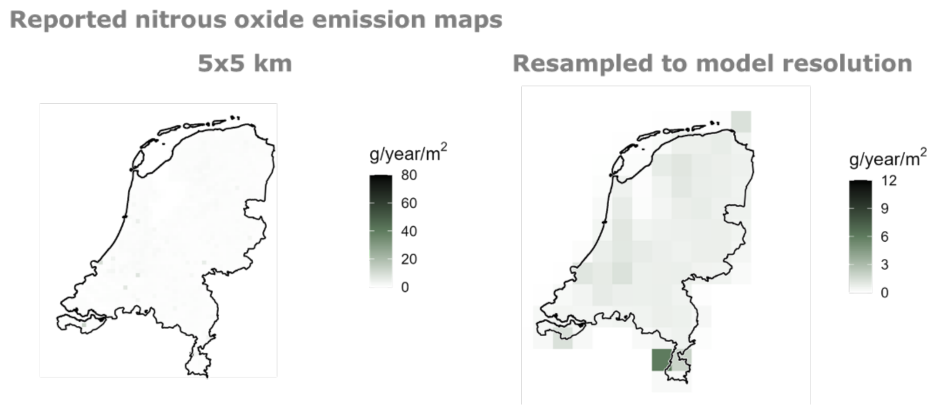

Figure A8.6 Maps of reported nitrous oxide emissions for 2022 in 5x5 km resolution and resampled to the resolution of figure A8.5

Many important N_2O emission sources, like direct and indirect soil emissions, are associated with large uncertainties. Additionally, there are considerable biogenic emissions of N_2O. Considering these factors, the atmospheric observations agree reasonably well with the reported emissions. The deviation that was observed might also be caused by relatively strong emissions in grid cells that lie directly on the border to

Belgium and Germany. These emissions are distributed to the countries according to the area fraction of the grid cells in the respective country, which might place emissions in the wrong country. Additionally, also the spatial localization of emissions from atmospheric observations can contain uncertainties. In particular, comparing figure A8.5 and A8.6, it appears that emissions from the Antwerp area might be falsely attributed to the Netherlands.

While the deviation of the absolute emissions for nitrous oxides is not very pronounced, the emissions derived from atmospheric observations also suggest an emission trend that is clearly deviating from the constant decline of the reported emissions. It will be very interesting to see if this remains this way in the coming years and to understand what causes this deviation.

A8.5 Hydrofluorocarbons

Atmospheric observations were used to estimate emissions of HFC-23, HFC-32, HFC-125, HFC-134a, HFC-143a, HFC-152a, HFC-227ea, HFC-245fa, HFC-365mfc. While these are not all HFCs included in the reported emissions, the missing HFCs present only a negligible share of the overall global warming potential of the reported HFCs. A comparison of total Dutch hydrofluorocarbon (HFC) emissions to emission estimates derived from atmospheric observations is shown in figure A8.7. It shows that the atmospheric observations indicate much higher emissions than the reported HFC emissions. While the reported emissions show a slight decrease from 1.25 Tg CO_2-eq in 2018 to 0.79 Tg CO_2-eq in 2023, the emissions estimated from atmospheric observations indicate higher emissions of 2.9 – 3.5 Tg CO_2-eq in 2018 and 2.0 – 3.5 Tg CO_2-eq in 2023, with large interannual variations and a marked dip in 2020 and 2021. This dip coincides with the corona pandemic, however, there are no obvious relationship between HFC emission sources and the pandemic that are not included in the reported emissions.

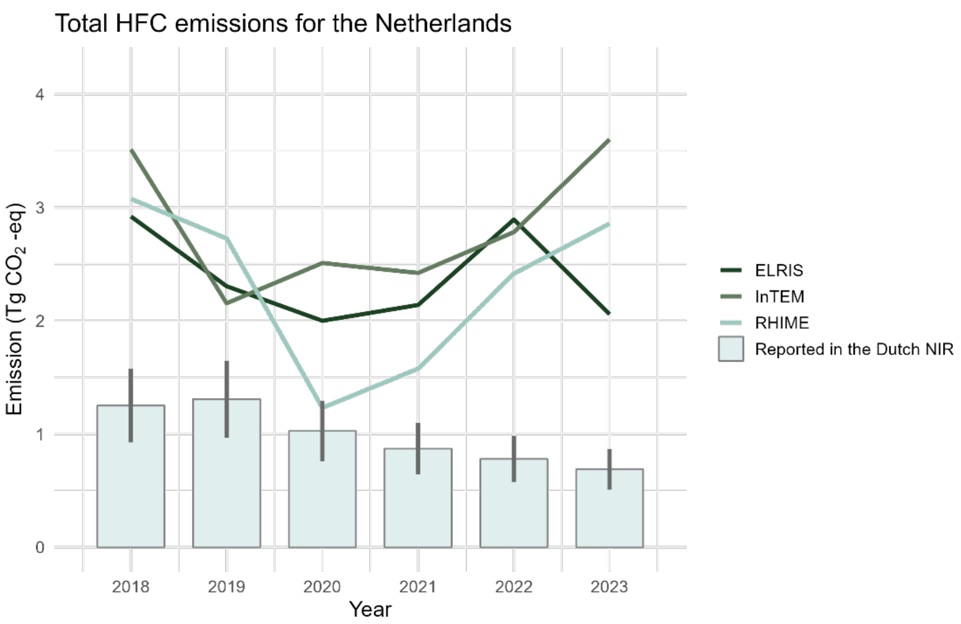

Figure A8.7 Comparison of the reported Dutch hydrofluorocarbon emissions with emission estimates derived from atmospheric observations of 3 different inverse system (ELRIS, InTEM, RHIME). Sum of all different reported HFCs.

Emissions of some individual HFCs are listed in table A8.1. Similarly to the total HFC emissions, emissions from atmospheric inversions are generally higher than the reported emissions and there are substantial variations between the three different inversion systems. The large differences between the three inversion systems might be explained by the very low atmospheric concentrations of HFCs. As there are no natural sources of HFCs, the discrepancy between reported emissions and atmospheric observations cannot be explained by emission sources of natural origin not included in the reported emissions for the individual HFCs.

Table A8.1 Comparison of the reported Dutch nitrous oxide emissions with emission estimates derived from atmospheric observations of 3 different inverse systems (ELRIS, InTEM, RHIME) in Tg CO_2-eq for a selection of HFCs in 2023.

Gas	**ELRIS**	**InTEM**	**RHIME**	**Reported in the Dutch NIR**
HFC-23	0.097	0.28	0.036	0.06
HFC-32	0.076	0.14	0.17	0.02
HFC-125	0.62	1.06	0.97	0.11
HFC-134a	0.70	1.40	1.10	0.43
HFC-143a	0.47	0.61	0.48	0.02

Looking at the spatial distribution of HFC emissions for a selection of HFCs as shown in figure A8.8, there are emission hotspots in the Rotterdam area (which is a centrum of industrial activity in the Netherlands) and at the border to Belgium. Emissions in grid cells that are on the border between two countries are distributed between the two countries according to the respective area fraction, which can lead to wrong assignment of the emissions. Additionally, also the spatial localization of emissions from atmospheric observations can contain uncertainties. Therefore, the large concentrations of emissions at the border between the Netherlands and Belgium led to the hypothesis that the difference between the reported Dutch HFC emissions and atmospheric observations might be caused by errors in the distribution of emissions between the Netherlands and Belgium.

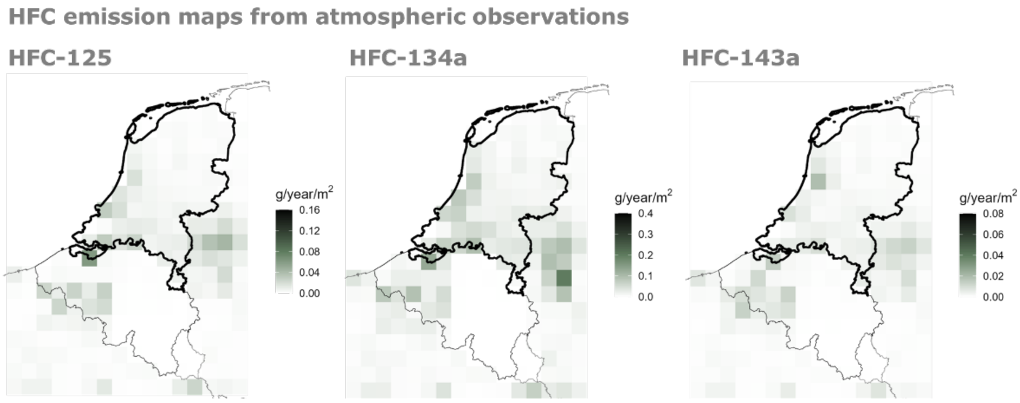

Figure A8.8 Maps of emissions of HFC-125, HFC-134a, and HFC143a for 2022 as obtained by the InTEM inversion systems. The other inversion systems showed the same qualitative result.

As a comparison, the spatial distribution of the reported emissions is shown in figure A8.9. The general pattern matches that of the atmospheric observations, as can be especially appreciated after resampling to the resolution of atmospheric observations. Notably, the emission hotspots at the Belgian-Dutch-boarders are not visible here, further indicating that these emissions might be in reality located in Belgium.

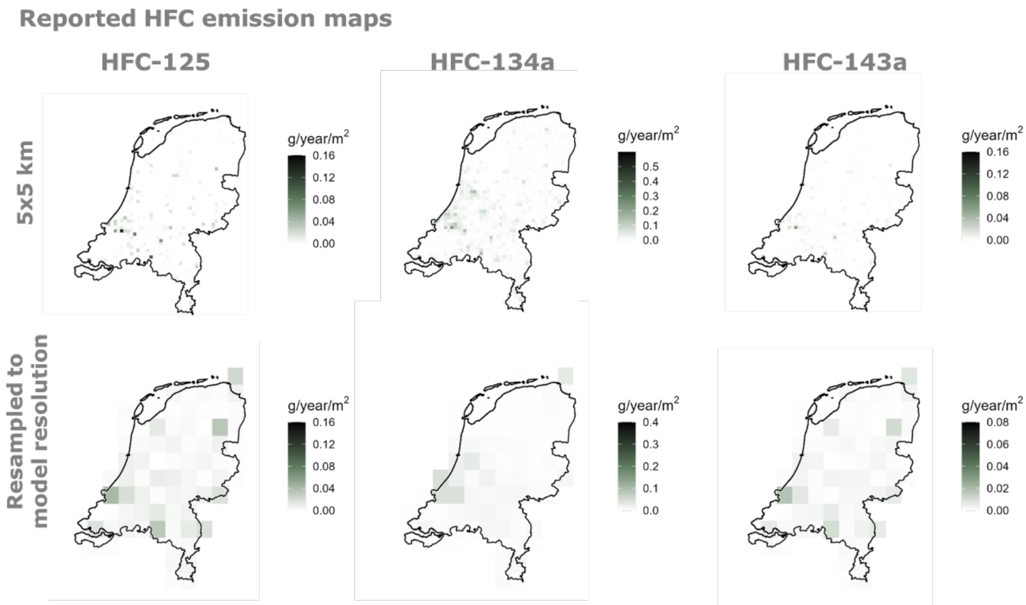

Figure A8.9 Maps of reported emissions of HFC-125, HFC-134a, and HFC143a for 2022 in 5x5 km resolution and resampled to the resolution of figure A8.8.

To test this hypothesis, reported emissions were compared to atmospheric inversions for an area that combines the Netherlands and Belgium as shown in figure A8.10. Belgian emissions were taken from the Belgian National Inventory Report 2024 (Belgium's greenhouse gas Inventory, 2024). And indeed, for this combined region, atmospheric observations agree much better with reported emissions, especially for the years 2018 to 2021. In 2018, the reported emissions were 5.4 Tg CO_2-eq, while atmospheric observations report emissions of 4.9 – 5.3 Tg CO_2-eq. For 2022, however, the reported emissions continue to drop to 3.0 Tg CO_2-eq, while atmospheric observations show more or less constant emissions at 3.9 – 4.9 Tg CO_2-eq.

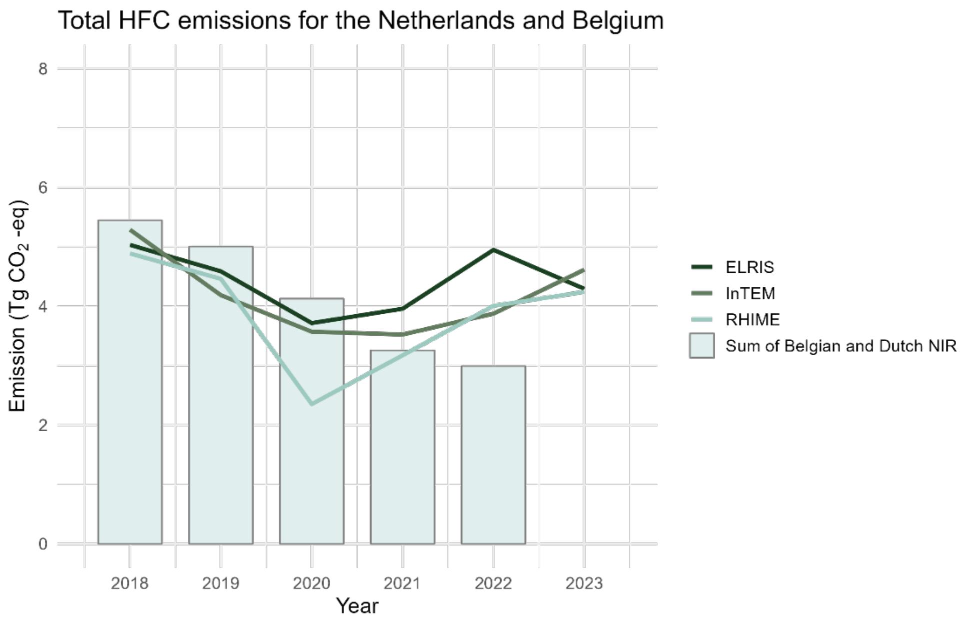

Figure A8.10 Comparison of the combined reported Dutch and Belgian hydrofluorocarbon emissions with emission estimates derived from atmospheric observations of 3 different inverse system (ELRIS, InTEM, RHIME). Sum of all reported HFCs.

The generally good agreement for this combined region supports the interpretation that the discrepancy observed in figure A8.7 and table A8.1 is caused by emission sources in the border region between the Netherlands and Belgium, which are not correctly split between the two countries. This result shows that further development is necessary to better distribute emissions in the border regions between countries. This could be done by increasing the resolution, but also other approaches are under development. Furthermore, it will be very interesting to see if the divergent emission trends from 2022 on will continue.

A8.6 Outlook

This annex only represents a starting point to more verification activities for emissions of different greenhouse gases. The results presented here illustrate the potential and challenges of these methods. Especially the large deviation observed for methane points to an area deserving of further investigation. . There are a couple of approaches and developments that might help to address them. Improving the spatial resolution will be certainly helpful to understand which emission sources lead to the deviation but will also allow better, more faithful attribution of emissions to countries, a challenge highlighted especially by the results for HFCs. On step in that direction will be to include additional measurements for HFCs in Cabauw and Taunus (Germany). Besides improving the spatial resolution, also the high temporal resolution of the atmospheric observations with monthly emission estimates has not yet been utilized in this analysis. This annex also did not yet include an analysis of uncertainties in the inverse modelling outputs, which will be added in coming years.

Another possible improvement that might greatly help to understand these results is the generation of sector specific emissions from atmospheric observations. To facilitate these developments, the emission inventory will continue to closely collaborate with academic partners, among others in the AVENGERS project funded by the European Research Council (https://avengers-project.eu/). We hope to be able to include results for methane from the AVENGERS project next years.

Besides attempting to answer the questions raised in this first analyses, it will also be of great interest to further explore the effect of different transport models and inverse modelling algorithms on the resulting emissions.

Acknowledgement

Gratitude is extended to Anita Ganesan (University of Bristol), Alistair Manning (UK Met Office) and Stephan Henne (Empa) and their respective teams for providing the data, for fruitful discussion and for critical reading.

Annex 9 Chemical compounds, GWP, units and conversion factors

A9.1 Chemical compounds

CF_4	Perfluoromethane (tetrafluoromethane)
C_2F_6	Perfluoroethane (hexafluoroethane)
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
HCFCs	Hydrochlorofluorocarbons
HFCs	Hydrofluorocarbons
HNO_3	Nitric acid
NF_3	Nitrogen trifluoride
NH_3	Ammonia
NO_x	Nitrogen oxide (NO and NO_2), expressed as NO_2
N_2O	Nitrous oxide
NMVOC	Non-methane volatile organic compounds
PFCs	Perfluorocarbons
SF_6	Sulphur hexafluoride
SO_2	Sulphur dioxide
VOC	Volatile organic compounds (may include or exclude methane)

A9.2 GWP of selected GHGs

Table A9.1 lists the 100-year GWP of selected GHGs. Gases shown in italics are not emitted in the Netherlands.

Table A9.1 100-year GWP of selected GHGs

Gas	**100-year GWP 1)**
CO_2	1
CH_4 2)	28
N_2O	265
HFCs 3):	
HFC-23	12,400
HFC-32	677
HFC-41	116
HFC-43-10mee	1,650
HFC-125	3,170
HFC-134	1120
HFC-134a	1,300
HFC-143	328
HFC-143a	4,800
HFC-152	16
HFC-152a	138
HFC-161	4
HFC-227ea	3,350
HFC-236cb	1,210
HFC-236ea	1,330
HFC-236fa	8,060
HFC-245ca	716
HFC-245fa	858
HFC-365mfc	804
PFCs 3):	
CF_4	*6,630*
C_2F_6	*11,100*
C_3F_8	*8,900*
C_4F_{10}	*9,200*
c-C_4F_8	*9,540*
C_5F_{12}	*8,550*
C_6F_{14}	*7,910*
$C_{10}F_{18}$	*7,190*
c-C_3F_6	*9,200*
SF_6	23,500
NF_3	16,100

1) GWPs calculated using a 100-year time horizon in compliance with the UNFCCC Guidelines for reporting (UNFCCC, 2013).
2) The GWP of methane includes the direct effects and the indirect effects due to the production of tropospheric ozone and stratospheric water vapour; the indirect effect due to the production of CO_2 is not included.
3) The GWP-100 of emissions reported as 'HFC-unspecified' and 'PFC-unspecified' differ per reported year. They are in the order of magnitude of 3,000 and 8,400, respectively.

Source: IPCC 5th assessment report (2013).

A9.3 Units

MJ	Mega Joule (10^6 Joule)
GJ	Giga Joule (10^9 Joule)
TJ	Tera Joule (10^{12} Joule)
PJ	Peta Joule (10^{15} Joule)
Mg	Mega gramme (10^6 gramme)
Gg	Giga gramme (10^9 gramme)
Tg	Tera gramme (10^{12} gramme)
Pg	Peta gramme (10^{15} gramme)
ton	metric ton (= 1,000 kilogramme = 1 Mg)
kton	kiloton (= 1,000 metric ton = 1 Gg)
Mton	Megaton (= 1,000,000 metric ton = 1 Tg)
ha	hectare (= 10^4 m^2)
kha	kilo hectare (= 1,000 hectare = 10^7 m^2 = 10 km^2)
mln	million (= 10^6)

A9.4 Conversion factors for emissions

From element basis to full molecular mass:		**From full molecular mass to element basis**	
C ® CO_2:	x 44/12 = 3.67	CO_2 ®C:	x 12/44 = 0.27
C ® CH_4:	x 16/12 = 1.33	CH_4 ®C:	x 12/16 = 0.75
C ® CO:	x 28/12 = 2.33	CO ® C:	x 12/28 = 0.43
N ® N_2O:	x 44/28 = 1.57	N_2O ® N:	x 28/44 = 0.64
N ® NO:	x 30/14 = 2.14	NO ® N:	x 14/30 = 0.47
N ® NO_2:	x 46/14 = 3.29	NO_2 ® N:	x 14/46 = 0.30
N ® NH_3:	x 17/14 = 1.21	NH_3 ® N:	x 14/17 = 0.82
N ® HNO_3:	x 63/14 = 4.50	HNO_3 ® N:	x 14/63 = 0.22
S ® SO_2:	x 64/32 = 2.00	SO_2 ® S:	x 32/64 = 0.50

Annex 10 List of abbreviations

AD	Activity Data
AER	Annual Environmental Reports
AGB	Above-Ground Biomass
AR	Afforestation and Reforestation
AER	Annual Environmental Report
BCEF	Biomass Expansion Function
BF	Blast Furnace Gas
BGB	Below-Ground Biomass
BOD	Biological Oxygen Demand
C	Carbon or Confidential information(notation code in CRF)
CO	Coke Oven Gas
COD	Chemical Oxygen Demand
CBS	Statistics Netherlands
CDM	Clean Development Mechanism
CHP	Combined Heat and Power
CLRTAP	Convention on Long-Range Transboundary Transport of Air Pollutants
COD	Chemical Oxygen Demand
CPR	Commitment Period Reserve
CRF	Common Reporting Format (of emissions data files, annexed to an NIR)
CSC	Carbon Stock Changes
D	Deforestation
DM	Dry matter
DOC	Degradable Organic Carbon
DOCf	Degradable Organic Carbon Fraction
DOM	Dead Organic Matter
DW	Dead Wood
e-AER	electronic Annual Environmental Report
EEA	European Environment Agency
EF	Emission Factor
ENINA	Task Group Energy, Industry and Waste Handling
ER	Emission Registration (system)
ERT	Expert Review Team
ERU	Emission Reduction Unit
ETS	Emission Trading System
EU	European Union
EWL	European Waste List
EZ	Ministry of Economic Affairs
EZK	Ministry of Economic Affairs and Climate Policy (EZK)
FAO	Food and Agricultural Organization (UN)
F-gases	group of fluorinated compounds comprising HFCs, PFCs and SF_6
FGD	Flue Gas Desulphurisation
FM	Forest Management
FMRL	Forest Management Reference Level
GE	Gross Energy
GHG	Greenhouse Gas
GWP	Global Warming Potential

HOSP	Timber Production Statistics and Forecast (in Dutch: ‘Hout Oogst Statistiek en Prognose oogstbaar hout’)
HWP	Harvested wood products
IE	Included Elsewhere (notation code in CRF)
IEA	International Energy Agency
IEF	Implied Emission Factor
IPPU	Industrial Processes and Product Use (sector)
IWWTP	Industrial Wastewater Treatment Plant
IPCC	Intergovernmental Panel on Climate Change
LDAR	Leak Detection and Repair
LEI	Agricultural Economics Institute
LPG	Liquefied Petroleum Gas
LULUCF	Land use, land Use Change and Forestry (sector)
MCF	methane conversion factor
MFV	Measuring Network Functions (in Dutch: ‘Meetnet Functievervulling’)
MR	Methane Recovery
MSW	Municipal Solid Waste
MW	Mega Watt
N	Nitrogen
NA	Not Available/Not Applicable (notation code in CRF)
NAV	Dutch Association of Aerosol Producers
NE	Not Estimated (notation code in CRF)
NEa	Netherlands Emissions Authority (Dutch Emissions Authority)
NFI	National Forest Inventory
NIC	National Inventory Compiler
NIE	National Inventory Entity
NIR	National Inventory Report (annual GHG inventory report to UNFCCC)
NL-PRTR	Netherlands’Pollutant Release and Transfer Register
NMVOC	Non-Methane Volatile Organic Compound
NO	Not Occurring (notation code in CRF)
NRMM	Non-Road Mobile Machinery
ODS	Ozone Depleting Substances
ODU	Oxidation During Use (of direct non-energy use of fuels or of petrochemical products)
OECD	Organisation for Economic Co-operation and Development
OX	OXygen furnace gas
PA	Paris Agreement
PBL	PBL Netherlands Environmental Assessment Agency (formerly MNP)
PE	Pollution Equivalent
PRTR	Pollutant Release and Transfer Register
QA	Quality Assurance
QC	Quality Control
RA	Reference Approach (vs. sectoral or national approach)
RIVM	National Institute for Public Health and the Environment
RVO	Netherlands Enterprise Agency
SA	Sectoral Approach
SCR	Selective Catalytic Reduction
SEF	Standard Electronic Format
SNCR	Selective Non-Catalytic Reduction
SWDS	Solid Waste Disposal Site

TNO	Netherlands Organisation for Applied Scientific Research
TOF	Trees Outside Forest
TOW	Total Organics in Wastewater
UN	United Nations
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
UWWTP	Urban WasteWater Treatment Plant
VOC	Volatile Organic Compound
VS	Volatile Solids
WAR	Working Group for Waste Registration
WBCSD	World Business Council for Sustainable Development
WEM	Working Group Emission Monitoring
WRI	World Resources Institute
WR	Wageningen Research
WenR	Wageningen Environmental Research
WWTP	WasteWater Treatment Plant

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